SMITHSONIAN MISCELLANEOUS COLLECTIONS

VOLUME 145

"EVERY MAN IS A VALUABLE MEMBER OF SOCIETY WHO, BY HIS OBSERVATIONS, RESEARCHES, AND EXPERIMENTS, PROCURES KNOWLEDGE FOR MEN"—JAMES SMITHSON

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By ALEXANDER WETMORE

Research Associate
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The observations and descriptions included in the following pages have come to attention during detailed studies of the birds of the Isthmus of Panamá and their comparison with forms from other tropical areas. They are based in the main on the collections of the United States National Museum, with addition of specimens seen in the course of work at other institutions.

I. GEOGRAPHIC VARIATION IN THE BLACK VULTURE, *CORAGYPS ATRATUS* (BECHSTEIN)

Opinion on recognition of races in the black vulture has varied from treatment of the entire population as undivided throughout the vast range, from southern United States south through Central America and South America to southern Chile and Argentina, and recognition of two races, one northern and one tropical, based on difference in size. The latter view has been abandoned currently in the main since a study by Friedmann (1933, pp. 187-188) in which he compared average size of North American birds with a small series from southern South America to find that the wing measurements appeared too similar to warrant separation. In the course of studies during recent years I have had opportunity to examine approximately 130 black vultures in various collections in the United States and to assemble a series of measurements that verify the findings of Brodkorb (1944, pp. 115-121) that three size groups are present, a smaller population in the tropical area and two larger ones in the temperate regions to the north and south on either side. Brodkorb was uncertain as to the nomenclature to be used since he could not distinguish between the two larger groups, which he therefore treated under one name. The extensive material that I have seen has justified the recognition of 3 races, as follows:

CORAGYPS ATRATUS ATRATUS (Bechstein)

Vultur atratus Bechstein, *in* John Latham's Allg. Uebers. Vögel, Bd. 1, Anh., 1793, p. 655. (Florida.)

Vultur urubu Vieillot, Hist. Nat. Ois. Amér. Sept., vol. 1, Sept. 1807, p. 23, pl. 2. ("Carolines . . . Florides et . . . pour patrie la Zone torride"=Carolina and Florida; cf. A. O. U. Check-list North Amer. Birds, ed. 3, 1910, p. 153.)

Characters.—Size large; light markings on undersurface of primaries less extensive; wing ♂ (32 specimens) 414-445 (426); ♀ (28 specimens) 414-438 (426).

Resident from the mountains of northeastern Sonora (Sásabe, Moctezuma), western Texas, eastern Oklahoma, southeastern Kansas, Missouri, southern Illinois, southern Indiana, central Ohio (northern Licking County), eastern West Virginia, and Maryland south to the lower Rio Grande Valley in Texas (Brownsville), Louisiana, the Gulf coast, and Florida. The breeding range in recent years has been extended slowly along the northern boundary, with stragglers recorded casually to Nebraska, the Dakotas, and southern Ontario, eastward to southwestern Quebec, Maine, and Nova Scotia.

A male from Guadalajara, Jalisco, with the wing 415 mm., seems to indicate that this large northern form extends south from the international boundary through the plateau region of México and the adjacent mountain areas. In this same connection Col. L. R. Wolfe has pointed out to me some interesting data concerned with egg size in these birds. Three sets comprising 6 eggs in his collection from La Laja, in northern Veracruz, on the coastal plain about 40 miles south of Tampico, Tamaulipas, average 73.5×48.4 mm., which agrees closely with an average of 74.3×50.1 mm. for 21 eggs in 11 sets in the U. S. National Museum from Texas and Florida. As eggs of the subspecies of true tropical range are smaller, as will be shown under that race, there is indication that the northern form may range into northeastern México, though this requires check whenever skins from that area may be available.

CORAGYPS ATRATUS BRASILIENSIS (Bonaparte)

Cathartes brasiliensis Bonaparte, Consp. Gen. Avium, vol. 1, pt. 1, 1850, p. 9. ("ex Amer. merid. Antill." "Brasil merid." designated by von Berlepsch, Nov. Zool., vol. 15, 1908, p. 289; hereby further restricted to Rio de Janeiro, Brazil.)

? *Cathartes (vultur) urbis incola* "Ricord," Lesson, Compléments de Buffon, ed. 2, 1838, p. 93. (Indes occidentales . . . Santo Domingo, . . . bords de l'Orenoque . . . port d'Espagne . . . Saint-Vincent, à Saint-Lucie, à la Dominique et à la Santiago-de-Cuba.)

? *Cathartes urbicola* Des Murs, Rev. Mag. Zool., 1853, No. 4, p. 153. (Based on Lesson, 1838, above.)

? *Cathartes Ricordi* Des Murs, Rev. Mag. Zool., 1853, No. 4, p. 153. (Alternate name for *C. urbicola*.)

? *Vultur urbis-incola* "Riccord," Cassin, U. S. Expl. Exped., Mamm. and Ornith., 1858, p. 81. (Based on Des Murs, 1853, above.)

Characters.—Size small; light markings on underside of primaries more extensive and clearer white; wing ♂ (17 specimens) 386-410 (401); ♀ (23 specimens) 388-413 (400).

Resident in the tropical zone; in México, along the Pacific coast from southern Sonora (Camoa on the lower Río Mayo), and on the eastern side from southern San Luis Potosí (Bledos, Xilitla) southward throughout Central America; and in South America on the west to the coastal region of Perú (Lima), and on the east to the lowlands of Bolivia (Buenavista, Santa Cruz), and southern Brazil.

The southern limit from the material seen is uncertain but appears to include most of Brazil. The small size is constant throughout this vast range. It appears desirable to pinpoint restriction of type locality from that proposed by von Berlepsch to Rio de Janeiro in the southern part of that great country. Two specimens in the U. S. National Museum from the Federal District are typical in small size. It is possible that the next race may be found along the far southern boundary since this is the form of Paraguay.

With regard to egg size in this race, Colonel Wolfe writes that 7 eggs (in 4 sets) in his collection from Trinidad average 70.1×49.4 mm. A set of 2 in U. S. National Museum, collected at Lagoa Santo, Minas Gerais, by E. G. Holt, measures 70.4×48.4 and 68.6×48.8 mm. These figures are definitely less than those listed above for the typical race.

Cathartes urbicola of Des Murs (1853, p. 153), listed in the synonymy above, is based on an account of "le Catharte citadin" given by Ricord to Lesson and published by the latter in the second edition of his Compléments de Buffon (Lesson, 1838, p. 93). The bird described by Ricord is a composite based in part on the black vulture, and in part on the turkey vulture, but with the size of a condor as it is said to be 48 inches tall. It is described as inhabiting the Spanish settlements in the West Indies, Trinidad, and on the Orinoco, where it was protected by the authorities as a scavenger. Lesson in a footnote gave it the name "*Cathartes* (*vultur*) *urbis incola,* Ricord," which was cited by Des Murs (p. 147) as "*Cathartes urbis incola* (Ricord) Lesson." Cassin (1858, p. 81) lists this under *Cathartes urbicola* Des Murs as "*Vultur urbis-incola,* Riccord." Des Murs also in the original citation wrote *ricordi* as an alternate name, his statement being as follows: "Jusque-la nous croyons devóir proposer pour le nom de ce Catharte, en tant qu'on le maintiendrait dans le série comme espèce douteuse ou à étudier, soit le nom de *Cathartes urbicola,* soit encore mieux celui de *Cathartes Ricordi.*"

While the black vulture undoubtedly is one of the birds to which these citations refer, the details of the accounts include the turkey vulture and possibly the condor in such a mixture that the names are of uncertain application. The earliest valid name is *brasiliensis* Bonaparte of 1850.

CORAGYPS ATRATUS FOETENS (Lichtenstein)

Cathartes foetens Lichtenstein, Verz. Ausgest. Säug. Vögel Zool. Mus. Berlin, 1818, p. 30. (Based on "Iribu Azara"; Paraguay; restricted to Asunción, Paraguay, by Brodkorb, in 1944.)

Characters.—Size similar to that of *C. a. atratus,* but light markings on under surface of primaries more restricted, the under wing definitely darker than in the two more northern races. Wing, male (10 specimens) 412-437 (421), female (5 specimens) 416-422 (419).

Resident in the Andes from northern Ecuador (Quito) to northern Bolivia (Cochabamba); in Chile, south to Aysen; Paraguay, including the Chaco, from the north-central section (Horqueta, 200 kilometers west of Puerto Casado), and Argentina south to the Río Negro; probably through Uruguay (no specimens examined).

The large size of the southern group has been the main cause of confusion in recognition of races in this species, since when birds of southern South America have been examined they have not appeared separable from northern representatives of equivalent measurements. This misunderstanding has completely overshadowed the vast tropical population of uniformly small dimension. The true status was clearly outlined by Brodkorb (1944, pp. 115-121), but his analysis has been disregarded since he applied the name of the nominate race to the large birds of both north temperate and south temperate areas in spite of their wide separation by another form.

With regard to eggs, Colonel Wolfe writes that a set of 2 from Argentina in his collection measures 74.5×45.0 and 72.0×47.0, and that the average of 54 eggs taken in Chile, according to figures furnished by A. W. Johnson, is 72.58×49.5 mm. These figures are close to the sizes found in the typical race of the north.

II. THE CRESTED BOBWHITE, *COLINUS CRISTATUS* (LINNAEUS), OF WESTERN CHIRIQUÍ

The quail of Panamá, described as *Colinus cristatus panamensis* by Dickey and van Rossem, is locally common from western Veraguas through Coclé to the western area of the Province of Panamá. To the south it ranges down the eastern side of the Azuero Peninsula through Herrera and Los Santos, including the valley of the Río Tonosí. There have been few records for the Province of Chiriquí until recently, when I found crested bobwhites in small numbers in the coastal lowlands between Alanje and Puerto Armuelles, as well as near Boquete. The birds of this region are an isolated population separated by a considerable area, where no quail are known, from the main group of the species in the Republic. The bird of Chiriquí differs so decidedly in coloration that it requires recognition as another form.

COLINUS CRISTATUS MARIAE subsp. nov.

Characters.—Similar to *Colinus cristatus panamensis* Dickey and van Rossem [1] but decidedly darker, the markings of the upper surface blacker, and the black areas of the lower surface more extensive in both sexes; darker than any other population of the species.

Description.—Type, U.S.N.M. No. 471174, male adult, from 7 kilometers south of Alanje, Province of Chiriquí, Panamá, collected March 8, 1960, by A. Wetmore (original number 23600). Forehead, lores, a narrow feathered area surrounding the eye, and side of head down to the ramal area, dull white; shorter anterior feathers of the narrow, elongated crest pale drab-gray, the longer ones fuscous, tipped, and spotted irregularly along the edges, with drab; a broad superciliary extending from above the middle of the eye back to the side of the nape behind the auricular region mikado brown, lined irregularly with black; crown black, edged narrowly with white and adjacent to the superciliary with bright brown; auricular area dull olive-buff; black of crown extended down over nape, hindneck, and sides of neck, to extreme upper back, and spotted rather irregularly with white; feathers of back, scapulars, tertials, wing coverts, rump, upper tail coverts, and tail black, freckled with fine markings of fawn color, grayish white, and white, the inner secondaries edged, and the wings spotted more prominently, with dull white; primaries dull mouse gray, with the edge of the outer web and the tip of both webs varied from dull white to tilleul-buff; chin drab-gray; throat, foreneck, and sides of upper neck, below auriculars, russet; base of neck black, spotted with white and irregularly with russet, changing across upper breast to sayal brown, with each feather banded basally with white and medially with black below the brown tip to produce an appearance of irregular spotting; abdomen pinkish buff, with partly concealed bars of dull black, spotted with white and pinkish

[1] *Colinus leucotis panamensis* Dickey and van Rossem, Condor, vol. 32, No. 1, Jan. 20, 1930, p. 73. (Aguadulce, Coclé, Panamá.)

buff; under surface of wings mouse gray, with the under wing coverts tipped and edged lightly with dull white. Bill black; tarsus and feet dusky neutral gray (from dried skin.)

Measurements.—Males (6 specimens), wing 92.6-95.3 (93.7), tail 46.3-52.3 (49.2), culmen from cere 12.7-13.9 (13.2), tarsus 27.9-29.1 (28.5) mm.

Females (3 specimens), wing 92.0-96.1 (94.0), tail 45.7-50.0 (48.4), culmen from cere 12.4-13.4 (12.8), tarsus 27.2-29.4 (28.5) mm.

Type, male, wing 93.3, tail 52.3, culmen from cere 13.0, tarsus 27.9 mm.

Range.—Western Chiriquí on the southern slopes of the Volcán de Chiriquí near Boquete (El Salto, 1,350 meters elevation), and Francés near El Banco; and on the coastal plain below Alanje. Apparently restricted in distribution but fairly common when it is found.

Remarks.—The crested bobwhite of Panamá has been known principally from Veraguas and Coclé, with few specimens in museum collections from Chiriquí. Present information indicates that the population in Chiriquí is isolated as it is known only from the western part of the province, and there are no records of the related race *Colinus cristatus panamensis* beyond a point about 10 kilometers west of Soná in western Veraguas. From this western limit the subspecies *panamensis* is recorded in open country eastward to the western sector of the Province of Panamá (where I have found it near Nueva Gorgona, and 10 kilometers east of Bejuco), and south on the eastern side of the Azuero Peninsula through Herrera and Los Santos to Pedasí and near the Río Oria below Los Asientos; also in the lower Tonosí valley. It is evident that the additional race here described is one of restricted range, since it is reported to date only from three localities in an area between 50 and 60 kilometers in length. As I have been long familiar with the brown subspecies *panamensis* of farther east in the Republic the much darker coloration of the form here described was immediately evident on my first sight of it in life. It marks the western extension of the species *cristatus*.

The new form is named for Mrs. Robert A. Terry, who as Mary E. McLellan Davidson, through her studies in field and laboratory, has added much to our knowledge of the bird life of the Province of Chiriquí.

III. AN ADDITIONAL RACE OF THE CHESTNUT-BACKED ANTBIRD, *MYRMECIZA EXSUL* SCLATER

The chestnut-backed antbird, found widely through the tropical lowlands of the Republic of Panamá, is a forest-inhabiting species that still remains in small numbers in inhabited sections since a part of its haunt is in swampy woodlands where the land is too wet to be available for cultivation. Here it still finds suitable habitat when the surrounding forest has been destroyed. Three subspecies have been recorded from Panamá. A detailed study of the series now available from the entire isthmus has indicated a fourth that requires description.

MYRMECIZA EXSUL NIGLARUS subsp. nov.

Characters.—Similar to *Myrmeciza exsul exsul*,[2] but paler above and below; darker than *M. e. occidentalis* Cherrie,[3] especially in the female.

Description.—Type, U.S.N.M. No. 423427, male, from the Río Chimán about 10 kilometers above Chimán, Province of Panamá, collected February 20, 1950, by A. Wetmore and W. M. Perrygo (original number 15208): Crown, sides of head, throat, and foreneck black, shading to dark neutral gray on hindneck; rest of upper surface Mars brown, shading to russet on rump and upper tail coverts; rectrices fuscous, edged with russet; bend of wing black, edged with white, the alula being fuscous-black with the outer webs edged with white; lesser wing coverts with a shaft line of dusky neutral gray, terminating in a slightly expanded tip of the same color; primaries and secondaries fuscous-black, with the outer webs Mars brown, except the outermost, which has a narrow white outer edge; black of foreneck shading progressively to deep neutral gray on chest, and neutral gray on lower breast; under wing coverts dusky neutral gray, mixed scantily with white; posterior part of sides, flanks, and under tail coverts cinnamon-brown. Bill black; feet fuscous-brown (from dried skin).

Measurements.—Males (15 specimens), wing 65.0-70.1 (67.1), tail 42.5-49.7 (45.7), culmen from base 20.2-22.3 (21.4), tarsus 27.5-29.7 (28.4) mm.

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[2] *Myrmeciza exsul* P. L. Sclater, Proc. Zool. Soc. London, vol. 26, 1858 (Jan.-May 1859), p. 540. ("Panama," type locality hereby restricted to near Gatun, Canal Zone.)

[3] *Myrmeciza immaculata occidentalis* Cherrie, Auk, vol. 8, No. 2, April 1891, p. 191. (Pozo Azul de Pirris, Pacific slope of Province of San José, Costa Rica.)

Females (10 specimens), wing 62.7-67.0 (64.2), tail 40.2-47.6 (43.3), culmen from base 19.9-22.2 (20.8), tarsus 26.4-29.6 (28.1) mm.

Type, male, wing 66.8, tail 42.5, culmen from base 20.7, tarsus 28.2 mm.

Range.—Eastern Panamá; on the Pacific slope from the western end of the Cerro Azul east through the Province of Panamá to western Darién; on the Caribbean slope from the upper Chagres Valley, above Madden Lake (Quebrada Candelaria on the Río Pequení, Quebrada Peluca on the Río Boquerón), and western Comarca de San Blas (Mandinga) east to the Colombian boundary, and beyond to Acandí in northernmost Chocó, Colombia.

Remarks.—The wing coverts are plain in most individuals of this race, with the white spotting typical of *M. e. cassini* and *M. e. maculifer* found only casually in a few. Specimens from the middle Chucunaque Valley, near the mouth of the Río Tuquesa, are intermediate between the new form and *cassini*, which ranges through the rest of the lowlands of the Tuira basin.

The name *niglarus* is taken from the Greek νίγλἄρος, a small fife, in allusion to the whistled calls of these birds, heard constantly as they move through the undergrowth on the forest floor.

IV. THE GEOGRAPHIC RACES OF THE SILVER-THROATED TANAGER, *TANGARA ICTEROCEPHALA* (BONAPARTE)

Specimens now available, particularly those from Costa Rica and the western half of Panamá, permit a better understanding of geographic variation in the tanager *Tangara icterocephala* (Bonaparte). The species, described from Ecuador in 1851, soon was recorded also from Costa Rica, and from Veraguas and Chiriquí in western Panamá. Cabanis, in 1861, named the Costa Rican bird *frantzii*, but Ridgway in 1902, with limited series, was not able to distinguish this as a separate race. Hellmayr, in 1936, and others have followed Ridgway's treatment, though with indication by some that there may be two forms. It is only recently that De Schauensee, in 1951, in his account of the birds of Colombia, recognized formally that there are two races. The uncertainty has resulted from the interesting fact that the populations of these birds in Ecuador and in Costa Rica both are bright in color, which obscures their differences. Specimens that I have collected in recent years from the mountains immediately west of the Canal Zone include another subspecies distinct from both of the others.

Females in all three races are duller, more greenish throughout, a fact that should be borne in mind in comparing specimens in which the sex is not marked. Juvenile birds differ from adult females in more greenish back, hindneck, and crown, duller-colored rump, less definite streaking on the back, and duller yellow of the under surface.

TANGARA ICTEROCEPHALA ICTEROCEPHALA (Bonaparte)

Calliste icterocephala Bonaparte, Compt. Rend. Acad. Sci. Paris, vol. 31, No. 3 (séance du 20 janv.), 1851, p. 76. (Valley of Punta Playa, near Quito, Ecuador.)

Characters.—Similar to *T. i. frantzii* in bright coloration, but with feathers of crown and nape somewhat greenish basally, so that the yellow in this area appears less intense; partly concealed ring around the base of the hindneck deeper blue; foreneck and throat averaging faintly darker.

Measurements.—Males (12 specimens), wing 71.2-75.0 (72.7), tail 44.2-48.5 (45.8), culmen from base 12.1-12.5 (12.3), tarsus 16.0-17.3 (16.8) mm.

Females (9 specimens), wing 66.6-72.3 (68.7), tail 41.9-46.2 (43.4), culmen from base 12.2-14.2 (12.7), tarsus 16.2-17.5 (17.2) mm.

Range.—Mountains of eastern Darién, Panamá (Cerro Tacarcuna, Cerro Pirre) south in the western Andes through Colombia to southern Ecuador.

TANGARA ICTEROCEPHALA ORESBIA subsp. nov.

Characters.—Decidedly duller yellow throughout than either *T. i. frantzii* or *T. i. icterocephala;* partly concealed band on hindneck more greenish blue; foreneck and throat darker; sides and flanks darker, with a greenish-yellow cast: Female, in addition, with edging on back feathers more green, less yellow.

Description.—Type, U.S.N.M. No. 433998, male, south face of Cerro Campana, 850 meters elevation, western sector of the Province of Panamá, Panamá, collected March 7, 1951, by A. Wetmore and W. M. Perrygo (original number 16221). Lores, a very narrow line around eyelids, a small spot behind the eye, a narrow line posterior to the nostrils, and another from the gape across the lower margin of the cheeks to the nape, black; crown and sides of head slightly duller than light cadmium; nape washed with pyrite yellow; band across hindneck bluish gray-green; back feathers distinctly streaked, black centrally, edged broadly with sulphine yellow anteriorly, changing posteriorly to wax yellow; rump between light cadmium and apricot yellow; upper tail coverts oil green, tipped indistinctly with warbler green; wings and tail black; lesser and middle wing coverts edged with lettuce green, with a light tipping of lemon chrome; greater wing coverts, primaries, and secondaries edged heavily with lettuce green; inner webs of central pair of rectrices cedar green; outer webs of all rectrices edged with lettuce green; point of chin black; feathers of throat, foreneck, and upper margin of chest dark green-blue gray, washed on throat and adjacent ramal area with dark bluish glaucous, on foreneck with light grape green, and on sides of neck with pinkish buff, with the darker basal color showing through in varying amount with change in angle of the light; center of breast and abdomen between light cadmium and lemon chrome; sides between light cadmium and aniline yellow; flanks and under tail coverts aniline yellow; tibia citrine; bend of wing warbler green, stippled lightly with black; under wing coverts light yellowish olive externally, changing to white internally, edged lightly with cream-buff. Bill black; tarsus and toes fuscous (from dried skin).

Measurements.—Males (8 specimens), wing 72.4-77.4 (73.6), tail 45.8-49.8 (47.3), culmen from base 12.0-14.8 (12.9), tarsus 17.5-18.8 (18.3) mm.

Females (9 specimens), wing 68.7-72.4 (71.1), tail 43.5-47.6 (45.6), culmen from base 12.5-14.0 (13.2, average of 8), tarsus 17.8-18.8 (18.3) mm.

Range.—Mountain areas of west central Panamá from Cerro Campana, western Provincia de Panamá, to Coclé (El Valle, Río Guabal).

The name of this form is taken from the Greek ὀρέσβιος, living on mountains.

TANGARA ICTEROCEPHALA FRANTZII (Cabanis)

Callispiza (Chrysothraupis) Frantzii Cabanis, Journ. für Orn., vol. 9, pt. 2, March 1861, p. 87. (Costa Rica.)

Characters.—Similar to *T. i. icterocephala,* but with crown and hindneck more yellow; partly concealed ring on base of hindneck paler, more greenish blue; foreneck and throat paler: definitely brighter yellow above and below than *oresbia.*

Measurements.—Males (14 specimens from Costa Rica), wing 72.3-78.6 (75.5), tail 44.7-49.8 (47.8), culmen from base 11.5-12.8 (12.3), tarsus 17.2-18.8 (18.0) mm.

Females (12 specimens from Costa Rica), wing 69.5-73.7 (71.7), tail 43.0-46.3 (44.9), culmen from base 11.5-12.6 (11.9), tarsus 17.2-18.5 (17.9) mm.

Range.—Mountains of Costa Rica and western Panamá, east to eastern Veraguas (Chitra).

V. ADDITIONS TO THE RECORDED LIST OF BIRDS FROM THE REPUBLIC OF PANAMÁ

SALMON'S TIGER-BITTERN, *Tigrisoma salmoni* SCLATER AND SALVIN:

This species, described from Medellín in the Province of Antioquia, northwestern Colombia, with a recorded range east to Venezuela and south through Ecuador and Perú to western Bolivia, ranges also along the Caribbean slope of the Isthmus of Panamá. It was first noticed for this area on February 29, 1952, when I collected an adult male on the Río Uracillo, near the town of that name in the foothills of the Caribbean slope of Coclé. I secured another, an immature bird, near the Peluca Hydrographic Station on the Río Boquerón, Province of Colón, on February 21, 1961, and have a third, shot on the Río Changena, Bocas del Toro, September 9, 1961. This species differs from the banded tiger-bittern *Tigrisoma lineatum* (Boddaert) structurally in the form of the bill, which is shorter and also heavier, less attenuate at the tip. The adult *salmoni* is definitely blacker, but the immature differs only in being more extensively white on the lower surface. With the presence of the species known I have found several immature birds in other collections taken earlier in Darién and the eastern Comarca de San Blas, but wrongly identified as *Tigrisoma lineatum*.

SLENDER-BILLED KITE, *Helicolestes hamatus* (TEMMINCK):

The slender-billed kite is reported for Colombia on the basis of a record by Salmon from the Río Ité, near Remedios in Antioquia, and is known from scattered localities from eastern Perú to Venezuela (Caicara), Surinam, and the lower Amazon. In Darién, on February 24, 1959, as I landed from a piragua at the mouth of a tiny stream that enters the Río Tuira a short distance above where the Río Paya joins this larger river, I was interested to note shells of an apple snail scattered along the sandy shore, and immediately saw one of these kites perched over a shaded pool inside the forest border. The bird was a female. Later I received another skin from the Gorgas Memorial Laboratory, taken near the same point in the previous year. These are the first reports of this little-known species beyond South America.

GUÁCHARO, *Steatornis caripensis* HUMBOLDT:

On the night of March 19, 1959, Bernard Feinstein, assistant to Dr. Charles O. Handley, Jr., captured a female of this species in a mist net set for bats at an elevation of 975 meters near the old Tacarcuna village site on Cerro Tacarcuna, Darién. The guácharo has a wide distribution in northern South America, including Trinidad, but has not been found previously outside those limits.

Short-tailed Swift, *Chaetura brachyura brachyura* (Jardine):

On September 12, 1960, Dr. Nathan Gale found one lying dead at Corozal, Canal Zone, and brought it to the laboratory of the Malaria Control Service. Here Eustorgio Méndez of the Gorgas Memorial Laboratory secured it and prepared the skin, which is now in the U. S. National Museum. The species has a wide range in South America from the north coast to eastern Perú and central Brazil, with populations in St. Vincent, Trinidad, and Tobago. The Canal Zone record is the first report of it for Panamá.

VI. ADDITIONS TO THE LIST OF BIRDS KNOWN FROM COLOMBIA

Studies of the extensive collections of birds from northern Colombia in the U. S. National Museum in connection with work on the avifauna of Panamá continues to add to the forms known from that republic. Recent additions in this field are as follows:

Savanna Hawk, *Heterospizias meridionalis rufulus* (Vieillot):

Examination of a considerable series of these beautiful hawks verifies recognition of two forms on the basis of size. The southern group that breeds from southern Paraguay and Rio Grande do Sul, Brazil, to the provinces of Córdoba and Santa Fé, in northern Argentina, ranges in wing measurement, regardless of sex, from 418 to 452 mm. During the period of southern winter part of these larger birds move northward into the territory of the typical race. The northern population, true *meridionalis,* resident from Panamá, Colombia, and Venezuela to Bolivia, northern Paraguay, and south-central Brazil, varies in wing measurement from 379 to 412 mm.

A female that I shot near Maicao in the Guajira Peninsula, northeastern Colombia, on April 14, 1941, with primaries worn at the tip, has the wing still 418 mm. long, and so represents a migrant or wanderer of the southern subspecies. Other breeding specimens taken during the same period in the Guajira in their smaller size are typical *meridionalis.*

Gray Hawk, *Buteo nitidus blakei* Hellmayr and Conover:

A female collected by M. A. Carriker, Jr., at Acandí in northern Chocó, on the western side of the Gulf of Urabá, is typical of this race of adjacent Panamá. It differs from *Buteo nitidus nitidus,* found elsewhere in northern Colombia, in being darker gray above, particularly on the crown and hindneck. Apparently *blakei* does not extend far into Colombia since De Schauensee has reported typical *nitidus* from the Río Juradó on the Pacific slope of northern Chocó, and Carriker secured that subspecies at Nazaret, in western Córdoba, beyond the Río Sinú.

PIGEON HAWK, *Falco columbarius bendirei* SWANN:

A male taken by Carriker February 26, 1946, at Manancanaca in the higher levels (3,600 meters) of the Sierra Nevada de Santa Marta is a well-marked adult of this migrant from western North America. The race *bendirei* has not been reported previously in South America. In this connection another specimen, a female that W. M. Perrygo and I secured April 15, 1946, at Jaque, Darién, only 40 kilometers from the Colombian boundary, is also of interest as the only record at present for Panamá.

BANDED WOOD-QUAIL, *Rhynchortyx cinctus cinctus* (SALVIN):

A series taken by Carriker at Socorro and Quebrada Salvajín, Córdoba, near the Río Sinú, at Tarazá, in northern Antioquia, near the Río Cauca, and at Volador in southern Bolívar, represents the typical race, hitherto unknown outside Panamá. *Rhynchortyx cinctus australis* Griscom, described from the Comarca de San Blas, on the Caribbean coast of eastern Panamá, with additional material proves not separable from typical *cinctus,* as the characters on which it was based are those of individual variation.

HOUSE WREN, *Troglodytes aedon inquietus* BAIRD:

Male and female taken January 5 and 7, 1950, by Carriker at Acandí, Chocó, on the western side of the broad entrance of the Gulf of Urabá, are good examples of this race, which is the form found throughout most of Panamá. The occurrence at Acandí is not surprising since this subspecies has been recorded east in the Comarca de San Blas to Puerto Obaldía near the Colombian frontier. Carriker secured another male *inquietus* February 9, 1950, at Necoclí, on the eastern shore of the Gulf of Urabá (called also Gulf of Darién), north of Turbo, and collected two house wrens April 28 in the same year farther south at Villa Artiaga in northwestern Antioquia that are intermediate toward *Troglodytes aedon striolatus,* but nearer to *inquietus.* It appears, therefore, that the form typical of most of Panamá extends around the head of the Gulf.

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NOTES ON FOSSIL AND SUBFOSSIL BIRDS

By ALEXANDER WETMORE
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Smithsonian Institution

The following pages cover several studies on fossil and subfossil birds, based mainly on material in the U.S. National Museum. The collection from the Pleistocene of Augusta County, Va., has come through the kindness of John E. Guilday of the Carnegie Museum. The bones from Bermuda were collected for the Smithsonian Institution by David B. Wingate.

I. AN UPPER CRETACEOUS BIRD RELATED TO THE IBISES

In the summer of 1958, Dr. Shelton P. Applegate, now at State College, Arkansas, collected a broken humerus of a bird in Greene County, west-central Alabama, that appears related to the storks and ibises of the order Ciconiiformes. According to data supplied by Dr. Applegate, the specimen came from Hewletts farm, 3 miles northeast of the town of Boligee, where it was found in the farther side of a series of gullies that lie to the west of the county road, before this reaches the farmhouse entrance. The location, in the Mooreville formation of the Selma chalk, was about 10 feet below the Arcola limestone.

The form of the humerus indicates a species about half the size of the living white ibis *Eudocimus albus.*

PLEGADORNIS gen. nov.

Diagnosis.—A fossil storklike bird, with the distal end of the humerus flattened, ectepicondyle long, and the brachial depression shallow and relatively large. Characters in detail those of the only known species, *Plegadornis antecessor,* the type of the genus.

PLEGADORNIS ANTECESSOR sp. nov.

Characters.—Known from a fragmentary left humerus that is generally similar to living species of the suborder Ciconiae; much smaller than the smallest of living forms of the suborder (half the size of *Plegadis,* or less). Outline of distal end of the humerus (fig. 1) somewhat similar to that of species of the family Threskior-

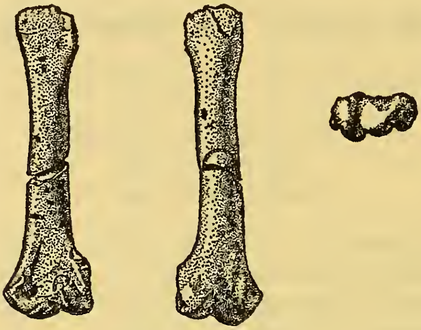

FIG. 1.—Type of *Plegadornis antecessor* from the Upper Cretaceous of Alabama. Natural size.

nithidae, but with the ectepicondyle elevated above the level of the internal condyle at a slightly greater angle; attachment of anterior articular ligament relatively much larger; internal condyle relatively longer and slightly narrower; external condyle slightly less angular on upper end, with more separation from the ectepicondyle on its outer margin; the ectepicondyle much larger, so that one-fourth of its length extends up the shaft above the level of the upper end of the external condyle; brachial depression large and only slightly depressed; a slight expansion from the side of the shaft at the lower end of the deltoid crest, below the actual articular area, like that in modern species of Threskiornithidae, particularly of the subfamily Plataleinae.

Transverse breadth across distal end 10.5 mm.; transverse breadth of shaft near center 4.9 mm.

Type.—Distal end of left humerus, with part of the shaft from the upper end, U.S.N.M. No. 22820, from the Mooreville formation of the Selma chalk, Upper Cretaceous, 3 miles northeast of Boligee, Greene County, Ala., collected by Shelton P. Applegate about June 20, 1958.

Remarks.—The important part of the specimen is the distal end, which is somewhat worn, but where sufficient character is present to allow indication of relationship. The upper segment shows a trace of the curvature characteristic of the suborder in which it is allocated, and an indication of the form at the extreme lower end of the deltoid crest, but has lost other details. A section of the shaft between the upper and lower portions is missing.

The fossil is important because of its indication, slight though that may be, of the occurrence of ibislike birds at this early period, and in its general similarity to species of this group that still exist. It is the first fossil bird recorded from Alabama.

While it appears allied to species now classified in the suborder Ciconiae, which includes the families of the hammerhead (*Scopus*), the storks (family Ciconiidae), and the ibises (Threskiornithidae), its differences, as indicated in the diagnosis, are such that it requires a separate family, Pelagodornithidae, to be allocated in a superfamily Pelagodornithoidea, adjacent to the superfamily Threskiornithoidea.

The generic name for this interesting species is formed from the Greek root for *Plegadis,* a widely distributed modern genus of ibises, viz, πληγάς, αδος, and ὄρνις, bird. The specific name, the Latin word "antecessor," signifies a forerunner (or ancestor).

II. A RECORD OF THE COMMON LOON, *GAVIA IMMER* (BRÜNNICH), FROM THE PLEISTOCENE OF MARYLAND

The cranium of a loon found in December 1959 on the shore between Chesapeake Beach and Plum Point, on Chesapeake Bay, in Calvert County, Md., has been presented to the U.S. National Museum by Miss Alice H. Howe of Arlington, Va. The specimen (U.S.N.M. No. 22552) is stained dark brown in color and still retains a film of fine clay silt in the deeper impressions. Its appearance, both in color and in the clay deposit, is indication of ancient age and is typical of the Pleistocene deposits that lie above the Miocene beds in the earthern cliffs that line this section of Chesapeake Bay. There is no reason therefore against listing the bone as of that age.

The bone (fig. 2) includes the upper surface of the cranium from the base of the premaxilla to the foramen magnum, except that the ridge immediately above the foramen is missing, and there are minor breaks in the posterior area of the frontal. Below, the basioccipital area has been lost.

The bone obviously is representative of an adult of a large species of the genus *Gavia.* On comparison of 10 skulls of *Gavia immer* with 6 of *G. adamsii,* all of adult age, I find that the cranial section in the former averages less massive in form. The angle of the anterior end of the frontals, immediately posterior to their junction with the nasals, in most is less abrupt, and the transverse width through the heavy postorbital processes is less. In *G. adamsii* the cranium is more massive, the anterior end of the frontals slopes more abruptly, and

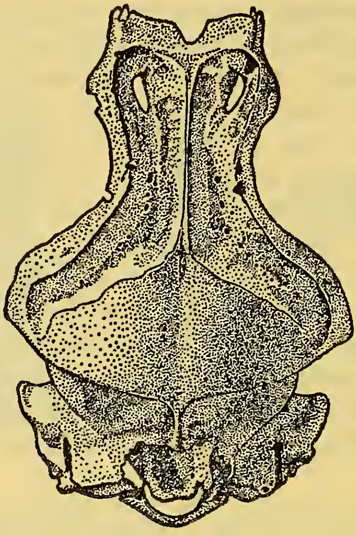

FIG. 2.—Dorsal view of the cranium of a common loon, *Gavia immer,* from the Pleistocene of Maryland. Natural size.

the transverse width indicated is greater. While the largest skulls of *immer* are close to *adamsii* the smaller ones appear distinct. The specimen under identification agrees with the medium-sized and smaller samples of *immer* and is identified as that species.

The occurrence on Chesapeake Bay is an additional Pleistocene record for *Gavia immer,* which has been reported previously from deposits of that age in California and Florida.

III. THE WHOOPING CRANE, *GRUS AMERICANA,* IN MICHIGAN

In a recent visit to the Chicago Natural History Museum I noted a Pleistocene bone identified tentatively as this species, which Dr. Rainer Zangerl has kindly placed in my hands for study. The specimen is a left tarsometatarsus of a juvenile individual which apparently had developed the full length of this segment of the bone, but in which the upper end was not fully ossified, as the surface of the articulation is not completely formed. The shaft also is slender with its outlines rounded, less angular than in adult specimens, and the entire bone presents the slightly roughened spongy appearance that marks an immature stage. The distal trochlea and the talon both are broken and missing, but it is possible to ascertain the length from the anterior end to the distal foramen, which equals that of modern adult tarsometatarsi in the U.S. National Museum Collections. It is identified, without question, as *Grus americana* (Linnaeus), the whooping crane.

The specimen, Chicago Natural History Museum No. P25538, found one-half mile northwest of Ferry, Oceana County, Mich., in what was reported to be a Pleistocene marl, was presented to the Museum by George W. Bowen. The record is of particular interest since it is not only a new fossil locality for this species, but also is the first report of this crane from the State of Michigan.

The species has been recorded previously as a fossil from the Upper Pliocene of Idaho, and from the Pleistocene of California and Florida.

IV. BIRDS OF LATE PLEISTOCENE AGE FROM AUGUSTA COUNTY, VIRGINIA

Through the kindness of John E. Guilday of the Carnegie Museum a collection of bird bones from small caves and fissures at the bases of the rock columns known as the Natural Chimneys, a mile north of Mount Solon, Va., has come to me for study. According to data supplied by Mr. Guilday, the presence of bones at this site was reported first in 1949 by Theodore B. Ruhoff, who has collected the bulk of the material. Parties from the Carnegie Museum, directed by J. LeRoy Kay, curator emeritus of the section of vertebrate paleontology, also participated, until 1961. The work was possible through the kind permission and assistance of Mr. and Mrs. Gordon E. Brown, owners of the property.

The bird remains were associated with abundant bones of mammals and a smaller representation of reptiles and amphibians. Most of the specimens are of such size and condition as to indicate the probability that the deposit was accumulated through pellets regurgitated by ancient owls. It must be stated, however, that no bones of owls are included. The casual intrusion of fragments of larger birds is assumed to have come through predators that sheltered in the caves, or through the activities of wood rats, abundantly represented among the small mammals.

A complete report on the site prepared by Mr. Guilday (in press) will contain a list of all the vertebrates, a detailed account of the mammals, and a discussion of the entire fauna and its significance. In the present account it is sufficient to state that the mammalian remains include a number of boreal forms foreign to the area in historic times, as well as four extinct species of the Pleistocene. These indicate the probable age as near the end of Wisconsin time. The birds support this assignment, as among them the spruce grouse and the gray jay today are inhabitants of northern coniferous forests, and the sharp-tailed grouse and the magpie also are northern and northwestern in modern distribution. None of the birds may be regarded as typically southern since all the others identified are species that, while found today as residents or migrants in Virginia, range widely to the north. The presence of all at the end of the Pleistocene in what Mr. Guilday has named the Natural Chimneys local fauna is definitely of outstanding interest since this is the first extensive avian fossil deposit reported for the State. The list includes 38 species, with 2 others identified to genus. Fragmentary bits that could not be named include several additional small passeriform species.

The bird bones are pale ivory to nearly white in color, except for a few that are gray or blackish gray, due apparently to staining, as none are mineralized. All are well preserved, only occasional ones being friable or brittle. A few come from juvenile individuals, some of them probably from young grouse, though this is not certain.

ANNOTATED LIST OF SPECIES

Family ANATIDAE: Ducks

Anas discors Linnaeus: Blue-winged Teal.

At least two individuals: Central section of right ramus of a mandible, from the anterior end of the surangular forward to include somewhat more than half of the dentary; proximal ends of two right humeri; left tarsometatarsus with the head missing.

Difference in size in the fragmentary wing bones indicates that male and female birds may be represented. The part from the lower leg is one with maximum development of the sculptured lines marking the location of tendons and their attachment found in individuals more than a year old.

This teal is recorded from several Pleistocene localities in Florida.

Bucephala albeola (Linnaeus): Bufflehead.

One individual: A left carpometacarpus, with the shaft of metacarpal III missing. This agrees in the details of length of the distal symphysis, angle of anterior slope of metacarpal I, form of the facet for articulation of the pollex, and angular compression of the inner margin of the shaft of metacarpal III, with modern specimens.

The several Pleistocene records for the bufflehead include reports from Oregon, California, and Florida.

Oxyura jamaicensis (Gmelin): Ruddy Duck.

One individual: Proximal two-thirds of a left humerus. The small size indicates that the bird, which appears to have been adult, was a female.

The ruddy duck has been identified in Pleistocene deposits in Oregon, California, and Florida.

Family ACCIPITRIDAE: Hawks

Accipiter striatus Vieillot: Sharp-shinned Hawk.

One individual: A right carpometacarpus, complete, is from a bird of small size that agrees in dimension with males.

The sharp-shinned hawk has been identified from the Pleistocene of California and Florida, and from pre-Columbian cave deposits of ancient but uncertain age on Great Exuma in the Bahama Islands.

Buteo jamaicensis (Gmelin): Red-tailed Hawk.

One individual: A left femur, with broken shaft and some wear on the proximal end.

The red-tail, widely distributed in modern time from northern Canada to western Panamá, has been found in several Pleistocene localities in California and Florida.

Buteo lineatus (Gmelin): Red-shouldered Hawk.

One: Distal end of a right humerus, small in size.

The red-shouldered hawk, found in eastern North America from Minnesota and southern Quebec to central México and Florida, and west of the Rocky Mountains in California and Baja California, is known from Pleistocene time in Florida and California.

Buteo platypterus (Vieillot): Broad-winged Hawk.

One individual: Distal third of a right tarsometatarsus, with the trochlea intact. The specimen has the size of male birds.

Broad-wings nest in eastern North America from southern Canada to Texas and Florida, and in the West Indies. There is one report of the species from the Pleistocene of Florida.

Family TETRAONIDAE: Grouse

Canachites canadensis (Linnaeus): Spruce Grouse.

One individual, possibly more: Distal third of left humerus; distal two-thirds of left ulna; right tarsometatarsus complete. The humerus in this species in length is similar to that of the ruffed grouse, but the shaft is more slender, the internal condyle and the ectepicondyle are slightly smaller, and the impression for the brachialis anticus is less clearly outlined. The ulna is more slender, with the external condyle smaller. The slightly shorter tarsometatarsus has the trochleae somewhat narrower, with the outer one swung more toward the center line, so that support for the toes is narrower. Also the facet for the articulation of the hind toe is of lesser size, and on the anterior face the excavation below the head is smaller, with the tubercle for the tibialis anticus shorter and less prominent.

This species definitely represents a boreal element in the fauna, as in its modern distribution it is widely spread through the Canadian zone forests from Alaska across Canada, south in the eastern half of the United States only to northern Wisconsin, northern New York, northern Vermont, northern New Hampshire, and Maine. The present record is the first report south of these limits, as well as the first from ancient time.

Bonasa umbellus (Linnaeus): Ruffed Grouse.

Three or more individuals: Two premaxillae; proximal end of two left humeri, and shaft and distal end of another; a left ulna; one left coracoid, and the proximal end of another; one right carpometacarpus, and two others nearly complete; distal half of a left tarsometatarsus. The carpometacarpus is heavier than that of *Canachites canadensis,* especially in the shaft of metacarpal III, and the intermetacarpal tuberosity is larger.

The ruffed grouse, common today in western Virginia, is known from deposits of Pleistocene age in California, Tennessee, Maryland, Pennsylvania, and Florida.

Pedioecetes phasianellus (Linnaeus): Sharp-tailed Grouse.

Four or more individuals: One partial premaxilla; a fragment from the anterior end of a sternum; one right coracoid, somewhat worn, head of another from the left side; heads of three left and one right humeri, with distal ends of two from the left side, and one from the right; one right carpometacarpus with the shaft of metacarpal III missing; and a fragment of the distal end of a right tarsometatarsus. The head of the left humerus is distinctly larger than any of the three from the right-hand side, so that it is certain that it came from a fourth individual.

In modern time the sharp-tailed grouse has been a species of the north and west, with a range that extends from north-central Alaska across to central Quebec, south to eastern Oregon, in the mountains to northern New Mexico, and east to Nebraska, Minnesota, and northern Michigan. Formerly it ranged a little farther south to northeastern California, western Kansas, and northern Illinois, areas from which it has disappeared with agricultural use of the land, and increase in hunting. The only previous report of the species east of this modern range is from bones of late Wisconsin age found by John E. Guilday and his associates in Lloyd's Rock Sinkhole in the New Paris Sinkholes of Bedford County, western Pennsylvania. The present record, about 120 miles to the south, is indication of a former range in the late Pleistocene, and the period immediately following, through the valleys of the northern Appalachian region.

The bird is known also from deposits of Pleistocene age at Fossil Lake, Ore.

Family PHASIANIDAE: Pheasants, Quails

Colinus virginianus (Linnaeus): Bobwhite.

One individual: Head of a left humerus; a right femur, nearly complete.

The bobwhite, of wide range in eastern North America, has been found in the Pleistocene in Tennessee, and at several localities in Florida.

Family MELEAGRIDIDAE: Turkeys

Meleagris gallopavo Linnaeus: Turkey.

Two individuals: The shaft of a left coracoid; the broken distal end of a left tarsometatarsus. The two differ so definitely in size that it is evident they are from separate birds.

Turkey bones have been recorded widely from Pleistocene time in New Mexico, Illinois, Indiana, Tennessee, Arkansas, and Florida.

Family GRUIDAE: Cranes

Grus americana (Linnaeus): Whooping Crane.

One: Shaft and proximal end of a left coracoid. The bone is fragmentary, with indications of the tooth marks of rodents, but enough remains to indicate clearly that it is a crane, while the large size identifies it as from the whooping crane.

This species, now much reduced in numbers, was reported in eastern United States in the early days of European settlement from New York, New Jersey, and South Carolina. The present record is the first from ancient time north of Florida, where bones have been found in Pleistocene deposits at three localities. It is also the only report of this bird within the boundaries of present-day Virginia.

Family CHARADRIIDAE: Plovers

Charadrius vociferus Linnaeus: Killdeer.

One: Distal end of a right humerus.

The killdeer has been recorded from the Illinoian stage of the Pleistocene in Florida.

Family SCOLOPACIDAE: Snipe, Sandpipers

Philohela minor (Gmelin): American Woodcock.

One individual, possibly two: Proximal half of a left humerus; a complete left tarsometatarsus. The leg bone appears to be from a slightly smaller individual than the humerus.

The woodcock, found locally throughout Virginia, is reported from a Pleistocene cave deposit in Florida.

Bartramia longicauda (Bechstein): Upland Plover.

One: Right and left coracoids. These are identical in size and color and may be from the same individual.

The upland plover, formerly common in Virginia, is now much reduced in number. It has been found in late Pleistocene deposits in Kansas.

Catoptrophorus semipalmatus (Gmelin): Willet.

One: Distal half of a right tarsometatarsus. The modern skeletons at hand include a pair each of the two geographic races currently recognized in this species. The humeri in these show the same differences in size that separate the birds in the flesh, or when preserved as museum skins, the females in each being larger than the males. It is significant to record that the humerus in the female of the subspecies *Catoptrophorus semipalmatus semipalmatus* is appreciably smaller than that of the male *C. s. inornatus*. The bone from Natural Chimneys has the size of male *inornatus* and is identified as that race. In modern times this subspecies nests through the western part of our continent, but is common in migration and winter along the eastern seaboard.

The only previous ancient record for the willet is from Pleistocene deposits on the Newport Bay Mesa near the coast of southern California.

Erolia minutilla (Vieillot): Least Sandpiper.

One: A complete right humerus, typical of this bird.

This is the first ancient report for the species, which now nests in the north and spreads widely in migration, as far as Perú and central Brazil.

Family COLUMBIDAE: Pigeons, Doves

Ectopistes migratorius (Linnaeus): Passenger Pigeon.

More than 21 individuals: 11 fragments of right humeri, and

2 entire and 8 fragments of the left side; 1 entire and 3 fragmentary ulnae from the right side, with 1 entire and 3 fragments from the left side; 1 entire and 6 broken right carpometacarpi, with 4 fragments from the left side; anterior ends of 11 sterna; 5 entire, 16 or more fragmentary right coracoids, and 4 entire and 10 fragments from the left side; anterior ends of 3 right and of 6 left scapulae; distal end of 1 right and of 2 left tibiotarsi; 1 entire and 3 partial right tarsometatarsi, and parts of 4 from the left size.

From the abundance of these remains the passenger pigeon must have been common and easily taken, probably from a roost, if the deposit of bones is accepted as an accumulation from cast pellets of night-feeding owls. All the bones are from fully adult birds which points to a gathering outside the nesting season. This species, now long extinct, was abundant during the period of settlement in Virginia, with extensive roosts recorded as late as 1872. It was last reported in the State definitely in 1890, uncertainly in 1892.

Passenger pigeon bones have been found frequently in Indian village sites of pre-Columbian age, and are recorded from the Pleistocene in California, Tennessee, and Florida.

Family ALCEDINIDAE: Kingfishers

Megaceryle alcyon (Linnaeus): Belted Kingfisher.

One: Proximal half of a left humerus.

There is one report of this kingfisher from the Pleistocene of Florida.

Family PICIDAE: Woodpeckers

Colaptes auratus (Linnaeus): Yellow-shafted Flicker.

One: Distal half of a right tarsometatarsus.

The occurrence at Natural Chimneys is listed under the name of the eastern species of the genus, following the modern geographical ranges of these woodpeckers. But it should be noted that in available skeletons there appear no trenchant characters on which the three species of *Colaptes* of the A.O.U. Check-list may be separated.

In the eastern region of North America flickers have been reported from three localities in the Pleistocene of Florida.

Centurus carolinus (Linnaeus): Red-bellied Woodpecker.

One: A left tarsometatarsus, complete.

The species is recorded from the Pleistocene of Florida.

Melanerpes erythrocephalus (Linnaeus): Red-headed Woodpecker.

Two individuals: A right humerus, complete, and another from the left side without the head; a right tarsometatarsus, complete. The humeri are not a pair as they differ slightly in size.

There is one Pleistocene record for this species from Florida.

Dendrocopos pubescens (Linnaeus): Downy Woodpecker.

One: A right humerus with the distal end missing.

This is the first ancient record for this species.

Family TYRANNIDAE: Tyrant Flycatchers

Sayornis phoebe (Latham): Eastern Phoebe.

Three individuals: Two right humeri, and another from the left side, all complete. Slight differences in size indicate that each bone comes from a separate individual. The occurrence of this species is one that would be expected from its habit of placing its nest on sheltered projections on rock faces.

The record is the first one for this bird in ancient time.

Contopus virens (Linnaeus): Eastern Wood Pewee.

One: A complete left humerus. This agrees with the wood pewees, and is listed as above on geographic grounds.

It is the first report of this group in prehistoric time.

Family HIRUNDINIDAE: Swallows

Petrochelidon pyrrhonota (Vieillot): Cliff Swallow.

Eight or more individuals: A series of humeri that includes two complete and two fragments from the right side, and four complete and three additional segments from the left.

The humerus in this species is approached in size among our smaller swallows by the tree swallow, but has the head slightly larger and the shaft heavier. The other species concerned are all distinctly smaller.

The relative abundance of bones of this species compared to those of other of the small birds indicates a nesting colony, a supposition that appears to be verified by one bone with the porous structure of the head typical of immature individuals not fully grown.

Cliff swallow bones are reported from the Pleistocene of California.

Family CORVIDAE: Jays, Magpies, Crows

Perisoreus canadensis (Linnaeus): Gray Jay.

One: A right tarsometatarsus with the trochlea for the fourth digit missing, but otherwise complete. More slender form, greater outward slant of the external face of the talon, relatively smaller trochleae, and more widely open groove on the anterior face of the head between the external and internal cotylae, identify this bone in the gray jays from species of similar size of the genera *Cyanocitta* and *Aphelocoma*.

This is another bird that is found in modern times in the coniferous forests of the north and northwest, with extension southward only along the higher mountains of the west. In much of this area it ranges in the same regions as the spruce grouse, also its companion in ancient Virginia.

The present record is the first report of the gray jay in the prehistoric period.

Cyanocitta cristata (Linnaeus): Blue Jay.

One: A complete left humerus.

The widely ranging eastern blue jay is reported from the Pleistocene of Florida.

Pica pica (Linnaeus): Black-billed Magpie.

One: Proximal half of a left humerus.

This record is one of particular interest since, though the magpie in the Old World is spread from western Europe across northern Siberia, in North America it has been restricted to the western half of the continent. The find in Virginia indicates an early distribution to the eastward, with subsequent withdrawal westward, a circumstance without apparent explanation. Many magpie bones have been found in caves and other ancient deposits throughout Europe, but the present find is the first report from America, since Dr. Brodkorb informs me that a record for it from the lower Pleistocene of Randall County, Tex., refers to another species.

Family SITTIDAE: Nuthatches

Sitta canadensis Linnaeus: Red-breasted Nuthatch.

One: A left humerus, complete.

This nuthatch is present in Virginia now as a breeding species wherever spruce forest remains on the higher mountains, and as a winter visitor from the north.

It is recorded from deposits of late Pleistocene age in California.

Family MIMIDAE: Mockingbirds, Thrashers

Toxostoma rufum (Linnaeus): Brown Thrasher.

One: A complete right humerus.

This is the first report of this bird in the prehistoric period.

Family TURDIDAE: Thrushes, Bluebirds

Turdus migratorius Linnaeus: Robin.

One or more: A premaxilla; a complete right humerus, and one from the left side with the head missing. The wing bones are of maximum size for this species.

The only other ancient record for the robin is from the late Pleistocene of California.

Hylocichla sp.: Thrush.

One: A left humerus complete. This comes from one of the smaller species of this group. It is not the wood thrush, which is larger, but except for this, it is not practicable to indicate relationship, since the related species may not be separated from one another on the basis of this single bone.

Family ICTERIDAE: Meadowlarks, Blackbirds, Orioles

Agelaius phoeniceus (Linnaeus): Red-winged Blackbird.

Two individuals: Right and left humeri with the heads broken. These differ in size so that they come from two individuals.

The species is known from the Pleistocene of Ontario and Florida.

Molothrus ater (Boddaert): Brown-headed Cowbird.

One or more: Right and left humeri of such similar size that they may be a pair.

This is the first ancient record for the species.

Family FRINGILLIDAE: Grosbeaks, Finches, Sparrows, Buntings

Junco sp.: Junco.

One: A complete right humerus.

While this agrees with the slate-colored junco it is not practicable to make a specific identification among the several species of similar size in this genus.

Zonotrichia albicollis (Gmelin): White-throated Sparrow.

One: A complete left humerus.

This is the first ancient record for this species.

Passerella iliaca (Merrem): Fox Sparrow.

One: The symphysis of a lower mandible. This agrees in full detail with modern skeletons. The form of the thickened inner margin of the anterior end of the dentary, smooth and rounded when viewed from above, and shelflike when seen from below, is characteristic of this species. The bone is similar to that of the small-billed eastern subspecies.

Fox sparrows have been recorded from two Pleistocene localities in California.

Melospiza melodia (Wilson): Song Sparrow.

One: A right humerus.

The widely ranging song sparrow is reported from the Pleistocene of California.

V. BONES OF BIRDS FROM COCKROACH ISLAND, BERMUDA

In November 1958, David B. Wingate forwarded a considerable collection of bones from Bermuda, collected on Cockroach Island, located in Harrington Sound off the base of Abbott's Cliff. Most of these specimens were dug from about 4 cubic feet of sandy soil and rubble, some of them from near the surface where they were among roots of plants. Many are of young birds, ranging from nearly adult to half or even one-third grown indicating a breeding colony. In careful digging no associated skeletons were encountered, so that the site was one where separate bones had accumulated.

While the age of these specimens is unknown, the material probably is Recent, though, with one exception from the pre-Columbian period. The few remains of the white-tailed tropicbird obviously are of modern age. The uniform pale brownish-white cast in all the other material indicates a deposit of some antiquity, though whether this is of hundreds of years or of a longer period remains uncertain. A few molluscan shells that accompanied the bones have been identified by Dr. J. P. E. Morrison of the National Museum as *Poecilozonites bermudensis* Pfeiffer, a living species that in time ranges back to deposits of Pleistocene age.

There have been several reports of bones of birds from caves in the Bermudas but usually without identification, the earliest account that I have seen being that of Nelson (1840, p. 113). In view of the small amount of definite information on such deposits in Bermuda, I have prepared the brief account of the collection made by Mr. Wingate which follows.

Family PROCELLARIIDAE: Shearwaters, Fulmars

PUFFINUS LHERMINIERI Lesson: Audubon's Shearwater

Puffinus [sic] *lherminieri* Lesson, Rev. Zool., vol. 2, No. 3, April (May), 1839, p. 102. (Guadeloupe, Lesser Antilles.)

Puffinus parvus Shufeldt, Ibis, ser. 10, vol. 4, No. 2, Oct. 2, 1961, p. 632. (Recent deposits in the bone caves of Bermuda.)

The few bones of this species include humeri, radii, ulnae, metacarpals, coracoids, a femur, tibiotarsus, tarsometatarsi, a sternum, and parts of a skull, that probably represent half a dozen individuals. While the wing and leg bones may be sorted in two groups one of which is slightly smaller than the other, it is seen on close scrutiny that the specimens of lesser size all are obviously immature, some of them quite young. It is my opinion therefore that the smaller size in these is due to their not having attained full growth.

Shufeldt (1916, p. 632) in study of a collection of cave bones from Bermuda noted two apparent size groups and named the smaller one *Puffinus parvus*. While I have not had opportunity as yet to examine his material, the plates that he published in a later account (Shufeldt, 1922) do not appear to substantiate his claims, particularly since at the time he had available only one skeleton of *Puffinus lherminieri* in the U. S. National Museum for comparison. This individual is near the maximum size for the species. His smaller specimens as illustrated show no differences in size from the range of variation found in the series now available, particularly when it is understood that all Shufeldt's illustrations are not natural size, though so indicated in the legends. I regard *parvus*, therefore, as a synonym of *lherminieri*.

Puffinus mcgalli Shufeldt (1916, p. 630; 1922, p. 354), based on a nearly complete sternum, appears to be an example of *Puffinus puffinus*, as the figures agree exactly with a sternum of a female *Puffinus puffinus puffinus*, No. 227465 in the U. S. National Museum collections.

PTERODROMA CAHOW (Nichols and Mowbray): Bermuda Petrel

Aestrelata cahow Nichols and Mowbray, Auk, vol. 33, No. 2, April (March 31), 1916, p. 194. (Southeast side of Castle Island, Bermuda.)

Aestrelata vociferans Shufeldt, Ibis, ser. 10, vol. 4, No. 4, Oct. 2, 1916, p. 633. (Bermuda.)

The greater part of the bones in the present collection are those of this species, including abundant representation of wing and leg bones, parts of 12 skulls, 12 sterna, 23 furculae, several coracoids, scapulae and parts of more than 14 pelves. The indication is that more than 25 individual birds are represented. About one-half come from young birds that range from one-third grown to full size, but the latter with the ends of some of the long bones still spongy. The indication is clear that the site where the bones were found was a breeding colony of this petrel, formerly abundant in Bermuda.

The adult bones all agree in detail with the modern skeletons of the cahow in the U. S. National Museum.

Family PHAËTHONTIDAE: Tropicbirds

PHAËTHON LEPTURUS Daudin: White-tailed Tropicbird

Phaëton lepturus Daudin, *in* Buffon, Hist. Nat., ed. Didot, Quadrupédes, vol. 14, 1802, p. 319. (Mauritius.)

The right and left ulna, right and left radius, carpometacarpus, and scapula that represent this species are obviously modern in appearance, and are believed to represent an intrusion in the older deposit. It is probable that all come from one individual as the duplicate elements are paired.

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THE PROBLEM OF THE VIDUINAE IN THE LIGHT OF RECENT PUBLICATIONS

By
HERBERT FRIEDMANN
Director, Los Angeles County Museum

(Publication 4506)

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THE PROBLEM OF THE VIDUINAE IN THE LIGHT OF RECENT PUBLICATIONS

By Herbert Friedmann

Director, Los Angeles County Museum

While my study of the parasitic weaverbirds (1960) was in press, an important paper by Steiner (1960) appeared. Although his attention was centered largely upon the waxbills and their allies (the spermestids of his paper; estrildids of mine), he briefly discussed the systematic position of the Viduinae and their relationships with the waxbills and came to conclusions different from my own. Inasmuch as Steiner's experience and thinking concerning the waxbills were both prolonged and extensive, it is necessary to consider his comments carefully and objectively, even though I am still of the opinion that to accept them poses more difficulties than it solves.

The various recommendations made by Steiner and others prior to 1959 were reviewed in my account (1960, pp. 3-9), where a consideration of their not altogether harmonious contents led me to conclude that it was more nearly correct and acceptable to keep the waxbills and their allies in the Ploceidae than to erect a separate family for them. It was recognized that there were substantial arguments for recognizing a separate family for the estrildines, but there were equally suggestive ones for keeping them as a subfamily of the Ploceidae. One could not lightly overlook the conclusion that they constitute a distinct family arrived at by two of their most careful investigators, Steiner and Nicolai, under conditions of aviculture. On the other hand, Chapin's very extensive field acquaintance with many of the included genera and species and his interest in the classification of the whole assemblage caused him to consider them as one family. In his last extensive treatment of a good portion of the whole weaverbird complex, Chapin (1954, pp. 286-287) has this to say:

> The three most highly specialized subfamilies are believed to be the Passerinae, Ploceinae, and Estrildinae. The most primitive group of all is the Bubalornithinae, which at one time I believed should be treated as a distinct family. In 1925 Peter Sushkin convinced me that the Plocepasserinae are distinctly intermediate between the buffalo-weavers and the sparrows, and he

regarded *Sporopipes* as fairly close to the ancestral line of both Ploceinae and Estrildinae.

I still find it difficult to visualize a possible common ancestor for these two subfamilies. Sushkin considered the *Vidua* group to be fairly close to the Estrildinae, yet showing some rather primitive characters in their anatomy. I have always felt that the Viduinae, now commonly raised to subfamily rank, are closely allied to the Estrildinae, of which they appear to be always nest parasites. They share the curious mouth markings and gape wattles of nestlings, and these were not acquired independently, in my opinion, by the Viduinae through mimicry.

None of the characters that have been cited for the recognition of the Estrildidae is completely trenchant, and none is wholly constant. While it is true that the estrildines show no seasonal plumage dimorphism, which many of the ploceids do have, there are numbers of the latter group that agree in this respect with the waxbills. Among such examples may be cited such genera as *Amblyospiza, Bubalornis, Dinemellia, Histurgops, Malimbus, Passer, Petronia, Philetairus, Phormoplectes, Plocepasser, Ploceus* (many species, especially of the subgenera *Heteryphantes, Hyphanturgus, Icteropsis, Melanoploceus, Melanopteryx, Otyphantes,* and *Xanthoploceus,* although many other species have marked seasonal plumages in the adult males), *Sorella, Sporopipes,* and *Symplectes.* As shown in my 1960 summary, the presumed behavioral differences are also not constant and therefore they cannot be looked upon as trenchant systematic criteria. It may seem that the point at issue is a very minor one—whether we have two closely related families or two subfamilies of one family—but the difference in the status of the two is supposed to reflect something of the closeness or remoteness of their relationship, and this is important.

The recognition of a separate family Estrildidae, based on admittedly "average," nontrenchant characters, would result in either of two unfortunate situations. If the viduines were to be included as a specialized subfamily of the waxbills, the supposed criteria of the family would break down completely. If the viduines were not included, but were left as a subfamily of the Ploceidae, they would then be separated systematically from the birds to which they seem most closely allied. The closeness of their affinity to the waxbills appears to be agreed upon by most students of the viduines—Chapin, Delacour, Friedmann, Sushkin, and others. For that matter, Steiner, who places them as a subfamily of the Ploceidae and recognizes a separate family for the waxbills and their relatives, admits that the widowbirds developed reflection globules and buccal patterns essentially similar to their estrildine hosts, ". . . auf Grund wirklicher Verwandtschaft . . . ," and he considers the Viduinae as the section of Ploceidae nearest to the Estrildidae.

The immediate problem of uppermost concern to me was, and still is, how to interpret most cautiously and most accurately the parasitic breeding habit of the viduines, and it was obvious that to do so entailed an appreciation of the degree of their phylogenetic affinity to their chief hosts, the waxbills forming the estrildine group.

If the two groups, Viduinae and Estrildinae, were considered as closely related and as stemming from a common ancestral stock, the striking similarity in the mouth markings and reflection globules of their nestlings could be interpreted readily as something retained by both from the stock from which the two groups bifurcated. If, however, the two groups were looked upon as not so closely related and as not derived from a common ancestry, this important feature of their young would have to be treated as a parallel development, and quite probably as an adaptive one on the part of the parasitic Viduinae. This is, in fact, what Steiner concludes when he writes (translation mine) that "in the viduines, as a specialized small subfamily of the ploceines, we have nothing else but a case of true mimicry, which, in the imitation of the mouth markings, is not more astonishing than are other known examples in insects, snakes, and other creatures, and which have developed in the viduines in place of the complicated reflex behavior of nestlings of other brood parasites . . . ," such as the evicting behavior of young cuckoos of some species, and the deliberate and usually lethal attacks by newly hatched Indicators on their nest mates. Steiner expressly calls the mouth markings a "spermestid character" in the viduines, and he considers that in any evaluation of them a decisive role would have to be assigned to the thought that the viduines obtained or developed "through true relationship, in their 6 or 7 species, various distinct mouth-markings similar to those of their similarly distinguishable host species—*Pytilias, Granatinas, Lagonostictas,* and *Estrildas.* This would presume that each of their species had developed with its coordinated host species from a primitive form, which, in retrospect, must be assumed to have had a disclosed value for each presumed parasite–host pair of species." As I pointed out in my account, this point of view has also been stated by Southern (1954), who accepted the opinion that the viduines were extremely specialized brood parasites, each species being practically an obligate parasite of a single species of estrildine host to which it was thought to be permanently attached by virtue of a "very complicated form of mimicry. . . ."

The great difficulty in accepting this appraisal of the host-parasite situation lies in the fact that the several species of *Vidua* are not each rigidly restricted to single species of hosts. Of some of these birds our knowledge is still very scanty (or even wanting), but of others, such as *V. macroura* with 18 recorded kinds of hosts, *V. regia* with 7, *V. chalybeata* with 2, and *Steganura* with 9, the available data certainly contradict any postulated rigid host specificity. To account for the development of nestling mouth markings similar to those of the host species would necessitate, as Steiner himself outlined, a strictly limited host–parasite specificity, and this we do not find to be the case. It is true that each of the species of viduines does appear to have a single most-favored host, but the percentage of deviates from it is too great to ignore. Thus, of the best known species, *Vidua macroura,* I was able to assemble data on 77 records with 18 species of hosts, and of these more than three-quarters were of 10 species of waxbills of the genus *Estrilda* and more than half were of the races of a single species, *Estrilda astrild.* However, the different species of waxbills differ as much in their mouth markings among themselves as do the species of *Vidua.* If, as Steiner implies, the mimetic similarity of buccal patterns of each species of parasite and its normal host can only be looked upon as having an importantly selective survival value, we would expect a considerably higher adherence to the specific host relationship it is supposed to serve.

It might be considered that there may have been such a rigid host selection originally and that subsequently the parasites broadened their range of fosterers, but this would imply a subsequent denial of an original, and ostensibly a continuing, selective force. In view of the inconstant nature of the differences tabulated in support of familial rank for the waxbills, and in view of the great difficulties such an arrangement would make in interpreting the breeding biology of the widowbirds, I still think it better to keep them all in one systematic family group.

It has occurred to me that the above argument may make it seem that the conclusions arrived at may imply something akin to a manipulation of classification to simplify or to eliminate what would otherwise be a perplexing problem, rather than to maintain a systematic arrangement based purely on traditional characters, and to let the tangential problem continue to perplex us if need be. This is not the case, as the characters advanced by the proponents of familial rank for the waxbills are not constant, on the one hand, and the mouth markings of the nestlings are also valid morphological characters in themselves. The fact that these buccal patterns may be functional as well as morphological, and hence to some extent possibly subject to the pressure of natural selection, need not rule out the possibility, the probability even, that they are also phylogenetically stable characters, useful as indicators of relationship. This idea is by no means novel at this point, nor was it in my 1960 discussion, where (p. 24) I pointed out that Morris (1957, p. 199) concluded that these mouth markings were conservative taxonomic characters and as such were useful aids to understanding the evolution of the birds that have them.

Nicolai (1961) has recently published in abbreviated form the results of a study of the vocalization of several species of *Vidua* under aviary conditions. He studied with a tape recording the sounds produced by *V. macroura, V. regia, V. chalybeata,* and *Steganura paradisaea* and reported that part of the notes of each was a fairly accurate copy of the song of their host species. He stated that the viduine sounds comprised a "weaverbird-like" series of notes, scarcely distinguishable in the four species, and a series of loud notes and songs of the respective host species (various species and races of *Estrilda*). Nicolai found in the ploceids and estrildids closest to the viduines all songs and notes to be consistently innate and nonvariable, and he concluded that probably the notes of the viduines were similarly somewhat "fixed." He went on to speculate that the young Viduinae probably acquired their vocabulary from their foster parents during their period of dependency in and out of the nest. Only in this way did he think the exclusive reproduction of the vocabulary of the particular host species could have been made possible. Furthermore, he pointed out that in the case of *V. macroura,* which is known to parasitize a number of species of *Estrilda,* each male had invariably only the notes of one host species. There were no cases of mixed songs, a fact which he considered in agreement with his premise as to how the imitative process could have taken place. On the other hand, Nicolai further contended that the "whispering nest notes" of the male, which appear in the vocalization of *V. regia* and *V. chalybeata,* were learned somewhat later, after the birds had become self-sufficient and no longer were in constant contact with their fosterers, when the latter began preparing to breed again and began nest building anew.

Nicolai further concluded that whereas, at the close of the period of parental dependency, the young of other, self-breeding, passerines might go through what seemed like playing at nest building or playing at heterosexual pursuit, the young parasitic widowbirds were interested in watching the breeding preparations of their fosterers. The precise observations they made and the degree to which they seemed to incorporate these impressions were thought to become important later in their lives in helping to synchronize their reproductive cycles and activities with those of their hosts, and so to become significant in the breeding success of the widowbirds.

Inasmuch as Nicolai's work has not yet been published with sufficiently detailed documentation, it is somewhat difficult to appraise and to criticize his conclusions. The following comments must be read with this in mind, and some doubts that are raised here may prove to be baseless. I must stress that the observations, surprising as they seem to me, merit serious and respectful consideration. Their interpretation seems to be less certain.

For one thing, in a state of captivity birds may sometimes do things they would have little chance of doing or, as far as we know, do not do, in a wild state. I do not know whether Nicolai's birds had the presumed fosterers with them in the cage or in nearby cages where they could hear them. If they were not actually raised in captivity by these fosterers, one wonders how Nicolai could know which was the foster parent species in each instance, unless he assumed the most likely one from the total recorded literature (as was brought together in my book), or unless he assumed the identity of the host from the vocabulary of the parasite. The latter would be a matter of circular reasoning which would hardly be convincing, and which I cannot believe was done. Yet this was the way in which some of Neunzig's original (1929) conclusions seem to have been achieved.

I am wholly convinced that it is possible to learn many things, including vocalizations, from captive birds that it would be very difficult to learn in the free state, but I am still surprised that no one ever reported any constant and marked specific differences in the notes of the various species of *Vidua* in Africa. Although my own fieldwork is now many years past, and I do not pretend to remember accurately the songs and calls of these birds, I can find no mention in my journals of any marked differences between them, and I have found no published observations of others to this effect. This suggests that the differences noted in aviary birds are not sufficiently striking to be obvious in the field but require close-up observation for their discrimination. As a matter of fact, the vocalizations of the various host species of the genus *Estrilda,* as described in the literature, are all quite similar, or at least their specific patterns vary only slightly among themselves. This does not mean that the differences are less real, but I cannot dispell the thought that these portions of the songs resembling the notes of the presumed host species may have been due to the limiting conditions of the aviary, whereas the "weaverbird-like" notes common to all four species agree with what is known of their calls in the state of nature.

The very abbreviated form in which Nicolai's data were reported caused them to appear to imply further evidence for a definite host–parasite relationship, but this is not actually implicit in them. We are not informed how many individuals of each species of viduine were observed or under what conditions. Thorpe's (1958) work on the learning of song patterns by small passerine birds, especially the chaffinch, has indicated that the learned, as opposed to the innate, pattern of song is restricted to the "first 13 months of life and towards the end of this time there is a peak period of learning activity of a few weeks during which a young Chaffinch may learn, as a result of singing in a territory, the fine details of as many as six different songs." If Nicolai's assumption is correct, that the young parasitic widowbirds learn the utterances of their foster parents during the first two or three weeks of life, they are apparently more precocious than chaffinches in this respect. Furthermore, we may recall that in the case of parasitic cowbirds and cuckoos there is no sign whatever of the young learning any of the vocalisms of their fosterers. This cannot be looked upon as meaning that the same situation necessarily is true for the parasitic weavers, but judgment must be delayed until evidence is forthcoming. If eventual fuller publication of Nicolai's work should convince us that the viduines enhance their reproductive potential even very slightly by vocal mimicry of their common hosts, we would have to admit an unexpected uniqueness in these birds.

Another study that appeared too late for me to discuss in my account was Ziswiler's (1959) paper on features of the ontogenetic development of the waxbills. While presenting some data on the relative lack of sensitivity of later developmental stages to increasingly long interruptions of brooding, and also some data on the postembryonic (i.e., nestling) growth curves of several species, Ziswiler does not concern himself with the viduines at all; he does not even mention them. His paper therefore gives us no opinions to evaluate in the present connection. He does consider the waxbills a systematic family, but he gives no arguments or data either supporting or contradicting this treatment. The data he does present are not given as systematic criteria and show nothing peculiar to the "Spermestidae."

The problem as to which of the numerous described species or races of the combassous are really valid still awaits an answer based on much more extensive and more complete knowledge of them in the field. From my own field studies of many years ago and from much more recent examination of large numbers of museum specimens I arrived at the arrangement given in my 1960 publication. However, almost simultaneously, Wolters (1960) proposed a somewhat different treatment, based in part on observations of aviary birds. These differences are not particularly important, as no one has the data on which to formulate a completely convincing and wholly satisfying classification, but they do point out that until such information is assembled, all our judgments can have only limited validity. In our understanding of the combassous, as contrasted with the present knowledge of the long-tailed viduas, we are still confronted with the species of the systematists rather than the species of the naturalists. This is bound to continue until the living birds are studied much more thoroughly, as further examination of their preserved corpses will only lead to divergent and inconclusive arrangements.

Still more recently, Wolters (1961) has published an arrangement of the viduines in which the short-tailed species (subgenus "*Hypochera*") are placed at the top, whereas I put them at the base of the group. Wolters considers the absence of elongated rectrices in the breeding plumage of adult males to be a secondarily arrived at condition, and that the long-tailed species (subgenus *Vidua* proper) are to be looked upon as representing the original, ancestral character of the group. Also, he suggests that *Steganura* is the basic or primitive member of the viduines, whereas I placed it at the apex of the assemblage. While it is obvious that each of us came to our respective conclusions on the basis of all the evidence we could muster, it now becomes clear that, in the absence of any really conclusive data, these alternate, and, in fact, opposite, arrangements can only be looked upon as interpretations of the purely circumstantial evidence afforded by the appearance and the habits of the existing species. Actually the two classifications agree closely in the relative placement of the included species and genera, but differ in their overall orientation.

In defense of the arrangement proposed in my book I can only repeat here what I outlined there, namely, that inasmuch as rectricial elongation in male nuptial plumage is a character that has developed wholly independently in two of the main groups or sections of the family, it seems probable that within each of these groups the short-tailed species are nearer the stock from which they evolved than are their long-tailed relatives. There is nothing in the life histories of the short-tailed species to suggest that they are in any way more advanced than their congeners with elongated rectrices; in fact, the reverse is more in keeping with our still all too incomplete information. The courtship antics of the combassous are simpler, less involved, apparently more primitive than are those of the long-tailed species. All the viduines are quite similar in their vocalisms and, except for size (in *Steganura*), in the appearance of their eggs. It is perhaps a necessary commentary on so much of our present avian systematics to end this discussion with the observation that the one point of agreement in all these attempts is that we need to know more about the birds themselves.

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UNIFORMITY AMONG GROWTH LAYERS IN THREE PONDEROSA PINE

(With 13 Plates)

By

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CITY OF WASHINGTON
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Andrew Ellicott Douglass

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UNIFORMITY AMONG GROWTH LAYERS IN THREE PONDEROSA PINE

(WITH 13 PLATES)

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Dedicated to

ANDREW ELLICOTT DOUGLASS

with affection and high esteem

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I. INTRODUCTION

The present report concerns the behavior of growth layers in the stems of three mature specimens of *Pinus ponderosa* Laws., which were felled and sectioned August 22, 23, 1947.

PURPOSE

Previous studies of tree growth by Shreve (1924) and by Glock (1937) emphasized the need for a thorough study of dissected trees from a botanical and dendrochronological standpoint. These studies also emphasized that we needed to know more about the behavior of individual growth layers throughout the stem of a tree and, in addition, the extent to which results obtained by microscopic work on branches (Glock, Studhalter, and Agerter, 1960) could be carried into the trunk with some assurance that the growth records approximately paralleled each other. These were our primary objectives.

Secondarily, and more specifically, we wanted (1) to trace the relationships of growth layers throughout the stem—absolute and relative thicknesses around the circuit, along the trunk, and into the branches; (2) to trace the distribution and extent of lenticular growth layers in branches and trunk; and (3) to determine the constitution, distribution, and relationships of possible intra-annual growth layers (some of which are the so-called "double" or "false" rings). Much of the value of work in growth layers which has been or is being done depends upon the answers to the problems inherent in the above purposes.

On the whole, the work has two aspects: The evaluation of growth layers as they exist at one place in a tree or over the entire stem, and a contribution to the understanding of tree growth. It is hoped that a small addition to our knowledge of the two has been made.

ACKNOWLEDGMENTS

The American Philosophical Society, by means of grant No. 973 to the senior author, made it possible to carry on final field studies and to fell and section the three mature ponderosa pine used in the present study. The Supervisor of the Coconino National Forest gave permission to fell the three trees. Analytical and statistical work was supported by grants from the Smithsonian Institution, the National Science Foundation (G 610 and 4398), and Macalester College.

Time and facilities were made available by Macalester College through its President. The College of St. Thomas generously provided space and facilities for Germann to carry on his portion of the investigation. Dr. Harold S. Colton and the Arizona State College at Flagstaff aided materially during the field investigation. Prof. James Newcomb of Macalester College assisted in preparation of photographs.

To these organizations and their officials, to each individual mentioned, and to many others, our sincere gratitude is due, for without their invaluable assistance the work would have been impossible.

A study of tree OL-SO-57 by Germann served as a basis for his doctoral dissertation in the Department of Botany at the University of Minnesota, 1953.

II. RELATED WORK

Many trees have no doubt been dissected, but very few have been used for detailed exploration of each growth layer throughout the stem. Although a full cross section will permit a study of circuit uniformity, the common procedure is to average the measurements of several radii. The necessity for such an average implies a certain lack of uniformity. The use of two increment cores from the same tree would of course constitute a study of uniformity in its most rudimentary form.

Shreve (1924) dissected a Monterey pine (*Pinus radiata*) from the coast of central California into 20 sections 1 meter long. Two or three radii were measured on each section. Shreve found that a ring is seldom "continuously greater or less than an adjacent ring when followed for several meters up the trunk" (p. 99). Circuit uniformity, he found, was none too good because of the many cases of irregularity in the relationships between adjacent growth layers.

Burns (1929) did not actually state that he dissected trees in his work in Vermont. However, he does mention uniformity and he adds interesting remarks on the use of linear dimensions of growth layers in contrast with volume dimensions. "The diameter growth of the stem must include the entire increment. This is not laid down evenly in the trunk and the width of the ring at any one place cannot be an index of the total increment" (p. 5). Burns refers to the work of Hartig "and many others who have pointed out the variations in width of the same ring at different elevations on the tree" (p. 5). Shreve, he said, recorded a similar fact for Monterey pine, as did Adams for Jack pine.

MacDougal (1936) worked with pine and redwood in the coastal region of central California. A table of ring widths (p. 33) on cores from each of six directions shows great variation around the circuit and much variation from ½ to 1 meter up from the ground. An old pine and a redwood were observed to add wood to the upper part of the trunk and branches after radial growth had ceased at the base. Layers of wood may be added locally around the circuit or longitudinally because of root or branch influence. A great share of MacDougal's work was done by the dendrographic method.

Glock (1937) completely dissected a mature ponderosa pine and found that "each annual ring has a high degree of uniformity around the circumference and lengthwise of the stem" (p. 62) in a relative sense. Agreement between amount of tip growth and thickness of corresponding growth layers was of a "high order, although it is not perfect" (p. 54). Agreement among one root and three branch sections was "fairly good" (p. 54) considering the nature of the materials. Lenticular growth layers appeared to prefer the upper part of the tree, and the gaps between the cusps of the lenses clustered on the west side of the bole. In the case of double rings the situation was a bit more complex. Generally speaking, doubling increased upward; however, this may have been due to "proximity of the top, or proximity of the axis" (p. 53). "The chances are about even that a ring which is double either at the base or at the top of the stem will not be double at the opposite end" (p. 53).

Graphs given by Glock were analyzed for uniformity of trend. The growth layers of the section taken 7½ feet above ground had been measured along six radii, and these six were then compared with regard to uniform increase or decrease from one growth layer to the next. In 77 cases out of 265, one or more of the radii did not agree with the others in the direction of increase or decrease of thickness in a specific year. The section at 31 feet above ground showed 47 cases of disagreement out of 195. At 49 feet above ground the section showed 42 cases of disagreement out of 162.

Two tests were applied for vertical uniformity. The averages of the three sections at 7½ feet, 31 feet, and 49 feet were compared for uniformity of growth trend from 1830 to 1879. In 7 out of 49 cases there was disagreement, and in 4 of these 7 the lowest section failed to agree with the upper 2. For the second test of vertical uniformity, the most representative radius of each of the 10 sections was chosen for comparison. There were 42 cases of disagreement out of 115. Of these 42, 13 disagreed in one section only. Of these 13, 6 were in the basal portion of the trunk.

Only when averages were used does there seem to have been a high degree of uniformity in this ponderosa pine from near the lower forest border.

Marr (1948) studied tree growth close to the north edge of the forest-tundra ecotone in the Richmond Gulf region on the southeast shore of Hudson Bay. Three of the largest symmetrical trees, spruce, were dissected by taking cross sections 5 feet apart, the first of the five or six sections being taken 1 foot above the soil. Four cores from each of about 10 other trees were taken from each stand. In the material collected, Marr found excellent circuit and vertical uniformity. "Study of a single core taken at any point, therefore, gives an accurate representation of the relative width of the growth-layers in trees of this region and an average of data obtained from cores along four radii is more than adequate. It should be emphasized that these statements apply to relative growth only and do not hold true for absolute quantity of growth" (p. 139). All the material collected did not yield a single example of a lenticular growth layer or of multiple layers in a year, no doubt owing largely to the very short growing season.

Bannan (1941) studied the roots of eight species of Ontario conifers and found the thickness of growth rings to be highly variable, one ring being thick whereas those preceding or succeeding were thin. Some rings were more or less uniform around the circuit, others decidedly eccentric.

Burns and Irwin (1942) apparently dissected 53 trees, 26 red pine and 27 white pine. In height the trees averaged from about 20 to 26 feet. Sections were taken at approximately 18-inch intervals so that 14 sections were obtained from each tree. "Increment borings were not used as growth indicators since, as has often been shown, the width of the annual ring at any level is not directly proportional to the annual increment's total volume" (p. 6). Measurements along six radii of each section were averaged. From this it is inferred that circuit variation was sufficiently great to require an average. Attention was concentrated on the thickness of the 1940 annual ring, which in all cases was thinnest near the bases and the tips of the trees. Thickest portions of the 1940 annual increment occurred at $1\frac{1}{2}$ to 6 feet below the tip of the leader. Among the many trees measured, the thickest portions of the increments exceeded the thinnest portions in the same tree by factors ranging from 1.75 to 13.

Oosting (1948) cited an extreme case of circuit nonuniformity discovered by W. S. Cooper. A trunk section taken at 24 feet above ground from a Monterey cypress which grew near Carmel, Calif., had a diameter of 74 inches parallel to the prevailing wind and 9 inches across the opposite diameter. The leeward portion of the section showed 304 rings whereas the windward showed only 50 rings. This of course is an extreme illustration of eccentricity, a feature not uncommon in trees growing in exposed positions, in old branches of the high-altitude western juniper, and many redwood trees.

From a study of 75 trees distributed among four species of southern yellow pine, Paul and Smith (1950) concluded that thick growth layers were more prevalent in the lower than in the higher part of a tree. This is the reverse of what many others have found.

Miller (1950) took sections from the basal and the top areas of four black oaks, *Quercus velutina,* and of six white oaks, *Quercus alba,* in Indiana. The growth layers of each section were measured along four equidistant radii and the measurements added. In the comparison of top and bottom sections, trend coefficients were used to show amount of agreement. For the black oaks the agreement between top and bottom averaged 82 percent, ranging from 76 to 86 percent; for the white oaks the agreement averaged 80 percent, ranging from 71 to 87 percent. Such figures imply only fair agreement.

Lyon (1953) dissected two white pine, one hemlock, and one red spruce from New Hampshire. Cross sections were taken as follows: One white pine, 7 sections, 5 feet apart; second white pine, 9 sections, 8 feet apart; a hemlock, 5 sections, 8 feet apart; and a red spruce, 10 sections, 8 feet apart. After the "average of ring-width along three good radii for each section" (p. 11) was obtained, the average thicknesses of the growth layers for each section for three of the trees were plotted, whereas sections of the second white pine were compared by a series of skeleton plots.

In the first white pine, "the vertical uniformity is good for the portion of the trunk without large branches" (p. 11). "The integrity of crossdating for all sections is obvious from 1900 on and reasonably good for all but the oldest portions of the four lower sections" (p. 11). An analysis of the graphs of the seven sections from 1900 onward showed that, in 31 cases out of the 46, the increase or decrease of growth from one ring to the next did not correspond in one to three sections compared with the rest. In other words there were 31 cases out of 46 of nonuniform response. The 31 negative responses contained 13 cases wherein only one section disagreed with the rest.

In the case of the second white pine, Lyon said, "vertical uniformity is good enough . . . to permit crossdating between any of the nine sections" (p. 14). He adds, however, that allowance would have to be made in crossdating because of new lows at crown levels.

The data derived from a study of the hemlock "emphasize the essential vertical uniformity of the hemlock and its value for problems of both climatology and archeology" (p. 14). An analysis of the graphs of the five sections from 1900 onward showed that, in 22 cases out of 46, the increase or decrease of growth from one ring to the next did not correspond in one to two sections compared with the rest. The 22 negative responses contained 8 cases wherein only one section disagreed with the rest.

In the red spruce, Lyon found "about the same degree of uniformity" (p. 14), although from 1862 to 1945, in contrast with several decades prior to 1860, growth had very little variation from year to year.

As stated previously, many trees have undoubtedly been dissected for one purpose or another, and many have been felled to obtain a single transverse section. The least material taken from a tree entails the removal of two or more cores. Of the numerous cases not involving full dissection the following may be cited perhaps as typical and as having some reference to the present work.

Nördlinger (1861) said that the first ring of what he thought to be a double annual became thinner down the trunk. MacDougal thought that Hartig (1869) was the first to write that rings in overtopped pine and spruce might extend only part way from the bases of the branches toward the base of the trunk. In 1871 Hartig considered ring thicknesses at different levels and ascribed the variations to availability of nutrients. Kny (1879), in contrast with Nördlinger, found that the second growth layer of a double became thinner downward on the twig. As a matter of fact, he found that doubles were not constant either longitudinally or around the circuit, or from one branch to another. The work of Jost (1891) gave essentially the same results.

In a book published in 1909, Mills described the life history of a big yellow pine which grew within sight of Mesa Verde. The tree was 115 feet tall and 8 feet in diameter breast high. Mills cut and split the trunk and limbs, and thoroughly dissected the roots. He also dissected another pine on the St. Vrain watershed, but apparently no uniformity studies were made in spite of the great labor involved.

Haberlandt (1914) stated that ring widths increase upward on the trunks of conifers. In contrast, Janka (1918) stated that ring thicknesses in larch generally decrease upward.

Among oaks introduced into Java from the Temperate Zone, Coster (1927) observed second tip flushes whose corresponding growth layers did not go far down the branch. Büsgen-Münch (1929) noted that different thicknesses at different heights on the trunk followed injury or suppression of the tree.

Baker (1934) divided the regions of thickest annual rings into two: (1) Physiological, just below the crown where nutrition of the cambium is the best, and (2) mechanical, near ground level where mechanical stress, as that due to wind, is important. In very dry years or in case of serious defoliation spread over more than one year, the annual growth for the second year may be merely a narrow ring in the upper part of the tree.

Schumaker and Meyer (1937) took cross sections at ground level, at 4, 8, and 12 meters, from 12 white fir 32 to 38 meters high. Three radii, 120 degrees apart on the 4-meter sections, were averaged and the results used in statistical calculations.

Hansen (1938), working in the Snowy Range of Wyoming at an elevation of 10,000 feet, took north-south cores 2 feet above the ground through the trunks of some 47 spruce trees. Growth to the south was nearly 50 percent greater than to the north. In 1940 Hansen took north–south cores at breast height from 40 spruce and fir in the Medicine Bow Range of Wyoming. The differences on the two radii were negligible. In 1941 Hansen took north–south cores, 10 from each of 3 species, western yellow pine, western larch, and Douglas fir, which grew in central Washington. He used the average of the two radii and found little or no deviation between them. "Intraspecific cross identification was readily effected and perfect agreement with respect to increase and decrease in ring width occurred for many years, . . ." (p. 170).

Trendelenburg (1939) said that vertical uniformity of ring thicknesses tends to be the rule.

The prevention of sway in Monterey pine and in eucalyptus caused a reduction of diameter growth in the lower trunk (Jacobs, 1939).

Friesner (1940) studied sections of black oak taken 12 to 18 inches above the soil and found that the growth on the radii vertically above roots averaged 5.5 to 15.6 percent greater than the growth vertically above the spaces between roots. Age increases the number of years when this holds true. Competition from other trees and variations in slope did not seem to affect asymmetrical growth, although there was some evidence in favor of the uphill side.

Schulman (1940) distinguished two types of coast redwood, one characterized by the presence of, the other by the absence of, circuit uniformity. The second type possessed many discontinuous or wedged-out rings. One redwood at the 140-foot level "showed good crossdating between opposite radii for the first 600 years of growth with no missing rings and approximately concentric growth. For the next 340 years, however, growth became extremely compressed and one-sided and the short radius showed 99 rings missing as compared with the long radius in this interval" (p. 23). Of course there was no crossdating in the 340-year sequence. The redwood may represent a special case, and even the presence of crossdating does not necessarily mean excellent uniformity.

For the purpose of comparing tree growth with rainfall, Meyer (1941) obtained 16 cross sections from hemlock of northern Pennsylvania and averaged three radii on each section.

Will (1946) preferred a cross section if available. "A full circular section is preferable for study as there are often variations in the width of rings at different points in their circumference" (p. 4).

In his study of a Douglas fir believed to be 800 years old at Mesa Verde, Schulman (1947) measured ring widths along several radii and used them to construct a growth record.

Eames and MacDaniels (1947) stated that ring thicknesses vary in different parts of the plant, thickening occurring below the insertion and along the under side of branches, about wounds, and near other abnormalities.

Hustich (1948), working in Finland, depended to a great extent upon cores, and one may presume that he felt he could rely upon one radius to represent a tree. In his work on the Scotch pine (1948) he had 553 cores from which he selected 214 for his studies. He took his cores at a height of 1.3 meters and on the south side of the trees. In 1949 Hustich examined about 1,000 pine seedlings and hundreds of cores of pine and spruce. He was not sure that he had seen a single case of a so-called false or double ring.

Lyon (1949) sectioned six white pine in New Hampshire and averaged ring thicknesses on three radii.

Brown, Panshin, and Forsaith (1949) stated that increments grown under optimum conditions are widest near the top and narrowest at the base of a tree. Also, they narrow from the pith outward.

Wareing (1950) quotes Priestley and Scott to the effect that radial growth in diffuse-porous trees moves basipetally from expanding buds with relative slowness but that in ring-porous trees resumption of growth takes place rather rapidly throughout the trunk at an early stage of bud development. As an experiment, buds were removed from an ash on March 30. Wide vessels were formed throughout the tree, greatest near the base of the main trunk and least in the twigs. From this Wareing concluded that the gradient in cambial activity showed that no influence traveled from the buds to the basal trunk.

Marts (1950) sectioned 10 longleaf pine at 4-foot intervals and calculated average ring thicknesses along four radii taken at the cardinal directions.

Miller (1951) cut nine sections of maple in Indiana, measured three radii, and added the thicknesses of rings along the three radii of each section.

In British Columbia, Mathews (1951) studied the fluctuations of alpine glaciers by comparing trees overturned by ice advance with trees standing a few yards away. No wholly satisfactory correlation could be made perhaps because of missing or false rings. ". . . the presence of such missing or false rings is indicated by studies of duplicate cores from different sections of the trees" (p. 366).

In his review of the work of Lodewick in the northeast, Schneider (1952) said "Lodewick concluded that the measurement of new xylem in sections was the only accurate method for determining radial growth which occurs over short periods of time, but he realized that the width of annual rings is variable around the tree" (p. 332). Schneider found that cambium could be active locally on some trees late in the summer.

Ghent (1952), working on trembling aspen in Ontario, considered cores to be of less value for ring measurement than sections. He measured three radii on each section and "Empirical tests indicated that between 90 and 95 percent of the actual growth trends of trembling aspen are accurately depicted by the average of three radii"

(p. 86). "Studies made on trembling aspen at Black Sturgeon Lake showed little difference in the growth pattern along the main trunk, except within the early rings . . ." (p. 86).

Holmsgaard (1955) examined ring variations rather extensively in Denmark. Examining several trees at six different heights, he found fair uniformity. Annual rings were found to be absent in 14 cores out of 53 trees in one locality. When he took 3 new cores from each of these 14 trees he found absent rings in 5 cases. "The absence of annual rings seems to have been caused by heavy seedbearing" (p. 182). Study of beech on a poorer site was abandoned because of "too great dating inaccuracy" (p. 182).

Students have studied tree growth and wood anatomy from many different viewpoints. None gives us the detailed information we are here seeking, but each gives a hint concerning the disposition of growth layers within the stems of trees.

Theodor Hartig (1854) thought that growth began in the crown, commonly at the buds, and progressed downward. Nördlinger (1872) said that diameter growth in oak began at the tip and progressed downward, whereas in the chestnut it began at the base and progressed upward. Strasburger (1891) said that in hardwoods growth began in the middle of the trunk.

Child (1883) described a Vermont hemlock which was used in a boundary dispute. Perhaps because the tree had 40 to 50 growth layers on one side and 9 or 10 on the other, the court ruled that rings were not a sure indication of a tree's age. In Nebraska, Child said, there were many examples of multiple rings. A pig hickory, 11 years old, had 16 rings; a green ash, 8 years old, had 11 rings; a Kentucky coffee tree, 10 years old, had 14 rings; a burr-oak, 10 years old, had 21 rings; and a black walnut, 5 years old, had 12 rings. Child also studied a section of spruce from Puget Sound known to be nearly 15 years old; it had 18 rings on one side and 12 on the other. Of course we do not know whether these sections came from typical or atypical trees.

Brown (1912) studied growth in two examples of pitch pine in New York. Growth began at some distance below the apical shoot and progressed both downward and upward, spreading down the main axis faster than along lateral shoots. The width of the completed ring decreased from apex to base. Double rings, he found, were common in old trees. "These might easily cause miscalculation as to age" (p. 401).

In 1915 Brown studied growth in 50 eastern white pine. Several of them were felled and sectioned. In general, growth began and ended first in the upper parts of the trees. The amount of growth was very irregular at different heights in the trees, but the cambium tended to even up. Irregularities of growth characterized not only the dimensions of newly formed tissues but also the xylem elements.

Bethel (1941) dissected six loblolly pines in order to study the relation of fiber length to height of tree.

Church (1949) reviewed the effects of defoliation, both natural and artificial, and concluded that growth was reduced to the greatest extent in the basal portion of the tree in a majority of cases. However, growth had not been reduced at a uniform rate throughout the stem.

Chowdhury and Tandan (1950) worked with broad-leaved trees in India and found that radial growth began at the end of the previous year's shoot and progressed downward.

According to Amos, Bisset, and Dadswell (1950) growth in eucalyptus commonly began at the higher levels. Because of variations in width of growth layers within the tree, counts were made from opposite sides of a tree in many cases. They also studied fiber length in different parts of the trunk and in different parts of a growth layer. Wardrop (1951) observed the length of tracheids in conifer stems and determined that their length increased in any one growth layer from the base of the tree upward until it reached a maximum some distance up the stem.

A study of the literature reveals many instances of trees felled or sectioned or cored for one purpose or another. Not too many cases exist of rather complete stem analysis. Many fruitful studies remain: The areal characteristics of growth layers; the microscopic characteristics of cells in different parts of a tree and different parts of various growth layers; and the rhythmic and compensatory activity of the cambium in different portions of the stem.

III. LOCATION

Figure 1 shows the general location of the tree groups which have been under study since 1934. The O'Leary groups, containing the three dissected trees, are represented by the rectangle north of Flagstaff. On figures 2 and 3 vegetational and climatic relationships are shown in a highly generalized fashion.

The geographic locations and topographic relations of the three tree groups, each of which gave one of the dissected trees, appear in some detail on figure 4. All groups approached directly from U. S. Highway 89 between Camp Townsend and the lower forest

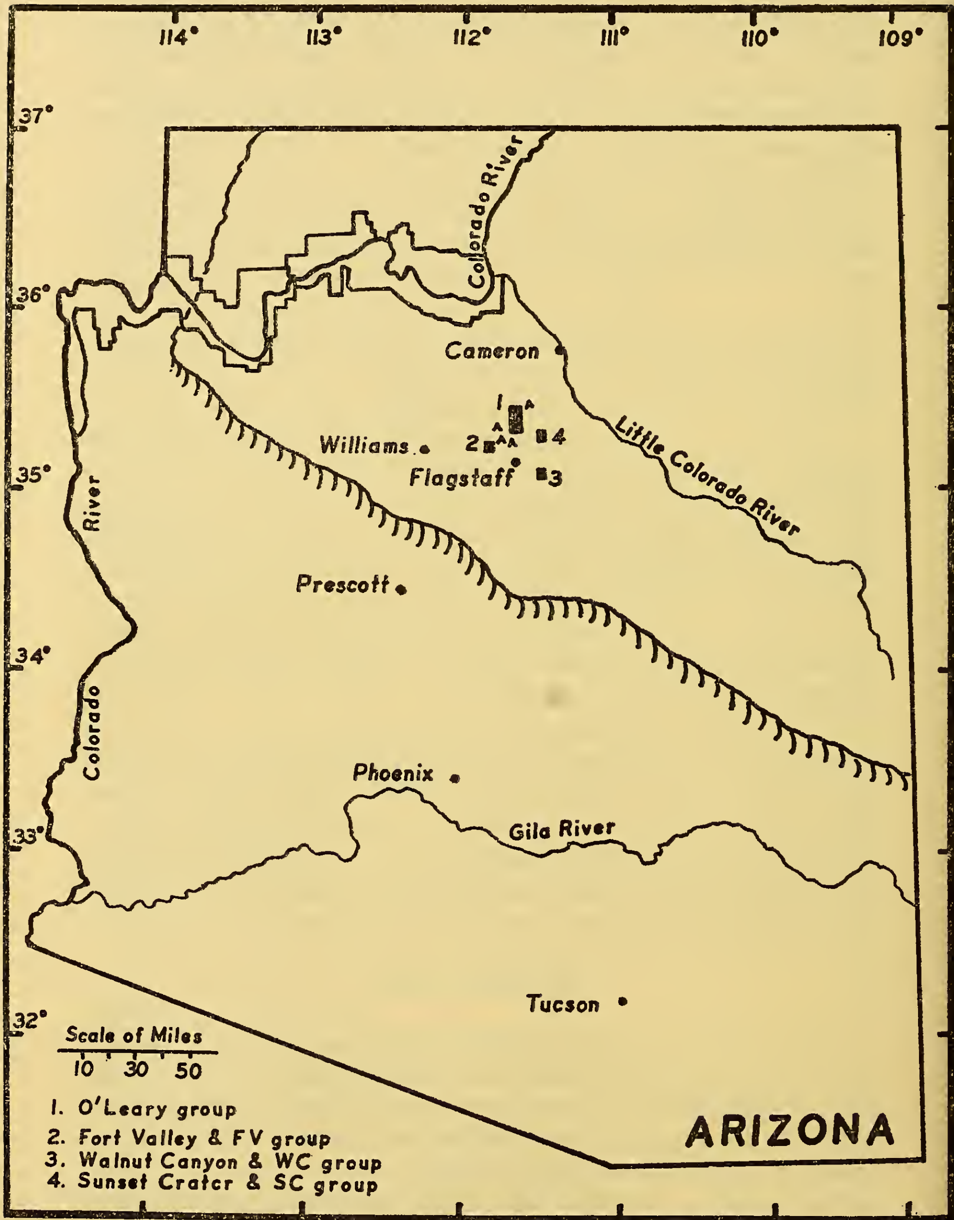


FIG. 1.—Outline map of Arizona to show location of tree groups under study.

FIG. 2.—Generalized natural vegetation map of Arizona to show distribution of ponderosa pine and piñon–juniper. (From Nichol, A. A., The natural vegetation of Arizona. Univ. Ariz. Coll. Agric. Bull. 68, 1937.)

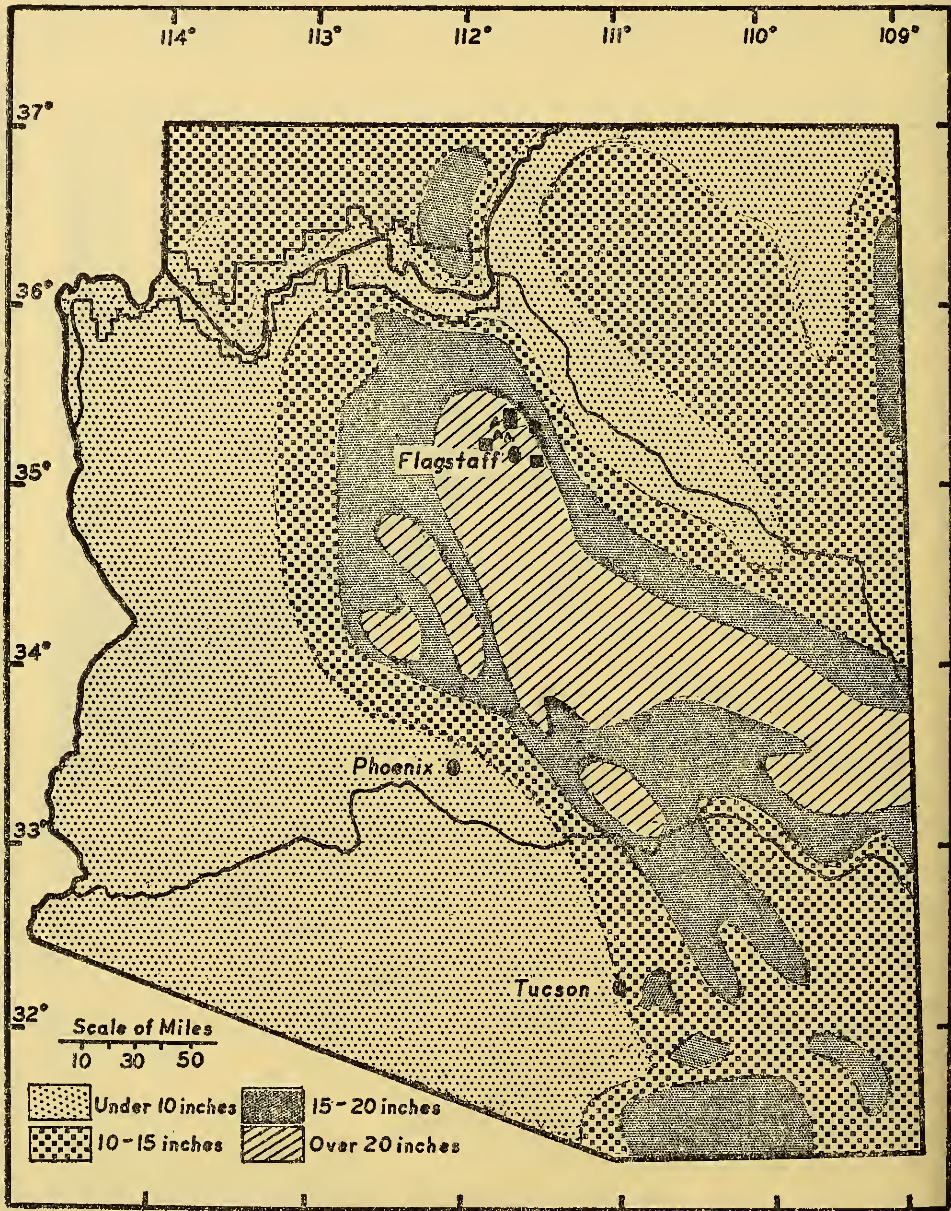


FIG. 3.—Generalized average annual precipitation map of Arizona. (From Atlas Amer. Agric., Climate, precipitation, and humidity, pp. 6-7, 1922.)

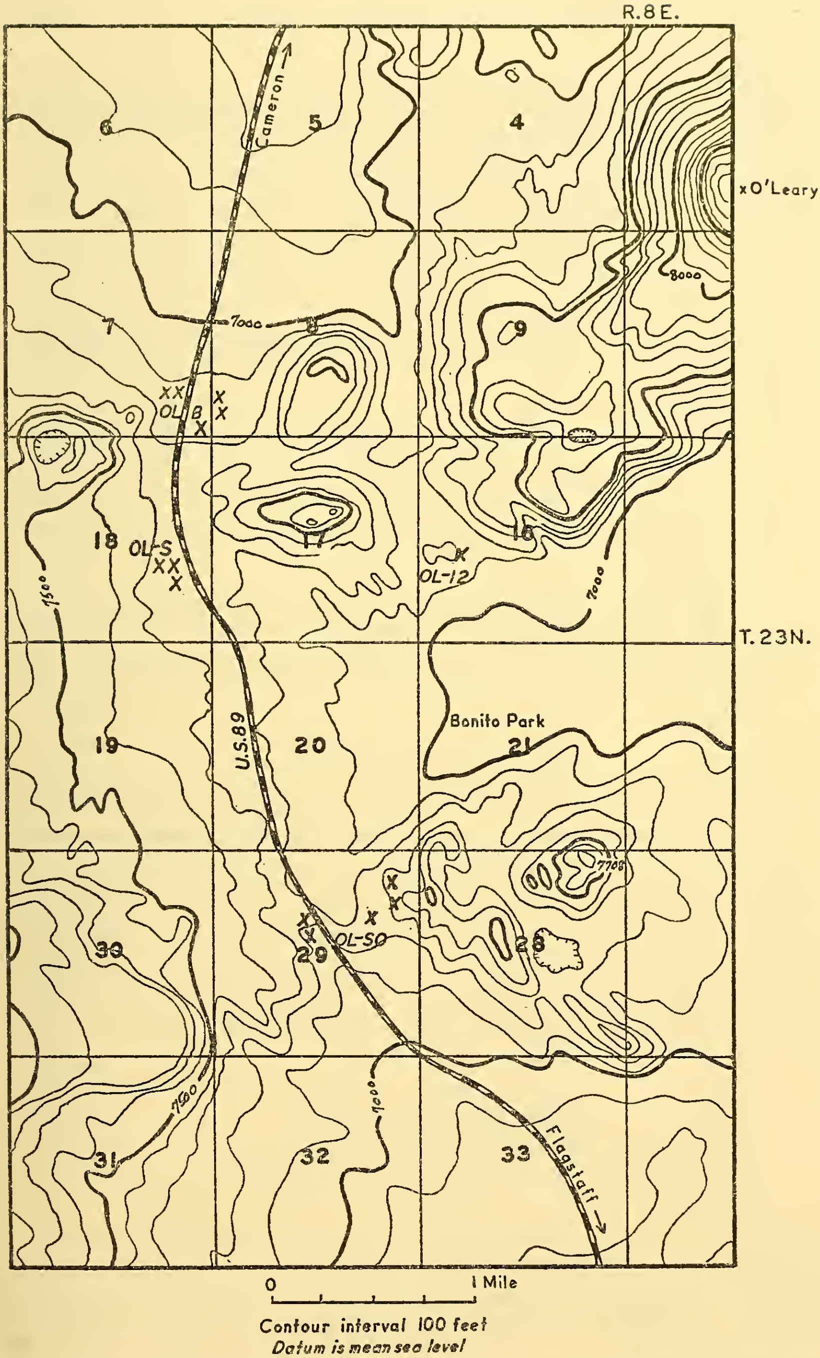


FIG. 4.—Topographic map of O'Leary area, north of Flagstaff, Ariz. (Sources: U.S. Dept. Agric. Forest. Serv. Topographical map of Coconino Nat. Forest, Coconino Nat. Forest Fire map, and U.S. Dept. Interior, Geol. Surv. of Coconino County.)

border northward on the road to Cameron have been designated O'Leary: O'Leary-Border (OL-B), O'Leary-South (OL-SO), and O'Leary-Summit (OL-S). Thus the trees felled and sectioned are referred to as OL-B-42, OL-SO-57, and OL-S-62.

The tree OL-B-42 was situated 17 miles north of Flagstaff in the southern part of the SE¼ sec. 7, T. 23 N., R. 8 E., about 50 yards west of the highway, and on a broad northeast-facing topographic spur some 35 feet above the road and flat to the northeast. It grew on the northernmost forested spur approaching the road from the west just before the road drops to the piñon–juniper and grassland zones.

OL-SO-57 grew on the rather flat top of a westward trending spur in a rather hilly area 14.3 miles north of Flagstaff and 2.7 miles south of the site of OL-B, in the NE¼ sec. 29, T. 23 N., R. 8 E. It grew 150 feet above the valley to the west and some 80 yards east of the highway.

OL-S-62 grew on a low, rounded ridge declining gently to the east, about 150 yards west of the highway, in the N½SE¼ sec. 18, T. 23 N., R. 8 E., which is 0.8 mile south of the location of OL-B-42 and 1.9 miles north of OL-SO-57.

IV. ENVIRONMENT

The trees grew on the San Francisco volcanic field (Robinson, 1913) in the southwestern part of the Colorado Plateau in north-central Arizona. Located on the general slope east and northeast of San Francisco Mountain (5 to 5½ miles away), they were in a region said to be (Douglass, 1928) in the rain shadow of the mountain mass. However that may be, the trees grew on a hilly terrain underlain by a mixture of basaltic lava and cinders (fig. 5) in a region where the summer rains may be intense and severely local.

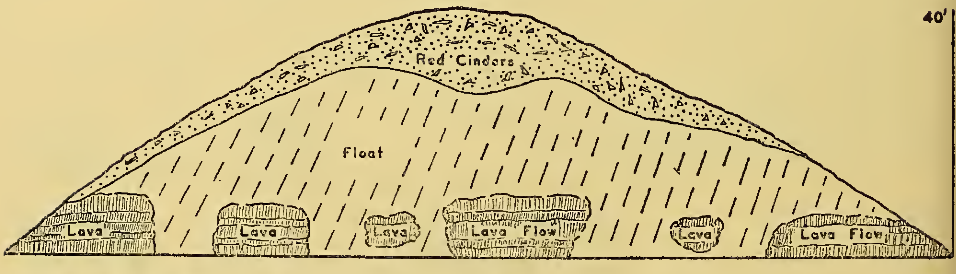


FIG. 5.—South face of road cut between upland and lowland trees of OL-SO group, 14 miles north of Flagstaff on Highway U.S. 89.

The volcanic materials rest in general upon the Permian Kaibab limestone and locally on later red beds. Small fragments of limestone have been found on the fresher cinder slopes. Because of the elevation of the Plateau, the jointed and porous nature of the Kaibab, the porous nature of the volcanic cinders, and the relief of border escarpments and canyons, ground-water level must in general be far below the surface. Soil moisture may be at or above field capacity locally for brief periods of time.

TABLE 1.—*Rainfall data, Flagstaff and Winslow, Ariz., 1897-1946, and 1915-1946*

	Flagstaff 1897-1946	Winslow 1915-1946
Average annual rainfall, inches	20.27	8.14
Elevation, feet	6,907	4,848
Average monthly departure, %	66.7	72.4
Average monthly variation, %	89.9	99.2
Average departure, %:		
January	60.5	73.8
February	55.1	53.4
March	57.2	69.5
April	70.8	68.0
May	83.1	71.3
June	94.6	69.8 (113.0)
July	46.2	56.7
August	41.1	44.7
September	60.3	64.4
October	78.5	87.5
November	88.7	93.4
December	63.6	74.1
Average variation, %:		
January	74.7	97.5
February	76.9	86.2
March	76.6	89.8
April	89.6	102.3
May	79.8	81.0
June	120.3	132.5
July	100.7	126.3
August	65.2	62.2
September	79.7	74.0
October	88.9	92.7
November	122.0	129.8
December	104.7	112.5

Table 1 gives pertinent information[1] concerning the rainfall of

[1] Precipitation data from United States Weather Bureau records.

Flagstaff and of Winslow, which is 54 miles east of Flagstaff and far beyond the lower forest border. Winslow data are given for comparative purposes, although the O'Leary trees are judged to have lived under conditions much more nearly similar to those of Flagstaff than to those of Winslow.

In table 1 monthly precipitation in inches was converted into percentages of the monthly mean. Average departures were calculated as the average above and below 100 percent. Average variation was taken as the mean of the algebraic differences between monthly values.

In table 2 the intervals, as January to April, were taken as units by combining monthly values. Departures and variations between months within the month-intervals are given in table 1. The amount of average departures and average variations from year to year for the different month-intervals is rather striking.

TABLE 2.—*Rainfall data for certain month-intervals at Flagstaff, Ariz.*

	Average departure %	Average variation %
November-April	30	43
January-April	28	43
January-July	23	35
March-June	37	57
March-July	31	53

Table 3 is based upon rainfall measurements taken quarterly from 1934 to 1955 and is included because the Coconino Divide Station was approximately one-half mile from OL-S-62.

A study of tables 1 to 3 reveals fluctuations in rainfall sufficient to influence soil moisture which affects trees throughout the year. Fortunately, the Coconino Divide rainfall station was rather centrally located with respect to the tree stations of OL-B, OL-SO, and OL-S. Annual rainfall at Flagstaff for the interval 1934-1955 exceeded that at the Coconino Divide by $1\frac{1}{3}$ inches. In 7 years out of 22, Coconino Divide averaged 2.90 inches per year more rainfall than did Flagstaff; in the remaining 15 years Flagstaff exceeded Coconino Divide by an average of 3.30 inches of rainfall. Only summer (June–August) rainfall at Coconino Divide exceeds that of Flagstaff. Fifteen summers at Coconino Divide average 1.31 inches more rainfall than Flagstaff; seven summers average 2.04 inches less.

Figure 6 demonstrates the dominance of summer rainfall. This dominance, for the years 1934-1955, becomes progressively greater

TABLE 3.—*Rainfall data,* Flagstaff, Ariz., compared with that of Coconino Divide, 16 miles north of Flagstaff, 1934-1955*

	Flagstaff	Coconino Divide
Elevation, feet	6,907 (6,997)	7,282
Average annual rainfall, inches	18.38	17.06
Average quarterly departure, %	39.1	42.9
Average quarterly variation, %	56.8	58.3
Average departure, %:		
Winter (Dec.-Feb.)	38.3	46.0
Spring (Mar.-May)	38.7	49.1
Summer (June-Aug.)	28.1	29.1
Fall (Sept.-Nov.)	50.9	47.5
Average variation, %:		
Winter	70.0	76.2
Spring	49.5	40.0
Summer	45.1	58.4
Fall	63.5	59.0

* Rainfall measurements taken from Harold Sellers Colton, Precipitation about the San Francisco Peaks, Arizona. Mus. Northern Ariz., Techn. Ser. No. 2, 1958.

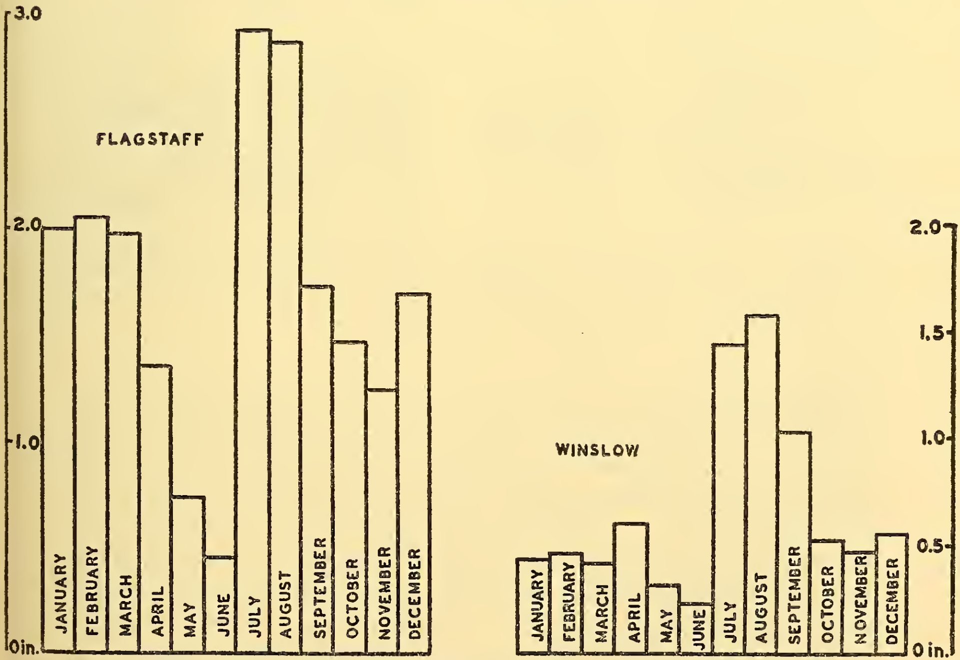


FIG. 6.—Average monthly precipitation. Flagstaff: elevation 6,907 feet; average annual precipitation 20.27 inches, 1897-1946. Winslow: elevation 4,848 feet; average annual precipitation 8.14 inches, 1915-1946.

(fig. 7) from the forest interior at Fort Valley (annual rainfall, 22.63 inches) to Flagstaff (18.38 inches), to Coconino Divide (17.06 inches), and to Winslow (7.08 inches) out beyond the lower forest border.

Figure 8 gives the minimum, maximum, and average monthly rainfall at Flagstaff and Winslow. It shows clearly that there are

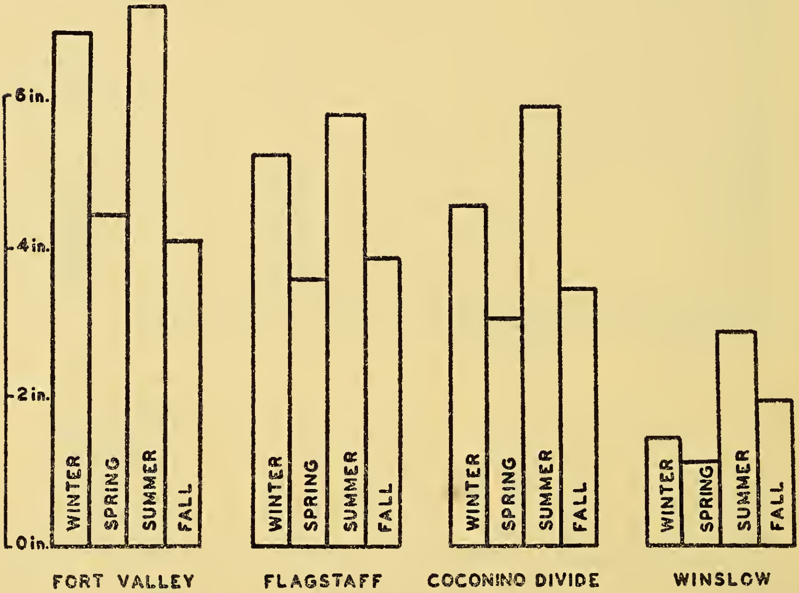


FIG. 7.—Average quarterly precipitation at Fort Valley (8 miles northwest of Flagstaff), Flagstaff, Coconino Divide (14 miles north of Flagstaff), and Winslow, 1934-1955. Winter: Dec.–Feb.; Spring: Mar.–May; Summer: June–Aug.; Fall: Sept.–Nov. (Data from Colton, 1958.)

months with little or no rain even in the rainy season, that there are months with heavy rainfall even in the dry season, that dry may follow wet months and vice versa, and that different seasons in different parts of the year or in different years may be either wet or dry. A year does not necessarily follow the record of any single season within it; almost any combination of months can be found in the monthly rainfall records. There is no reason to believe that the amplitude, the length, and hence the intensity of rainfall fluctuations at Coconino Divide are less than those at Flagstaff. They probably are greater; observations during some 14 summers indicates such to be the case.

Rainfall at the trees OL-B, OL-SO, and OL-S, possesses decided variability of two kinds: Month to month and season to season in sequence, and month to month and season to season from one year to the next. If tree growth responds more or less to soil moisture as conditioned by rainfall, the O'Leary trees may be expected to show variability among their growth layers corresponding roughly at least to that of the rainfall, within genetic limitations.

FIG. 8.—Minimum, average monthly, and maximum precipitation at Flagstaff, Ariz., 1897-1946, and at Winslow, Ariz., 1915-1946. Solid color means minimum.

Each of the three trees felled was chosen as a normal healthy tree representing its locality near the lower border of the ponderosa pine or Transition Zone. The map of figure 4 shows that there is little difference in elevation among the three trees.

The tree OL-B-42 grew on an east-facing slope only slightly below the crest of a northeastward-trending spur which declines within 150 feet to the road and to road level. Approximately 1 mile to the north of OL-B site and 200 to 250 feet lower, ponderosa ceases to be the dominant tree in the forest although widely scattered individuals go down 200 feet lower. Some 2½ to 3 miles beyond the site of OL-B, piñon pine gives way to a pure stand of juniper at an elevation of 6,600 feet. Along the highway extending northward from OL-B and with decreasing elevation, ponderosa gives way to piñon, piñon to juniper, and juniper to grassland and desert. The transition is gradual and the different species intermingle over a rather wide range. Even so, the lower border of juniper is extremely frayed, with fingers extending for miles. Isolated individuals and small groups exist almost down to the elevation of Wupatki National Monument (4,900 feet at the Headquarters). A double traverse along the highway from the Summit (7,282 feet), or Coconino Divide, to Wupatki National Monument (4,900 feet), a distance of 27½ miles, gave the following elevations from Wupatki upward: Frayed edge of juniper extending over a range of more than 1,000 feet, 5,000 to 6,500 feet; first piñon, 6,600 feet; first scattered ponderosa, 6,700 feet; and main stand of ponderosa beginning at 6,900 to 7,050 feet.

The slope where OL-B-42 stood varied from a few degrees to 10 or more. The volcanic soil contains an admixture of cinders and small blocks of scoria. Ground litter is extremely sparse or absent over large areas. If one may judge from many windblown trees, the root system of the ponderosa pine in the region is characteristically confined to the upper foot or two of the soil and spreads laterally in all directions. Because of the highly porous nature of the soil there was very little or no surface drainage to or from the tree.

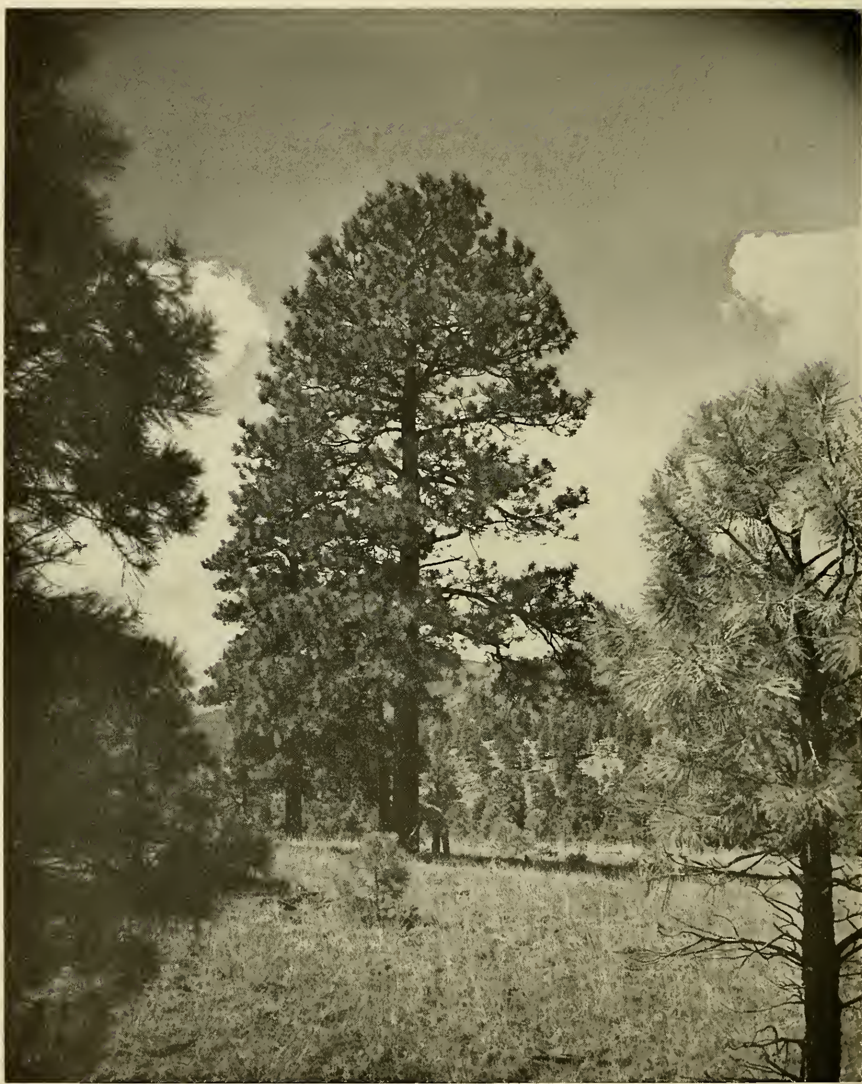
OL-B-42 was 23 inches d.b.h. (diameter breast high) in 1946 and measured approximately 53 feet in height when felled August 22, 1947. It was a normal, healthy tree, typical of the stand of which it was a part, with a blunt top, well-developed crown, rather large leaf area, and many branches (pl. 2). Approximately 80 percent of the trunk supported branches, the first live branch coming out 9 to 9½ feet above the ground. Among the trees at the OL-B site west of the highway, OL-B-42 had neither the heaviest nor the lightest crown.

Competition around OL-B-42 was practically nonexistent except for a sparse grass cover. Clumps of ponderosa seedlings, 2 to 4 feet high, grew downslope to north and northeast sufficiently distant to give little or no root competition. Plate 2 shows one of the two junipers at the OL-B site. There were also a half-dozen widely scattered piñon seedlings (1947) in an otherwise pure stand of ponderosa.

OL-SO-57 [2] grew on a generally westward-facing slope and on a

[2] The study and analysis of OL-SO-57 formed the basic material for a doctoral thesis by Germann in the Department of Botany at the University of Minnesota, 1953.

Ponderosa pine, OL-B-42, in August 1947, 52 feet high, 23 inches d.b.h. View from the northeast, looking partially across and up to rounded spur upon which OL-B-42 grew.



Ponderosa pine, OL-SO-57, in August 1947, 55 feet high, 22 inches d.b.h. View from the northeast; beyond the gentle slope upon which the tree stood, there is a sharp drop to the valley below.

Ground cover on soil of cinders and lava fragments at site of OL-SO-57, August 1947.

Ponderosa pine, OL-S-62, at the moment of felling, August 23, 1947; 59 feet high, 22 inches d.b.h. View east by south toward Sunset Crater. Seedlings and saplings plentiful.

local northwesterly slope. Plate 3 shows a very slight incline at the tree, perhaps as much as 5 degrees. A very gentle rise 80 feet to the southeast culminates in a small crest of large lava blocks. To the west and northwest the gentle slope continues for nearly 100 feet, then begins to drop more steeply until at a distance of about 200 feet it drops precipitously at the road cut. The main drainage way, flowing south-southeast and containing an ephemeral stream, lies 100 to 150 yards to the westward and 150 to 175 feet below the tree. In general, the tree stood on the south edge of a broad shallow basin or terrace-top surmounting the steeper slope downward to the northwest.

The material underlying the surface at the site of OL-SO consists chiefly of a mixture of red cinders and small blocks of red scoria (fig. 5). At the surface there are blocks of dark lava up to 2 feet long. Ground litter is only slightly more plentiful here than at the site of OL-B. The soil shows little evidence of a profile but appears to be better developed than at OL-B; it is "richer," with a higher organic content. Organic materials are intermingled with weathered and slightly weathered cinders in the upper 2 to 3 inches of soil. The black soil at the surface gives way to light brown below.

On August 16, 1952, two soil samples were obtained from the site of OL-SO-57, sample A at a depth of 3 inches, sample B at 15 inches. Because these samples were analyzed in some detail with the help of the Division of Soils of the University of Minnesota and because the soil at OL-SO represents an intermediate position between OL-B and OL-S insofar as site factors are concerned, the soil samples are considered in detail. The trench, cut to a depth greater than 2 feet, revealed no evidence of a clay layer or of compacted material which could arrest the downward percolation of water. The entire profile as exposed in the trench and in the road cut (fig. 5) is made up of highly porous materials.

Approximately half the original volume of the two samples consisted of slightly weathered lava fragments one-half inch or more in diameter. These were eliminated in the field. Physical and chemical tests were run on the remaining 50 percent of the samples.

Mechanical separation with a 2-mm. sieve gave the following:

Sample A (3 in. below surface)

	Volume $cm.^3$	Weight *grams*
Nonactive gravel	28	51.7
Active soil material	252	287.0
Sums	280	338.7

Sample B (15 in. below surface)

	Volume $cm.^3$	Weight *grams*
Nonactive gravel	34	68.8
Active soil material	228	264.0
Sums	262	332.8

In addition to the 50 percent eliminated in the field, a further 5 percent of nonactive gravel in Sample A and 6½ percent in Sample B were eliminated in the initial screening.

Analyses of the active materials gave the following:

	Sample A (depth 3 in.) %	Sample B (depth 15 in.) %
Sand	58	42
Silt	29	34
Clay	13	24

A rough textural classification of these materials places Sample A as a sandy loam and Sample B as a loam.

Ratios of the constituents in the original field samples before any portions were eliminated are as follows:

Textural summary

Grade	Sample A (depth 3 in.) %	Sample B (depth 15 in.) %
Gravel eliminated in the field	50	50
Gravel screened—over 2 mm.	5	6.5
Sand	26	18.3
Silt	13	14.8
Clay	6	10.4

In the active soil material there appears to be a decrease in sand with depth and an increase of silt and clay. Infiltrating water could have carried small amounts of the finer particles downward, but this would not explain the increase of fine gravel downward. Extensive work must be done to provide reliable conclusions.

Two soil samples from each depth were centrifuged in order to determine the moisture equivalent.[3] The two determinations at

[3] Moisture equivalent is defined by Johnstone and Cross as "the moisture content which the soil, initially saturated, will retain against a centrifugal force one thousand times the force of gravity." Elements of Applied Hydrology, p. 121. New York, 1949.

3-inch depth gave 18.7 percent and 18.7 percent; the two at 15-inch depth gave 21.5 percent and 21.3 percent. These percentages seem to bear out the decrease in particle size shown in the Textural Summary.

Further tests of the active soil material showed the following:

	Sample A (depth 3 in.)	Sample B (depth 15 in.)
pH	7.1	7.3
Available phosphorus	"Very high"	"Very high"
Available potassium	"Very high"	"Very high"
Nitrogen	0.065%	0.0524%
Organic matter *	1.370%	1.048%

* Calculated from the N using factor of 20.

The hydrogen ion concentration (pH) is very close to neutral, a fact also ascertained by Pearson (1931, 1950), who had many soil analyses made.

There was no direct evidence concerning the root system of OL-SO-57. However, a 32-inch ponderosa (OL-SO-59) some 200 feet northward from OL-SO-57 and 12 feet below in a broad, shallow draw which had no evidence of either standing or running water, was blown down and its root system exposed between August 31, 1949 and July 31, 1950. Here, as in all cases so far observed, the root system was of the spreading shallow type, the mass of roots being in the upper 2 to 2½ feet of the soil. Because of the porous nature of the soil, because of its height above the valley to the westward, and because of its position with respect to the steep descent to the road, tree OL-SO-57 is judged to have been entirely dependent upon moisture in the soil-water zone immediately below the surface. There was very little or no surface drainage to or from the tree.

OL-SO-57 was 22 inches d.b.h. in 1946 and measured 55 to 56 feet in height when felled August 23, 1947. It was a normal, healthy tree with rounded top, well-developed crown, good leaf area, and excellent branches (pl. 3). The first live branch came at 14 feet above ground; hence the bole was about 75 percent branched.

A sparse cover of grass was the only serious competition to tree OL-SO-57, which formed part of a pure stand of ponderosa pine. Plate 4 shows not only the nature of the ground cover in the vicinity of the tree but also the soil of cinders and lava fragments. The closest tree was 30 feet away downslope to the northwest. In the opposite direction the nearest tree was 85 feet away. Within the area of the OL-SO station, seedlings and saplings are numerous;

they were rather inconspicuous in 1946 and 1947, but were growing into prominence five and six years later.

The third tree, OL-S-62, grew on the crest of a broad, gently rounded ridge rising gradually to westward. To both sides of the ridge and some 200 feet apart there are broad shallow draws that have no evidence of stream flow. They lie 8 to 12 feet below the crest of the ridge.

Soil materials closely resemble those at OL-B and OL-SO; they consist of cinders and lava fragments intermingled with their weathered products. Ground litter is noticeably more plentiful at OL-S than at the other two sites. There were no specific indications concerning the root system of this tree or any neighboring tree except that large roots spread out laterally. Because of the high soil porosity, the position of the tree, and the gentle slopes, surface drainage to or from the tree was practically nonexistent. Subsurface drainage laterally to the tree was equally nonexistent, a conclusion based upon the geologic section exposed at the site of OL-SO. If one may judge from repeated observations during and immediately after heavy rains, surface flow is very exceptional and is not normal to a cinder area.

OL-S-62 was 22 inches d.b.h. in 1947 and 59 to 60 feet tall when felled August 23, 1947. This tree also was normal, healthy, and representative of the stand of which it formed a part. It had a rounded top, a full crown, rather plentiful leaf area, and a straight symmetrical bole. Plate 5 shows OL-S-62 a moment after it began to fall. Live branches began at a height of about 20 feet above ground, giving a clear bole for one-third of its length.

The tree formed part of a pure stand of widely scattered mature ponderosa pine. Aside from a good cover of grass, OL-S-62 had no serious competition when felled and there was no evidence of former competition. The OL-S site had many old, dark-gray, partially decayed stumps but none so close that the felling of the tree could have had a marked release effect on OL-S-62. The site also bears many seedlings and 5- to 10-foot saplings (pl. 5); reproduction is good and surpasses that at the other two sites.

V. METHODS OF STUDY

Two increment cores on opposite radii were removed from OL-B-42 on August 25, 1946, and the tree was felled August 22, 1947. One core was removed from OL-SO-57 on August 25, 1946, another on August 15, 1947, and the tree was felled August 23, 1947.

Two cores were taken from OL-S-62 on August 14, 1947, and the tree was felled August 23, 1947. In comparison with the cores from some 30 other trees, those from the three trees chosen for felling showed variable ring sequences as well as typical examples of thin, thick, double, and "locally absent" growth layers.

Insofar as branches permitted, 3-inch transverse sections were cut from each trunk at 4- to 5-foot intervals and from two main branches at intervals of 1 to 2 feet. These relationships are shown in figure 9 and in table 4, which also gives the central growth layer and the

TABLE 4.—*Central growth layer, years used, and height of each section in the trunks of three ponderosa pine*

	OL-B-42			OL-SO-57			OL-S-62		
Section	Center of trunk	Years used	Height of section *feet*	Center of trunk	Years used	Height of section *feet*	Center of trunk	Years used	Height of section *feet*
To t. bud....	...	...	52.5	...	...	54.9	...	...	59.3
15	...	...	...	...	...	...	1939	09	57.8
14	...	...	...	1935	12	52.6	1923	24	56.3
13	1927	17	49.9	1928	20	51.2	1898	50	54.0
12	1917	29	47.2	1922	26	49.9	1882	66	50.8
11	1898	50	43.7	1909	39	47.9	1865	83	47.7
10	1843	105	39.7	1887	61	45.6	1838	110	42.9
9	1801	147	36.4	1853	95	41.7	1814	134	37.7
8	1769	179	32.5	1833	115	37.8	1795	153	33.4
7	1754	194	28.3	1797	151	32.3	1787	161	30.1
6	1727	221	22.8	1772	176	27.6	1758	188	25.0
5	1721	227	19.1	1747	201	21.3	1740	198	19.3
4	1711	237	15.3	1726	222	14.7	1724	218	14.4
3	1693	255	10.2	1711	237	9.7	1712	236	9.9
2	1681	267	5.7	1692	256	5.4	1685	253	5.4
1	1645	303	0.5	1666	282	1.2	1674	274	1.2

years used. Similar data for branches are given in table 5. The measurements in tables 4 and 5 are not as accurate as they appear to be because of uneven ground surface at the base of the trunk, uneven saw-cuts, and errors in holding the tape measure.

The top surfaces (outer surfaces in the case of branches) of all sections were sanded and polished. On the basis of the 1947 increment and the principles written out in 1937 (Glock, 1937), all growth layers were identified and dated in conformity with Northern Arizona chronology painstakingly worked out over the years by Douglass.

The stereoscopic microscope, used for examination and analysis, was equipped with 10× wide-field ocular and a triple nosepiece

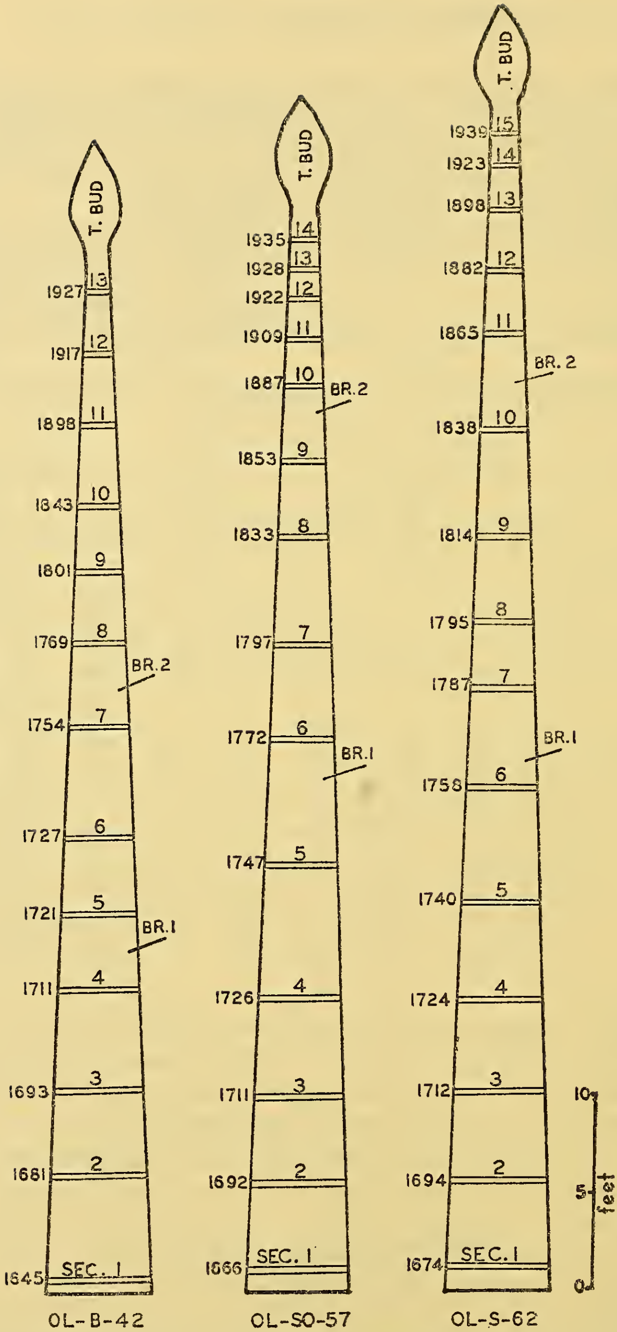


FIG. 9.—Vertical elevation of the three ponderosa pine to show positions of the sections, central growth layers, and emergences of the branches which were dissected.

fitted with 0.7×, 1.5×, and 2.0× objectives, thus giving magnifications of 7, 15, and 20 diameters with field area diameters of 280, 125, and 90 mm. respectively. A vertical pillar, rising from a heavy base, carried a horizontal bar which supported the microscope out over the surface of the section under study. The horizontal bar was of sufficient length to allow examination to the pith of the largest section.

By means of a traveling microscope with a magnification of 25 diameters, growth-layer thicknesses were measured to 0.01 mm. Cross

TABLE 5.—*Central growth layer, years used, and distance from trunk of each section in the branches of two ponderosa pine*

OL-SO-57				OL-S-62			
Section	Center of branch	Years used	Distance from trunk *feet*	Section	Center of branch	Years used	Distance from trunk *feet*
1-A	1783	165	1.2	1-A	1780	168	0.6
1-B	1824	124	3.7	1-B	1787	152	2.0
1-C	1837	111	5.6	1-C	1793	155	3.1
1-D	1851	97	7.4	1-D	1808	139	5.1
1-E	1871	73	9.2	1-E	1831	116	7.1
1-F	1919	29	11.9	1-F	1854	93	8.6
To t. bud...	...	...	15.3	1-G	1868	78	10.0
				1-H	1893	55	11.6
				To t. bud...	...	...	15.8
2-A	1880	68	0.4	2-A	1860	85	0.8
2-B	1895	52	1.8	2-B	1873	73	3.0
2-C	1913	35	3.9	2-C	1889	56	5.0
2-D	1920	27	5.0	2-D	1897	48	6.3
2-E	1931	15	7.0	To t. bud...	...	...	9.8
To t. bud...	...	...	9.2				

hairs in the field served as guide lines for measuring from the outer face of the densewood of the latest growth layer (1947) inward across 1947 to the outer face of the next older growth layer and thence inward chronologically to the pith. Although the traveling microscope measures to 0.01 mm. or less, such accuracy can be driven too far and becomes meaningless because the normal fluctuations in thickness of a growth layer around the circuit of a tree section very commonly exceed 0.01 mm. All growth layers along three radial lines 120 degrees apart were measured uniformly, and no attempt was made to adjust the lines so as to include "normal" sequences. However, where the lines did not pass through the growth layers at right angles, measurements were made in the vicinity of the line and at right angles to the course of the growth layer at the particular place. Thus, no subjective judgment tempered the growth record.

Growth-layer thicknesses were measured along three radii on each trunk section—north, southeast, and southwest. Two additional radii—east-northeast and west-northwest—were measured on sections 1, 5, and 9 of trees OL-B-42 and OL-S-62. For purposes of comparing lower, mid, and upper trunks, sections 2, 6, and 9 were used for OL-B-42 and OL-S-62 and sections 2, 5, and 8 for OL-SO-57. Figure 10 shows the position of the center and the relative lengths of measured radii on sections 2, 6, and 9 on the three trees. The total number of years used in each section is given in table 4. In the upper sections several of the innermost growth layers were not used because their excessive thicknesses would have distorted the averages.

Data concerning the branches are given in table 5. Further information is added at the beginning of the discussion on circuit uniformity in the branches of OL-SO-57 and OL-S-62 (p. 119).

Raw millimeter thicknesses of growth layers on each were turned into percentages of their own mean in order to make a uniform standard of comparison among different radii by dealing with relative rather than absolute thicknesses. Otherwise the greater length of the north radius would overbalance the other two radii in the computation of averages on single sections. The extra weight in the north radius could be eliminated by application of a reducing factor; however, the method used here—conversion to percentages—has added advantages in the derivation of departures and variations.

As here used, departure refers to the difference between the thickness of an individual increment and the mean thickness of the increments in the particular sequence on which it occurs. Average departure gives the average fluctuation of a growth layer above or below the mean of its group of growth layers. From a table of appropriate departures, average departure for a radius, a section, or a tree may be obtained.

Variation refers to the difference in thickness between successive growth increments. Average (or mean) variation gives the average difference in thickness of the growth layers on a given sequence, section, or tree.

Departure from mean variation refers to the excess or deficit in the variation in thickness from one growth layer to the next compared to the mean or average variation of the given sequence of growth layers. Average departure from mean variation gives the average excess or deficit from the mean difference in successive thick-

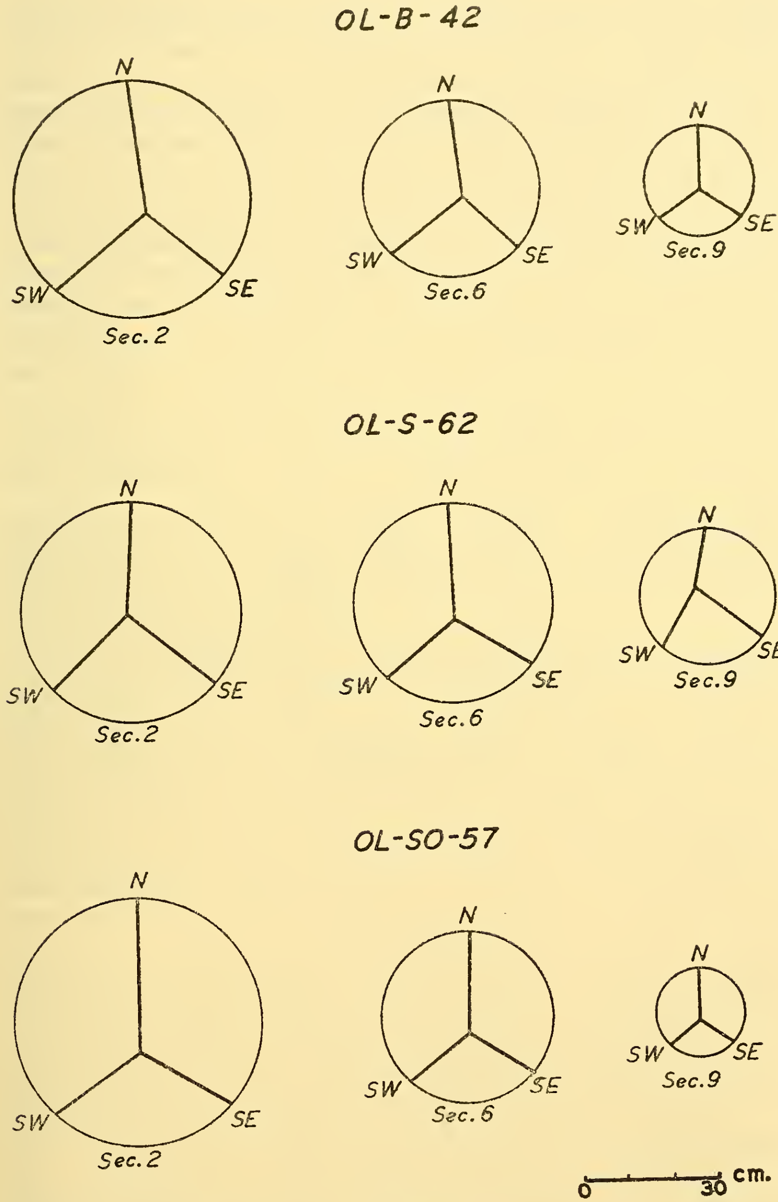


FIG. 10.—Three sections of each of the three ponderosa pine to show position of the pith and the three measured radii.

nesses throughout a sequence, section, or tree. This parameter is perhaps a more sensitive index to extraordinary fluctuations in the impact of growth factors than either simple departure or variation.

Variation is quantitative, whereas trend is qualitative. By trend we refer to direction of variation; an increase in thickness from one annual increment to the next is positive and a decrease is negative. If the trend between two successive years on one radius is plus, it must be plus on all radii of the section in order to have strict circuit uniformity. The same holds true for longitudinal uniformity. Of course there can be a reversal of trend between successive years here and there in the trunk and, if so, one increment must still have a greater volume than the other. This would be the true trend. If complete uniformity does not exist throughout a tree, a single radius, such as an increment core, may or may not yield an accurate record of trend. Perhaps reliance on one radius has been responsible for the rather weak correlation between tree growth and rainfall in many cases.

Mean sensitivity (Douglass, 1928) is computed by dividing the difference between each two successive rings by their mean thickness. Values of the index vary from 0.0 to 2.0; as the thicknesses of the two rings approach equality, the index approaches 0.0. As the difference in thickness between the two rings approaches a maximum, that is, one approaches zero thickness, the index approaches 2.0. Mean sensitivity emphasizes total variability of ring thicknesses on a given sequence or section and gives an excellent measure, it is thought, of the impact of dominant and variable growth factors whatever they may be.

Skeleton plots (Glock, 1937) illustrate graphically on coordinate paper the relative thinness of those growth layers which are strikingly thin in comparison to the immediately adjacent growth layers. Time in years is measured along the horizontal axis. Parallel to the vertical axis, lines are drawn inversely proportional to the thickness of the growth layer; that is, the thinner a growth layer is in relation to its two adjacent growth layers, the longer the line on the appropriate year. Plots may be made directly from the wood, the more rapid method, or from the millimeter measures, as was done here. Skeleton plots yield a synoptic view of those particular trees out of a group which have responded roughly in the same direction to the impact of the same growth factors and which have responded roughly in unison insofar as the production of xylem is concerned. To interpret further than this from a similarity of skeleton plots is probably unsafe.

The Northern Arizona chronology, based upon diagnostically thin or partial growth layers and the intervals between them on a sequence, has been used as a frame of reference to designate individual growth layers known to be present on the materials at hand. Thus all sharply bordered growth layers have been given a calendar date. If unidentifiable multiplicity should exist within the trees studied, then the annual increments would possess somewhat less average variation than the individual growth layers possess. Growth-layer patterns by themselves, whether or not they show multiplicity, yield much environmental information. The validity of the principles here used for dating purposes will be discussed in the last section of this report.

VI. CIRCUIT UNIFORMITY

Circuit uniformity refers to the behavior of a growth layer throughout its extent around the trunk at any one level. In general, uniformity refers to the consistency of growth, its rate, its time, and its amount; specifically, it refers to absolute thickness around the circuit and to the thickness of each growth layer in relation to the two adjacent growth layers.

Both absolute and relative thicknesses are of concern to work in tree growth. Douglass (1928, p. 22) restricted circuit uniformity to relative thickness. In similar manner, Glock (1937, p. 35) restricted the use of the term circuit uniformity and, in addition, considered absolute thickness of comparatively little concern. However, it is now thought that the variation of absolute thickness around the circuit may be one of the parameters defining growth-layer patterns under differing soil-moisture regimes.

TREE OL-B-42

Absolute thickness.—Ring thicknesses for OL-B-42 along three radii on three sections, T-2, T-6, and T-9, of OL-B-42, are plotted on figures 11, 12, and 13. Although uniformity is striking, it is far from perfect. The graphs reveal an almost total lack in uniformity of absolute thicknesses. Except for the case of zero thickness on the three radii, there is no growth layer whose thickness is identical on all three radii. The same growth layer on two radii may be identical in a few instances. In extreme cases the thickness of a growth layer on one radius may vary by a factor of 5, or even 15, in comparison with one of the other radii. A difference by a factor

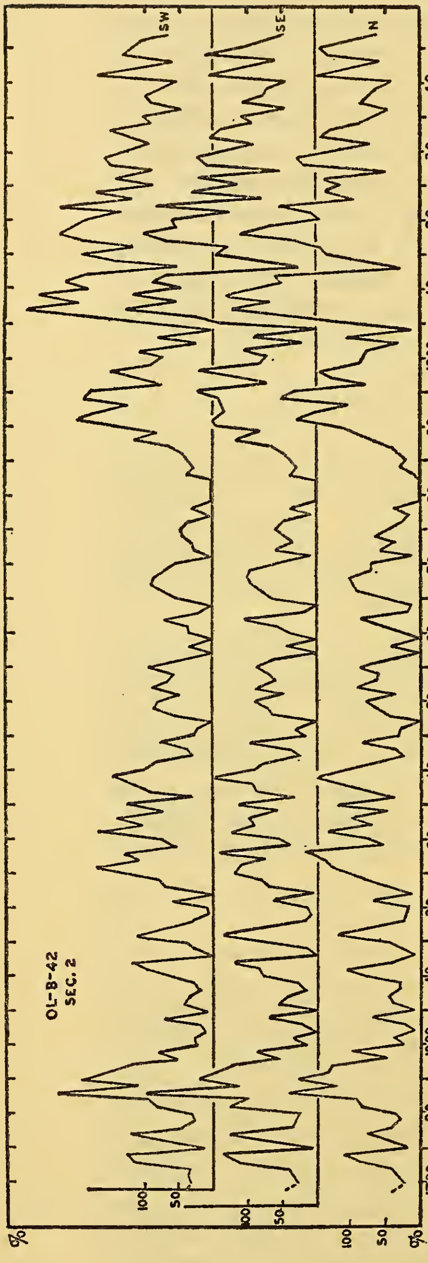


FIG. 11.—Graphs of growth-layer thicknesses, 1780-1947, along three radii of section T-2, about 6 feet above ground level, OL-B-42.

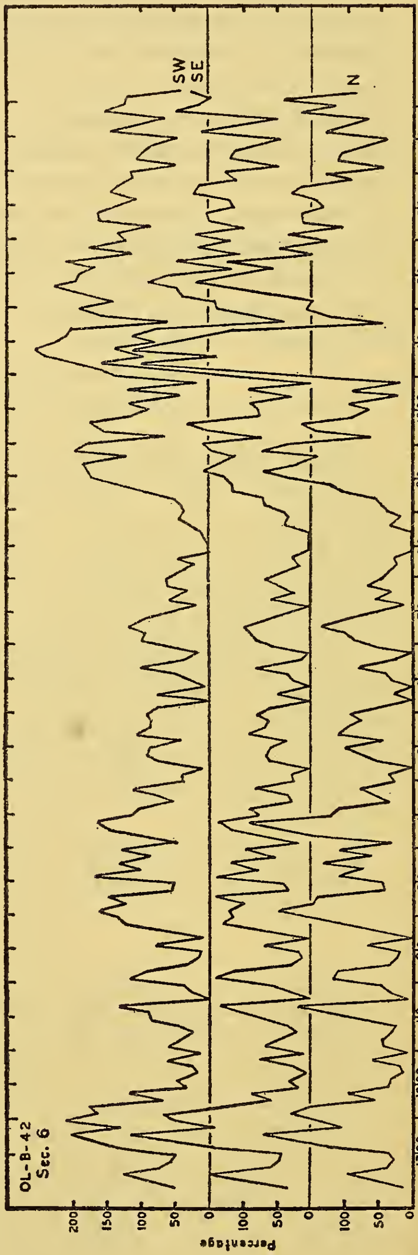


FIG. 12.—Graphs of growth-layer thicknesses, 1785-1947, along three radii of section T-6, about 23 feet above ground level, OL-B-42.

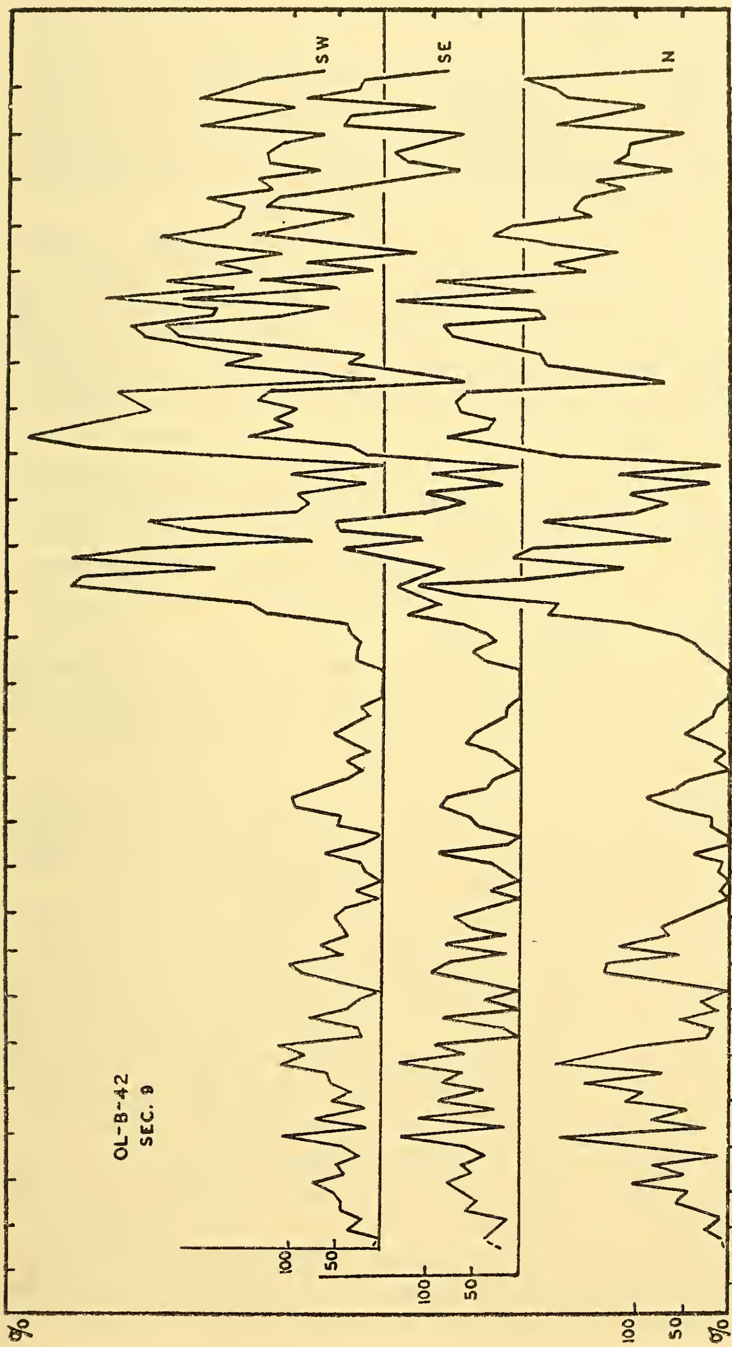


FIG. 13.—Graphs of growth-layer thicknesses, 1820-1947, along three radii of section T-9, about 36 feet above ground level, OL-B-42.

of 2 is not uncommon among the three radii or between one and the average of the three.

From figure 10 it might be inferred that the thickest portions of growth layers are on the north side of the tree. This is not always true, however (table 14), because on section T-2 in 73 cases out of 267 the thickest measurement is not on the north radius. Of these 73 cases, 67 occur on the southwest radius.

On section T-6, there are 112 cases out of 221 where the thickest portions of the growth layers are not on the north radius. Of these 112, 96 occur on the southwest radius. Growth layers are not uniformly thicker on any one radius; on section T-6, 43 percent of the growth layers are thicker on the southwest than on the other two radii (on section T-2, 25 percent). Of the 16 cases where the southeast radius is the thickest, 13 occur in the interval 1727 to 1776; the other 3 occur between 1886 and 1947. A great majority of the growth layers thickest on the southwest lie between the intervals where the growth layers on the southeast are the thickest. This distribution of the thickest portion of growth layers contrasts with that on section T-2 where the thick portions appear to be distributed rather uniformly in time.

On section T-9, there are 41 cases out of 147 where the thickest portions of the growth layers are not on the north radius. Of these 41, 26 occur on the southwest radius and 15 on the southeast; the 26 cases represent 18 percent in contrast to the 43 percent on section T-6 and 25 percent on section T-2. The distribution in time where the thickest portions are on the southwest is fairly uniform on T-9; but where they are on the southeast, 10 out of the 15 cases occur between 1801 and 1827 at the center of the section.

The ratios of thickest portions of growth layers not on the north radius to thickest portions on the north radius and the percentage of growth layers thickest on the southwest (table 14), indicate that the least uniformity in thickness distribution exists at mid-tree as shown on T-6. Here, approximately 50 percent of the growth layers have their thickest portions away from the north radius, whereas near the base and near the top of the tree (T-2 and T-9) the areas of thick growth tend to cluster about certain radii.

Another facet of the subject of absolute thickness of growth layers around the circuit lies in the question, Does the thickness of a growth layer fluctuate about a mean rather than gradually thickening and thinning once in its course around the circuit? An analysis of growth-layer measurements for the years 1830 to 1879 for T-1, T-5, and T-9 around the circuit gives the following ratios for the incidence of thickness fluctuation about a mean: T-1, 2.37; T-5, 1.96; T-9, 3.67. Thus, fluctuation about a mean has a very slight dominance at mid-tree but is comparatively rare at the base and near the top of the trunk. This disposition of thick growth differs from that determined for OL-12 (Glock, 1937, p. 37) where fluctuation about a mean dominated the base of the trunk and depended, it was thought, upon root influence.

Relative thickness and trend.—Relative thickness refers to the ratio of thicknesses between one growth layer and one or more of the two adjacent growth layers. Trend refers to the relation of the thickness of one growth layer to that of the preceding growth layer. A summary of trends illuminates parallel or opposed fluctuations on

TABLE 6.—*Circuit uniformity, trunk of OL-B-42. Number and percentage of opposed trends between different pairs of radii and among all three radii of sections T-2, T-6, and T-9*

	T-2 (146 cases)		T-6 (146 cases)		T-9 (146 cases)	
Radii	*No.*	%	*No.*	%	*No.*	%
N. vs. SE.	23	16	16	11	26	18
SE. vs. SW.	12	8	21	14	24	16
N. vs. SW.	20	14	18	12	31	21
All 3 radii	27	18	27	18	39	27

two or more radii, or two or more sections, in a simple and effective manner. Trends were counted for the interval 1802-1947 on all three radii for sections T-2, T-6, and T-9 and the following comparisons made: N. vs. SE., SE. vs. SW., N. vs. SW., and N. vs. SE. vs. SW. Table 6 shows the number and percentage of cases, out of 146, where the trend on the two radii being compared is opposite in direction. In the lower line of the table the three radii are compared simultaneously. Section T-6, in contrast to T-2 and T-9, has the greatest number of opposite trends where the SE. and SW. radii are compared. This may be related to the dominance of fluctuation about a mean in absolute thickness. Disagreement in trend appears to be most common toward the top of the trunk. Close comparison of figures 11, 12, and 13 will show the particular years with one reversed trend.

In order to determine the effect of more than three radii on trend disagreements around the circuit, five radii were measured for section T-1 and contrasted for trend. The number of opposed trends out of 146 years are:

N.-SE.	25	SE.-WNW.	23
N.-SW.	23	SW.-ENE.	20
N.-ENE.	22	SW.-WNW.	20
N.-WNW.	19	ENE.-WNW.	24
SE.-SW.	20	N.-SE.-SW.	34
SE.-ENE.	23	All five	44

All five radii taken together showed 44 out of 146 opposite trends; the three radii, N., SE., and SW., showed 34 out of 146. Hence, two more radii revealed 10 more reversals of relative thicknesses. A further increase in the number of radii measured would very probably increase the number of growth layers with reversals of trend.

Figure 14 A illustrates the prevalence of trend reversals around the circuit and the number of cases of reversals when five radii rather than three are examined. It is clear that disagreements are far from uniformly distributed when plotted by decades. On section T-1 the 30-year period 1740-1769 has only 10 percent disagreement for three radii, whereas the 20-year period 1770-1789 has 30 percent and that for 1880-1899 has 45 percent reversal. On section T-5 for three radii, six decades have complete agreement in trend and five decades have 40 percent or more disagreement. Table 7 summarizes figure 14 A.

Table 7.—*Circuit uniformity, trunk of OL-B-42. Percent of opposed trends or disagreements, comparing three and five radii*

	T-1 (1680-1947)	T-5 (1730-1947)	T-9 (1801-1947)
3 radii	21	17	25
5 radii	27	23	33

The greatest amount of trend disagreement resides near the top of the trunk, whereas the least is in the central parts both for three and for five radii. Figures in table 7 vary from those in the bottom line of table 6, further evidence of fluctuation in the relative thicknesses of growth layers. Thus, relative thickness fluctuates to a certain extent from radius to radius around the circuit and local trend reversals on the circuit increase with the number of radii measured.

Figure 15 shows the lack of uniformity in relative thicknesses by trend reversals around the circuit for each section of OL-B-42 for every year. Each shaded column indicates a trend reversal some-

FIG. 14 A.—Columnar graphs by decades of sections T-1, T-5, and T-9 in tree OL-B-42 to show the increase in circuit disagreement of five radii per section over three radii. Shaded signifies disagreement in relative thicknesses among three radii; open signifies increased disagreement of five over three radii.

where on the circuit of the particular section. Uniformity or its lack sets no very definite pattern. On some sections there are long intervals with no reversals around the circuit; for instance:

T-1 1715-1731	T-4 1746-1767	T-7 1854-1874
1902-1915	1797-1816	
1922-1934		T-8 1821-1840
	T-5 1739-1767	1857-1874
T-2 1748-1767	1810-1825	1917-1932
1828-1845	1856-1872	
		T-12 1914-1925
T-3 1705-1743	T-6 1932-1945	

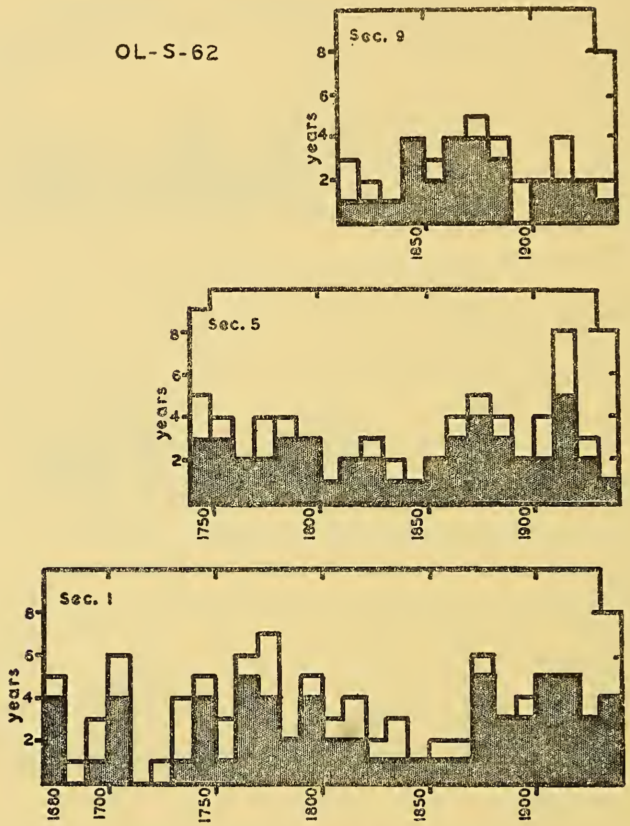


FIG. 14 B.—Columnar graphs by decades of sections T-1, T-5, T-9 in tree OL-S-62 to show the increase in circuit disagreement of five radii per section over three radii. Shaded signifies disagreement in relative thicknesses among three radii; open signifies increased disagreement of five over three radii.

Time intervals are much shorter where complete uniformity exists around the circuit for more than one section for five or more years; for instance:

T-1 – T-5....1724-1731	T-2 – T-8....1831-1840	T-1 – T-10...1922-1928
T-1 – T-6....1748-1756	T-1 – T-7....1856-1866	T-5 – T-8....1936-1945
T-5 – T-7....1810-1819	T-7 – T-9....1896-1907	

On sections T-1 to T-8, a consistent trend on one section will have the same trend on the other seven sections for 48 percent of the years, 1770-1947. If section T-9 is added to the eight sections, the

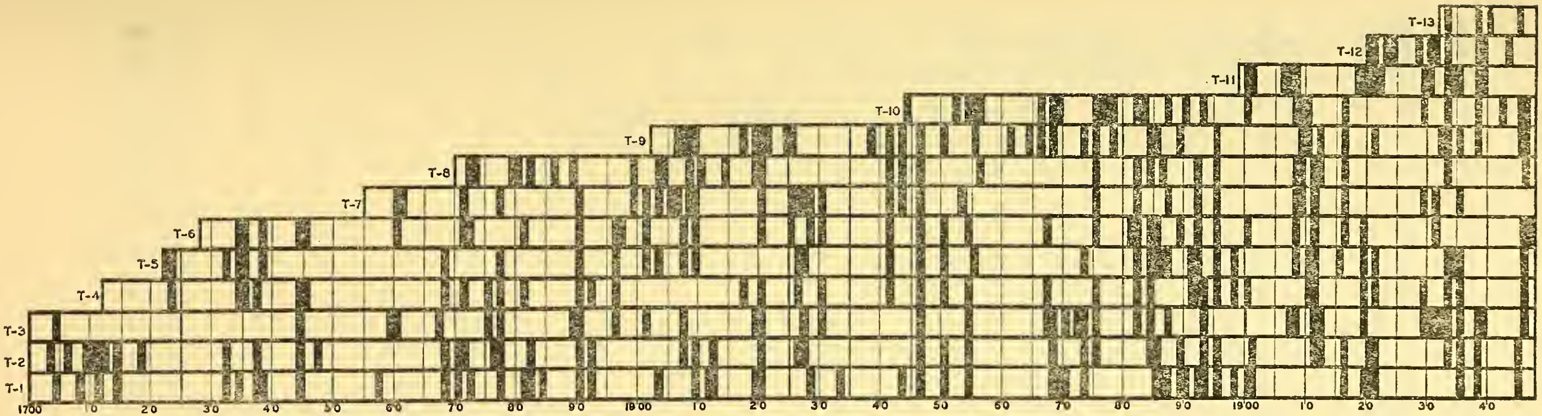


FIG. 15.—Lack of circuit uniformity around each section, OL-B-42. Each shaded rectangle indicates a trend disagreement, or reversal, in relative thicknesses between growth layers somewhere on the circuit, as represented by measured radii, of the particular section.

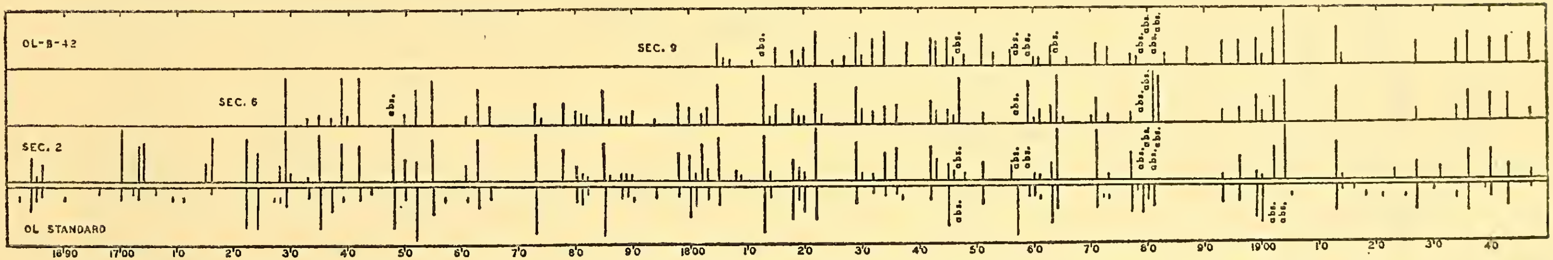


FIG. 16.—Skeleton plots of sections T-2, T-6, and T-9, of OL-B-42 compared to the "Standard," a synthesis of the plots of other trees in the same area. Inked lines occur on the years whose growth layers are strikingly thin; the longer the line the thinner the growth layer.

percentage of uniform trend becomes 45, 1802-1947; T-10 added gives 43 percent, 1844-1947; and T-11 added, gives 41 percent, 1899-1947.

Thus far we have analyzed uniformity of trend in relative thicknesses for certain years on the various sections of OL-B-42. A few more words may be added concerning opposed trends or trend reversals. The number and percentage of trend reversals on the sections of OL-B-42 are given in table 8.

Close examination of comparable time intervals on the various sections (fig. 15 and table 8) reveals that the sections with the greatest number of years with trend reversals are in the upper part of the tree, the second greatest near the base, and the least at mid-tree. Percentages also testify to the same distribution of reversals.

Consistency of reversal around the circuit for several sections for the same year does not seem so common as uniformity of trend.

Years with reversals on three consecutive sections:

1734	1808	1850	1875
1735	1809	1868	1938
1801	1843	1873	1946

Years with reversals on four consecutive sections:

1744	1820 (2)	1893	1919
1796	1854	1908	1933
		1909	1946

Years with reversals on five consecutive sections:

1777	1884	1916	1938
1875	1892	1935	

Years with reversals on six consecutive sections;

1841	1882	1895	1933

Years with reversals on seven consecutive sections: 1790 and 1911.

Year with reversals on nine consecutive sections: 1846.

After 1710, 42 years have a reversal somewhere on one section only. After 1722, 96 years have no reversals on any measured radius or on any section.

TABLE 8.—*Circuit uniformity, trunk of OL-B-42. Number and percentage of opposed trends for all sections*

Section	Time interval	Number of years	Number of years of trend reversals	Percent reversal
T-13	1932-1947	16	4	25
T-12	1920-1947	28	11	39
T-11	1899-1947	49	17	35
T-10	1844-1947	104	27	26
T-9	1802-1947	146	39	27
T-8	1770-1947	178	32	18
T-7	1755-1947	193	34	18
T-6	1728-1947	220	40	18
T-5	1722-1947	226	40	18
T-4	1712-1947	236	41	17
T-3	1700-1947	248	42	17
T-2	1700-1947	248	47	19
T-1	1700-1947	248	53	21

Reversals localized on one section out of six or more, after 1728, occur as follows:

Out of 6 sections	1747	T-2		
Out of 7 sections	1757	T-1	1761	T-7
	1759	T-3		
Out of 8 sections	1773	T-8	1784	T-1
	1776	T-2	1786	T-8
	1779	T-8	1797	T-6
	1780	T-8		
Out of 9 sections	1802	T-9	1814	T-8
	1804	T-8	1821	T-9
	1805	T-7	1824	T-9
	1810	T-8	1833	T-1
	1811	T-1	1838	T-9
Out of 10 sections	1852	T-10	1876	T-10
	1853	T-7	1877	T-10
	1861	T-9	1881	T-6
	1864	T-9	1883	T-10
	1872	T-3		
Out of 11 sections	1906	T-11	1918	T-11
	1915	T-5		
Out of 12 sections	1922	T-11	1924	T-12
	1923	T-12	1928	T-12
Out of 13 sections	1942	T-10	1947	T-6
	1943	T-12		

Such localization of reversals presents a problem to the student who works with restricted samples from a tree.

As shown by figure 15, no definite time pattern emerges from the analysis of the successive sections. Localized reversals occur more plentifully in the central growth layers of a section. An approximate measure of circuit uniformity for all sections of the entire tree may be obtained by dividing the sum of trend reversals for all sections by the total number of years for all sections (table 12). The tree as represented by the 13 sections averages about 80 percent circuit uniformity, sections T-2 to T-8 having more than 80 percent, followed by a sharp decrease to 61 percent in T-12.

The apparent lack of definite pattern, either in time or place, in the distribution of trend reversals raises the problem of diagnostic rings (Glock, 1937, p. 12) and crossdating (Glock, 1937, p. 16-21) not only among the radii of one section, but also among the successive sections and, ultimately, among different trees. Figure 16 shows skeleton plots for sections T-2, T-6, and T-9 compared with an OL Standard plot constructed from other trees of the same general area. On a skeleton plot only strikingly thin (diagnostic) growth layers receive attention; that is, they are thin in relation to adjacent growth layers. The OL Standard was made directly from the wood, whereas the plots for the three sections were made from the millimeter measures with a knowledge of the wood as a background. Recognizable similarity exists among all plots and among any two of them.

Two points must be noted: First, that the so-called "absent rings" are more numerous on OL-B-42 than on the Standard and absent on different dates, and second, that section T-9 departs farther from the Standard than do the other two sections. In general, sections T-2 and T-6 agree rather well with the Standard. A ring sequence taken from a section in the lower half of the tree is identifiable in terms of the other sections or in terms of the Standard plot. Identification, or crossdating, based on section T-9 or on a single radius does not carry the same assurance of accuracy. However, the quality of the crossdating in this tree from very near the lowest limit of ponderosa pine is sufficiently high to impart confidence in the methods of identification.

Diagnostic rings, such as 1943, 1936, 1927, 1913, 1904, 1902, 1863-4, 1857, 1851, and 1847, are not known to change their relative thicknesses. Trend reversals apparently occur among the less diagnostic rings and among the average to thick rings. To illustrate reversals on growth layers which at times could be diagnostic, the following examples are cited from sections T-1, T-6, and T-9. The growth layer for 1900, characteristically thinner than that for 1901, is thicker on the north radius of T-1 and T-2 and west-northwest radius of T-9. Growth layers for 1899 and 1900 reverse their relative thicknesses somewhere around the circuits of T-1, T-4, and T-6. The growth layer for 1893 is thicker than that for 1892 on the southwest radius of T-1 and the southeast radii of T-2 and T-4. The growth layer for 1868, commonly very thick, is thinner than that for 1867 at places on T-1, T-2, T-3, and T-9. Growth layers for 1845 and 1846 reverse their relative thicknesses locally on T-1 to T-6, and T-9; 1842 and 1843 reverse each other on T-9, as do 1818-1819 and 1805-1806.

TABLE 9.—*Relative thicknesses of certain growth layers, trunk of OL-B-42. Ratio of thicknesses of certain thin growth layers to the mean of the sum of two adjacent growth layers*

Section	1943	1936	1927	1913	1904	1896	1871	1851
T-12	2.4	2.8	3.0	...	...	...	...	...
T-11	1.7	1.6	2.7	3.1	3.5	...	...	...
T-10	1.5	1.5	1.9	5.6	29.3	2.5	4.5	3.1
T-9	1.8	1.9	1.6	4.2	24.0	2.4	4.0	2.5
T-8	1.8	2.7	1.6	3.3	23.0	1.9	3.5	1.8
T-7	2.0	2.1	1.3	3.4	13.7	2.3	3.4	1.8
T-6	2.2	2.3	1.6	3.5	5.3	2.4	3.7	2.2
T-5	1.7	2.0	1.8	3.3	12.3	2.0	3.6	1.8
T-4	2.2	1.9	1.1	4.3	51.5	2.3	4.4	1.9
T-3	1.9	2.0	1.8	4.6	45.5	1.5	2.9	2.2
T-2	2.0	1.8	2.2	4.1	18.4	2.0	6.0	1.8
T-1	2.4	2.0	2.2	5.4	6.7	1.9	4.1	1.7

No better idea of the change in relative thicknesses from one section to another (not reversals) can be given than by the help of table 9, which gives the ratio of a thin ring to the mean of its two adjacent rings; i.e., 1943 in relation to the mean of 1942 and 1944. No clear-cut generalization can be made except that no definite pattern exists around the circuit as taken in successive sections. However, there is a tendency toward an increased ratio (i.e., the central growth layer increasingly thin compared with the adjacent growth layers) toward the top of the trunk in 1936, 1927, 1913, 1896, and 1851; and a slight tendency to increased ratio at the base of the trunk in 1927, 1913, 1904, and 1871.

Summary.—Strict circuit uniformity does not exist, either for absolute or for relative thicknesses on any of the 13 sections of tree

OL-B-42. Absolute thickness has its extreme fluctuation in the case of a lenticular growth layer. Relative thicknesses vary from zero change to a complete reversal in the direction of the relationship. Trend is a rough but critical expression of the change from one growth layer to the next progressively on a sequence, a section, or a series of sections. Tree OL-B-42 shows an average trend agreement of 80 percent around its circuit, computing this agreement as described in reference to table 12. Uniformity is highest near the center of the trunk, dropping 9 percent from T-8 to T-9. If we consider the sections with five radii, T-1, T-5, and T-9, uniformity decreases from that where three radii are used; 6 percent for T-1, 5 percent for T-5, and 8 percent for T-9. Thus, three radii do not reveal all trend reversals; perhaps even five do not. Such reversals may be one of the prime reasons why many students obtain low correlations between measured ring thicknesses and an environmental factor such as rainfall, at least in the lower forest border. The results here obtained emphasize the effectiveness and utility of visual crossdating based upon the wood (Glock, 1953, p. 50) in contrast with that based upon exact measurements of each ring only.

Table 10.—*Average growth-layer thicknessess, mm., for the three radii of each section and for each section, trunk of OL-B-42*

Section	Average growth-layer width for each radius, mm.			Average growth-layer width, each section *mm.*	Maximum difference 3 radii *mm.*
	N.	SE.	SW.		
T-13	0.34	0.26	0.26	0.29	0.08
T-12	0.73	0.44	0.47	0.55	0.29
T-11	0.79	0.82	0.96	0.86	0.17
T-10	0.94	0.86	0.57	0.79	0.37
T-9	0.89	0.52	0.63	0.68	0.37
T-8	1.06	0.59	0.76	0.80	0.47
T-7	0.98	0.68	0.72	0.79	0.30
T-6	0.96	0.72	0.88	0.85	0.24
T-5	1.04	0.86	0.93	0.94	0.18
T-4	1.11	0.85	0.89	0.95	0.26
T-3	1.10	0.94	0.79	0.94	0.31
T-2	1.10	0.77	0.96	0.94	0.33
T-1	1.12	0.85	1.07	1.01	0.27
Average *	1.03	0.771	0.848	0.88	0.296

* In order to give proper weight to the small number of growth layers in the upper sections, averages were obtained by adding the values of all growth layers from all sections and dividing by the total number of values.

Growth-layer thicknesses.—Table 10 gives the average growth-layer thickness for each radius of each section of OL-B-42, the average growth-layer thickness for each section, the maximum spread among the three radii on each section, and the overall averages for each radius and for the trunk as a whole. The average growth-layer thickness for the trunk as represented in the sections is 0.88 mm.

With the exception of T-11, the north radius contains the thickest growth layers, averaging 1.03 mm.; with the exception of T-3 and T-10, the southeast radius contains the thinnest growth layers, averaging 0.771 mm.; the southwest radius averages 0.848 mm.

The maximum difference among the radii of any one section comes on T-8 with 0.47 mm.; the minimum (excluding T-13 because of its short radius and restricted circumference) comes on T-11 and T-5, 0.17 and 0.18 mm. Sections with the greatest differences are at the base of the trunk and from T-7 to T-10.

In general, the thickest growth layers are at or near the base of the trunk, T-1 being the thickest with 1.01 mm. The first 20 to 22 feet of the trunk, T-1 to T-5, contain relatively thick growth layers, 0.94 mm. or thicker, whereas throughout the trunk from T-6 to T-12 thicknesses range from 0.86 to 0.55 mm.

Average departure.—Departure as defined in Section V, Methods of Study, refers to differences from a mean. The average departures of the various sections along three radii from the mean value for the entire radius are illustrated on figure 17. Prominent average positive departures occur about 32 to 40 feet above ground, T-8 and T-9 on the north radius and T-9 and T-10 on the other two radii. A secondary positive location occurs on T-1. Sections T-11 to T-13 contain a high negative average departure. In lower midtree, T-2 to T-7, average departures are more nearly normal.

Table 11 gives average departures for each radius on each section. On some sections, T-1 to T-3, and T-5, average departure is fairly uniform from radius to radius; on others, T-6, T-8, T-10, T-12, and T-13, the disparity from radius to radius is rather great. The lower part of the trunk is somewhat more consistent than the upper part where there is an alternation from section to section. Among the three radii, the north has the highest average departure (60.3 percent) from its mean; the southeast has an average departure of 57.5 percent and the southwest 57.3 percent.

Table 12 gives the average departure for the total number of growth layers on each section. Except for a slightly higher average departure in T-1 at the base of the trunk, average departure is fairly uniform and close to the mean up to a height of about 30 feet where a decided fluctuation begins (fig. 18A). For nearly 10 feet

TABLE 11.—*Circuit uniformity, trunk OL-B-42. Average departure, average variation, and average departure from mean variation for each radius of each section*

Section	Average departure, %			Average variation, %			Average departure from mean variation, %		
	N.	SE.	SW.	N.	SE.	SW.	N.	SE.	SW.
T-13 ...	37.6	34.1	30.8	55.8	47.9	43.0	42.6	24.5	18.8
T-12 ...	41.1	33.3	38.4	46.2	41.2	48.7	30.0	26.6	28.1
T-11 ...	41.1	38.4	37.2	51.0	49.2	40.8	31.0	28.0	25.0
T-10 ...	62.6	69.5	64.4	46.2	41.2	39.2	29.9	30.1	27.1
T-9	76.9	71.8	75.2	43.6	45.9	44.0	33.4	30.7	32.4
T-8	74.2	59.4	60.2	43.3	45.9	48.9	28.2	28.2	29.8
T-7	60.0	54.7	55.0	44.0	45.9	45.4	28.6	29.7	28.3
T-6	60.4	56.9	50.7	50.0	48.7	45.3	29.2	31.1	29.5
T-5	54.3	52.6	52.7	46.8	42.8	47.7	29.4	27.3	28.8
T-4	56.5	51.6	55.9	45.0	43.9	46.7	27.9	27.9	31.3
T-3	53.5	54.2	53.8	46.1	45.0	49.6	29.1	27.4	31.8
T-2	58.8	58.7	56.8	46.6	53.2	48.1	30.0	35.1	30.1
T-1	64.2	64.0	65.3	51.3	57.9	52.2	33.7	39.2	35.9

TABLE 12.—*Circuit uniformity, trunk of OL-B-42. Sectional averages of departure, variation, departure from mean variation, and trend*

Section	Average departure %	Average variation %	Average departure from mean variation %	Trend disagreements *No.*	Trend agreements *No.*	Circuit agreement %	Partial growth layers %
T-13	33.0	46.0	26.5	4	12	75	5.8
T-12	32.1	43.9	24.1	11	17	61	3.4
T-11	34.9	42.0	23.5	17	32	65	0.0
T-10	63.4	40.0	26.9	27	77	74	14.2
T-9	73.1	43.0	30.9	39	108	73	14.9
T-8	62.7	45.1	26.1	32	146	82	13.4
T-7	55.5	44.3	28.1	34	159	82	8.2
T-6	54.5	46.3	28.5	40	180	82	7.6
T-5	51.7	43.7	27.1	40	186	82	7.0
T-4	53.4	44.0	28.0	41	195	83	7.1
T-3	52.9	45.7	27.5	43	211	83	7.4
T-2	55.5	47.0	29.5	50	216	81	8.9
T-1	63.2	51.4	34.1	64	238	79	10.2
Average*.	56.8	45.5	29.1			80	

* See note to table 10, page 46.

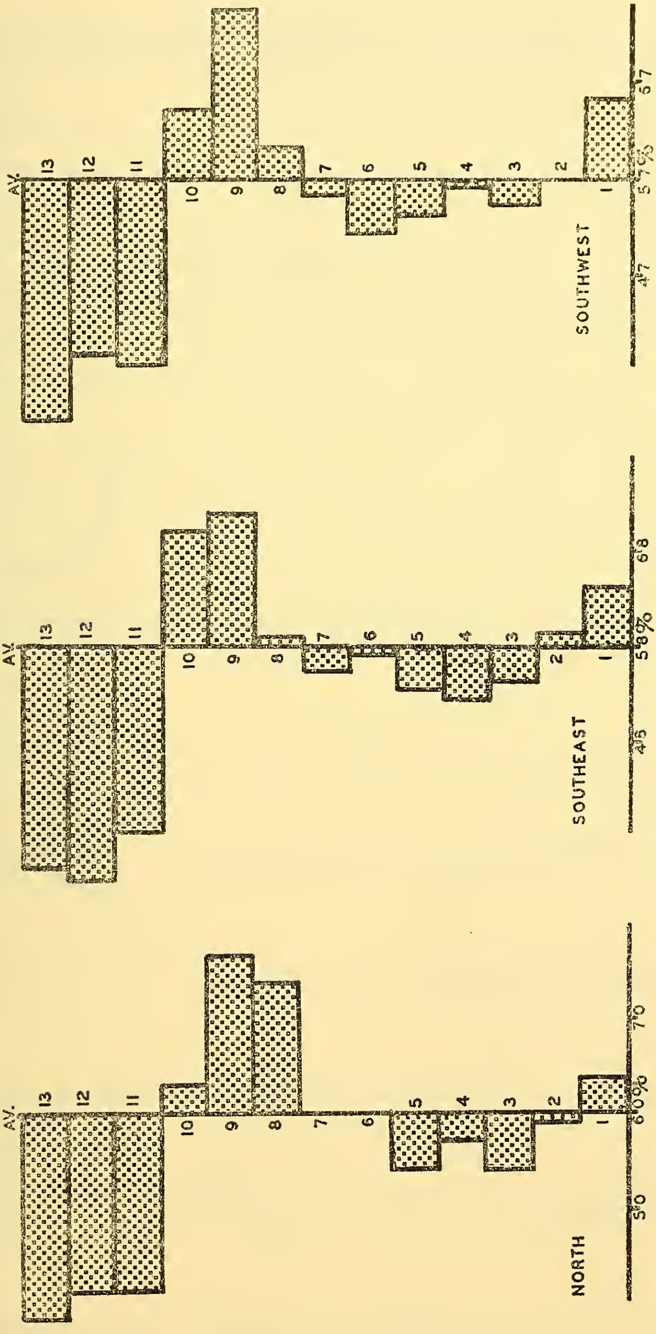


FIG. 17.—Columnar diagrams, three radii of all sections, OL-B-42, to show average departures from the radius mean. Above the mean to the right and below to the left of the vertical mean line.

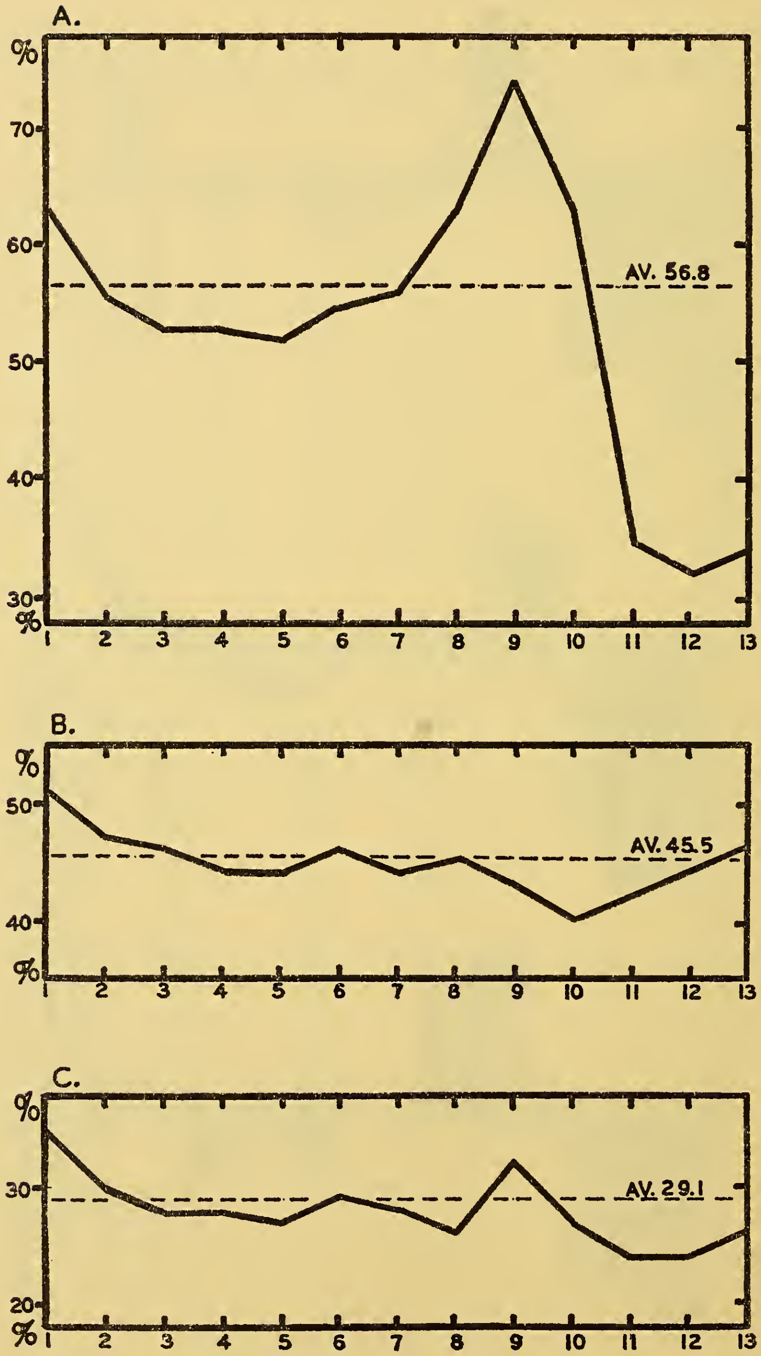


FIG. 18.—Circuit uniformity, OL-B-42. Graphs of average departure, upper graph (A), of average variation (B), and of average departure from mean variation (C), for all sections, T-1 to T-13, in percent.

(T-8 to T-10) the average departure is 10 to 20 percent greater on these sections than the tree average, and for the next 10 feet (T-11 to T-13) it is 15 to 25 percent less than the average. The average departure for the entire tree comes to 56.8 percent.

Average variation.—Variation as defined under Methods of Study refers to differences in thickness between each successive pair of growth layers. Figure 19 A shows the average variations of all sections along three radii in relation to the mean of the entire radius. The three radii do not appear to show as much agreement in relation to their own means as they did in the case of departures. Only on sections T-1, T-7, T-9, and T-10 is the direction of variation from the radius mean identical on all three radii; near identity exists on T-2 and T-4. There is little uniform divergence from the radius mean on the three radii of the various sections with the exception of a slight general decrease in variation from T-3 to T-9.

Average variation for each radius on each section is given in table 11. On three sections, T-4, T-7, and T-9, average variation is very uniform from radius to radius; on T-1 and T-2 and T-10 to T-13 the disparity among the radii is rather great. The upper four sections in the trunk of the tree show the greatest lack of uniformity, the lowest two sections the second greatest, and the central sections the highest similarity of average variation among the three radii.

The average variation for the total number of growth layers on each section is given in table 12. Except for sections T-1 and T-10 (fig. 18 B) variation is rather close to the mean. The lower part of the trunk, T-1 to T-6, has a slightly higher average variation than the upper part, T-7 to T-13. Section T-1 has the highest average variation of a section, T-2 the second highest, and T-10 the lowest.

Among the three radii (fig. 19 A), the southeast has the highest variation with 47.7 percent, the southwest is intermediate with 47.3 percent, and the north is lowest with 46.9 percent. This contrasts with average departure for the north radius which was the greatest. Average variation for the trunk as a whole is 45.5 percent.

Average departure from mean variation.—Departure from mean variation as defined under Methods of Study refers to the difference in variation in thickness from one growth layer to the next compared to the average variation of the sequence. Figure 19 B shows the average departure from mean variation of all sections along three radii in relation to the mean of the entire radius. Direction of departure from mean variation is somewhat more uniform than it is

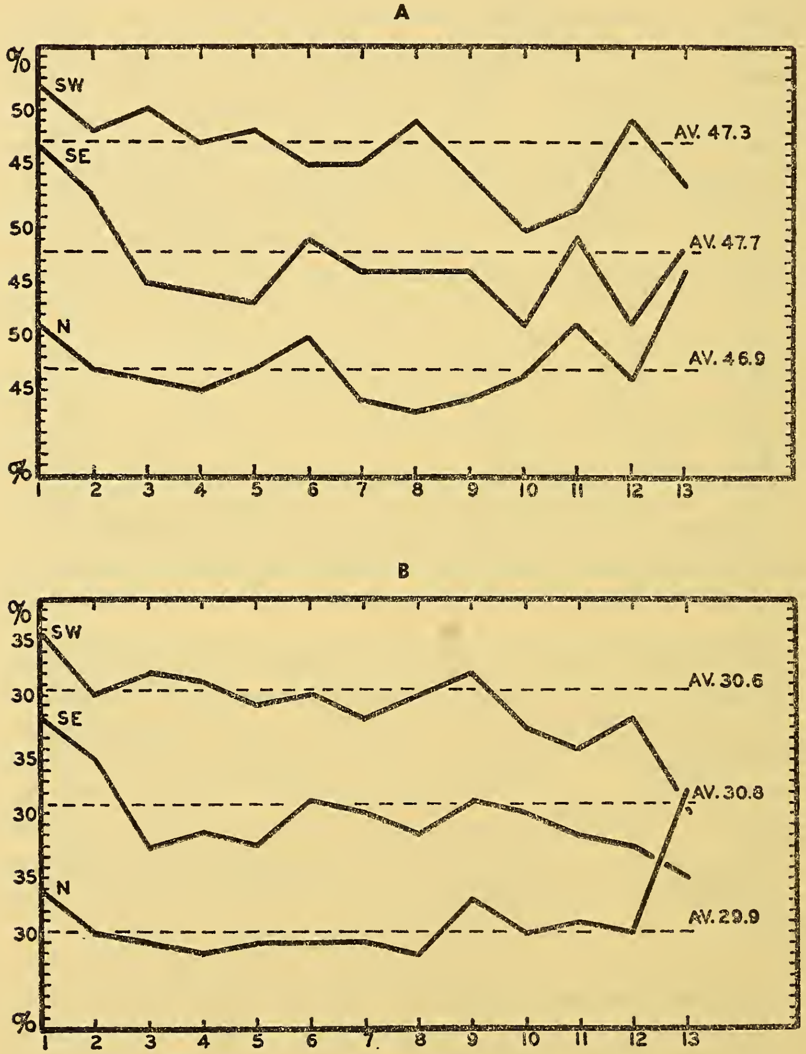


Fig. 19.—Circuit uniformity, OL-B-42, three radii, all sections, T-1 to T-13. Upper series shows average variation and lower shows average departure from mean variation.

for average variation. This direction of departure among the three radii is identical on T-1, T-5, T-8, and T-9, and nearly so on T-2, T-7, T-10, and T-12. Section T-1 has the strongest uniform departure, whereas T-13 has the highest irregular departure, the north radius being much greater than average and the other two radii being much less.

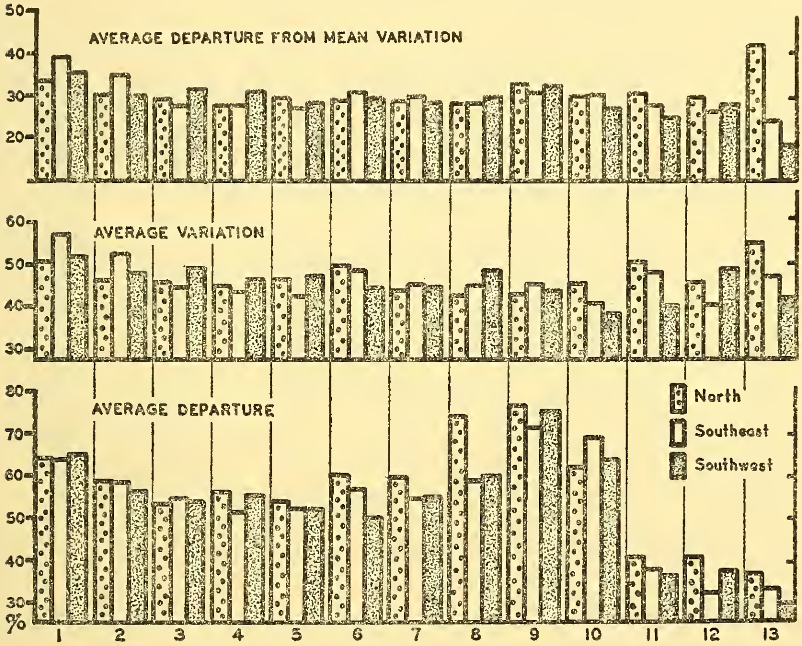


FIG. 20.—Columnar summary of the three parameters average departure, average variation, and average departure from mean variation for three radii of all sections, OL-B-42.

Table 11 gives the average departure from mean variation for each radius on each section of OL-B-42. In mid-tree from T-5 to T-10 the average departure from mean variation is nearly identical on the three radii. There is less uniformity in the two basal sections and least of all in the top three.

Table 12 gives the average departure from mean variation for the total number of growth layers on each section. Sections T-2 to T-7 cling rather closely to the tree average of 29.1 percent (fig. 18 C). From T-8 to T-13 the section averages depart considerably from the tree average, with T-9 being the only one to exceed that average. Thus the lower part of the tree above the basal section or sections is more uniform in its adherence to the average, whereas the upper sections have a decided decrease of average departure from mean variation except for T-9, which has an increase.

Among the three radii (fig. 19 B), the southeast (30.8 percent) and the southwest (30.6 percent) have very similar average departures from mean variation; the north radius has the lowest value

TABLE 13.—*Summary of circuit uniformity, trunk of OL-B-42*

Section	Average growth-layer thickness *mm.*	Maximum difference 3 radii *mm.*	Average departure %	Average variation %	Average departure from mean variation %	Circuit agreement %
T-13	0.29	0.08	33	46	26	75
T-12	0.55	0.29	32	44	24	61
T-11	0.86	0.17	35	42	24	65
T-10	0.79	0.37	63	40	27	74
T-9	0.68	0.37	73	43	31	73
T-8	0.80	0.47	63	45	26	82
T-7	0.79	0.30	56	44	28	82
T-6	0.85	0.24	55	46	29	82
T-5	0.94	0.18	52	44	27	82
T-4	0.95	0.26	53	44	28	83
T-3	0.94	0.31	53	46	28	83
T-2	0.94	0.33	56	47	30	81
T-1	1.01	0.27	63	51	34	79
Average * ..	0.88	0.296	56.8	45.5	29.1	80

Average growth-layer thickness for each radius	*mm.*
N.	1.03
SE.	0.771
SW.	0.848

* See note to table 10, page 46.

(29.9 percent). This resembles average variation but is unlike average departure.

Average departure from mean variation for the trunk as a whole is 29.1 percent.

Summary.—Various features in summary have been given in text, in tables, and on graphs. The more generalized averages appear in table 13 where the tree averages are based upon all rings for each section because the upper sections have fewer growth layers than the lower. Average growth-layer thickness on the 13 sections of OL-B-42 is 0.88 mm., and the average maximum difference among the three radii is 0.296 mm. On the average, the thickest portions of growth layers are on the north radius (1.03 mm.), those of inter-

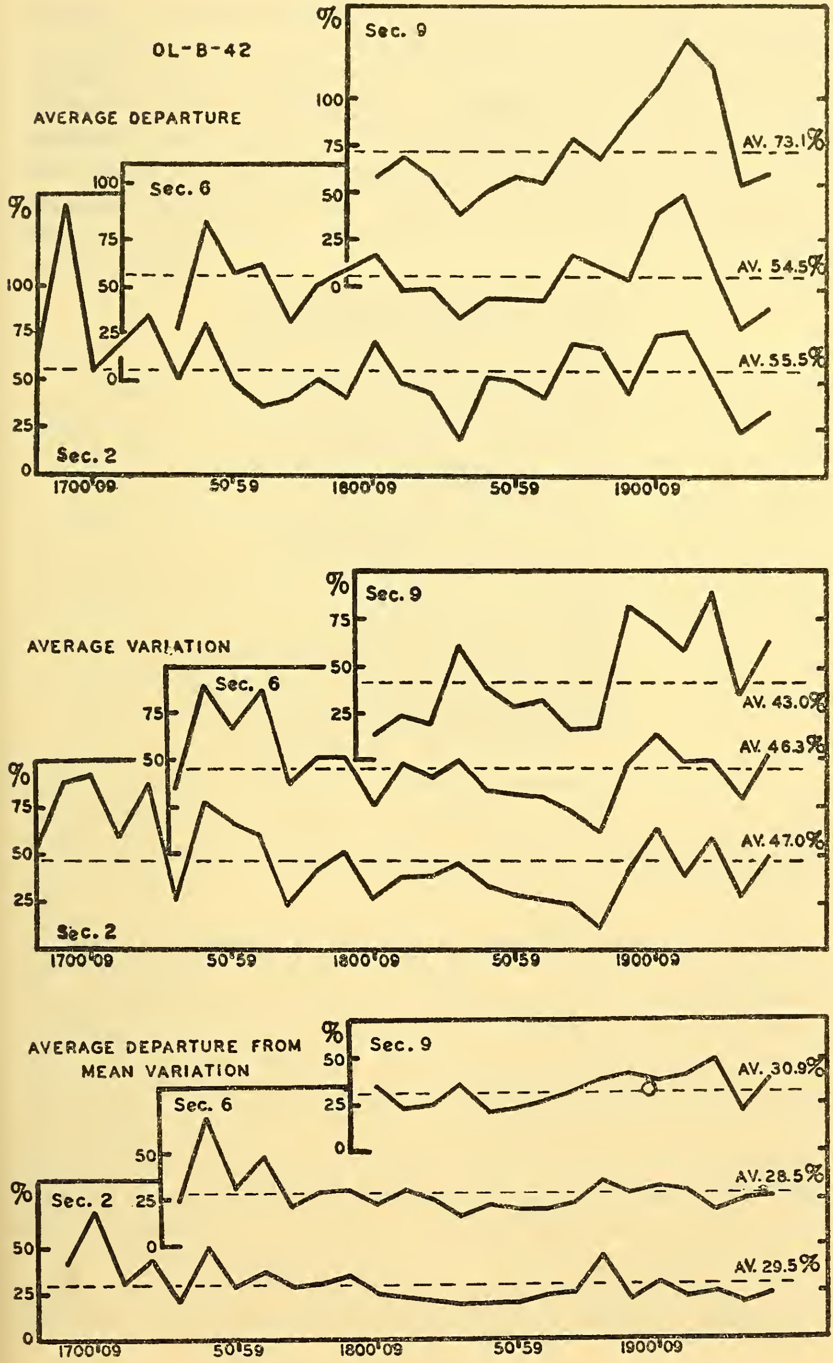


FIG. 21.—Circuit uniformity by decades, OL-B-42, sections T-2, T-6, and T-9. Graphs of three parameters average departure, average variation, and average departure from mean variation.

mediate thickness on the southwest radius (0.848 mm.), and the thinnest on the southeast (0.771 mm.).

The average percentage of trend agreement around the circuit for all sections united is 80 (table 13). For the entire tree based on the sections taken, average departure is 56.8 percent, average variation 45.5 percent, and average departure from mean variation 29.1 percent.

Figure 20 is a summary of average departure, average variation, and average departure from mean variation, separated into radii and

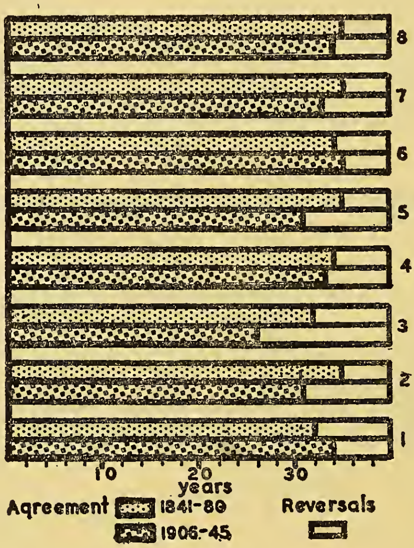


FIG. 22.—Comparison of circuit agreement on eight sections of OL-B-42 for the time interval 1841-1880 and 1906-1945.

sections. Certain features in common exist on figures 17 and 20—the former emphasizes particular features, springs from a different base line, and has a different scale. In addition to the general magnitude of the parameters, figure 20 also shows relationships section to section, among the three radii. It also shows that a high degree of consistency exists throughout the trunk insofar as the absolute magnitude of the parameters is concerned. Only for average departure are there decided differences, at the base and near the top of the trunk, and then the differences are among the sections rather than among the radii of one section. The absolute magnitude of these parameters and the total trend agreement are the features worthy of note.

On figure 21 the three parameters for T-2, T-6, and T-9 are plotted by decades. Fluctuations are not clear cut. Crests are from 40 to 110 years apart and troughs from 80 to 100 years. Such treatment of the parameters carries suggestions in relation to growth-factor fluctuations.

Figure 22 was constructed in order to detect a possible change in uniformity of trend between two 40-year time intervals, 1841-1880 and 1906-1945. It clearly illustrates that the interval 1906-1945 has less uniformity than the earlier interval; only in sections T-1 and T-6 is there greater uniformity (fewer reversals) during the earlier period of 1841-1880.

TREE OL-SO-57

Sections T-2, T-5, and T-8 from OL-SO-57 were chosen for comparisons because they correspond to T-2, T-6, and T-9 of the other two trees in distance above ground.

Absolute thickness.—Growth-layer thicknesses along three radii on sections T-2, T-5, and T-8 are plotted on figures 23, 24, and 25. Gross similarity is evident; at least, most of the major differences fall on the same year on any one section. Among the three sections, the uniformity of peaks and troughs is not so good as among the three radii of a single section, for instance, 1944, 1932, 1924, 1919, 1911, 1908, 1868, and others.

Growth-layer thicknesses reveal a lack of uniformity around the circuit of any section except for cases of zero thickness. It is not uncommon for the same growth layer on two radii to have the same measured thickness. In extreme cases the thickness of a growth layer on one radius may vary by a factor of 4 or more in comparison with the other two radii. A fluctuation by a factor of 2 is very common especially on section T-1. Above section T-1 fluctuation in absolute thickness is not so great as it is at the base of the trunk.

All growth layers do not necessarily have their thickest representation on the north radius. Table 14 shows that on T-2, 64 cases out of 250 do not fall on the north radius; of these 64, 30 occur on the southwest radius. On T-5, 23 cases out of 196 do not occur on the north radius; of these 23, 5 occur on the southwest radius. On T-8, 24 cases out of 111 do not occur on the north radius; of these 24, 8 occur on the southwest radius. Out of 64 instances where the thickest growth layer is not on the north radius, 43 occur in the years 1690-1749.

Tree OL-SO-57 has the thickest portion of growth layers more commonly on the north radius than does OL-B-42. In OL-SO-57,

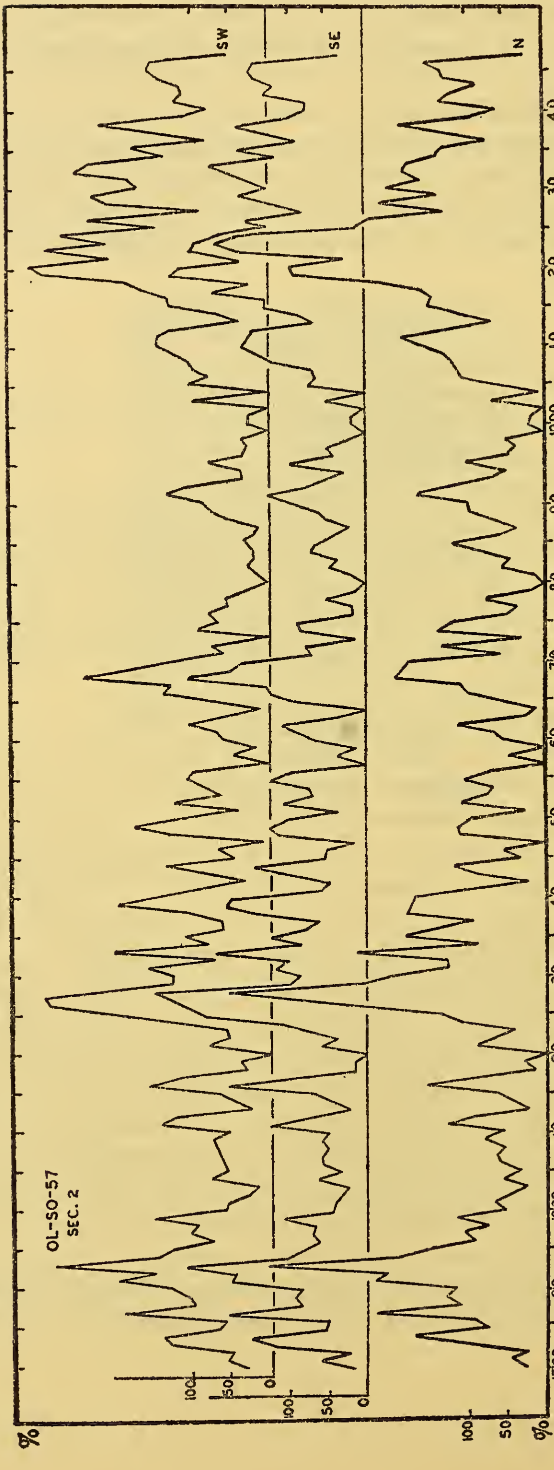


FIG. 23.—Graphs of growth-layer thicknesses, 1780-1947, along three radii of section T-2, about 5½ feet above ground level, OL-SO-57.

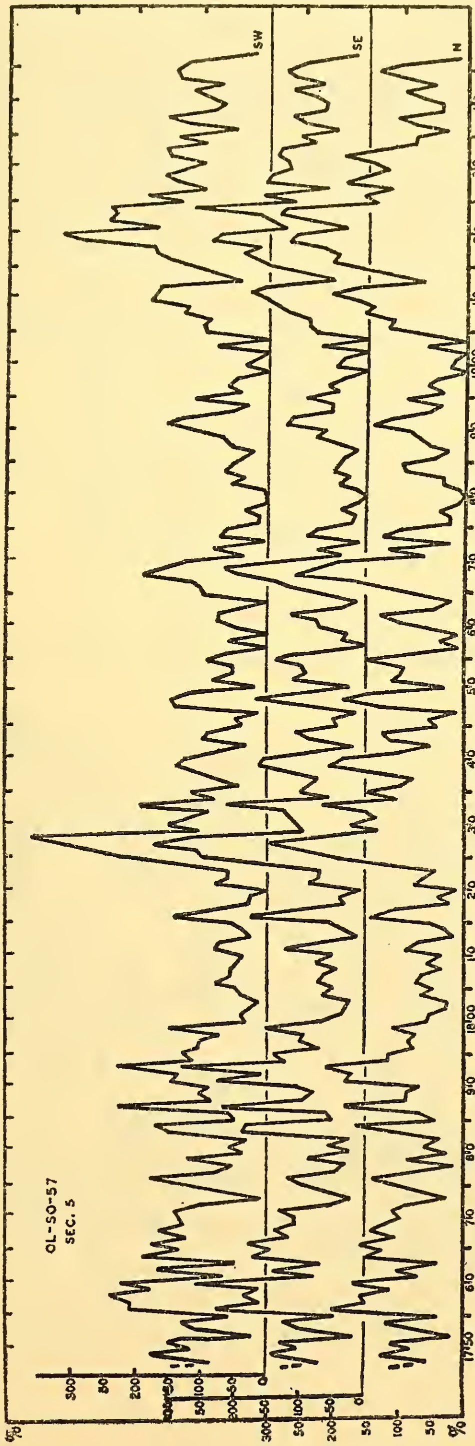


FIG. 24.—Graphs of growth-layer thicknesses, 1748-1947, along three radii of section T-5, about 21 feet above ground level, OL-SO-57.

TABLE 14.—*Thickness comparison along three radii of three sections, trunk of OL-B-42, OL-SO-57, and OL-S-62*

Tree	Total number of growth layers	N. radius No.	N. radius %	SE. radius No.	SE. radius %	SW. radius No.	SW. radius %
OL-B-42:							
T-9	147	106	72.1	15	10.2	26	17.7
T-6	221	109	49.3	16	7.2	96	43.4
T-2	267	194	72.7	6	2.2	67	25.1
OL-SO-57:							
T-8	111	87	79.0	16	14.4	8	7.2
T-5	196	173	88.2	18	9.1	5	2.5
T-2	250	186	74.4	34	13.6	30	12.0
OL-S-62:							
T-9	134	7	5.2	107	79.8	20	14.9
T-6	190	140	73.7	20	10.5	30	15.8
T-2	251	115	45.8	95	37.8	41	16.3

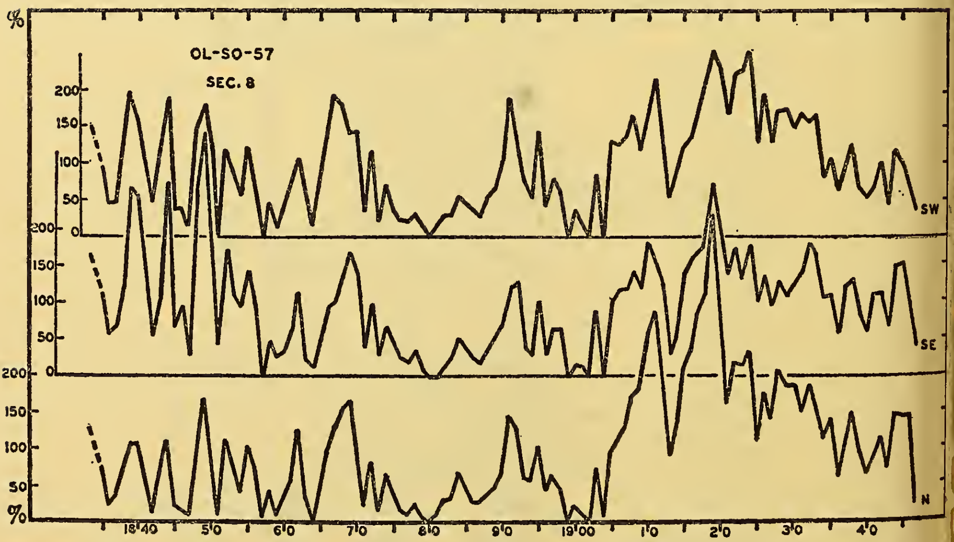


FIG. 25.—Graphs of growth-layer thicknesses, 1835-1947, along three radii of section T-8, about 37½ feet above ground level, OL-SO-57.

20 percent of the total cases of all growth layers on the three sections do not occur on the north radius, whereas in OL-B-42, 36 percent of the total growth layers do not have the thickest portion of their circuits on the north radius. The thickest portion of the growth layers occurs primarily on the north radius and secondarily on the southwest radius (OL-B-42) or the southeast radius (OL-SO-57). Divergence from the north radius occurs most commonly on section T-6 (mid-tree) in OL-B-42 and on T-2 (near base of tree) in OL-SO-57.

A comparison of three and five measured radii on certain sections cannot be made because only three radii were measured on OL-SO-57.

TABLE 15.—*Circuit uniformity, trunk of OL-SO-57. Number and percentage of opposed trends between different pairs of radii and among all three radii of sections T-2, T-5, and T-8*

	T-2 (146 cases)		T-5 (146 cases)		T-8 (114 cases)	
Radii	*No.*	*%*	*No.*	*%*	*No.*	*%*
N. vs. SE..........	30	20	13	9	14	12
SE. vs. SW.........	24	16	21	14	15	13
N. vs. SW..........	27	18	20	14	14	12
All 3 radii..........	40	27	27	18	20	18

Relative thickness and trend.—The meaning of these terms and their use have been explained in the discussion of tree OL-B-42.

Trends were counted for the interval 1802-1947 on all three radii for sections T-2, T-5, and T-8 and the following comparisons made: N. vs. SE., SE. vs. SW., N. vs. SW., and N. vs. SE. vs. SW. Table 15 shows the number and percentage of cases out of 146 in T-2 and T-5 and out of 114 in T-8 where the trend on the two radii being compared is opposite in direction. The lowest line gives the comparison among all three radii taken at the same time. On sections T-5 and T-8 the greatest number of opposed or reversed trends occurs where the southeast radius is contrasted with the southwest; on T-2, the greatest number occurs where the north radius is contrasted with the southeast. The two lower sections of both trees, OL-B-42 and OL-SO-57, resemble each other in the location of the greatest number of reversals. In general, OL-SO-57 has less disparity among the pairs of contrasted radii than does OL-B-42. Another contrast between the two trees is in the location within the trunk of the greatest number of reversals: in OL-B-42 (table 6) in the upper part of the trunk and in OL-SO-57 (table 15) in the lower part.

Figures 23, 24, and 25 show the year-to-year details of agreement and disagreement.

On figure 26 each shaded column indicates a trend reversal somewhere on the circuit of the particular section for a certain year. The figure shows no definite pattern either for agreement or reversal. Single sections possess some rather long intervals of agreement around the circuit:

T-1	1855-1868
T-2	1720-1738
	1773-1785
	1791-1800
	1809-1818
	1855-1866
T-3	1713-1742
	1811-1822
	1932-1945
T-4	1729-1740
	1766-1775
	1802-1811
	1813-1822
T-5	1747-1756
	1758-1769
	1771-1783
	1870-1882
	1891-1906
T-6	1773-1785
	1791-1800
	1855-1868
	1934-1947
T-7	1836-1853
	1855-1868
	1921-1931
T-8	1847-1867
	1870-1880
	1912-1922
	1934-1944
T-9	1855-1867
	1908-1917
	1934-1944
T-10	1888-1908

Only those intervals with 10 or more consecutive agreements have been listed.

Agreements in uniformity for more than one section are not so numerous and do not cover such long intervals as for one section only, those with five or more years being:

T-2 – T-3	1720-1738
T-1 – T-3	1761-1766
T-1 – T-6	1777-1781
T-2 – T-5	1813-1818
T-5 – T-7	1838-1843
T-1 – T-9	1857-1861
T-6 – T-9	1855-1867
T-2 – T-5	1870-1874
T-7 – T-9	1870-1874
T-4 – T-7	1878-1882
T-3 – T-6	1912-1916
T-6 – T-8	1924-1928
T-6 – T-10	1934-1941
T-4 – T-6	1941-1947

On sections T-1 to T-7 a consistent trend around the circuit of one section will have the same consistency on the other six sections for 46 percent of the time for the interval 1798-1947. If T-8 is added to the seven sections, the percentage of uniform trend becomes 47.4, 1834-1947; T-9 added, gives 43.6 percent, 1854-1947; T-10 added, gives 38.3 percent, 1888-1947; and T-11 added, gives 31.6 percent uniformity among the sections for 1910-1947.

FIG. 26.—Lack of circuit uniformity around each section, OL-SO-57. A shaded rectangle indicates a trend disagreement, or reversal, in relative thicknesses between growth layers somewhere on the circuit, as represented by measured radii, of the particular section.

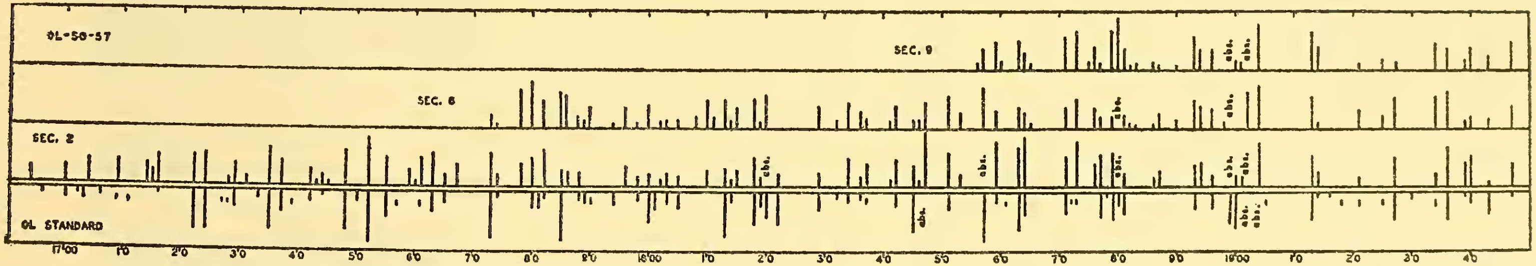


FIG. 27.—Skeleton plots of sections T-2, T-6, and T-9 of OL-SO-57 compared to the "Standard," a synthesis of the plots of other trees in the same area. Inked lines occur on the years whose growth layers are strikingly thin; the longer the line the thinner the growth layer.

Consistency of reversal around the circuit on several sections for the same year is not so common as uniformity of trend.

Years with reversals on three consecutive sections:

1760	1854 (2)	1901	1930
1772	1862	1906	1931
1789	1883	1918 (2)	1932
1790	1898	1929	1934

Years with reversals on four consecutive sections:

1754	1832	1890	1924
1823	1846	1894	1945
1831	1876	1920	

Years with reversals on five consecutive sections:

1828	1907	1931	1942
1869	1929		

Years with reversals on six consecutive sections: 1801, 1931, and 1933.

Years with reversals on seven consecutive sections: 1837 and 1885.

There is a certain consistency in reversals on particular years; for instance, after 1750, the years 1754, 1790, 1801, 1837, and 1885 have reversals on all sections save one; after 1840, the years 1846 and 1854 have reversals on all sections save two. Except for the years mentioned above, little consistency exists in reversals from section to section year after year.

A summary of trend reversals as shown on figure 26 is given in table 16. Here, as in OL-B-42, the highest percentage of reversals

TABLE 16.—*Circuit uniformity, trunk of OL-SO-57. Number and percentage of opposed trends for all sections*

Section	Time interval	Number of years	Number of years of trend reversals	Percent reversal
T-14	1936-1947	12	1	8
T-13	1929-1947	19	4	21
T-12	1923-1947	25	7	28
T-11	1910-1947	38	6	16
T-10	1888-1947	60	12	20
T-9	1854-1947	94	20	21
T-8	1834-1947	114	20	18
T-7	1798-1947	150	30	20
T-6	1773-1947	175	36	20
T-5	1748-1947	200	34	17
T-4	1727-1947	221	42	19
T-3	1712-1947	236	44	19
T-2	1700-1947	248	52	21
T-1	1700-1947	248	67	27

is near the top of the trunk, and the next highest is at the base. The average reversal per section (20.4 percent) for T-1 to T-13 for OL-SO-57 is only slightly, and perhaps not significantly, higher than that of T-1 to T-13 for OL-B-42 (19.8 percent). Thus both trees have an approximate circuit uniformity of 80 percent, sections T-9 to T-13 of OL-B-42 having much lower uniformity (higher percentage of reversals) than the same sections on OL-SO-57.

Table 20 (p. 71) gives the percentage of trend agreement based on longer sequences than those given in table 16. In tree OL-SO-57 sectional differences from the tree mean are not as large as in OL-B-42. For instance, the maximum difference from the tree mean in OL-B-42 is 19 percent, whereas in OL-SO-57 it is 13 percent. Average difference from the mean is 5.2 percent for tree OL-B-42 and 3.4 percent for OL-SO-57.

Reversals localized on one section out of six or more (starting with 1773) are comparatively rare. For instance, only on the following dates is a reversal restricted to one section (fig. 26).

Out of 6 sections..............	1784	T-5		
Out of 7 sections..............	1810	T-3	1826	T-7
	1811	T-6	1827	T-1
	1815	T-6		
Out of 8 sections..............	1835	T-1		
	1839	T-2		
Out of 9 sections..............	1855	T-4	1864	T-4
	1856	T-4	1876	T-2
Out of 10 sections.............	1888	T-1		
	1902	T-1		
Out of 11 sections.............	1910	T-1	1921	T-10
	1915	T-11		
Out of 12 sections.............	1925	T-12		
Out of 14 sections.............	1941	T-2		

A highly localized reversal would add a slight distortion to the more "normal" sequence of the trunk should the wood sample be taken to include the reversal.

Skeleton plots of T-2, T-6, and T-9 are compared with the OL Standard on figure 27. The similarity among the sections and of each section with the Standard is obvious. It is, if anything, better than in the case of OL-B-42 (fig. 16). Growth layers absent on certain sections are more numerous than on the Standard. In comparison with OL-B-42, the skeleton-plot method of crossdating appears more reliable section to section. The same cannot be said, however, for a single radius compared with any other radius from the same trunk.

Diagnostic growth layers are not so consistently thin relative to their neighbors as were the same growth layers in OL-B-42. The growth layer dated 1943, which does not change its relative thickness on any section of OL-B-42, becomes locally thicker than 1942 on the north radius of T-1 in OL-SO-57 and on the southwest radius of T-2; 1936 is thicker than 1937 on all three radii of T-14; and 1927 is only slightly thinner than 1926 on the southeast radius of T-9. Otherwise the diagnostic rings (1913, 1904, 1902, 1863-4, 1857, 1851, and 1847 as listed for OL-B-42) do not change their relative thicknesses. It is perhaps true that those growth layers which show reversals are less diagnostic than those which show no reversals, a factor to be considered when one passes judgment on the reliability of sequences correlated from tree to tree. Diagnostic growth layers should not be so limited in number that crossdating becomes hazardous.

Trend reversals are more common among the less diagnostic growth layers. The dated growth layers cited in OL-B-42 have the following behavior in OL-SO-57: 1900, commonly thinner than 1901, is thicker on all radii of T-1, T-3, T-5, T-8, and T-10, on the southeast and southwest radii of T-2, T-4, and T-9, and on the north and southwest radii of T-6 and T-7; 1899 and 1900 do not reverse their relationships anywhere on the sections; 1893 is not thicker than 1892 at any place; 1868, commonly thicker than either 1867 or 1869, is thinner than one or the other on all radii of T-8, on the north radius of T-1 and T-6, on the southeast radius of T-4 and T-5, and on the southwest radius of T-7 and T-9; 1845, commonly thinner than 1846, is thicker on the southeast and southwest radii of T-1, on the north and southwest radii of T-8, on the north radius of T-6, and on the southeast radius of T-2, T-3, and T-4; 1842 and 1843 do not reverse their relationships anywhere on the sections studied; 1818 and 1819 reverse themselves on the southeast and southwest radii of T-7, on the southeast radius of T-2, and on the southwest radius of T-5; and 1805 and 1806 reverse their relationships on the southeast radius of T-3 and on the southwest radius of T-7. Some of the above illustrations have more, some less, reversals than in the case of OL-B-42.

Changes in relative thicknesses from one section to another without reversal in trend are given in table 17. No clear-cut consistent change can be noted. However, there is a tendency toward an increased ratio (central growth layer increasingly thin compared with adjacent growth layers) toward the top of the trunk for 1943, 1936, 1913, 1896, 1871, and 1851; and a tendency to increased ratio at or near the base of the trunk for 1927 and 1904. In OL-SO-57, in contrast with OL-B-42, certain growth layers are more decidedly diagnostic in the upper portions of the trunk, that is, in the upper

Table 17.—*Relative thicknesses of certain growth layers, trunk of OL-SO-57. Ratio of thicknesses of certain thin growth layers to the mean of the sum of two adjacent growth layers*

Section	1943	1936	1927	1913	1904	1896	1871	1851
T-14	2.0	1.5	...	...	...	...	...	...
T-13	2.3	2.7	...	...	...	...	...	...
T-12	2.6	2.5	1.5	...	...	...	...	...
T-11	2.1	2.1	1.5	5.2	...	...	...	...
T-10	1.8	2.0	1.7	3.2	3.6	1.8	...	...
T-9	1.8	1.9	1.3	2.3	7.5	2.6	4.6	...
T-8	1.9	1.8	1.3	2.1	21.2	2.3	3.6	7.2
T-7	2.0	2.0	1.8	2.0	6.2	1.9	2.3	4.1
T-6	1.6	2.3	2.1	2.0	13.2	1.9	2.1	3.2
T-5	1.6	2.3	1.9	2.2	...	1.8	2.5	4.2
T-4	1.7	2.2	1.8	2.0	13.0	1.9	2.2	3.5
T-3	1.4	2.1	1.3	2.2	31.0	1.9	2.1	3.6
T-2	1.2	1.8	1.7	1.8	23.3	1.6	2.0	3.0
T-1	1.3	1.7	2.2	1.7	...	1.7	1.9	3.2

portion at the time the particular growth layers were formed. On certain dates, 1943, 1913, 1896, 1871, and 1851, the smallest ratios are near the base of the trunk.

Summary.—Conclusions to be drawn from a consideration of absolute and relative thicknesses resemble so closely those set out under OL-B-42 (p. 45) that no repetition is necessary.

Growth-layer thicknesses.—Table 18 gives the average growth-layer thickness for each radius of each section of OL-SO-57, the average growth-layer thickness for each section, the maximum difference among the three radii on each section, and overall averages for each radius and for the trunk as a whole. Average growth-layer thickness for the trunk as represented by 14 sections is 0.957 mm.; this compares with 0.88 mm. for OL-B-42.

With the exception of sections T-11 to T-14, the north radius contains the thickest growth layers on the average. Thinnest growth layers are on the southwest radius for T-2, T-3, T-5, T-7, and T-11 to T-14, the other sections being thinnest on the southeast. This differs from OL-B-42, where, with the exception of two sections, thinnest growth layers were on the southeast radius. Total average for the north radius is 1.20 mm., for the southeast radius 0.85 mm., and for the southwest radius 0.83 mm.

Maximum difference among the radii of any one section exists on T-10 with 0.65 mm.; minimum on T-13 with 0.10 mm. or on T-12

TABLE 18.—*Average growth-layer thicknesses, mm., for the three radii of each section and for each section, trunk of OL-SO-57*

Section	Average growth-layer width for each radius, mm. N.	SE.	SW.	Average growth-layer width, each section mm.	Maximum difference 3 radii mm.
T-14	0.50	0.62	0.50	0.54	0.12
T-13	0.67	0.77	0.73	0.72	0.10
T-12	0.87	1.05	0.79	0.90	0.26
T-11	0.85	1.15	0.83	0.94	0.32
T-10	1.27	0.62	0.82	0.90	0.65
T-9	1.17	0.76	0.80	0.91	0.41
T-8	1.24	0.70	0.76	0.90	0.54
T-7	1.16	1.09	0.84	1.03	0.32
T-6	1.12	0.78	0.86	0.92	0.34
T-5	1.20	0.90	0.76	0.95	0.44
T-4	1.29	0.92	0.92	1.04	0.37
T-3	1.18	0.92	0.87	0.99	0.31
T-2	1.23	0.86	0.84	0.98	0.39
T-1	1.29	0.71	0.81	0.94	0.58
Average * ..	1.20	0.851	0.830	0.957	0.412

* See note to table 10, page 46.

with 0.26 mm. Following these sections, all near the top of the trunk, is T-3 with 0.31 mm. Greatest differences are not sharply localized.

In general for the trunk, thickest section averages exist in the lower seven sections, 1.04 mm. in T-4 and 1.03 mm. in T-7. Thicknesses in the lower seven sections range from 0.92 to 1.04 mm. and in the upper sections (excluding T-14) from 0.72 to 0.94 mm.

Average departure.—Average departures of the various sections along three radii are shown on figure 28. Highest average positive departures occur on T-7 to T-9 (28 to 42 feet above ground) on the north radius and on T-6 to T-9 (22 to 42 feet above ground) on the southeast and southwest radii. Section T-1 is not uniformly positive as it is in OL-B-42. The upper portion of the tree trunk, sections T-10 to T-14 (42 to 53 feet above ground), contains a high

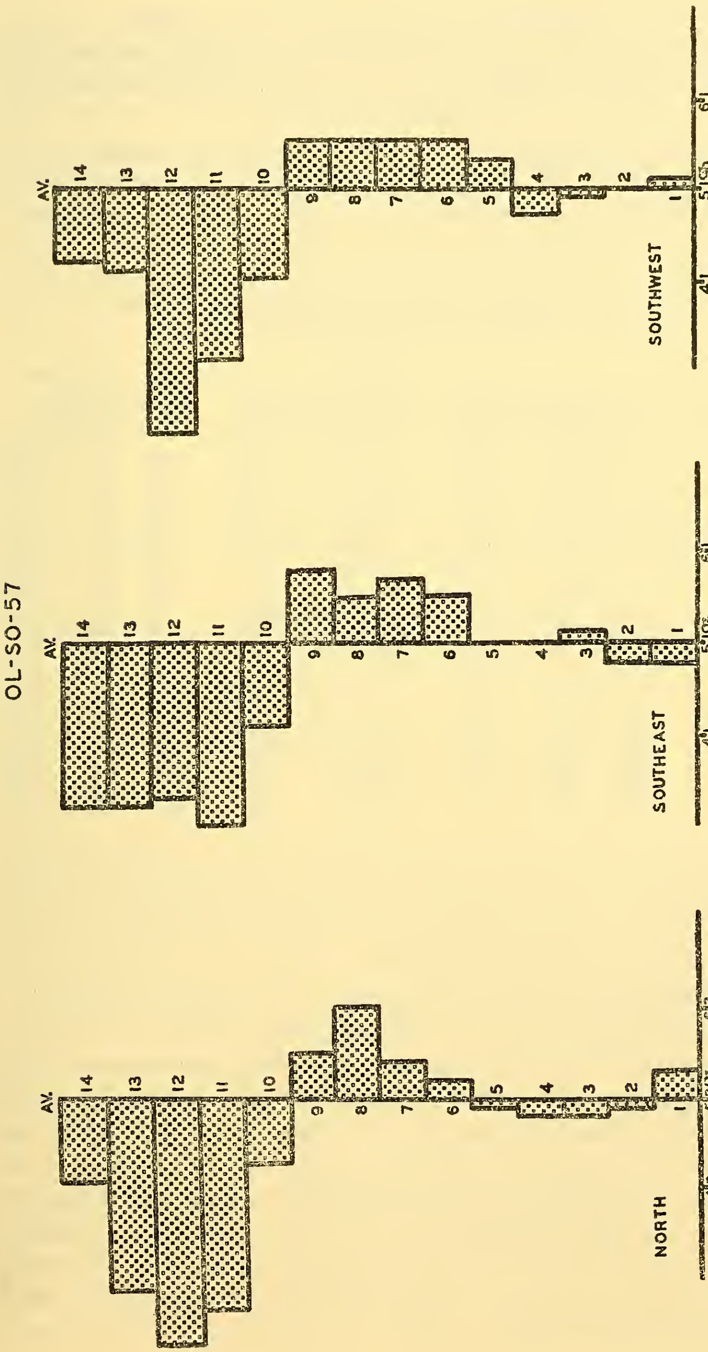


FIG. 28.—Columnar diagrams, three radii of all sections, OL-SO-57, to show average departures from the radius mean. Above the mean to the right and below to the left of the vertical mean line.

average negative departure and thus resembles OL-B-42. In the lower portion of the trunk, T-1 to T-6 on the north radius and T-1 to T-5 on the other two radii, average departures are more nearly normal.

Table 19 gives average departure for each radius on each section. On sections T-2 to T-7, T-9, and T-11, average departure is fairly uniform around the circuit; on T-1, T-8, and T-12 to T-14, the disparity among the radii around the circuit is rather high. Thus, the lower part of the trunk (lower 30 feet), with the exception of T-1, is somewhat more consistent around the circuit as shown by three radii than is the upper part of the trunk.

TABLE 19.—*Circuit uniformity, trunk of OL-SO-57. Average departure, average variation, and average departure from mean variation for each radius of each section*

	Average departure, %			Average variation, %			Average departure from mean variation, %		
Section	N.	SE.	SW.	N.	SE.	SW.	N.	SE.	SW.
T-14	42.3	32.2	43.2	47.5	39.3	53.5	32.4	20.6	27.3
T-13	32.4	32.0	41.8	42.2	35.8	46.3	25.6	21.3	24.5
T-12	26.0	33.1	24.3	39.3	37.9	36.2	20.8	25.8	21.0
T-11	29.5	30.0	31.5	31.6	36.1	37.9	18.6	19.8	26.5
T-10	46.0	41.1	41.2	33.7	39.0	33.4	19.5	21.9	18.6
T-9	58.4	58.1	56.2	37.0	43.5	40.1	23.3	26.7	24.9
T-8	62.9	54.8	56.3	41.6	46.2	44.0	25.2	31.2	26.8
T-7	57.1	57.5	55.6	39.6	43.8	39.2	25.5	29.8	24.6
T-6	54.7	54.8	55.8	43.0	43.6	43.0	28.6	28.3	28.5
T-5	51.9	50.5	54.3	43.3	45.7	47.3	24.2	30.9	31.7
T-4	50.8	50.1	47.6	41.5	43.3	43.8	26.8	28.3	28.0
T-3	51.2	51.4	49.6	43.1	45.2	43.7	27.6	28.6	28.1
T-2	51.8	48.0	50.8	43.2	42.7	44.7	27.1	27.6	29.2
T-1	55.6	48.3	52.5	44.9	47.7	44.1	27.6	29.1	27.2

Average departures for the sections as units are given in table 20, which shows that departures are rather uniform for the lower 25 feet of the trunk, T-1 to T-5, where more decided fluctuations begin (fig. 29 A). In contrast to OL-B-42 (table 12), T-1 has a departure nearly identical to the mean of the tree. From T-5 to T-9 the average varies from 8 to 14 percent more than the tree average. The remainder of the tree, T-10 to T-14, varies from 16 to 46 percent below tree average. Between T-9 and T-10, the drop is sudden, from 12 percent above tree average to 16 percent below. Average departure for the entire tree is 49.9 percent, contrasting with 56.8 percent in OL-B-42.

Average variation.—Sectional variations along three radii are plotted on figure 30 A. The graphs fluctuate about the radius average. On sections T-1, T-3, T-5, T-10, T-11, and T-12 the direction of variation from the radius mean is identical on the three sections. Near identity exists on T-4, T-6 to T-9, and T-13. Variation in opposite directions on one radius in relation to the other two occurs on T-2 and T-14. Thus, OL-SO-57 has much greater uniformity than OL-B-42. From T-8 upward to T-12 on the north and southwest

TABLE 20.—*Circuit uniformity, trunk of OL-SO-57. Sectional averages of departure, variation, departure from mean variation, and trend*

Section	Average departure %	Average variation %	Average departure from mean variation %	Trend disagreements No.	Trend agreements No.	Circuit agreement %	Partial growth layers %
T-14	37.8	44.1	24.6	1	11	92	...
T-13	31.9	40.1	24.0	4	15	79	...
T-12	27.4	35.5	23.5	7	18	72	...
T-11	26.6	34.4	18.9	6	32	84	...
T-10	42.2	34.0	18.7	12	48	80	3.2
T-9	56.2	37.5	23.2	20	74	79	8.4
T-8	57.3	42.6	26.1	20	94	82	9.5
T-7	55.7	40.6	26.5	30	120	80	6.6
T-6	53.5	41.2	27.9	36	139	80	5.6
T-5	51.2	45.1	27.7	34	166	83	5.9
T-4	48.5	41.9	27.1	42	179	81	6.3
T-3	49.7	42.3	27.0	44	192	81	6.7
T-2	48.3	41.1	26.7	55	200	78	6.2
T-1	50.4	42.5	26.1	81	200	71	6.0
Average *	49.9	41.4	26.2			79	

* See note to table 10, page 46.

radii there is a marked decrease in average variation; this decrease holds throughout the southeast radius.

Table 19 gives the average variation for each radius of each section. On the whole, the lower trunk has the greatest uniformity from radius to radius, the differences in percentage variations among the three radii ranging from 0.6 in T-6 to 4.0 in T-5, although maximum variations exist primarily in the lower trunk. From T-7 to T-11 the differences are higher than in the lower trunk, ranging from 4.6 to 6.5. Greatest differences (least uniformity) among the radii exist in T-13 and T-14 where the growth layers are few.

Table 20 gives the average variation for the combined sequences on each section (see also fig. 29 B). Except for T-5, the lower part of the trunk, T-1 to T-8, lies very close to the mean. The upper part of the trunk, T-9 to T-12, is considerably less than the mean. Section T-14 has the second highest average variation. Thus, the lower 28 feet of the trunk have, in general, the highest average differences in consecutive years throughout the section sequences and

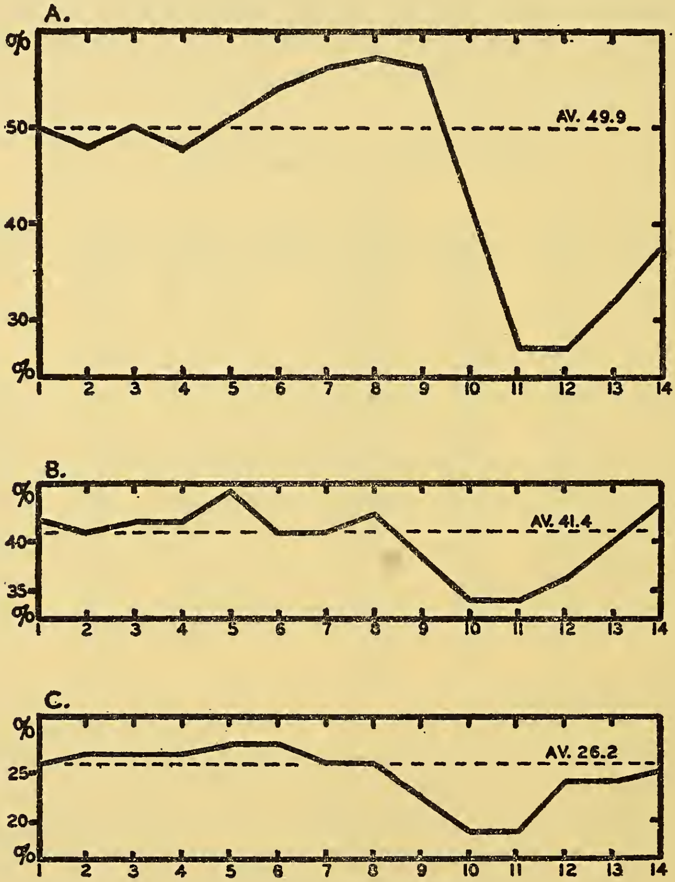


FIG. 29.—Circuit uniformity, OL-SO-57. Graphs of average departure (A), of average variation (B), and of average departure from mean variation (C), for all sections T-1 to T-14.

would, at least, not minimize any effects that environmental factors have on growth.

In tree OL-SO-57, the three radii (fig. 30 A) differ more among themselves than they do in OL-B-42. The southeast radius (44.3 percent) and the southwest radius (43.5 percent) are within 0.8

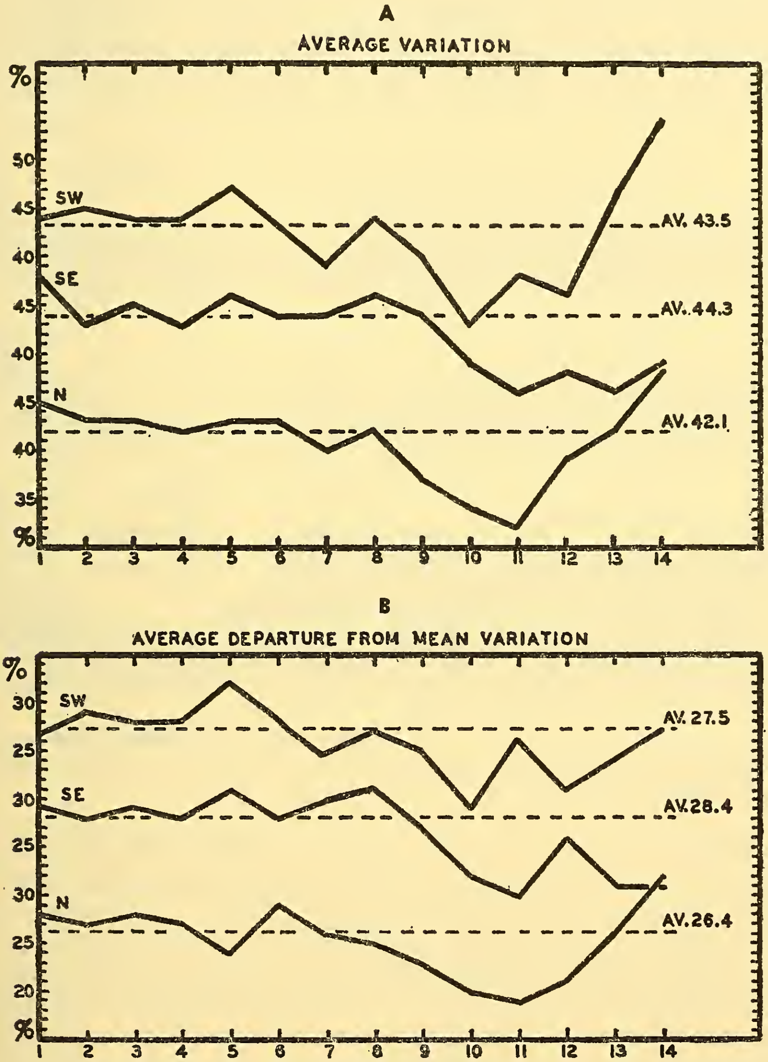


Fig. 30.—Circuit uniformity, OL-SO-57, three radii, all sections T-1 to T-14, Upper series shows average variation and lower shows average departure from mean variation.

percent of each other, whereas the north radius (42.1 percent) is 1.4 percent removed from the southwest radius. The greatest difference, 2.2 percent, exceeds that of OL-B-42, which is 0.8 percent.

Average variation for the trunk as a whole is 41.4 percent, or 8 percent less than that of OL-B-42. The north radii on the two trees have the lowest average variations although they have the greatest average growth-layer thicknesses.

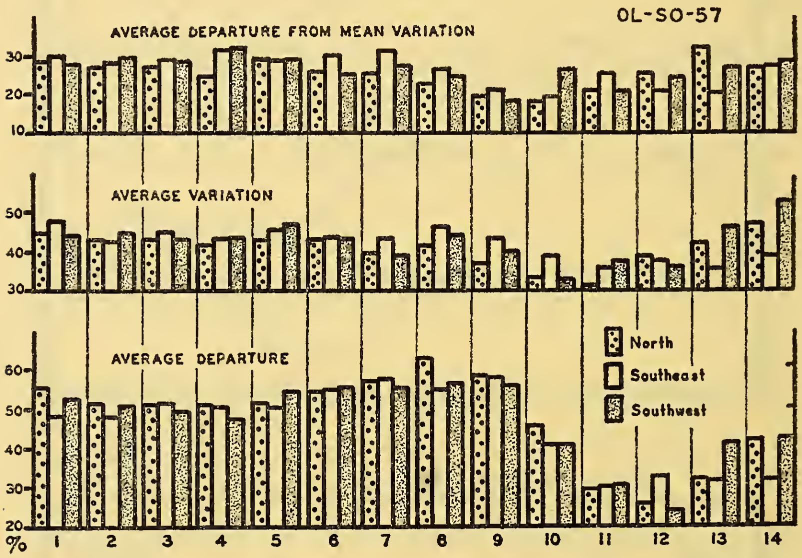


FIG. 31.—Columnar summary of the three parameters average departure, average variation, and average departure from mean variation for three radii of all sections, OL-SO-57.

Average departure from mean variation.—Figure 30 B shows the average departure from mean variation of all sections along three radii in relation to the mean of the entire radius. There seems to be no greater uniformity here than there was in the average variation of OL-SO-57 or OL-B-42. Direction of departure from the mean is identical on T-3 and T-9 to T-12; near identity on T-2, T-4, T-6, T-7, and T-13; and opposite on T-1, T-5, T-8, and T-14. On T-5 and T-14 the north radius is opposed to the other two, on T-1 it is the southwest radius, and on T-8 it is the southeast radius. The basal radii, T-1 to T-4, are much closer to the mean here than they were in OL-B-42.

Table 19 gives the average departure from mean variation for each radius on each section. Greatest uniformity exists near the base of the tree, T-1 to T-4, with a range of 1.0 to 2.1. Greatest differences among the radii lie on T-5, T-7 to T-8, and T-11 to T-14 with a range of 4.3 to 11.8. Sections T-9 and T-10 occupy an intermediate position, whereas the least difference among the three radii comes on T-6. Thus, insofar as departure from mean variation is concerned, the lower trunk for some 12 to 14 feet has the greatest uniformity among the radii.

TABLE 21.—*Summary of circuit uniformity, trunk of OL-SO-57*

Section	Average growth-layer thickness *mm.*	Maximum difference 3 radii *mm.*	Average departure %	Average variation %	Average departure from mean variation %	Circuit agreement %
T-14	0.54	0.12	38	44	25	92
T-13	0.72	0.10	32	40	24	79
T-12	0.90	0.26	27	36	24	72
T-11	0.94	0.32	27	34	19	84
T-10	0.90	0.65	42	34	19	80
T-9	0.91	0.41	56	38	23	79
T-8	0.90	0.54	57	43	26	82
T-7	1.03	0.32	56	41	26	80
T-6	0.92	0.34	54	41	28	80
T-5	0.95	0.44	51	45	28	83
T-4	1.04	0.37	48	42	27	81
T-3	0.99	0.31	50	42	27	81
T-2	0.98	0.39	48	41	27	78
T-1	0.94	0.58	50	42	26	71
Average *	0.957	0.412	49.9	41.4	26.2	79

Average growth-layer thickness for each radius	*mm.*
N.	1.20
SE.	0.851
SW.	0.830

* See note to table 10, page 46.

Average departure from mean variation for each section as a whole is shown in table 20. Sections T-1 to T-8 approximate closely the tree average of 26.2 percent (fig. 29 C). Sections T-9 to T-11 depart rather widely from the tree average by having a smaller variation. In general, the lower trunk has a percentage slightly greater than the tree average.

Among the three radii on figure 30 B, the average for the southwest radius is intermediate between the averages of the other two and thus resembles the situation in OL-B-42 except that average percentages in OL-SO-57 are lower for all three radii.

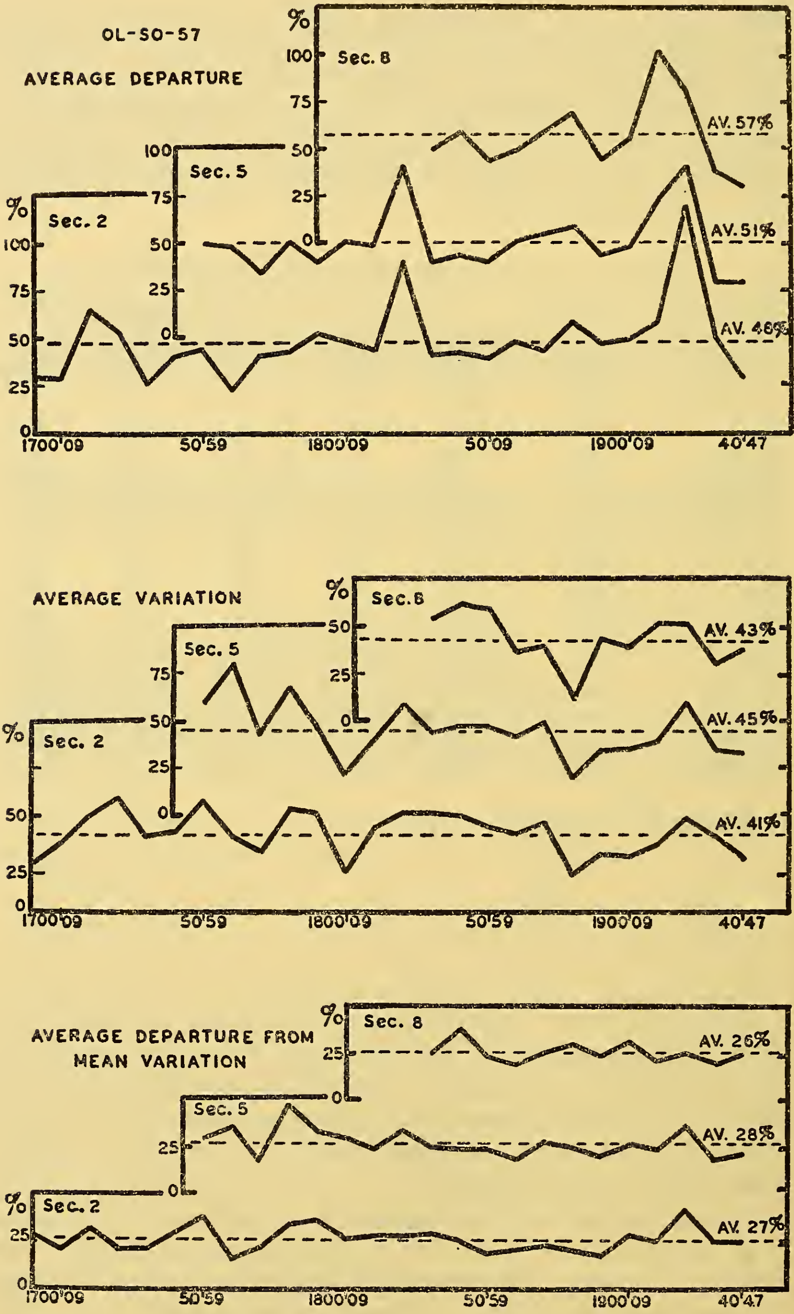


FIG. 32.—Circuit uniformity by decades, OL-SO-57, sections T-2, T-5, and T-8. Graphs of the three parameters average departure, average variation, and average departure from mean variation, in percent.

Average departure from mean variation for the trunk is 26.2 percent (table 20), which contrasts with 29.1 percent for OL-B-42 (table 12).

Summary.—Generalized averages for sections and for the entire tree as represented by 14 sections are given in table 21 where the tree averages allow for the progressively fewer growth layers in the upper sections. Average growth-layer thickness for the tree is

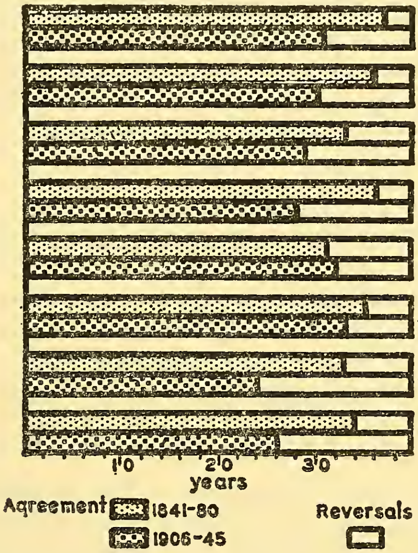


FIG. 33.—Comparison of circuit agreement on eight sections of OL-SO-57 for the time intervals 1841-1880 and 1906-1945.

0.957 mm. and the average maximum difference among the three radii is 0.412 mm. On the average, thickest portions of growth layers around the circuit exist on the north radius (1.20 mm.), portions of intermediate thickness on the southeast radius (0.851 mm.), and those of least thickness on the southwest (0.830 mm.). The average percentage of circuit agreement for all sections together is 79. For the tree as a whole, average departure comes to 49.9 percent, average variation 41.4 percent, and average departure from mean variation 26.2 percent.

These figures perhaps have more significance if they are set opposite their counterparts of OL-B-42 as is done in table 22. In OL-SO-57, thicknesses are greater than in OL-B-42; all other parameters are smaller except in the case of trend, where the difference between the two trees is slight. On the whole, OL-SO-57 has thicker and more uniform growth layers.

Average departure, average variation, and average departure from mean variation are summarized on figure 31. A high degree of consistency exists throughout the trunk, at least as shown by a fair number of cross sections, in average variation and in average departure from mean variation. Only in average departure is there a decided change from bottom to top of trunk. Sections T-10 to T-14 are below average, and T-11 and T-12 are very much so. At about mid-tree, from 22 or 30 feet to 40 feet above ground, average departures exceed the average on both trees, OL-B-42 and OL-SO-57. Consistency in average departure is as well marked in the lower portion of the trunks, T-1 to T-6 in the two trees, as were the other two parameters.

TABLE 22.—*Summary comparison between trunks of OL-B-42 and OL-SO-57*

	OL-B-42	OL-SO-57
Average growth-layer thickness, mm	0.88	0.957
Maximum difference among 3 radii, mm	0.296	0.412
Average departure, %	56.8	49.9
Average variation, %	45.5	41.4
Average departure from mean variation, %	29.1	26.2
Circuit agreement, %	80	79

A different treatment of these parameters is shown on figure 32 where three sections, T-2, T-5, and T-8, are plotted by decades. A plainly visible increase occurred in average departure and average variation in the decade beginning in 1820 and another one 100 years later. The same fluctuation occurs in a much more subdued form in average departure from mean variation.

Figure 33 was constructed, as was figure 22, to determine any possible change in uniformity between the two time intervals 1841-1880 and 1906-1945, similar to the contrasts found in New Mexico which suggested changes in the rainfall regime (Leopold, 1951; Glock, 1950). Uniformity was distinctly less during the interval 1906-1945 in OL-B-42 and OL-SO-57, suggesting a change of some growth factor in the opposite direction to that found by Leopold and by Glock in New Mexico.

TREE OL-S-62

Absolute thickness.—Growth-layer thicknesses for the several radii of sections T-2, T-6, and T-9 have been plotted on figures 34, 35, and 36. The graphs indicate gross similarity not only among the radii of a section but also among the sections, although in the latter case the differences are greater. Uniformity of crests and troughs leaves much to be desired; for instance, 1944, 1935, 1933, 1932, 1931, 1930, 1925, 1922, 1919, and many others.

Growth-layer thicknesses show the same lack of uniformity around the circuit as in OL-B-42 and OL-SO-57. On T-1 it is unusual to have the radii vary by as much as a factor of 2; in extreme cases by a factor of 8. Above T-1 and up to T-5, variations in thickness around the circuit are not nearly as great as in T-1; in T-6 there is a slight increase, which continues upward.

The north radius as a unit is longer than the other radii. That does not mean, however, that all growth layers have their thickest portions on the north radius. Table 14 shows that, on T-2 of OL-S-62, 136 cases out of 251 do not fall on the north radius; of these 136, 41 occur on the southwest radius. More than half the growth layers do not have their thickest portions on the north radius. On T-6, 50 cases out of 190 do not fall on the north radius; of these 50, 30 occur on the southwest radius. More than half of the growth layers, 73.7 percent, do fall on the north radius. On T-9, 127 cases out of 134 do not fall on the north radius; of these 127, 20 occur on the southwest radius. A great majority, 79.8 percent, fall on the southeast radius.

In OL-S-62, 54.4 percent of the total cases of growth layers on all the radii do not have their thickest portions on the north radius, a figure decidedly higher than for either OL-B-42, 36 percent, or OL-SO-57, 20 percent. Even so, the thickest portions of growth layers are primarily on the north radius, secondarily on the southeast, and least on the southwest, thus agreeing with OL-SO-57 but not with OL-B-42. Section T-9 favors the southeast radius to a high degree. Tree OL-S-62 does not possess the uniformity in distribution of the thickest portions of its growth layers as do the other two trees.

The measurement of five radii on T-1, T-5, and T-9 of OL-S-62 gives an opportunity for an examination of the thicknesses of the growth layers for 1830-1879 to determine whether a growth layer increases and decreases once around the circuit or whether it fluctuates about a mean. The incidence of such fluctuation about a mean has these ratios in respect to the 50 growth layers: For T-1, 1.92; for T-5, 1.92; and for T-9, 2.63. Obviously this fluctuation about a mean around the circuit is much more typical of OL-S-62 than it is of OL-B-42. Here, fluctuation about a mean dominates both at basal

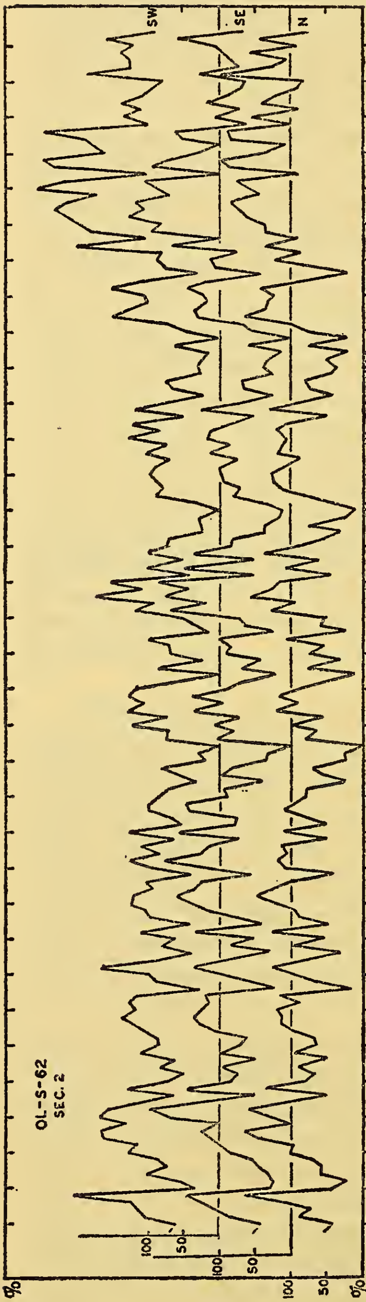


FIG. 34.—Graphs of growth-layer thicknesses, 1780-1947, along three radii of section T-2, about 5½ feet above ground level, OL-S-62.

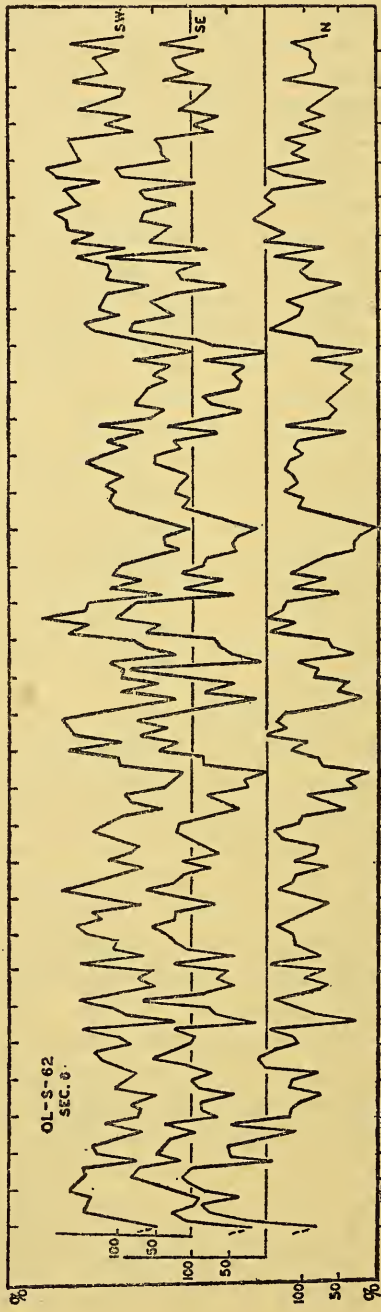


FIG. 35.—Graphs of growth-layer thicknesses, 1785-1947, along three radii of section T-6, about 25 feet above ground level, OL-S-62.

trunk and at mid-trunk. At the top of the tree there is a strong tendency toward a single direction of enlargement.

Relative thickness and trend.—The meaning of these terms and their use have been explained in the discussion of tree OL-B-42.

For the interval 1802-1947, trends were counted on the three radii of sections T-2, T-6, and T-9 and comparisons made between radii as shown in table 23. This table gives the number and percentage of cases out of 146 in T-2 and T-6 and out of 143 in T-9 where the trend on the two radii being compared is opposite in direction. The lowest line gives simultaneous comparison of the three radii. On T-2 and T-6 the greatest number of reversed trends occurs where the north radius is contrasted with the southwest; on T-9, the greatest number occurs where the southeast is contrasted with the southwest. Tree OL-S-62 resembles OL-SO-57 in having the greatest number of opposed trends near or at the base of the trunk. In general, OL-S-62 has somewhat more disparity among the pairs of radii than does OL-SO-57. It is clear, first, that considerable differences in trend occur around the trunk and, second, that these differences fluctuate from one portion of a trunk to another and from tree to tree. Figures 34, 35, and 36 give the year-to-year details of agreement among the radii of three sections.

Table 23.—*Circuit uniformity, trunk of OL-S-62. Number and percentage of opposed trends between different pairs of radii and among all three radii of sections T-2, T-6, and T-9*

Radii	T-2 (146 cases) No.	T-2 (146 cases) %	T-6 (146 cases) No.	T-6 (146 cases) %	T-9 (143 cases) No.	T-9 (143 cases) %
N. vs. SE.	25	17	22	15	20	14
SE. vs. SW.	25	17	24	16	21	15
N. vs. SW.	27	18	25	17	17	12
All 3 radii	37	25	36	25	29	20

As in the case of OL-B-42, section T-1 of OL-S-62 was analyzed for trend by contrasting each of the five radii with the other four for the years 1802-1947. Numbers of opposed trends out of 146 are as follows:

N.-SE.	29	SE.-WNW.	29
N.-SW.	25	SW.-ENE.	21
N.-ENE.	30	SW.-WNW.	19
N.-WNW.	28	ENE.-WNW.	20
SE.-SW.	27	N.-SE.-SW.	40
SE.-ENE.	28	All five	51

There are some 17 percent more reversals in T-1 of OL-S-62 than in the same section of OL-B-42.

All five radii considered simultaneously give 51 opposed trends out of 146, whereas the three radii, N., SE., and SW., taken together give 40 opposed trends out of 146. The addition of two radii reveals 11 more opposed trends or some 27 percent more. Figure 14 B illustrates the number of opposed trends among three radii contrasted with those among five. Disagreements are not uniformly distributed from decade to decade, and these disagreements do not harmonize with those in OL-B-42. On T-1 the interval from 1830 to 1879 has 10 percent opposed trends; in contrast, the interval from 1880 to 1929 averages 42 percent opposed trends for three radii.

TABLE 24.—*Circuit uniformity, trunk of OL-S-62. Percent of opposed trends or disagreements, comparing three and five radii*

	T-1 (1680-1947)	T-5 (1740-1947)	T-9 (1820-1947)
3 radii	25	24	21
5 radii	35	33	30

Table 24 summarizes the information on figure 14 B. The greatest number of trend disagreements occurs at the base of the trunk in T-1, the least near the top in T-9. This is in marked contrast with OL-B-42. In all three sections, the five radii show a much higher percentage of opposed trends.

On figure 37 each shaded column indicates a trend reversal somewhere on the circuit of the particular section for a certain year. No definite pattern attracts the eye either for agreement or disagreement. Single sections contain a few rather long intervals of agreement around the circuit, those of 10 or more years being:

T-1	1720-1743
	1813-1825
	1828-1838
	1862-1878
T-2	1729-1740
	1746-1756
	1758-1767
	1813-1825
	1850-1860
	1932-1942
T-3	1716-1725
	1733-1750
	1752-1767
	1812-1827
	1850-1864
	1866-1877
T-4	1813-1824
	1827-1836
	1850-1882
T-5	1778-1787
	1812-1824
	1838-1848
T-6	1812-1823
	1864-1877
	1933-1942
T-7	1892-1909
T-8	1812-1823
	1829-1848
	1855-1875
	1902-1914
T-9	1899-1909
	1934-1943
T-10	1839-1849
	1852-1864
	1933-1942
T-11	1868-1885

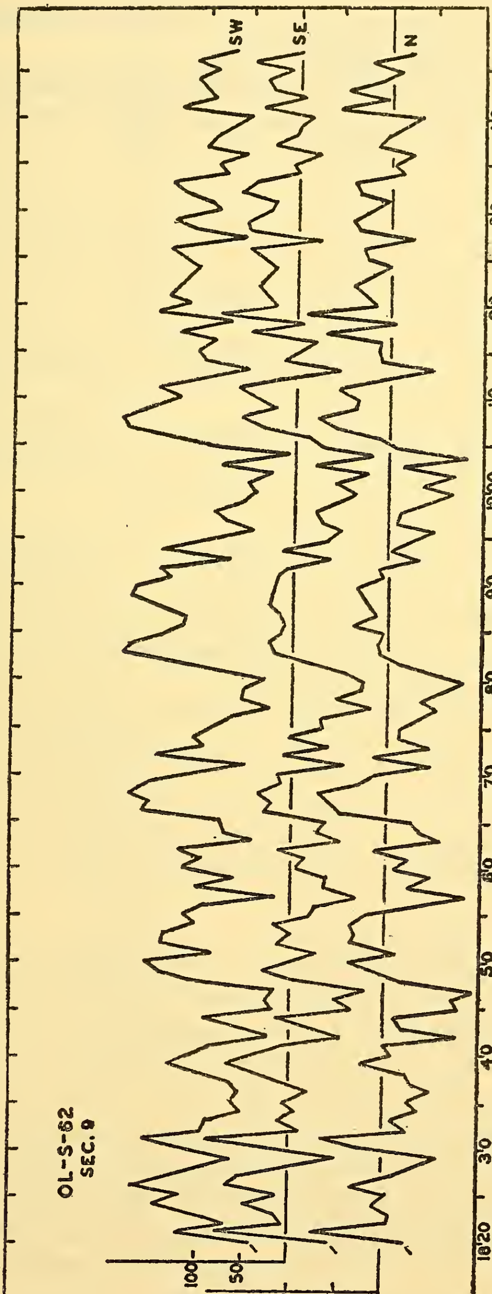


FIG. 36.—Graphs of growth-layer thicknesses, 1820-1947, along three radii of section T-9, about 37½ feet above ground level, OL-S-62.

The total number of years on T-1 to T-11 where no trend reversal occurs is 513; on OL-SO-57 it is 441.

When more than one section is considered, agreements are not so common or so prolonged. Those with five or more years in agreement are:

T-1 – T-3....1721-1725
T-1 – T-2....1720-1727
1729-1740
T-1 – T-3....1733-1740
T-1 – T-4....1735-1740
T-3 – T-4....1745-1749
T-3 – T-5....1752-1757
T-2 – T-5....1752-1756
T-1 – T-4....1760-1766
T-2 – T-3....1758-1767
T-4 – T-5....1772-1776
1778-1785
T-1 – T-8....1813-1819

T-5 – T-6....1812-1823
T-1 – T-3....1813-1825
T-8 – T-9....1817-1822
1834-1840
T-4 – T-8....1838-1845
T-2 – T-4....1850-1860
T-5 – T-6....1854-1860
T-1 – T-8....1855-1860
T-3 – T-4....1850-1864
T-8 – T-10...1860-1864
T-7 – T-8....1862-1866
T-6 – T-7....1868-1875
T-1 – T-8....1871-1875

T-6 – T-8....1868-1875
T-3 – T-4....1866-1877
T-10 – T-11..1877-1883
T-1 –T-12...1893-1897
T-1 – T-5....1893-1899
T-1 – T-11...1902-1907
T-7 – T-10...1902-1909
T-8 – T-10...1907-1912
T-8 – T-9....1924-1928
T-1 – T-10...1934-1938
T-9 – T-10...1934-1942
T-2 – T-4....1934-1942

Consistency of trend among two or more sections for prolonged intervals prevails in OL-S-62 to a much greater extent than in OL-SO-57. If sections T-1 to T-7 are taken as a unit, consistency of trend prevails for 52 percent of the time—78 years out of 150, 1798-1947. It was 46 percent for OL-SO-57. When T-8 is added to the seven sections, the percentage of uniform trend does not change; with T-9 the percentage drops to 48 for 1815-1947; with T-10 the percentage is 46 for 1839-1947; with T-11 it is 42 for 1866-1947; with T-12 it drops to 38; and with T-13 it drops to 31 percent for 1899-1947. Such decreases are to be expected.

Consistency of opposed trends around the circuit is not so prevalent as uniformity of trend.

Years with opposed trends on three consecutive sections:

1789	1839	1887	1921
1792	1846	1892	1931
1802	1854	1900	1933
1809	1861	1901	
1811	1879	1908	

Years with opposed trends on four consecutive sections:

1786	1828	1915	1938
1806	1876	1926	1943
1811	1879	1929	1944
	1886	1931	

Years with opposed trends on five consecutive sections:

1788	1825	1915	1923

Years with opposed trends on six consecutive sections:

1777	1837	1889
1796	1849	

Years with opposed trends on seven consecutive sections: 1891 and 1911.

TABLE 25.—*Circuit uniformity, trunk of OL-S-62. Number and percentage of opposed trends for all sections*

Section	Time interval	Number of years	Number of years of trend reversals	Percent reversal
T-14	1925-1947	23	6	26
T-13	1899-1947	49	17	35
T-12	1883-1947	65	15	23
T-11	1866-1947	82	17	21
T-10	1839-1947	109	21	19
T-9	1815-1947	133	29	22
T-8	1796-1947	152	25	16
T-7	1788-1947	160	36	22
T-6	1761-1947	187	50	27
T-5	1751-1947	197	46	23
T-4	1731-1947	217	35	16
T-3	1713-1947	235	42	18
T-2	1700-1947	248	53	21
T-1	1700-1947	248	63	25

The year 1891 has 10 consecutive sections, T-1 to T-10, with opposed trends somewhere on their circuits. Little consistency exists in the location of the reversals and, quantitatively, there is little to choose between OL-SO-57 and OL-S-62. Reversals seldom extend along the trunk for more than four sections.

Table 25 summarizes the trend reversals on figure 37. Again, as in OL-B-42 and OL-SO-57, opposed trends are more prevalent near the top of the trunk; elsewhere several sections are not consistently high or low in percentage of reversals.

The average reversal per section, 22.1 percent, is somewhat higher in OL-S-62 than in OL-SO-57, 20.4 percent. Thus, circuit uniformity approximates 78 percent, which is less than that of OL-SO-57. Sections T-9 to T-13 of OL-S-62 have circuit uniformity of 76.2 percent, which compares with 78.8 percent for OL-SO-57 and 69.8 percent for OL-B-42. It is clear that the tree nearest the lower forest border possesses the lowest degree of trend uniformity.

Percentages of trend agreement based on longer sequences than those given in table 25 are set out in table 29. The maximum difference of a section from the tree mean is 13 percent, identical with that of OL-SO-57 and much less than that of OL-B-42 (19 percent). Average difference of each section from the tree mean is 3.5 percent, which is nearly identical with OL-SO-57, 3.4 percent, but contrasts with OL-B-42, 5.2 percent. In this respect, trees OL-SO-57 and OL-S-62 resemble each other.

Figure 37 permits the identification of opposed trends localized on one section out of six or more starting with 1761. A reversal is restricted to one section on the following dates:

Out of 6 sections	1762	T-5	1779	T-1
	1764	T-6	1780	T-1
	1766	T-6	1783	T-6
	1769	T-6	1784	T-1
	1770	T-6	1785	T-1
	1775	T-1		
Out of 7 sections	None			
Out of 8 sections	1803	T-1		
Out of 9 sections	1815	T-9	1823	T-9
	1816	T-9	1827	T-1
	1820	T-7		
Out of 10 sections	1844	T-2	1859	T-9
	1851	T-10	1862	T-6
	1855	T-9	1863	T-6
Out of 11 sections	1874	T-10	1881	T-7
	1880	T-6		
Out of 12 sections	None			
Out of 13 sections	1899	T-13	1914	T-13
	1907	T-12	1917	T-13
	1912	T-12		
Out of 14 sections	1930	T-13		
	1936	T-11		
Out of 15 sections	1940	T-1	1947	T-15
	1946	T-14		

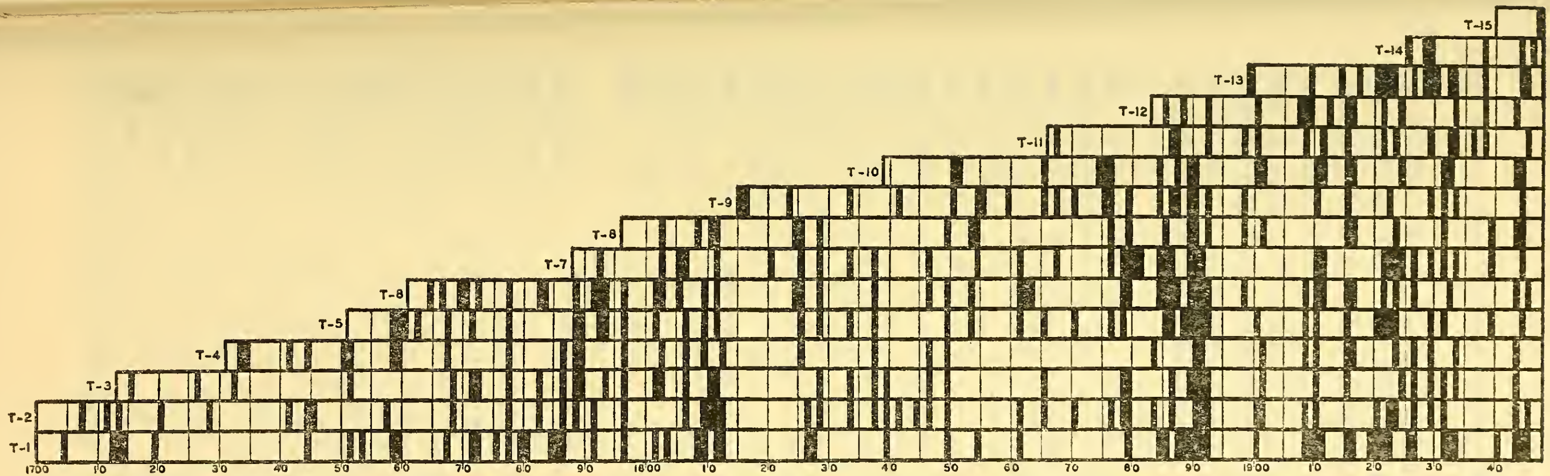


FIG. 37.—Lack of circuit uniformity around each section, OL-S-62. A shaded rectangle indicates a trend disagreement, or reversal, in relative thicknesses between growth layers somewhere on the circuit, as represented by measured radii, of the particular section.

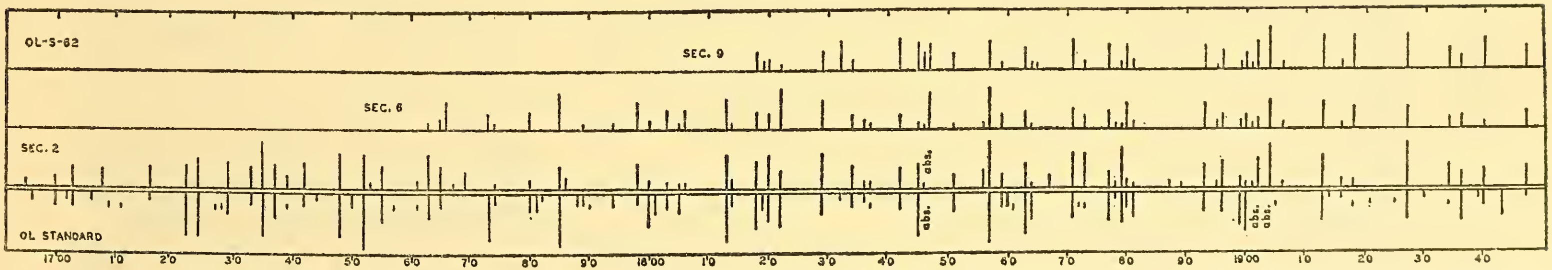


FIG. 38.—Skeleton plots of sections T-2, T-6, and T-9 of OL-S-62 compared to the "Standard," a synthesis of the plots of other trees in the same area. Inked lines occur on the years whose growth layers are strikingly thin; the longer the line the thinner the growth layer.

The incidence of an opposed trend localized on one section appears to be more common than in OL-SO-57. If so, this increases the possibility of including such reversal on a restricted sample of the trunk.

Skeleton plots of T-2, T-6, and T-9 of OL-S-62 are compared with the Standard plot on figure 38. Crossdating among the sections and with the Standard seems to be better than among the other two trees. At least on the three sections plotted, so-called absence of a growth layer is nearly nonexistent.

Diagnostic growth layers in the last several decades are not so consistently set apart from their adjacent growth layers as were earlier growth layers. The growth layer dated 1943, which in OL-B-42 and on the Standard plot is thinner than 1942, has many reversals of this relationship on entire sections of OL-S-62: T-5, T-7, T-8, T-9, and T-14, and nearly the entire sections of T-2, T-4, T-6, T-10, T-11, and T-12; 1943 is thicker than 1944 at many places. The growth layer for 1936 becomes thicker than 1935 on the entire sections of T-12, T-13, and T-14 and on the north and southwest radii of T-11; 1927 reverses its relationship with 1928 on the southeast radius of T-13 and the southeast and southwest radii of T-14. The highly diagnostic growth layers (1913, 1904, 1902, 1863-1864, 1857, 1851, and 1847) maintain their relationships as very thin growth layers except for 1864, which is thicker than 1865 on one or two radii of T-3, T-5, T-9, and T-10; except for 1851, which is thicker than 1850 on the southwest radius of T-10; and except for 1913, which is thicker than 1914 on the southeast radius of T-13.

Trend reversals are not uncommon among the less diagnostic growth layers. The growth layer for 1900, commonly thinner than that for 1901, is thicker than 1901 on one or more radii of T-2, T-3, T-4, T-8, T-9, and T-10; 1893 remains thinner than 1892; 1868 is thinner than 1867 around the circuit of T-11; 1845 is thicker than 1846 on one, more commonly two, radii of T-1 to T-7; 1842 is uniformly thinner than 1843; 1818 is thicker than 1819 around the circuit of T-9; and 1806 is thinner than 1805 save for one or two radii of T-1 to T-5 and T-7. Here as in OL-SO-57 most reversals occur among the less diagnostic and thicker growth layers.

Table 26 sets forth change in relative thicknesses among the various sections of OL-S-62 where no reversal is involved. In the table, the thinner the central growth layer is in relation to its adjacent growth layers, the higher the ratio. No consistent pattern emerges from the data because there is no consistent portion of the trunk where the diagnostic quality is greater than elsewhere. For 1940, the ratio is greater in the upper sections; for 1936, the ratio is less at the top; for 1927, it is greater at the base; for 1913, it is greater at the base; for 1904, it is greater in the lower 15 feet of the trunk; and for 1896, 1871, and 1851, no one portion of the trunk shows a decided increase or decrease.

Summary.—Analysis of the sections of OL-S-62 reveals little information differing from OL-SO-57. Perhaps it is fair to say that consistency within a tree, as shown by trend and crossdating studies, matches that of the merged general records of several trees from the immediate vicinity. Inconsistencies are present in all parts of the trunk. Crossdating from one portion of the trunk to another is no more striking than the crossdating of one section with the master chart. In fact, variations within a tree can be as great as, or even greater than, those from tree to tree.

TABLE 26.—*Relative thicknesses of certain growth layers, trunk of OL-S-62. Ratio of thicknesses of certain thin growth layers to the mean of the sum of the two adjacent growth layers*

Section	1940 *	1936	1927	1913	1904	1896	1871	1851
T-14	3.1	1.2	1.1	...	...	...	...	...
T-13	3.0	1.2	1.7	1.6	2.3	...	...	...
T-12	2.0	1.3	1.8	2.4	5.1	1.8	...	...
T-11	2.0	1.3	1.7	1.7	5.0	2.3	3.0	...
T-10	1.9	1.6	1.9	2.0	8.8	2.0	2.8	1.3
T-9	1.6	1.4	1.3	1.9	5.2	1.5	2.4	1.6
T-8	1.8	1.4	1.7	1.9	6.2	1.5	2.4	1.4
T-7	1.6	1.6	1.3	2.0	8.3	1.8	2.8	1.6
T-6	1.5	1.6	1.7	1.9	8.9	1.5	2.6	1.4
T-5	1.8	1.6	1.8	2.1	7.1	1.6	2.5	1.4
T-4	1.8	1.5	2.0	2.3	15.8	1.8	2.8	1.5
T-3	1.8	1.5	1.9	2.2	10.8	1.8	2.8	1.5
T-2	1.6	1.4	2.0	2.9	7.8	2.2	2.8	1.7
T-1	1.6	1.5	2.0	2.0	3.4	1.6	2.7	1.5

* 1940 used here in place of 1943 because in most instances 1943 was not a thin growth layer; in fact, many times it is larger than 1942 or 1944.

Growth-layer thicknesses.—Table 27 gives detailed information on growth-layer thicknesses. For the entire trunk as represented by 15 sections the average growth-layer thickness is 0.997 mm., which compares with 0.957 mm. for OL-SO-57 and 0.88 mm. for OL-B-42.

The north radius contains the thickest sequences on all sections except T-1, T-3, T-4, T-5, T-9, T-13, and T-15; the southeast radius contains the thickest sequences on T-1, T-3, T-4, T-9, T-13, and T-15, and contains the second thickest on T-2, T-5, T-6, T-8, T-10, T-11, and T-12; the southwest radius contains the thickest on T-5, and is second on T-4, T-6, T-7, T-9, T-13, and T-14. Here, as on OL-SO-57, the sequences on the southwest are the thinnest, 0.93 mm. The north radii on all sections average a little below 1.03 mm. and the southeast slightly more than 1.03 mm. Sections from T-5 to T-10 have the greatest average growth-layer thickness per section.

Average difference among the average thicknesses of the sections is 0.195 mm. (0.412 mm. for OL-SO-57 and 0.296 mm. for OL-B-

TABLE 27.—*Average growth-layer thicknesses, mm., for the three radii of each section and for each section, trunk of OL-S-62*

Section	Average growth-layer width for each radius, mm.			Average growth-layer width, each section	Maximum difference 3 radii
	N.	SE.	SW.	*mm.*	*mm.*
T-15	0.72	0.76	0.74	0.74	0.04
T-14	0.51	0.45	0.48	0.48	0.06
T-13	0.55	0.79	0.57	0.64	0.24
T-12	0.92	0.84	0.81	0.86	0.11
T-11	0.98	0.88	0.85	0.90	0.13
T-10	1.23	1.03	0.85	1.04	0.38
T-9	0.97	1.33	1.02	1.11	0.36
T-8	1.24	1.10	1.08	1.14	0.16
T-7	1.10	1.06	1.08	1.08	0.04
T-6	1.24	0.93	0.93	1.03	0.31
T-5	1.01	1.13	1.18	1.11	0.17
T-4	0.90	1.13	0.94	0.99	0.23
T-3	1.01	1.02	0.89	0.97	0.13
T-2	1.00	0.94	0.89	0.94	0.11
T-1	1.01	1.04	0.79	0.95	0.25
Average *	1.03	1.03	0.93	0.997	0.195

* See note to table 10, page 46.

42). Maximum difference among the radii of any one section comes on T-10 with 0.38 mm. This compares with 0.65 mm. on T-10 of OL-SO-57. Minimum difference is 0.04 mm. on T-7. Greatest differences are not localized in any part of the trunk. In general, however, greatest differences are at mid-trunk. Averages in the lower seven sections range from 0.04 to 0.31 mm. and in the next seven upward from 0.06 to 0.38 mm. The trunk of OL-S-62, in comparison with OL-SO-57, has thicker growth layers and less differences in average thicknesses among the radii.

Average departure.—Figure 39 gives the average departures of the various sections along three radii from the mean of the entire radius. The three radii here contrast strongly with figure 17 for OL-B-42 and figure 28 for OL-SO-57. Highest average positive

Fig. 39.—Columnar diagrams, three radii of all sections, OL-S-62, to show average departures from the radius mean. Above the mean to the right and below to the left of the vertical mean line.

departures occur in T-14 and T-15 on the north radius, in T-13 to T-15 on the southeast radius, and in T-14 on the southwest radius.

Positive departures characterize the lower portions of the trunk, which is not true at all for OL-SO-57 and only partially so for OL-B-42. Sections T-1, T-2, T-4, T-14, and T-15 have positive departures on all three radii; sections T-7 to T-12 have negative departures on all three radii; and sections T-3, T-5, T-6, and T-13 have mixed departures on the three radii. If we disregard the two upper sections, the greatest departures are at mid-trunk.

Table 28.—*Circuit uniformity, trunk of OL-S-62. Average departure, average variation and average departure from mean variation for each radius of each section*

Section	Average departure, %			Average variation, %			Average departure from mean variation, %		
	N.	SE.	SW.	N.	SE.	SW.	N.	SE.	SW.
T-15	47.8	50.7	40.1	52.8	60.2	44.0	27.0	33.0	17.8
T-14	39.7	42.0	59.0	45.4	44.4	59.0	34.3	22.9	37.2
T-13	34.0	43.9	35.9	42.0	43.9	38.8	27.8	30.7	27.8
T-12	33.9	36.3	35.4	33.3	38.2	35.1	22.4	23.0	23.8
T-11	33.0	35.6	36.1	33.6	33.0	34.8	21.2	21.8	21.5
T-10	29.9	35.8	34.7	30.7	35.2	35.4	18.7	21.4	21.1
T-9	32.4	30.6	34.3	30.9	30.7	33.3	19.5	18.9	21.0
T-8	33.0	31.5	31.2	33.9	34.4	33.0	21.9	21.5	19.6
T-7	35.0	32.0	37.3	33.1	33.2	34.8	20.1	19.3	21.7
T-6	38.3	39.0	37.1	31.0	35.3	32.1	19.6	22.2	20.2
T-5	37.8	37.0	39.8	35.8	33.5	33.5	22.1	20.1	20.8
T-4	37.7	43.0	41.5	41.0	38.1	39.3	23.0	25.1	23.1
T-3	35.5	36.9	39.4	39.4	40.9	39.9	21.7	23.3	23.8
T-2	38.7	39.8	41.3	36.3	40.6	39.0	20.8	24.8	24.1
T-1	38.3	42.8	43.3	38.9	38.2	40.3	22.3	24.7	23.3

Table 28 gives the average departure for each radius on each section. On sections T-2 to T-3, T-5 to T-6, T-8 to T-9, and T-11 to T-12 average departures are fairly uniform around the circuits; on T-1, T-4, T-7, T-10, and T-13 to T-15 the disparity around the circuit among the radii is rather high. Low differences in average departure among the three radii are much more prevalent than high differences. In fact, it appears that every third section beginning with T-1 has high differences among the three radii. With the exception of the upper three sections, departure from section to section does not seem quite so consistent as in OL-SO-57.

Average departures for the sections as units are given in table 29. Sections T-1 to T-6 are uniformly higher than the mean, and sections T-7 to T-12 are much lower than the mean (fig. 40 A). Here, as in OL-SO-57 (table 20), T-1 has an average almost identical with that of the trunk as a whole. From T-2 to T-6, the average varies from 0.2 to 1.2 percent above the trunk average. From T-7 to T-12 the average varies from 1.8 to 4.8 percent below trunk average. Section T-13 has the same departure, 36 percent, as that of T-1. The upper sections, T-14 and T-15, depart 9 to 10 percent from the trunk average.

Table 29.—*Circuit uniformity, trunk of OL-S-62. Sectional averages of departure, variation, departure from mean variation, and trend*

Section	Average departure %	Average variation %	Average departure from mean variation %	Trend disagreements No.	Trend agreements No.	Circuit agreement %	Partial growth layers %
T-15	46.3	51.1	25.4	1	7	88	...
T-14	45.0	46.3	30.8	6	17	74	12.5
T-13	36.1	39.8	26.7	17	32	65	0.0
T-12	34.2	34.0	21.9	15	50	77	1.5
T-11	33.9	33.0	20.4	17	65	79	1.2
T-10	32.2	33.7	19.7	21	88	81	1.8
T-9	31.2	30.5	18.2	29	104	78	2.2
T-8	30.8	33.1	20.5	25	127	84	1.9
T-7	33.5	32.5	20.2	36	124	78	4.3
T-6	37.1	31.3	19.4	50	137	73	4.2
T-5	37.3	33.4	20.3	46	151	77	4.0
T-4	37.9	38.1	22.4	35	182	84	5.0
T-3	36.8	38.4	22.3	42	193	82	3.8
T-2	38.7	36.8	22.0	57	195	77	5.1
T-1	35.6	37.3	21.4	68	205	75	3.6
Average *	35.8	35.1	20.9			78	

* See note to table 10, page 46.

For the entire trunk as a unit the average departure is 35.8 percent, which contrasts with 49.9 percent for OL-SO-57 and 56.8 for OL-B-42.

Average variation.—Sectional variations along three radii are plotted on figure 41 A. The graphs fluctuate rather uniformly and to a higher degree than do those in OL-SO-57. On sections T-1, T-3, T-4, T-6 to T-11, and T-13 to T-15, the direction of variation from the radius mean is identical on the three radii; that is, all sections enumerated were either uniformly above or below the mean. On section T-12 the direction of variation on one radius is opposite to that on the other two. Near identity exists on T-2 and T-5. Thus, tree OL-S-62 has considerably greater uniformity than OL-SO-57 in the amount of variation with respect to the radius mean.

Average variation for each radius of each section on OL-S-62 is set forth in table 28. In general, the lower nine sections possess fairly high uniformity from radius to radius—small percentage dif-

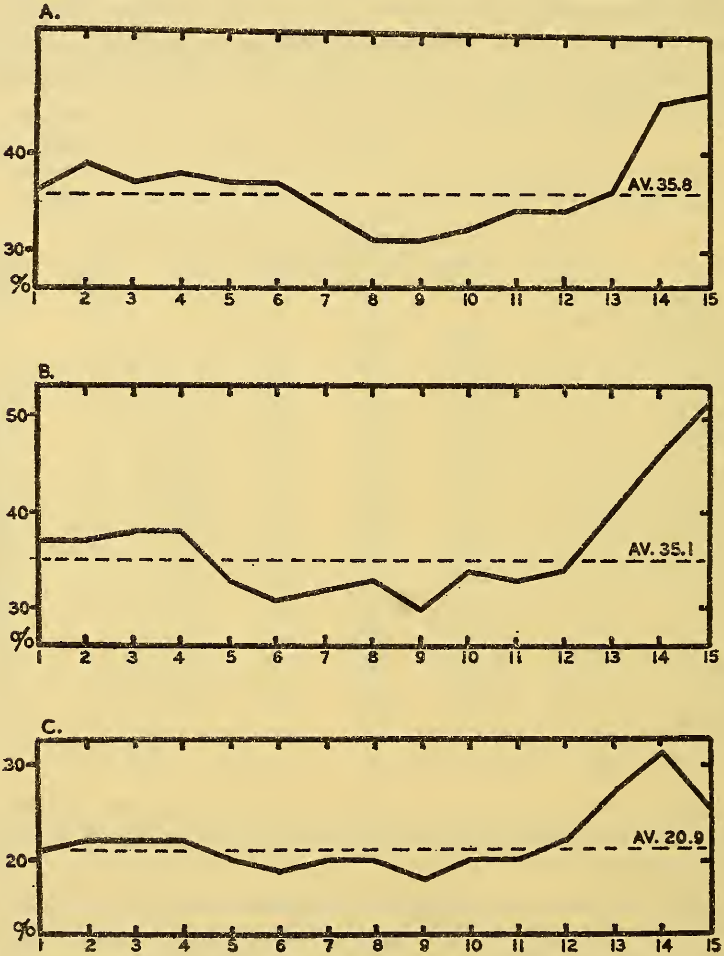


FIG. 40.—Circuit uniformity, OL-S-62. Graphs of average departure (A), of average variation (B), and of average departure from mean variation (C), for all sections T-1 to T-15.

ferences prevail. On T-1, T-3 to T-5, T-7 to T-9, and T-11 the range in percentage among the three radii is from 1.4 to 2.9. Sections T-2, T-6, and T-10 have high percentage differences—4.3 to 4.7 percent. The upper four sections, T-12 to T-15, range from 4.9 to 16.2

percent, these being maxima for the trunk. Of course, the four upper sections contain very few growth layers. Otherwise, the trunk possesses uniformity of variation noticeably greater than that of OL-SO-57. Section for section, OL-S-62 has not only more uniformity but also lower average variation than OL-SO-57.

Table 29 gives the average variation for the combined sequences on each section of OL-S-62 (see fig. 40 B). In OL-S-62 there is not the consistency from section to section as in OL-SO-57; the range is far greater. The first four sections have values greater than the average for the tree. Sections T-5 to T-12 have values less than the average, whereas T-13 to T-15 have much greater values. Except for the upper three sections, no part of the trunk exhibits a distinct advantage over any other part. Tree OL-S-62 resembles OL-SO-57 in that the highest average differences are found in the lower (about 16 to 18 feet) portion of the trunk.

In tree OL-S-62 the three radii, as plotted on figure 41 A, differ less among themselves than do the three radii of OL-SO-57. The southwest and southeast radii have nearly identical means; the north radius has a mean of 35.6 percent. The greatest difference among the radii is 1.3 percent, which compares with 0.8 percent for OL-B-42 and 2.2 for OL-SO-57. Although the average variation on each radius of all three trees is high, the three radii of each tree resemble each other rather closely in the separate trees.

Average variation for the trunk as a whole (combined sections) is 35.1 percent, which contrasts with 41.4 percent for OL-SO-57 and 45.5 percent for OL-B-42. The north radius here as in the other two trees has the lowest average variation.

Average departure from mean variation.—Figure 41 B shows the average departure from mean variation for all sections along three radii of OL-S-62 in relation to the mean along a particular radius. Direction of departure from average is identical on T-4, T-6, T-9 to T-11, T-13, and T-14; near identity on T-1, T-3, T-5, T-7, T-8, and T-12; and opposite in direction on T-2 and T-15. On T-2 the north radius is opposed to the other two, and on T-15 it is the southwest radius.

Table 28 gives the average departure from mean variation for each radius on each section. If we disregard sections T-2, T-14, and T-15, the three radii on any one of the sections differ very little from each other, ranging from a low of 0.6 percent on T-11 to a high of 2.6 percent on T-6 and 2.9 percent on T-13. The range of differences from one section to another on OL-SO-57 is more than

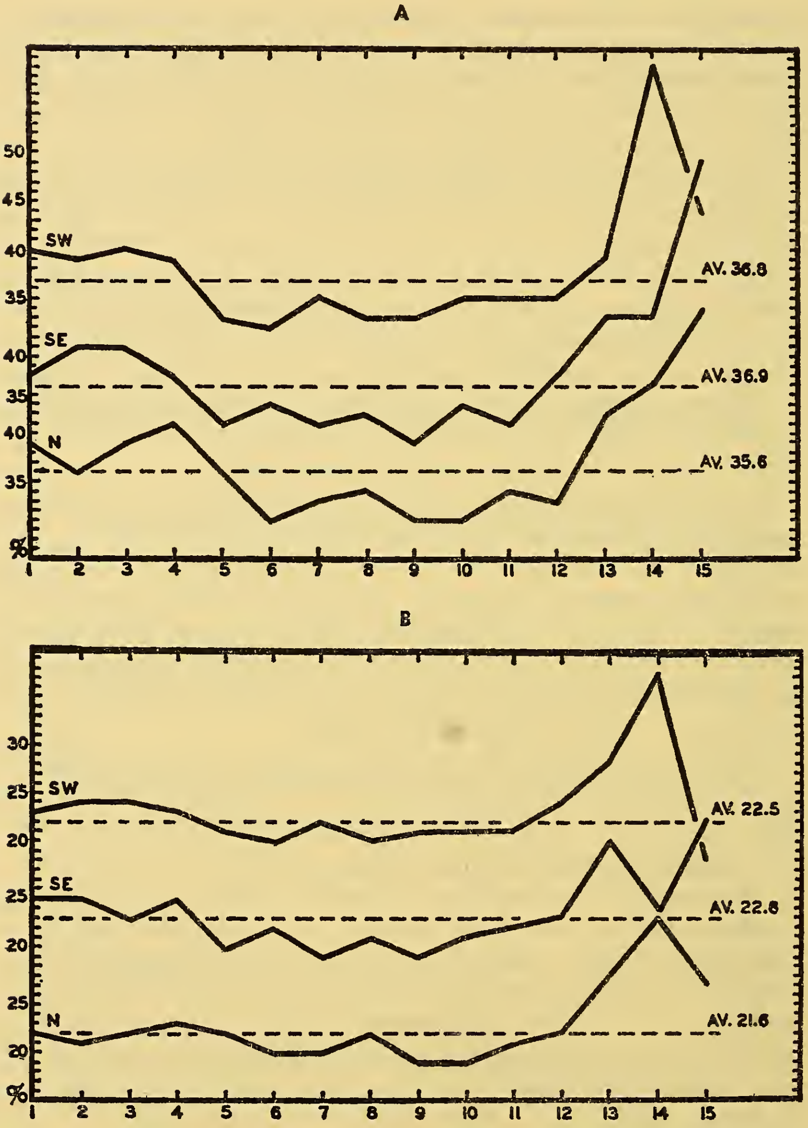


FIG. 41.—Circuit uniformity, OL-S-62, three radii, all sections T-1 to T-15. Upper series shows average variation and lower shows average departure from mean variation.

50 percent greater than on OL-S-62. Insofar as the trunk of OL-S-62 is concerned, there is marked uniformity among the radii of each section except for the two upper sections.

Summary figures for the average departure from mean variation on individual sections appear in table 29. Here, as in OL-SO-57, the differences of the sections from the tree mean are lowest toward the base of the trunk, slightly higher at mid-tree, followed by several sections of low differences, and highest of all near the top. The basal section almost exactly equals the mean for the trunk; there is little to choose from among the different parts of the tree except for the upper 12 to 16 feet.

TABLE 30.—*Summary of circuit uniformity, trunk of OL-S-62*

Section	Average growth-layer thickness *mm.*	Maximum difference 3 radii *mm.*	Average departure %	Average variation %	Average departure from mean variation %	Circuit agreement %
T-15	0.74	0.04	46	51	25	88
T-14	0.48	0.06	45	46	31	74
T-13	0.64	0.24	36	40	27	65
T-12	0.86	0.11	34	34	22	77
T-11	0.90	0.13	34	33	20	79
T-10	1.04	0.38	32	34	20	81
T-9	1.11	0.36	31	30	18	78
T-8	1.14	0.16	31	33	20	84
T-7	1.08	0.04	34	32	20	78
T-6	1.03	0.31	37	31	19	73
T-5	1.11	0.17	37	33	20	77
T-4	0.99	0.23	38	38	22	84
T-3	0.97	0.13	37	38	22	82
T-2	0.94	0.11	39	37	22	77
T-1	0.95	0.25	36	37	21	75
Average *	0.997	0.195	35.8	35.1	20.9	78

Average growth-layer thickness for each radius	*mm.*
N.	1.03
SE.	1.03
SW.	0.93

* See note to table 10, page 46.

Figure 41 B indicates that the average departure from mean variation for the three radii taken as units is nearly identical for the north and southwest radii (21.6 and 22.5 percent) and somewhat higher for the southeast radius (22.8 percent). The percentages for the three radii are lower than those of the three in OL-SO-57, which are lower than those in OL-B-42.

For the trunk as a unit, average departure from mean variation is 20.9 percent (table 29) which contrasts with 26.2 percent for OL-SO-57 and 29.1 percent for OL-B-42.

Summary.—Generalized averages for sections and for the trunk as represented by 15 sections are set forth in table 30. Tree averages as given in this table allow for the progressively fewer growth layers in the upper sections. Average growth-layer thickness for OL-S-62 is 0.997 mm. and the average maximum difference among the three radii is 0.195 mm., by far the least difference of any one of the trees. On the average, the thickest portions of the growth layers occur on the north and southeast radii (1.03 mm. each) and the least thick on the southwest radius (0.93 mm.). The growth layers on the three radii of OL-S-62 possess much more nearly the same thicknesses than do those of OL-SO-57. Average circuit agreement or trend uniformity is 78 percent for all sections together. For the tree as a unit, average departure comes to 35.8 percent, average variation 35.1 percent, and average departure from mean variation 20.9 percent.

TABLE 31.—*Summary comparison of trunks of OL-B-42, OL-SO-57, and OL-S-62*

	OL-B-42	OL-SO-57	OL-S-62
Average growth-layer thickness, mm.	0.88	0.957	0.997
Maximum difference among 3 radii, mm.	0.296	0.412	0.195
Average departure, %	56.8	49.9	35.8
Average variation, %	45.5	41.4	35.1
Average departure from mean variation, %	29.1	26.2	20.9
Circuit agreement, %	80	79	78

If we extend table 22 into table 31, the three trees can be readily compared. Average thicknesses are greater in OL-S-62 than in either of the other two trees. Average departure, average variation, and average departure from mean variation are distinctly lower than for OL-SO-57; in fact, they are farther removed from OL-SO-57 than OL-SO-57 is from OL-B-42.

These three parameters are shown for each radius for each section in summary fashion on figure 42. In general, the trunk shows a high degree of consistency except for the upper three sections. The lower trunk for some 14 to 16 feet exceeds slightly the average value of the parameters, whereas mid-trunk equals or falls below the average. A comparison of figures 42 and 31 brings out the higher degree of uniformity in OL-S-62 as well as the closer resemblance among the three parameters of OL-S-62 than among those of OL-SO-57.

Figure 43 shows the three parameters plotted by decades for sections T-2, T-6, and T-9. Fluctuations are not so well marked as in the graphs of figure 32 for OL-SO-57. The high percentage in average departure of decade 1820 in OL-SO-57 does not show in OL-S-62; T-2 of OL-S-62 has a high point on 1770 and T-6 on 1790. Both of these sections have highs on 1920, and all three, including T-9, have highs on 1900. A low point exists at decade 1800 in OL-S-62 for average departure, average variation, and average departure from mean variation; it also exists in OL-SO-57 for average variation and is suggested for average departure from mean

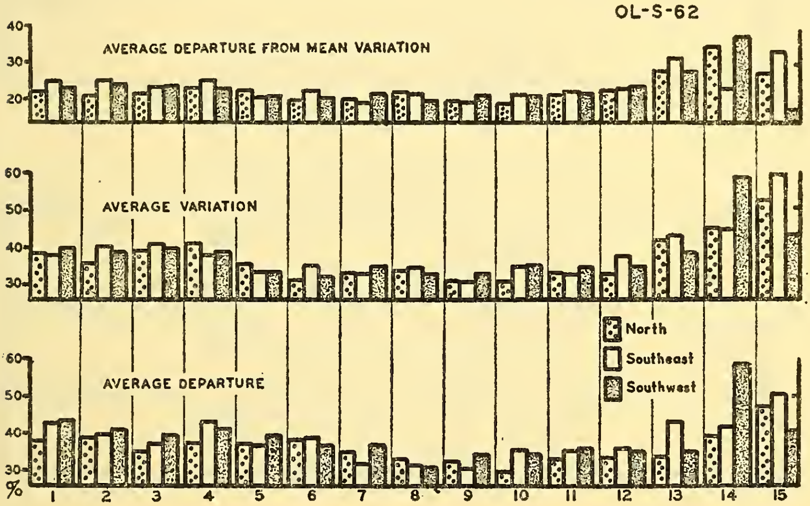


FIG. 42.—Columnar summary of the three parameters average departure, average variation, and average departure from mean variation for three radii of all sections, OL-S-62.

variation. A low point falls on decade 1880 in OL-S-62, very decidedly for average departure (T-2 and T-6), for average variation (all three sections), and suggestively for average departure from mean variation. In OL-SO-57 the low point of 1880 shows up only for average variation; in fact, it is a high point for average departure. We may conclude from a study of figures 32 and 43 that there is a fair degree of coincidence in peaks and troughs among the three radii of the different trees. However, the graph of one section does not in detail represent the record of the other two sections in any one tree. If the graphs were merged, certain peaks and troughs would be eliminated or drastically subdued. We are thus given the problem as to which section or which merged record gives us the most valid picture of growth fluctuations, or cycles.

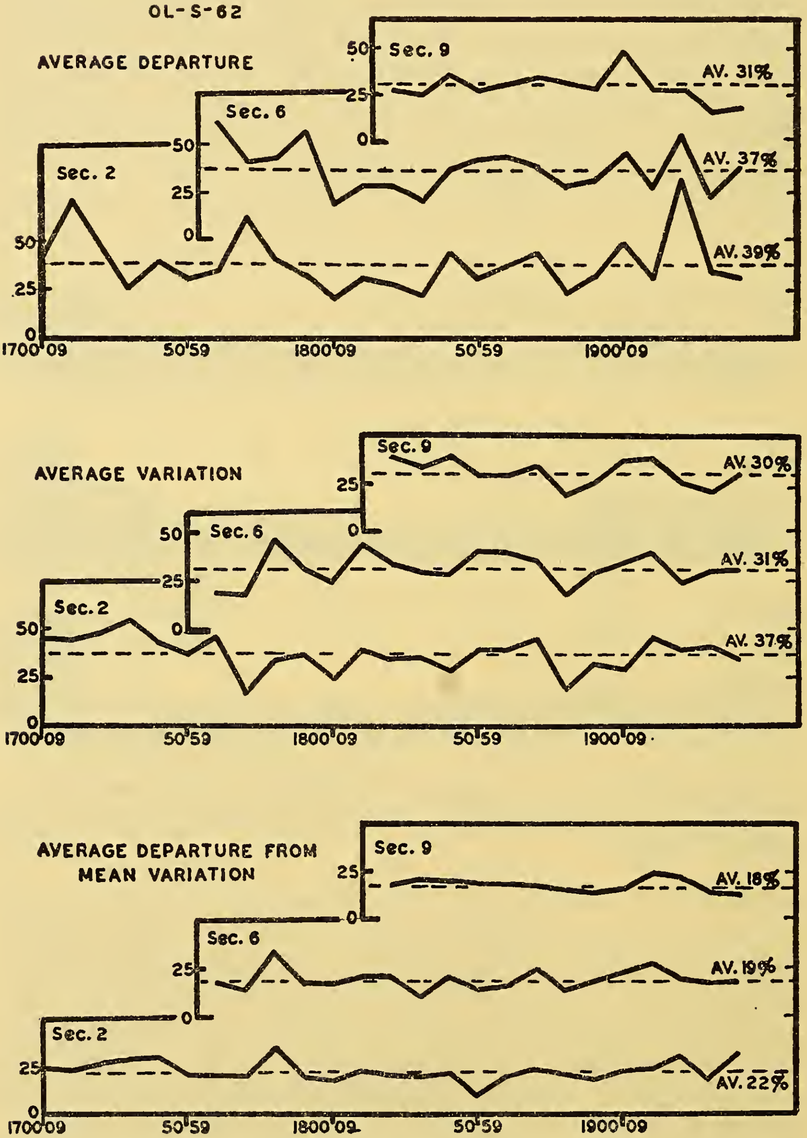


FIG. 43.—Circuit uniformity by decades, OL-S-62, sections T-2, T-6, and T-9. Graphs for the three parameters average departure, average variation, and average departure from mean variation.

In comparing figures 32 and 43, it is evident that the parameter values for sections at comparable heights in the trunks are considerably less in OL-S-62 than in OL-SO-57.

Figure 44 contrasts possible changes in uniformity, or conversely opposed trends, between the two time intervals 1841-1880 and 1906-1945. Uniformity is distinctly less during the interval 1906-1945—opposed trends are more numerous. This is especially true in T-1. Except for T-4, opposed trends, 1841-1880, are fairly uniform among the sections. Tree OL-S-62 emphasizes the probability, as do

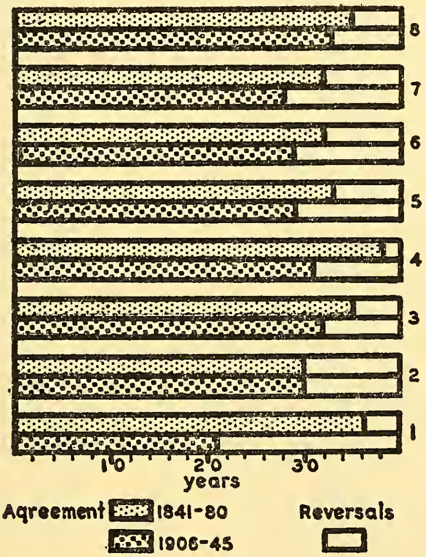


FIG. 44.—Comparison of circuit agreement on eight sections of OL-S-62 for the time intervals 1841-1880 and 1906-1945.

OL-B-42 and OL-SO-57, that the impact of a certain growth factor, or factors, changed between the intervals 1841-1880 and 1906-1945.

SUMMARY COMPARISON OF THE THREE TREES

Thicknesses and trend.—General graphs for the three trees OL-B-42, OL-SO-57, and OL-S-62 are plotted in figure 45. The graph of OL-B-42 has the greatest average amplitude and OL-S-62 the least. Very probably OL-B-42 and OL-SO-57 have greater similarity than either one has with OL-S-62, though points of similarity in respect to crests or troughs exist between any set of two. Figure 45 reveals long-term swings in the thicknesses of growth

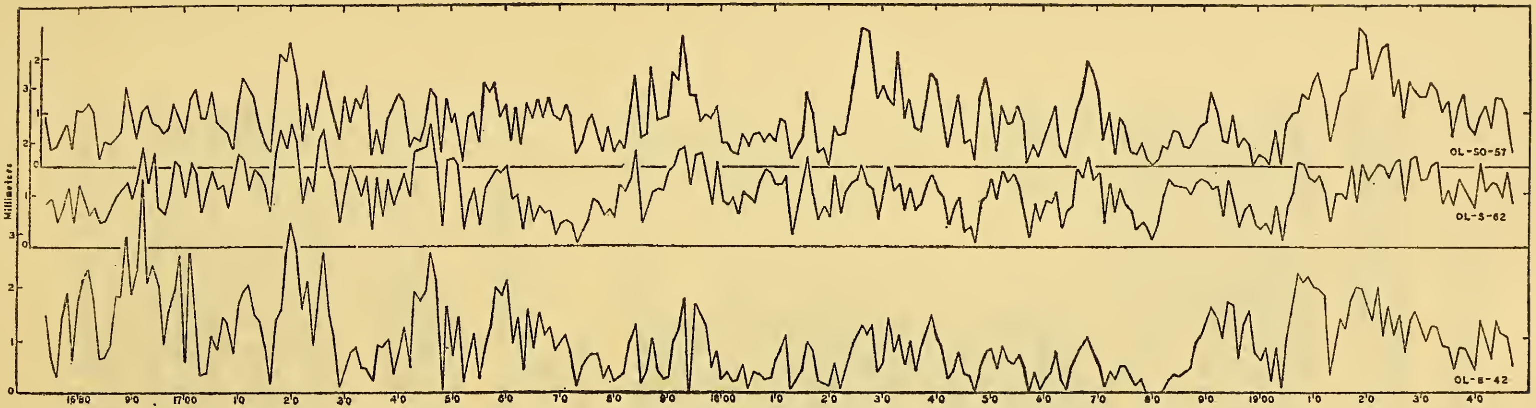


FIG. 45.—Graphs of growth-layer thicknesses for the three trees OL-B-42, OL-SO-57, and OL-S-62. Tree averages based on section averages which were based on averages of the three radii of each section.

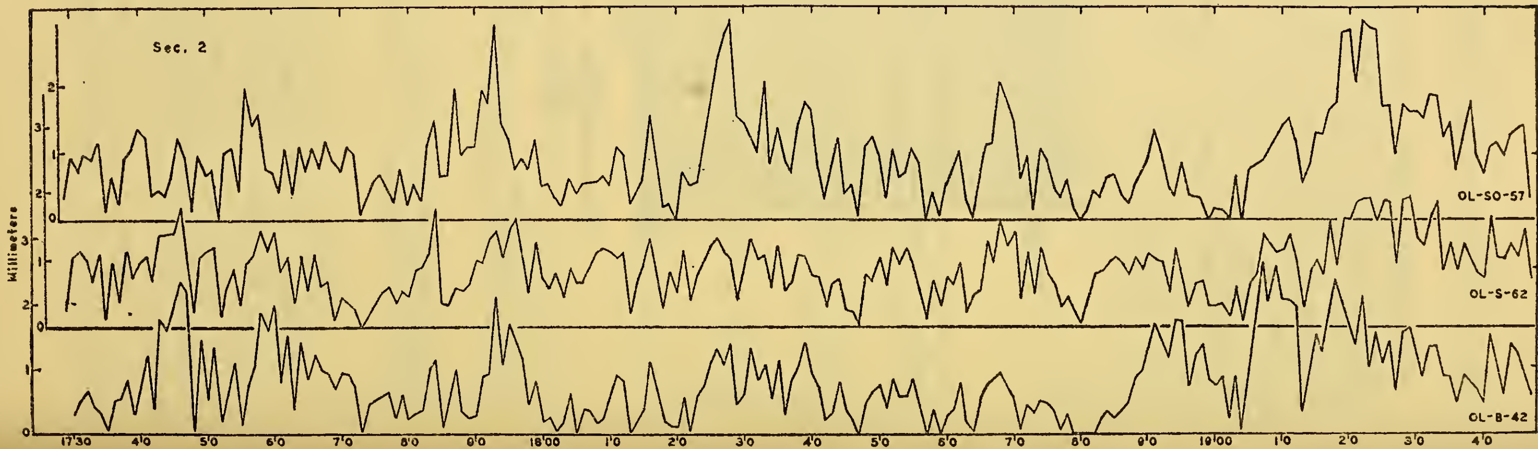


FIG. 46.—Graphs of growth-layer thicknesses for sections T-2 of OL-B-42, OL-SO-57, and OL-S-62. Based on averages of three radii for each section.

layers, centering about 1690, 1720, 1745, 1760, 1795, 1825, 1868, 1895, and 1915.

The three graphs not only do not fluctuate by similar amounts, but also do not move in unison in the same direction. Their trends are in agreement 66 percent of the time (table 32). A comparison of the sections at the bases of the three trees, at mid-tree, and near the top is made on figures 46, 47, and 48. Figure 46 shows that the fluctuations in growth-layer thicknesses of OL-SO-57 exceed those of the other two trees. This does not follow the fluctuations among the three entire trees as shown on figure 45, where OL-B-42 has the greatest fluctuations. The same appears to hold true to a limited extent at mid-tree (fig. 47) and is doubtful higher up the trunk (fig. 48). In the lower trunks as shown by the three sections the percentage of opposed trends is 38 (table 32); at mid-tree it is 38; and near the top it is 46. A comparison of any specific location among the three trees gives a greater number of trend reversals than does a comparison among the three trees as units.

TABLE 32.—*Summary table of opposed trends for the trunks of OL-B-42, OL-SO-57, and OL-S-62, and for certain sections at base, at mid-tree, and near the top*

	Opposed trends %
Three trees together (273 years)	34
Section T-2 of three trees (248 years)	38
Section T-6 (T-5 of OL-SO-57) (188 years)	38
Section T-9 (T-8 of OL-SO-57) (128 years)	46

TABLE 33.—*Summary comparison of opposed trends for each pair of trunks, and for lower, mid, and upper trunks, of OL-B-42, OL-SO-57, and OL-S-62*

	T-2 %	T-6 T-5 (OL-SO-57) %	T-9 T-8 (OL-SO-57) %	Entire trunk (12 sections) %
OL-B-42 vs. OL-SO-57	26 (254 gls.*)	24 (188 gls.)	31 (114 gls.)	22 (278 gls.)
OL-B-42 vs. OL-S-62	24 (252 gls.)	24	37 (133 gls.)	22 (273 gls.)
OL-SO-57 vs. OL-S-62	27 (252 gls.)	30	25 (114 gls.)	26 (273 gls.)

* gls. = growth layers.

Each tree was compared with each of the other two trees as units and at certain locations within the trunks (table 33). The comparison of the two trees OL-B-42 and OL-SO-57 yields a higher per-

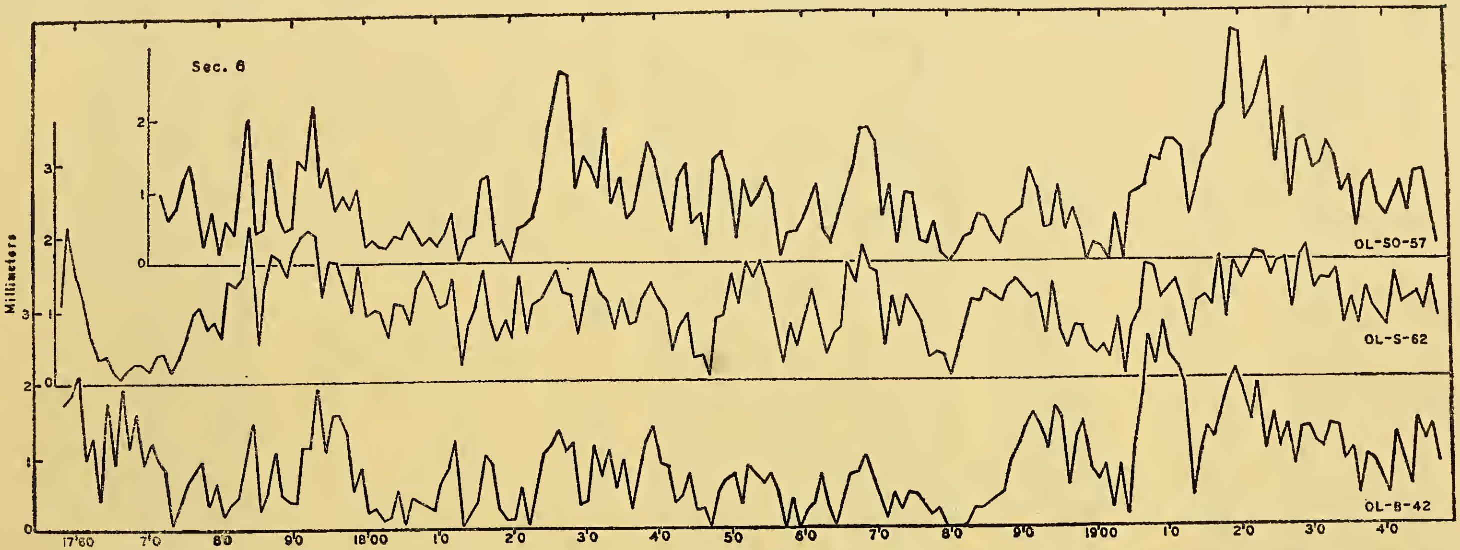


FIG. 47.—Graphs of growth-layer thicknesses for sections T-6 of OL-B-42, OL-SO-57, and OL-S-62. Based on averages of three radii for each section.

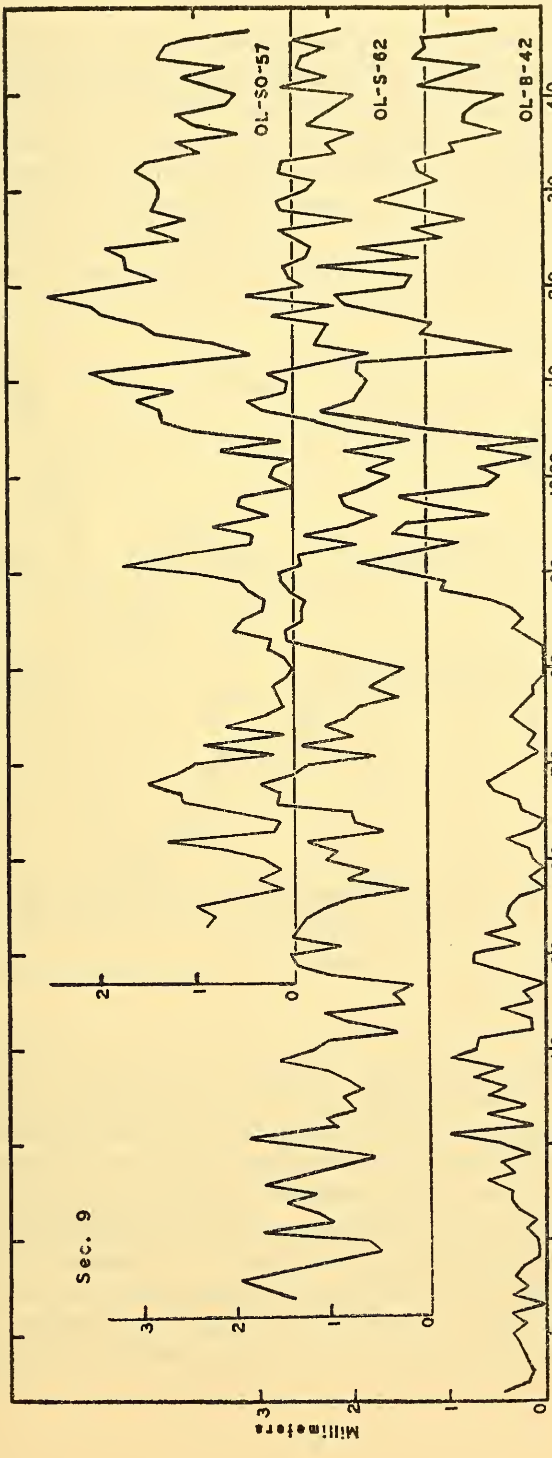


FIG. 48.—Graphs of growth-layer thicknesses for sections T-9 of OL-B-42, OL-SO-57, and OL-S-62. Based on average of three radii for each section.

centage of agreement than does either of the other two combinations of trees. Other comparisons for different portions of the trunk yield mixed results from which no general conclusions can be drawn except that the upper trunks perhaps have somewhat less agreement than the mid and lower trunks. This is well shown in figure 49.

The foregoing results have been based upon average thicknesses

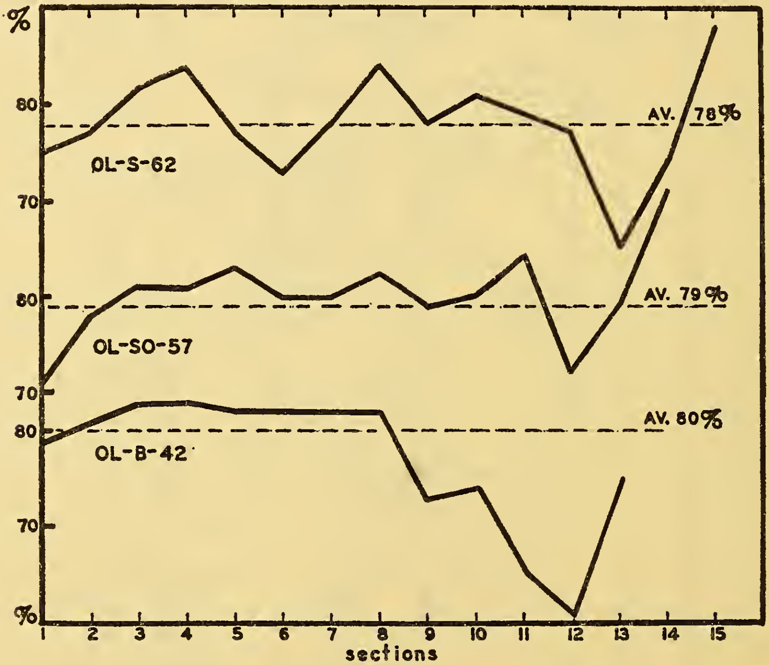


FIG. 49.—Graphs of circuit uniformity by section for the three trees OL-B-42, OL-SO-57, and OL-S-62.

for radius, section, or trunk. If we construct data from each locality within the tree and build up to the entire tree, the results fall short of those given above. The interval 1700 to 1947 is used. In tree OL-B-42, 47.6 percent of the years show agreement throughout the trunk as represented by 10 sections; this means that 52.4 percent of the years show disagreement, or reversal, in growth-layer thickness relationships from one year to the next somewhere within the trunk. Tree OL-SO-57 (10 sections) possesses 51.6 percent agreement, and OL-S-62 (12 sections) possesses 46.4 percent. If we compare the three trees year by year simultaneously, we find that 31 percent of the years have reversals in one tree only, that 29 percent of the years have reversals in two trees, that 22 percent of the years have reversals in the three trees at the same time, and that 18 percent of the years have no reversals anywhere in any of the three trees. The 31 percent of the years with reversals in one tree only are distributed as follows: 11.3 percent in OL-B-42, 9.3 percent in OL-SO-57, and 10.5 percent in OL-S-62. Thus one may seriously doubt that a single growth layer maintains entirely uniform relationships with adjacent growth layers throughout its areal extent.

TABLE 34.—*Summary comparison of growth-layer thicknesses for all radii of each of the three trees*

	North radius, mm.			Southeast radius, mm.			Southwest radius, mm.		
Section	OL-B-42	OL-SO-57	OL-S-62	OL-B-42	OL-SO-57	OL-S-62	OL-B-42	OL-SO-57	OL-S-62
T-14	...	0.50	0.51	...	0.62	0.45	...	0.50	0.48
T-13	0.34	0.67	0.55	0.26	0.77	0.79	0.26	0.73	0.57
T-12	0.73	0.87	0.92	0.44	1.05	0.84	0.47	0.79	0.81
T-11	0.79	0.85	0.98	0.82	1.15	0.88	0.96	0.83	0.85
T-10	0.94	1.27	1.23	0.86	0.62	1.03	0.57	0.82	0.85
T-9	0.89	1.17	0.97	0.52	0.76	1.33	0.63	0.80	1.02
T-8	1.06	1.24	1.24	0.59	0.70	1.10	0.76	0.76	1.08
T-7	0.98	1.16	1.10	0.68	1.09	1.06	0.72	0.84	1.08
T-6	0.96	1.12	1.24	0.72	0.78	0.93	0.88	0.86	0.93
T-5	1.04	1.20	1.01	0.86	0.90	1.13	0.93	0.76	1.18
T-4	1.11	1.29	0.90	0.85	0.92	1.13	0.89	0.92	0.94
T-3	1.10	1.18	1.01	0.94	0.92	1.02	0.79	0.87	0.89
T-2	1.10	1.23	1.00	0.77	0.86	0.94	0.96	0.84	0.89
T-1	1.12	1.29	1.01	0.85	0.71	1.04	1.07	0.81	0.79
Average * ..	1.03	1.20	1.03	0.771	0.851	1.03	0.848	0.830	0.930

* See note to table 10, page 46.

Skeleton plots of the three trees are shown on figure 50. With more and more radii merged into a plot for the entire tree, the resemblance to the O'Leary Standard becomes greater. Local differences within the tree are subdued or eliminated. During some years, as around 1830, OL-B-42 appears to depart farther from the Standard than do the other two trees; during other years, 1715-16, 1761, and 1900, the three trees resemble each other more closely than they do the Standard. It seems clear that general tree records resemble each other more closely than do local radii within a tree or between two or more trees.

Growth-layer thicknesses.—Table 34 presents a summary of

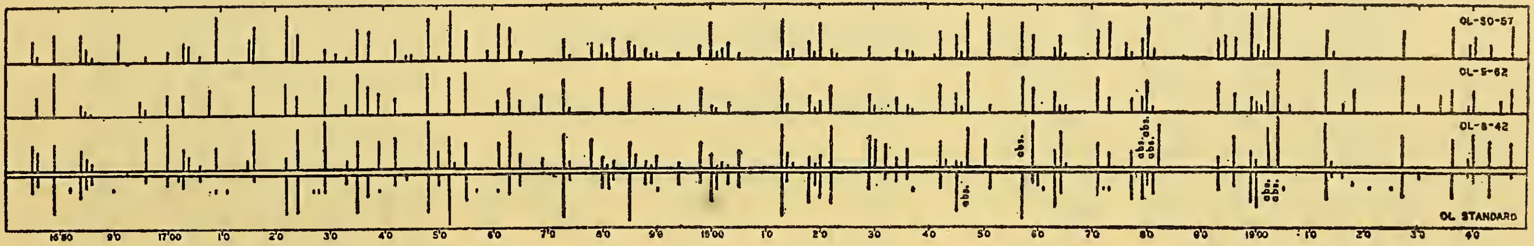


FIG. 50.—Skeleton-plots of the three trees OL-B-42, OL-SO-57, and OL-S-62 compared to the "Standard," a synthesis of the plots of other trees in the same area. Inked lines appear on the years whose growth layers are strikingly thin; the longer the line the thinner the growth layer.

growth-layer thicknesses. Among the three trees as units, OL-B-42 has minimum thickness of 0.880 mm., and OL-S-62 has a maximum of 0.997 mm. This relationship does not hold among the averages for the three radii except for the southeast radius. Where the radial averages are separated into sections (table 34), the southeast radius has seven sections with the same thickness relation as that of the trunks as a whole, whereas the north radius has but three sections. It would seem that the north radius is to be avoided if only one radius from a tree is available and that approximately mid-tree is to be preferred if a complete cross section is available. Table 34 reveals rather clearly the superiority of volume as a measure of growth response in the xylem of a tree. The averages of each section for the three trunks from table 34 are shown in figure 51.

In connection with trend agreements and disagreements it is of interest to analyze the decadal graphs on figure 52. Certain agreements are apparent to the eye, especially if the figure is held at an acute angle with the line of vision. Overall agreement in trend among the three trees is 52 percent; OL-B-42 vs. OL-SO-57 has 63 percent agreement; OL-B-42 vs. OL-S-62 has 74 percent; and OL-SO-57 vs. OL-S-62 has 67 percent. These values exceed those of individual growth-layer averages (table 33).

Average departure.—Information concerning average departures on successive sections for the three trunks for three radii and for the trunks as a whole is found in table 35. For the trunks averaged as units, average departure for OL-B-42 is 56.8 percent; for OL-SO-57, 49.9 percent; and for OL-S-62, 35.8 percent (table 31). Tree averages for the three radii have the same mutual relationships as do the averages for the trunks as units; that is, OL-B-42 has the highest percentage of departure on each radius and OL-S-62 the lowest. More sections of the three trunks possess the same relations along the north radius than along the other two radii. The southwest radius shows the most sections with mixed relations. In fact, seven sections on the southwest radius have reversed relations; the southeast radius has five sections so reversed; and the north radius has two sections, T-11 and T-12. Considering entire sections of the three trunks, five sections do not show the relationships that characterize the trunks as a whole. Thus, insofar as average departure is concerned, a section taken from the lower half of a trunk is more representative of the trunk as a whole than one taken from mid-trunk or upper trunk.

Average departures section by section of the three trunks are illustrated on figure 53. In OL-B-42 and OL-SO-57 wide differences

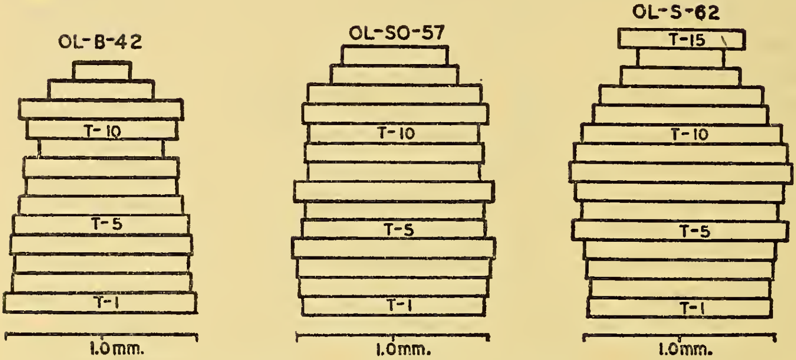


FIG. 51.—Graphic portrayal of average growth-layer thickness for each section of the three trees OL-B-42, OL-SO-57, and OL-S-62.

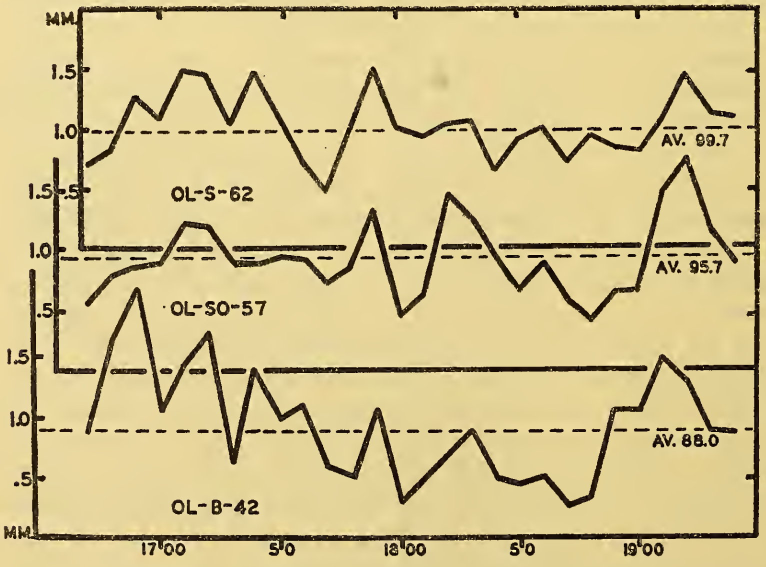


FIG. 52.—Graphs of decade averages of growth-layer thicknesses for the three trees OL-B-42, OL-SO-57, and OL-S-62. Based on average mean measurements for entire tree by decade.

from the mean occur above sections T-8. The lower 25 to 30 feet of the trunks maintain a rather uniform degree of departure. Trunk OL-S-62 possesses not only the lowest average departure but also maintains the most uniform amount of departure.

Average variation.—Table 36 summarizes data concerning all sections of the three trunks on three radii. Tree averages for combined sections bear the same relationship to each other as they do in

TABLE 35.—*Summary comparison of average departure for all radii of each of the three trees*

	North radius, %			Southeast radius, %			Southwest radius, %		
Section	OL-B-42	OL-SO-57	OL-S-62	OL-B-42	OL-SO-57	OL-S-62	OL-B-42	OL-SO-57	OL-S-62
T-14	...	42.3	39.7	...	32.2	42.0	...	43.2	59.0
T-13	37.6	32.4	34.0	34.1	32.0	43.9	30.8	41.8	35.9
T-12	41.1	26.0	33.9	33.3	33.1	36.3	38.4	24.3	35.4
T-11	41.1	29.5	33.0	38.4	33.0	35.6	37.2	31.5	36.1
T-10	62.6	46.0	29.9	69.5	41.1	35.8	64.4	41.2	34.7
T-9	76.9	58.4	32.4	71.8	58.1	30.6	75.2	56.2	34.3
T-8	74.2	62.9	33.0	59.4	54.8	31.5	60.2	56.3	31.2
T-7	60.0	57.1	35.0	54.7	57.5	32.0	55.0	55.6	37.3
T-6	60.4	54.7	38.3	56.9	54.8	39.0	50.7	55.8	37.1
T-5	54.3	51.9	37.8	52.6	50.5	37.0	52.7	54.3	39.8
T-4	56.5	50.8	37.7	51.6	50.1	43.0	55.9	47.6	41.5
T-3	53.5	51.2	35.5	54.2	51.4	36.9	53.8	49.6	39.4
T-2	58.8	51.8	38.7	58.7	48.0	39.8	56.8	50.8	41.3
T-1	64.2	55.6	38.3	64.0	48.3	42.8	65.3	52.5	43.3
Average * ..	60.3	52.7	36.2	57.5	50.4	38.0	57.3	51.2	38.6

* See note to table 10, page 46.

average departure, which is the reverse of growth-layer thicknesses. Average variation for OL-B-42 is 45.5 percent; for OL-SO-57, 41.4 percent; and for OL-S-62, 35.1 percent (table 31). Tree averages for the three radii have the same mutual relations as do the averages for the trunks as units; that is, OL-B-42 has the highest percentage of average variation on each radius and OL-S-62 has the lowest.

These mutual relationships among the three trees on separate radii and on merged radii as shown by the trunk averages and by the radial averages do not hold strictly on all individual sections, T-1 to T-13, although the changes are neither so numerous nor so striking as are the average departures. In the averages for sections, T-5 has the highest percentage of average variation in OL-SO-57 (table 38); all other sections follow the relationships present in the trunks as units. On the north radius, T-11 has a higher percentage of average variation in OL-S-62 than in OL-SO-57, OL-B-42 still

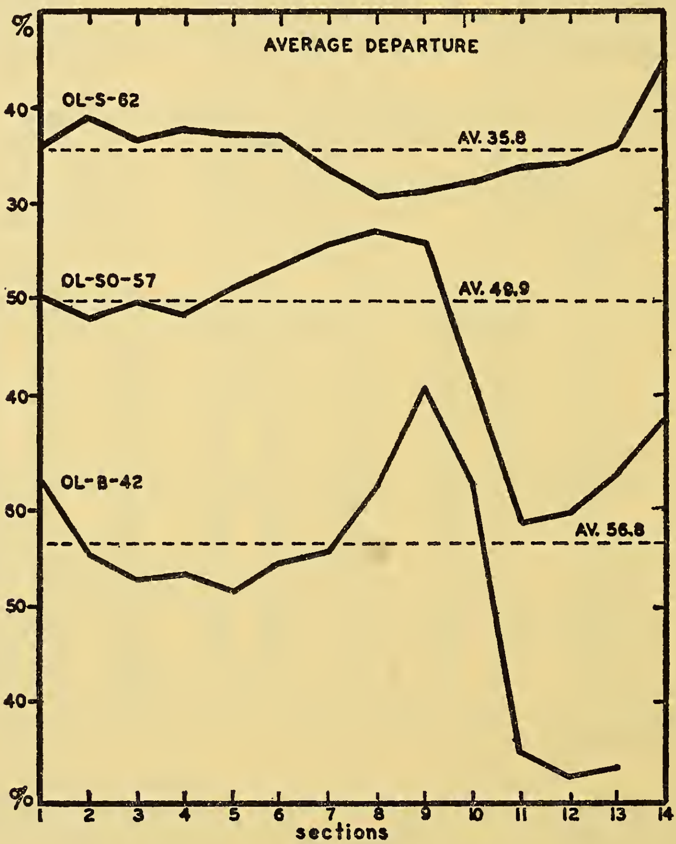


FIG. 53.—Graphs of average departure by section for the three trees OL-B-42, OL-SO-57, and OL-S-62.

being the highest by far of the three trunks. The southeast radius has more sections out of line with the general relationships than do either of the other two radii. On T-3 of the southeast radius, the average variation of OL-SO-57 is slightly higher than that of OL-B-42; on T-5 and T-8 the same holds true but to a higher degree; and on T-12 and T-13, average variation of OL-S-62 is higher than that of OL-SO-57, but both are smaller than that of OL-B-42.

The lower parts of the trunk give the average record for variation, the north and southwest radii are superior to the southeast, and a full section greatly exceeds in value any one part of a section or a single radius.

Figure 54 shows the average variation section by section for the three trunks. In contrast with the comparable graphs of average departure (fig. 53), these bear a striking resemblance to each other in general form, differing only in detail and in trunk average.

TABLE 36.—*Summary comparison of average variation for all radii of each of the three trees*

	North radius, %			Southeast radius, %			Southwest radius, %		
Section	OL-B-42	OL-SO-57	OL-S-62	OL-B-42	OL-SO-57	OL-S-62	OL-B-42	OL-SO-57	OL-S-62
T-14	...	47.5	45.4	...	39.3	44.4	...	53.5	59.0
T-13	55.8	42.2	42.0	47.9	35.8	43.9	43.0	46.3	38.8
T-12	46.2	39.3	33.0	41.2	37.9	38.2	48.7	36.2	35.1
T-11	51.0	31.6	33.6	49.2	36.1	33.0	40.8	37.9	34.8
T-10	46.2	33.7	30.7	41.2	39.0	35.2	39.2	33.4	35.4
T-9	43.6	37.0	30.9	45.9	43.5	30.7	44.0	40.1	33.3
T-8	43.3	41.6	33.9	45.9	46.2	34.4	48.9	44.0	33.0
T-7	44.0	39.6	33.1	45.9	43.8	33.2	45.4	39.2	34.8
T-6	50.0	43.0	31.0	48.7	43.6	35.3	45.3	43.0	32.1
T-5	46.8	43.3	35.8	42.8	45.7	33.5	47.7	47.3	33.5
T-4	45.0	41.5	41.0	43.9	43.3	38.1	46.7	43.8	39.3
T-3	46.1	43.1	39.4	45.0	45.2	40.9	49.6	43.7	39.9
T-2	46.6	43.2	36.3	53.2	43.7	40.6	48.1	44.7	39.0
T-1	51.3	44.9	38.9	57.9	47.7	38.2	52.2	44.1	40.3
Average * ..	46.9	42.1	35.6	47.7	44.3	36.9	47.3	43.2	36.8

* See note to table 10, page 46.

Average departure from mean variation.—Material having to do with this phase of the work is found in table 37. The same relationships, OL-B-42 highest and OL-S-62 lowest, hold for the parameter of average departure from mean variation as for the previously described parameters; OL-B-42 has an average departure from mean variation of 29.1 percent, OL-SO-57 of 26.2 percent, and OL-S-62 of 20.9 percent (table 31). In all trunk averages, OL-B-42 and OL-SO-57 are closer to each other than to OL-S-62.

Among the section averages, OL-SO-57 either equals or exceeds OL-B-42 on T-5 and T-8; OL-S-62 exceeds OL-SO-57 on T-10, T-11, and T-13 (table 38). On the north radius abnormal relationships exist between OL-SO-57 and OL-S-62 only at the levels of

T-11 to T-13. The southwest radius has abnormal relationships on T-5 and on the four sections T-10 to T-13 near the top of the trunk. Of the lower 13 sections of the southeast radius, 7 do not show normal relationships.

The evidence for uniformity in average departure from mean variation parallels that from which conclusions were drawn under average variation. These are: That the lower parts of the trunks give

TABLE 37.—*Summary comparison of average departure from mean variation of each of the three trees*

	North radius, %			Southeast radius, %			Southwest radius, %		
Section	OL-B-42	OL-SO-57	OL-S-62	OL-B-42	OL-SO-57	OL-S-62	OL-B-42	OL-SO-57	OL-S-62
T-14	...	32.4	34.3	...	20.6	22.9	...	27.3	37.2
T-13	42.6	25.6	27.8	24.5	21.3	30.7	18.8	24.5	27.8
T-12	30.0	20.8	22.4	26.6	25.8	23.0	28.1	21.0	23.8
T-11	31.0	18.6	21.2	28.0	19.8	21.8	25.0	26.5	21.5
T-10	29.9	19.5	18.7	30.1	21.9	21.4	27.1	18.6	21.1
T-9	33.4	23.3	19.5	30.7	26.7	18.9	32.4	24.9	21.0
T-8	28.2	25.2	21.9	28.2	31.2	21.5	29.8	26.8	19.6
T-7	28.6	25.5	20.1	29.7	29.8	19.3	28.3	24.6	21.7
T-6	29.2	28.6	19.6	31.1	28.3	22.2	29.5	28.5	20.2
T-5	29.4	24.2	22.1	27.3	30.9	20.1	28.8	31.7	20.8
T-4	27.9	26.8	23.0	27.9	28.3	25.1	31.3	28.0	23.1
T-3	29.1	27.6	21.7	27.4	28.6	23.3	31.8	28.1	23.8
T-2	30.0	27.1	20.8	35.1	27.6	24.8	30.1	29.2	24.1
T-1	33.7	27.6	22.3	39.2	29.1	24.7	35.9	27.2	23.3
Average * ..	29.9	26.4	21.6	30.8	28.4	22.8	30.6	27.5	22.5

* See note to table 10, page 46.

the most generalized record of growth, that the north and southwest radii are superior to the southeast, and that, in general, a full section greatly exceeds in value any one part of a section or a single radius.

Figure 54 shows average departure from mean variation section by section for the three trunks. These graphs do not resemble each other to the same degree as do those of average departure; they differ in general form, in detailed trends, and in trunk averages. All three show the greatest fluctuation from the trunk mean in the upper parts of the trunks.

Representative values for growth-layer characteristics, or parameters, as yielded by the three trees may be summarized as follows with respect to location within the trunks:

Highest trend agreement	Lower trunk and mid-trunk.
Growth-layer thicknesses	Southeast and southwest radii; mid-trunk.
Departure	North radius; lower trunk.
Variation	Southwest and north radii; lower trunk
Average departure from mean variation	Southwest and north radii; lower trunk.

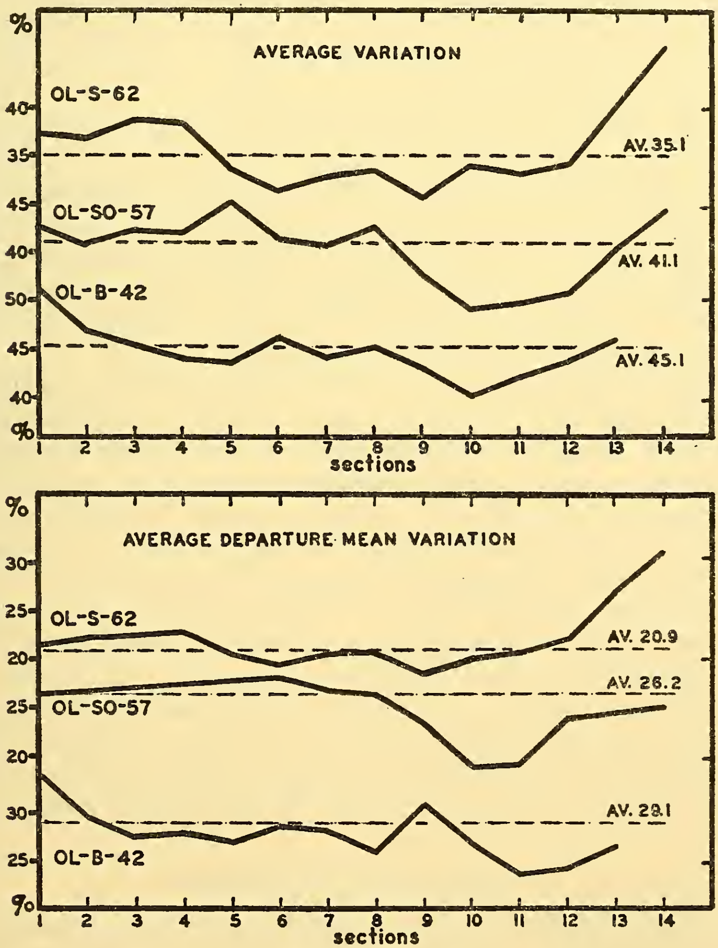


FIG. 54.—Graphs of average variation and average departure from mean variation by section for the three trees OL-B-42, OL-SO-57, and OL-S-62.

In further summary of the four parameters—average growth-layer thickness, average departure, average variation, and average departure from mean variation—tree OL-B-42 has the thinnest average growth layers and the highest values for the other three parameters, OL-S-62 has the thickest average growth layers and the lowest values for the other three parameters, and OL-SO-57 falls in the intermediate position (table 31).

Mean sensitivity.—Mean sensitivity is found by dividing the difference between each two successive growth-layer thicknesses by their mean. This parameter gives a measure of relative fluctuation in growth-layer thicknesses. The more variable are the thicknesses of the growth layers on a sequence, the higher the numerical value of the mean sensitivity whose limiting upper value is two when a growth layer is zero in thickness.

Only section T-1 of the three trunks was analyzed for mean sensitivity. For OL-B-42, the parameter is 0.659; for OL-SO-57, it is 0.563; and for OL-S-62, it is 0.438. These three figures indicate that the sectional record of T-1 in OL-B-42 is most variable, whereas that of OL-S-62 is the most uniform, a relationship apparently holding for three of the previously considered parameters.

Table 38 presents in summary form the data of previous tables as well as the percentages of circuit agreement.

Table 39 presents the matter of trend agreement in a more critical fashion than heretofore. Percentages in column A are based upon millimeter measures, on average thickness of each growth layer for the trunk or section specified, and on the direction of growth. For 66 percent of the years the direction of growth (either increase or decrease) is identical within the three trees. Percentages in column B are based upon the presence or absence of trend uniformity. A reversal in one tree or section for a certain year decreases the percentage of agreement or uniformity, whereas a reversal in all trees or sections increases the percentage of agreement. For instance, for 34 percent of the years no reversals occurred anywhere within the trunks of the three trees; in other words, for 66 percent of the years reversals occurred somewhere within the materials specified. Thus considered, the percentages in column B are surprisingly high.

BRANCHES OF TREE OL-B-42

Branch 1 emerged from the south side of the trunk between sections T-4 and T-5, some 18 feet above ground; it was the east member of a branch that forked 8 inches out from the trunk. Branch 2

TABLE 38.—*Summary of various parameters and of circuit agreement for all sections of the three trunks*

	Section														
	14	13	12	11	10	9	8	7	6	5	4	3	2	1	Average
Average growth-layer thickness, mm.:															
OL-B-42	...	0.29	0.55	0.86	0.79	0.68	0.80	0.79	0.85	0.94	0.95	0.94	0.94	1.01	0.88
OL-SO-57	0.54	0.72	0.90	0.94	0.90	0.91	0.90	1.03	0.92	0.95	1.04	0.99	0.98	0.94	0.96
OL-S-62	0.48	0.64	0.86	0.90	1.04	1.11	1.14	1.08	1.03	1.11	0.99	0.97	0.94	0.95	1.00
Maximum difference among 3 radii, mm.:															
OL-B-42	...	0.08	0.29	0.17	0.37	0.37	0.47	0.30	0.24	0.18	0.26	0.31	0.33	0.27	0.30
OL-SO-57	0.12	0.10	0.26	0.32	0.65	0.41	0.54	0.32	0.34	0.44	0.37	0.31	0.39	0.58	0.41
OL-S-62	0.06	0.24	0.11	0.13	0.38	0.36	0.16	0.04	0.31	0.17	0.23	0.13	0.11	0.25	0.20
Average departure, %:															
OL-B-42	...	33	32	35	63	73	63	56	55	52	53	53	56	63	56.8
OL-SO-57	38	32	27	27	42	56	57	56	54	51	48	50	48	50	49.9
OL-S-62	45	36	34	34	32	31	31	34	37	37	38	37	39	36	35.8
Average variation, %:															
OL-B-42	...	46	44	42	40	43	45	44	46	44	44	46	47	51	45.5
OL-SO-57	44	40	36	34	34	38	43	41	41	45	42	42	41	42	41.4
OL-S-62	46	40	34	33	34	30	33	32	31	33	38	38	37	37	35.1
Average departure from mean variation, %:															
OL-B-42	...	26	24	24	27	31	26	28	29	27	28	28	30	34	29.1
OL-SO-57	25	24	24	19	19	23	26	26	28	28	27	27	27	26	26.2
OL-S-62	31	27	22	20	20	18	20	20	19	20	22	22	22	21	20.9
Circuit agreement, %:															
OL-B-42	...	75	61	65	74	73	82	82	82	82	83	83	81	79	80
OL-SO-57	92	79	72	84	80	79	82	80	80	83	81	81	78	71	79
OL-S-62	74	65	77	79	81	78	84	78	73	77	84	82	77	75	78

emerged from the west side of the trunk between sections T-7 and T-8, 30.5 feet above ground. The lower branch was 16 feet long, the upper one 12 feet.

Sections taken from the two branches of OL-B-42 could not be dated in terms of the OL chronology which was used in all other

Table 39.—*Trend agreements, on two bases, for the three trunks and for certain sections in the three trunks. Trend agreements are based upon overall growth-layer averages and upon detailed sequences throughout the extent of the materials specified. Column A is based upon average thicknesses of growth layers in certain trunks or sections. Column B is based upon uniformity of trend within all sections of the trunks or along all radii within certain sections*

	A Percent of agreement in direction of growth	B Percent of consistency in trend throughout the trunk or section
Average:		
3 trees together (273 gls.)	66	34
OL-B-42 vs. OL-SO-57 (278 gls.)	78	58
OL-SO-57 vs. OL-S-62 (273 gls.)	74	59
OL-B-42 vs. OL-S-62 (273 gls.)	78	60
Section T-2:		
3 trees together (248 gls.)	62	55
OL-B-42 vs. OL-SO-57 (248 gls.)	76	70
OL-SO-57 vs. OL-S-62 (248 gls.)	73	70
OL-B-42 vs. OL-S-62 (248 gls.)	76	70
Sections T-5 and T-6:		
3 trees together (188 gls.)	62	55
OL-B-42 vs. OL-SO-57 (188 gls.)	76	72
OL-SO-57 vs. OL-S-62 (188 gls.)	70	68
OL-B-42 vs. OL-S-62 (188 gls.)	76	70
Sections T-8 and T-9:		
3 trees together (128 gls.)	54	55
OL-B-42 vs. OL-SO-57 (114 gls.)	69	70
OL-SO-57 vs. OL-S-62 (114 gls.)	75	71
OL-B-42 vs. OL-S-62 (133 gls.)	63	64

analyses. These branch sections displayed an excessive amount of variability, lenticularity, and so-called absence. The number of relatively thin layers interspersed between layers of normal thickness was so great that thin layers were no longer diagnostic landmarks in a chronological sequence. It was not possible to observe the characteristic number of growth layers that usually separate diagnostic layers. Partial layer rested upon partial layer so that all conception of chronology was lost. The distal sections showed the above characteristics to a greater extent than those sections cut closer to the trunk.

It does not seem proper to label the growth pattern in the branches as erratic. Rather it would appear that the response to the factors which cause fluctuations in the growth increment is recorded to a greater degree in the branches than in the trunk, particularly in the extreme lower forest border region where greater variability and narrow growth layers are the rule. In this marginal area where minimal conditions for existence obtain, the growth increments indicate that the activity of the cambium is critically affected. In this locality perhaps the trunk portrays a generalized history of the tree and indicates an average or mean of the growth factors from all the branches. Where trees do not grow under far less than optimum conditions, this difference is not so important. It would seem, then, that these branches do not necessarily imply a failure of consistency of growth pattern, but rather that it is our failure to understand exactly what the cambium in each branch has done in its response to minimal conditions.

BRANCHES OF TREE OL-SO-57

Branch 1 emerged from the south side of the trunk between sections T-5 and T-6, 25 feet above ground; Branch 2 emerged on the south side between T-9 and T-10, 44 feet above ground.

The approximate positions of the three measured radii are shown on figure 62 (p. 134), and the radii are designated down, up-west, and up-east. It was to be expected that the growth layers would be at their maximum thickness around the circuit on the down radius.

Table 5 (p. 29) gives data concerning the positions of the branch sections and the number of growth layers in each section.

Absolute thickness.—The combined growth-layer measures of each of the two branches are compared with the general graph for the trunk of OL-SO-57 on figure 55. It must be noted that the graphs are plotted on a millimeter scale; the average for OL-SO-57 trunk is 0.957 mm., for Branch 1, 0.41 mm., and for Branch 2, 0.53 mm. If the graphs were plotted on a percentage basis, the fluctuations of trunk and branches would bear a much greater resemblance to each other than they appear to have in their present forms. On the whole, the three graphs do have a striking resemblance, crests and troughs having a high degree of incidence. The branches seem to be as intimately related to each other as they are to the trunk. In fact, the branches resemble the trunk to as great a degree as do the various parts of the trunk to each other.

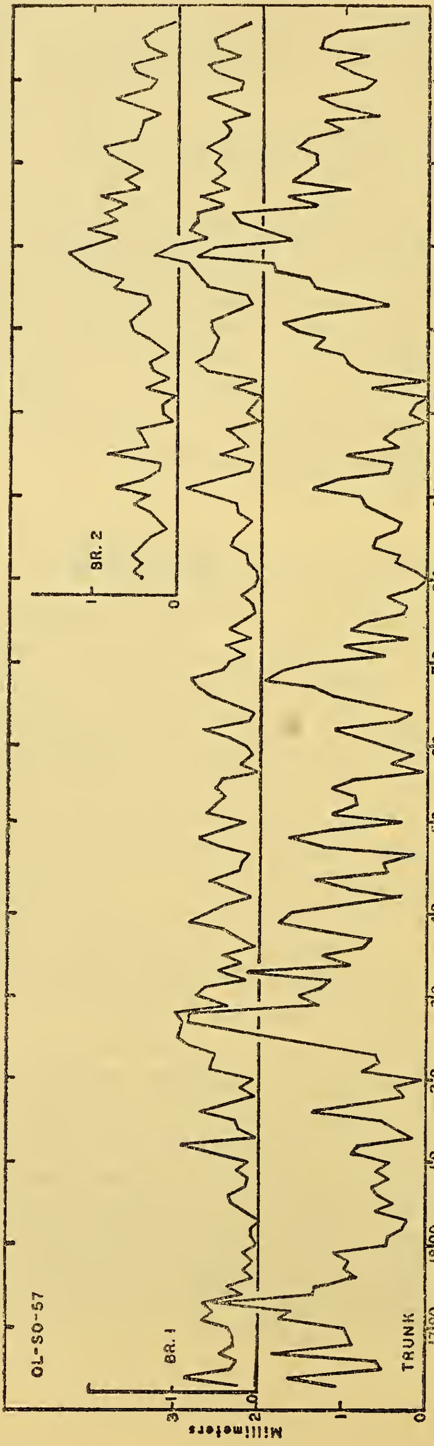


FIG. 55.—Graphs of average growth-layer thicknesses in two branches and trunk of OL-SO-57.

In Branch 1, 64 percent of the growth layers on the combined sections had their thickest parts on the down radius (table 40), 14 percent on the up-east, and 19 percent on the up-west. In Branch 2, 68 percent of the growth layers had their thickest portions on the down radius, 23 percent on the up-east, and 9 percent on the up-west. Percentages do not total 100 in Branch 1 because of missing growth layers.

TABLE 40.—*Percentage occurrence of thickest portions of growth layers on three radii for each branch section, OL-SO-57*

Section	Down %	Up-east %	Up-west %	Missing %
1-A	62.19	19.15	12.80	5.48
1-B	75.00	8.87	12.90	3.22
1-C	70.27	8.10	20.72	0.90
1-D	54.63	13.40	30.92	1.03
1-E	54.92	25.35	16.90	2.81
1-F	55.17	10.34	34.48	...
2-A	50.74	40.29	8.95	...
2-B	84.61	9.61	5.76	...
2-C	64.70	14.70	20.58	...
2-D	84.61	11.53	3.84	...
2-E	60.00	33.33	6.66	...
Average*:				
Branch 1	64	14	19	3
Branch 2	68	23	9	...

* See note to table 10, page 46.

Table 41 gives detailed data concerning the two branches of OL-SO-57.

Relative thickness and trend.—Uniformity of trend around the circuit on all radii combined for both branches is as follows, in percentage (see fig. 59 D, p. 130):

	A	B	C	D	E	F	Section average	T-5	T-6	T-9	T-10
Branch 1	80	79	77	74	62	68	75	83	80	..	..
Branch 2	76	75	76	77	72	..	77	..	..	79	80

The inner portions of the branches approximate the uniformity of the contiguous sections of the trunk. Outward on the branches the uniformity decreases. Values in the above table in general exceed those of OL-S-62.

Consistency in relative thicknesses as measured by trend uniformity does not differ too drastically in the branches from that of

TABLE 41.—*Circuit uniformity, three radii on all sections of both branches of OL-SO-57. Thicknesses in mm.; the three parameters of departure, variation, and departure from mean variation in percent*

Section	Average growth-layer thickness, mm.			Average departure, %			Average variation, %			Average departure from mean variation, %		
	Down	Up-E.	Up-W.	Down	Up-E.	Up-W.	Down	Up-E.	Up-W.	Down	Up-E.	Up-W.
1-A	0.52	0.30	0.32	71.7	66.8	66.9	56.8	60.2	59.3	38.3	41.1	40.7
1-B	0.74	0.30	0.37	62.8	60.9	56.3	47.0	59.8	52.2	32.9	37.8	33.5
1-C	0.66	0.34	0.40	63.0	53.2	51.8	49.4	56.0	48.5	32.6	32.6	32.4
1-D	0.52	0.35	0.34	65.2	53.4	60.4	39.0	46.5	45.4	26.3	27.7	29.4
1-E	0.40	0.29	0.29	62.8	47.9	50.0	44.6	40.5	44.0	39.0	31.4	33.6
1-F	0.53	0.44	0.52	36.1	37.3	36.6	36.9	37.3	32.2	28.4	22.6	23.2
Average *	0.577	0.321	0.354	64.5	57.1	61.4	48.1	53.5	50.1	33.7	34.9	34.2
2-A	0.56	0.51	0.45	49.2	44.2	54.0	42.2	47.0	42.2	24.5	30.0	23.6
2-B	0.69	0.45	0.43	49.3	52.0	46.2	42.6	36.6	37.3	24.4	28.1	23.2
2-C	0.70	0.61	0.61	34.3	30.9	30.5	34.6	31.5	31.2	17.0	18.2	16.1
2-D	0.58	0.47	0.47	32.2	31.2	35.0	30.1	29.3	36.1	22.3	22.7	25.7
2-E	0.50	0.39	0.34	47.8	48.1	48.3	51.6	50.2	33.7	25.3	19.3	29.9
Average *	0.617	0.497	0.467	43.9	42.3	44.0	40.1	39.5	37.3	22.7	25.6	23.0

* See note to table 10, page 46.

the trunk itself or of its various sections if comparative area is considered. A summation of the total number of years with so-called reversals in thickness relationships existing at any place in the area of the growth layers comes out as follows:

1784-1947 (164 years)		*1881-1947 (67 years)*	
Trunk (10 sections)	91 reversals, 55.5%	Trunk	41 reversals, 61.2%
Branch 1	67 reversals, 40.9%	Branch 2	29 reversals, 43.3%
T-5	32 reversals, 19.5%	T-9	17 reversals, 25.4%
T-6	36 reversals, 22.0%	T-10 (1888)	12 reversals, 20.0%

The trunk, with its greater number of sections and larger visible area for study, shows a greater tendency to reversal than do the branches.

Branch 1 and the trunk sections considered together over a span of 164 years have 83 separate years when reversals occur on one or the other. Of these reversals, 18 are common to all three; 32 reversals are exclusively on the branch; 5 reversals are common to the branch and to section T-5; 12 reversals are common to the branch and to section T-6; 7 reversals are exclusively on T-5; 4 reversals are exclusively on T-6; and 5 reversals are common to both T-5 and T-6.

Branch 2 compared after the same fashion with T-9 and T-10 reveals more reversals unique to the branch. Few reversals are unique to the trunk sections singly or together. It seems clear that the branches show greater nonconformity with contiguous portions of the trunk than do portions of the trunk among themselves and that the branch higher up on the trunk possesses greater nonconformity, or greater variability in thickness relations, than does the lower branch. If we view these results in the light of the total number of reversals in trunk or branches, we may conclude that the branches are not so prone to reversal as the trunk but are less uniform and less consistent in the particular years bearing the reversals.

A higher degree of similarity stands out vividly in the right-hand column of table 42. At the same time the table shows that the trunk or its sections have a somewhat greater uniformity than do either of the branches.

The foregoing discussion refers to uniformity within trunk, branch, or section and carries no strict comparison from one to the other. In contrast, table 43 gives trend comparisons in percentage between branches and trunk and between branches and the trunk sections nearest to them.

In table 43, a disagreement anywhere on the circuit, as shown by the known radii, has been counted as a reversal for the section; a disagreement on a certain year on any section has been counted as

TABLE 42.—*Summary data for trunk and branches of OL-SO-57: Thickness in mm.; average departure, average variation, average departure from mean variation, and circuit agreement in percent*

Section	Average growth-layer thickness *mm.*	Maximum difference 3 radii *mm.*	Average departure %	Average variation %	Average departure from mean variation %	Circuit * agreement %
OL-SO-57:						
Trunk	0.957	0.412	49.9	41.4	26.2	79
Branch 1	0.414	0.258	56.2	48.5	30.7	75
Branch 2	0.528	0.150	41.9	38.4	21.9	77
Sec. T-5	0.95	0.44	51	45	28	83
Sec. T-6	0.92	0.34	54	41	28	80
Branch 1	0.41	0.26	56	48	31	75
Sec. T-9	0.91	0.41	56	38	23	79
Sec. T-10	0.90	0.65	42	34	19	80
Branch 2	0.53	0.15	42	38	22	77

* Based on thickness measures.

TABLE 43.—*Uniformity of trend around the circuit in trunk and branches of OL-SO-57*

	%
Branch 1 vs. T-5 and T-6	49
1 vs. T-5 (below Branch 1)	52
1 vs. T-6 (above Branch 1)	54
Branch 2 vs. T-9 and T-10	43
2 vs. T-9 (below Branch 2)	45
2 vs. T-10 (above Branch 2)	48
Trunk vs. Branch 1 and Branch 2	61
Trunk vs. Branch 1	71
Trunk vs. Branch 2	68
Branch 1 vs. Branch 2	65

(Figures given represent the percentage of years when thickness relations remain the same throughout the area of the growth layers examined. A single reversal anywhere on a section or on any section decreases directly the percentage of agreement.)

a reversal for the group of sections or for the trunk or branch, as the case may be. Perhaps it should be pointed out that a trend agreement which reveals a reversal anywhere within section or trunk differs from, and commonly falls short of, a trend based directly upon average growth-layer thicknesses of section or trunk. The two branches, some 17 feet apart on the trunk, agree with each other by 65 percent. This is fairly high agreement if one considers the factors involved; it means that in 35 percent of the years disagreement exists somewhere within one or the other of the branches. In the case of both branches, agreement between branch and the trunk section just above the place of branch emergence is slightly higher than between branch and the trunk section just below. Table 43 indicates that approximately half the growth layers reverse their thickness relationships somewhere on the area of the growth layers examined.

A graphic display of trend reversals by years for all branch sections (fig. 56) shows no recognizable pattern. If we disregard sec-

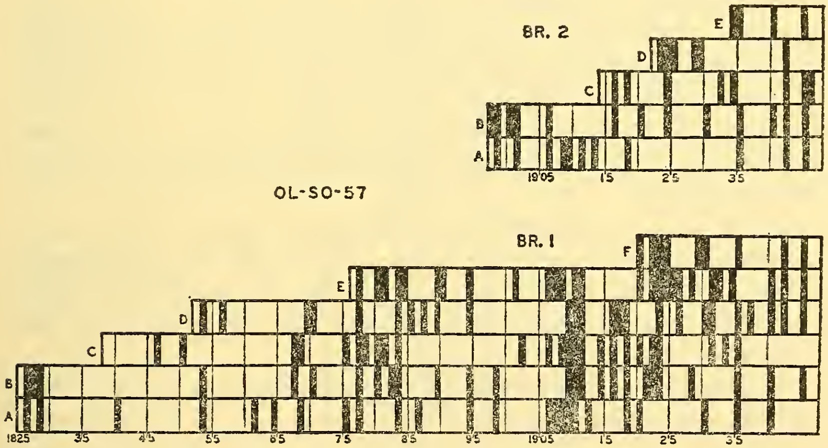


FIG. 56.—Lack of circuit uniformity around each section, both branches of OL-SO-57. A shaded rectangle indicates a trend disagreement, or reversal, in relative thicknesses between growth layers somewhere on the circuit, as represented by measured radii, of the particular section.

tion 1-F, the years with opposed trends on two consecutive sections of Branch 1 number 16 out of 123 years; on three consecutive sections, 2 out of 110 years; on four, 5 out of 96 years; on five, 3 out of 72 years. Opposed trends isolated on one section out of three on Branch 1 number 19 out of 110 years; on one out of four, 18 out of 96 years; on one out of five, 18 out of 72 years. These figures emphasize the localization of reversals. In the first four sections of Branch 1, 96 years, there are 49 years bearing no reversal in any section; in the first five sections, 72 years, there are 27 years bearing no reversal in any section. If the sections are considered singly, opposed trends come out as follows:

	%		%
1-A	19.7	1-D	26.0
1-B	20.5	1-E	37.5
1-C	23.6		

The inner portion of the branch, therefore, has fewer reversals than the mid or outer part.

Examples of opposed trends isolated on one section of Branch 2 are not cited because the sequences are too short to be of great significance.

Figure 57 compares skeleton plots of OL-SO-57 with its two branches. The similarities are striking, and one can say with some justification that the branches agree better with their trunk than some of the trunk sections agree among themselves or the trunk does to the regional standard. However, the branches appear to be more delicate recorders than the trunk in that more growth layers are relatively thin.

In the two branches the strictly diagnostic growth layers maintain relationships to adjacent growth layers except for the following cases in Branch 1: 1927 is thicker than 1928 on 1-B; 1913 is thicker than 1914 on 1-C; 1900 is thicker than 1901 on all sections; and 1845 is thicker than 1846 on all sections.

Growth-layer thicknesses.—The left-hand portion of table 41 details growth-layer thicknesses on the radii of all sections for both branches. The down radius on each section of each branch and on the average contains the thickest portions of the growth layers. In Branch 1 the up-west radius (both branches emerged on the south side of the trunk) equals or exceeds the up-east radius on all sections and the average except one, section 1-D. In Branch 2 the up-east radius equals or exceeds the up-west radius in thickness of growth layers for all sections and the average.

Average departure.—Figure 58 gives the average departures of the various branch sections along three radii from the mean of the particular radius on both branches. These departures contrast with those for the trunk shown in figure 28. With the exception of Branch 1, B to E, the departures section by section appear to exceed those of the trunk.

Average departure for each radius on each section of both branches is given on table 41. In Branch 1, the least differences around the

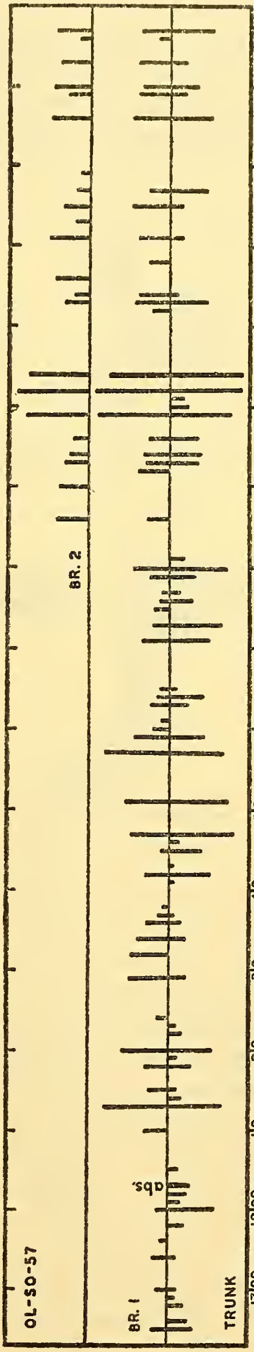


FIG. 57.—Skeleton plots of the two branches of OL-SO-57 compared to the trunk. Inked lines appear on the years whose growth layers are strikingly thin; the longer the line the thinner the growth layer.

circuit are on both the outermost section and the innermost two. All values are high in comparison to the trunk except for section 1-F. In Branch 2, the outermost section also has the least difference in average departure around the circuit, but here the innermost section has the highest difference. Differences in Branch 2 are much less than in Branch 1.

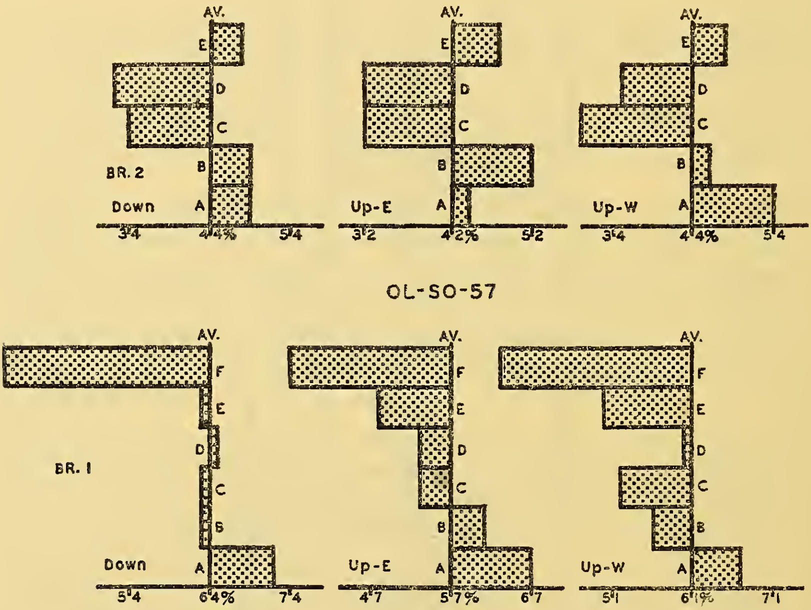


FIG. 58.—Columnar diagrams, three radii all sections of both branches, OL-SO-57, to show average departure from the radius mean. Above the mean to the right and below to the left of the vertical mean line.

Table 44 sets forth the average departures for the branch sections as units. On Branch 1 the section averages are lower than the mean for all sections except the inner two; on Branch 2 the two inner and the outer sections are higher than the mean. These departures are shown on figure 59 A. A comparison with figure 29 (the trunk of OL-SO-57) indicates little in common except that the outer part of Branch 1 has low average departure in much the same fashion as does the upper part of the trunk. Sections T-5 and T-6 have higher than normal average departure for the trunk as a whole, and Branch 1 likewise has average departure higher than the trunk. Sections T-9 and T-10 and Branch 2 have lower than normal average departure for the trunk as a whole. Thus a slight relationship exists between a branch and the portion of the trunk in the immediate vicinity of the branch emergence.

Average departure for Branch 1 is 56.2 percent and for Branch 2, 41.9 percent. These figures compare favorably with the trunk whose average departure is 49.9 percent.

Average variation.—Sectional variations along three radii from the mean of each radius are plotted on figure 60 for the two branches.

TABLE 44.—*Circuit uniformity, branches of OL-SO-57. Sectional averages of thickness, departure, variation, departure from mean variation, and circuit agreement*

Section	Average growth-layer thickness *mm.*	Average departure %	Average variation %	Average departure from mean variation %	Trend agreements *No.*	Trend disagreements *No.*	Circuit agreement %
1-A	0.38	66.0	57.1	36.2	132	32	80
1-B	0.46	56.5	51.5	31.0	98	25	79
1-C	0.46	53.4	49.3	28.7	84	26	77
1-D	0.40	52.9	41.0	24.8	71	25	74
1-E	0.33	51.8	38.7	30.7	45	27	62
1-F	0.50	34.1	31.9	22.9	19	9	68
2-A	0.51	46.9	42.7	23.0	53	14	76
2-B	0.52	46.8	39.5	22.9	38	13	75
2-C	0.64	31.8	31.6	17.0	26	8	76
2-D	0.51	31.3	31.0	22.6	20	6	77
2-E	0.41	44.3	40.5	22.8	10	4	72
Average*:							
Branch 1..	0.414	56.2	48.5	30.7	...	...	75
Branch 2..	0.528	41.9	38.4	21.9	...	...	77

* See note to table 10, page 46.

For Branch 1, the graphs have the same general form; the innermost section possesses the highest variations and the outermost the lowest. Sections B and C do not bear uniform relationships to their respective radius means. For Branch 2, the graphs do not have the same general form; the innermost section possesses the highest variations on all three radii and the outermost section even higher on two radii. Sections B and E do not bear uniform relationships to their respective radius means.

Table 41 gives the average variation for each radius of each section for both branches. Greatest differences of variation from radius to radius on a section exist on Branches 1-B and 2-E. These differences among radii appear to be somewhat greater in relation to

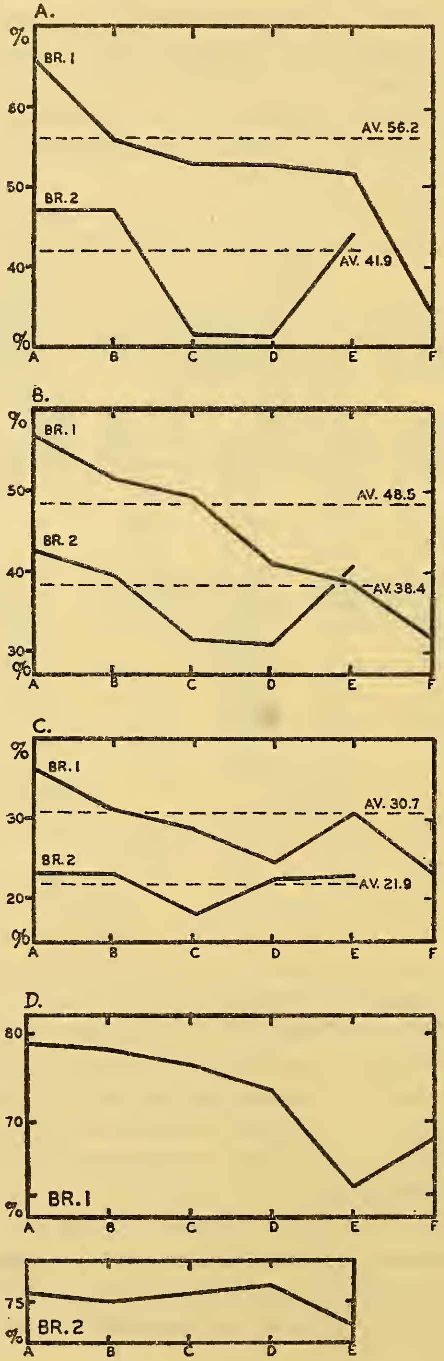


FIG. 59.—Circuit uniformity, all sections both branches, OL-SO-57. Graphs of average departure (A), average variation (B), average departure from mean variation (C), trend agreement for both branches of OL-SO-57 (D).

the trunk in the immediate vicinity of the branch in the case of Branch 1 and slightly less in the case of Branch 2.

Table 44 gives the average variations for the branch sections as units. On Branch 1 the inner three sections have average variations higher than the branch mean and the outer three have lower; on Branch 2 the two inner and the outer sections are higher. These relationships resemble those of average departure. Figure 59 B shows average variations for the sections. A comparison of this graph with that of figure 29 B for the trunk reveals a rather decided dissimilarity and also shows that the branches have a greater fluc-

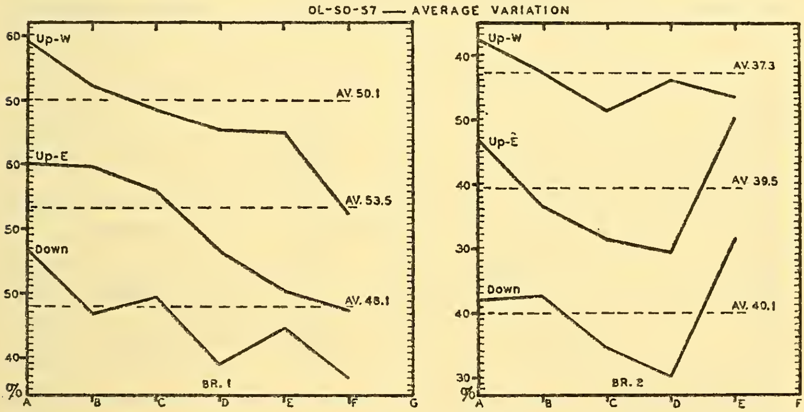


FIG. 60.—Circuit uniformity in average variation, three radii both branches, OL-SO-57.

tuation from section to section than does the trunk. Sections T-5 and T-6 have average variations equal to or higher than normal; Branch 1 has higher average variation than the normal for the trunk. Sections T-9, T-10, and Branch 2 have average variation lower than that of the trunk. Thus, the relationship between a branch and the portion of the trunk from which it emerges is the same for average variation as it is for average departure.

Average variation for Branch 1 is 48.5 percent and for Branch 2, 38.4 percent. As in the case of average departure, the figures for average variation in the branches compare favorably with the average of the trunk, 41.4 percent.

Average departure from mean variation.—Figure 61 gives the average departure from mean variation of the three radii from the respective radius means for the two branches. For Branch 1, the graphs have nearly identical forms, the differences being chiefly the relation of the radius to its mean on any one section. Section 1-A has the highest value and 1-F the lowest. For Branch 2, the graphs do not resemble each other to the extent that they do in Branch 1. Section 2-A has the highest value and 2-C the lowest, a condition different from that in Branch 1. Sections 1-B, 1-C, and 2-B possess values closer to the mean for the branch than do any of the other sections. In other words, a branch section taken somewhere between 2 or 3 feet out from the trunk represents the entire branch insofar as average departure from mean variation is concerned.

Table 41 gives the data upon which figure 61 is based—the data for each radius of each section for both branches. Greatest differences

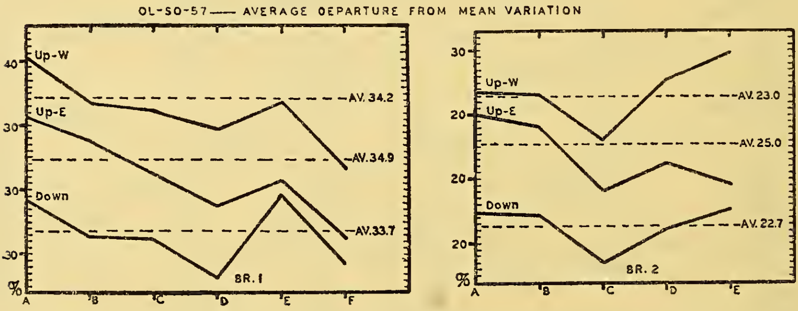


Fig. 61.—Circuit uniformity in average departure from mean variation, three radii both branches, OL-SO-57.

among the three radii of any one section come at the outer extremities of the branches and near the inner portions. The inner sections have values closer to the branch mean than do the mid or outer sections. Here, as in the case of average variation, branch values appear to be somewhat greater than the values for the trunk sections in the immediate vicinity of the branch emergences.

Average departure from mean variation for the branch sections as units is shown in table 44. In Branch 1, only the two inner sections have values higher than the mean; in Branch 2, all except the middle section have values higher than the branch mean. These relationships resemble roughly those of average departure and average variation. Data from table 44 are shown on figure 59 C. The two graphs show little similarity to each other or for that matter little similarity to the graph for the trunk (fig. 29 C). Branch 1 resembles T-5 and T-6 in having an average higher than that of the trunk as a whole, whereas Branch 2, T-9, and T-10 have averages below the trunk average. Thus, in this relation to the trunk, average departure, average variation, and average departure from mean variation resemble each other.

Average departure from mean variation for Branch 1 is 30.7 percent and for Branch 2, 21.9 percent. These figures compare with 26.2 percent for the trunk as a whole.

Summary.—Generalized averages for sections in each branch and for the branches as a whole are assembled in table 44 where the branch averages allow for the progressively fewer growth layers in the outer sections. The progression of values outward on both branches is worthy of note.

Summary data for the two branches as units have been gathered into table 42, where they are compared with trunk data. Consistent with morphological relationships, growth-layer thicknesses average much less in the branches than in the trunk. Thicknesses in Branch 1 average less than in Branch 2, but the trunk near Branch 1 averages greater than it does near Branch 2. The maximum difference among the three radii of Branch 1 is greater than that of Branch 2 but corresponds to an average thickness less than that of Branch 2. Higher values for Branch 1 accompany lower values in the adjacent trunk, whereas lower values for Branch 2 accompany higher values in the trunk sections where the branch emerges.

Insofar as average departure, average variation, and average departure from mean variation are concerned, the relations of the values for the two branches are roughly maintained by the particular trunk sections nearest the branches. Circuit agreement in the branches is less than in the trunk as a whole or in sections adjacent to the branches. Branch 2 has a higher degree of uniformity (i.e., lower numerical values for the parameters) among its growth layers around the circuit than the trunk; Branch 1 has a lower degree of uniformity (i.e., higher numerical values for the parameters with the exception of circuit agreement) than the trunk.

If the records of the two branches were combined and if the conclusions drawn from this study could be applied to all branches, then the trunk could be considered to give us a generalized record combining the influence of all branches, each of which contains its own detailed record.

BRANCHES OF TREE OL-S-62

Branch 1 emerged from the southwest side of the trunk between sections T-6 and T-7, 27 feet above ground. Branch 2 emerged on the northwest side between T-10 and T-11, 45 feet above ground.

Figure 62 shows the position of the measured radii in the branches of OL-S-62 as well as in those of OL-SO-57. Because of the nature of growth in branches, the down radius in the case of OL-SO-57 branches carried growth-layer thicknesses at their maximum for the circuit. The positions of the radii have been changed for the branches of OL-S-62, zero degrees designating the up-radius, and 120 and 240 degrees the radii clockwise from 0 degrees as one faces outward on the branch.

Data concerning the positions of the branch sections and the number of growth layers in each are set forth in table 5.

Absolute thickness.—Figure 63 compares the general growth-layer thicknesses, in millimeters, of each of the two branches with

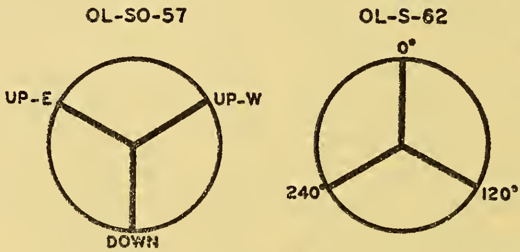


FIG. 62.—Position of measured radii in branches of OL-SO-57 and OL-S-62.

the trunk. Details of the three graphs are fairly similar; general fluctuations are not quite so similar. There are instances where the two branches have coincident fluctuations that do not correspond with the trunk and other instances where one branch agrees with the trunk but not with the other branch. Overall agreement among the three graphs of OL-S-62 does not seem to be of as high an order as that of OL-SO-57.

The thickest portions of growth layers are on the 120-degree radius for 38 percent of the cases and on the 240-degree radius for 45 percent. This leaves 13 percent for the cases in which the up-radius is thickest (table 45). Except for sections 1-F, 1-H, 2-A, and 2-D, the 240-degree radius has generally the thickest portions of growth layers. Table 45 shows the consistencies and inconsistencies in the position of the thickest portions of the growth layers. From section to section little change in percentage may occur on a particular radius, whereas elsewhere or on a different radius the change may be by a high factor.

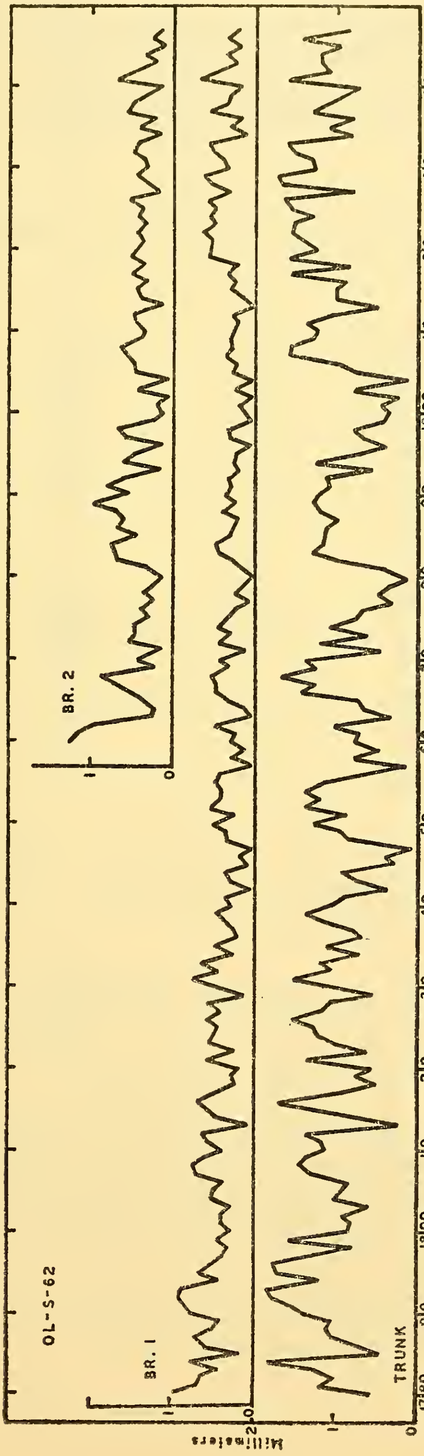


FIG. 63.—Graphs of average growth-layer thicknesses in two branches and trunk of OL-S-62.

Table 45 shows clearly the value of a whole section, or more than one section if available, for a valid record of tree growth, at least in the habitat situation existing in the O'Leary region.

Table 46 sets forth detailed data concerning the branches of OL-S-62.

TABLE 45.—*Percentage occurrence of thickest portions of growth layers on three radii for each branch section, OL-S-62*

Section	0° %	120° %	240° %	Missing %
1-A	14.88	36.30	42.85	5.95
1-B	7.45	35.71	51.86	4.96
1-C	10.85	38.27	46.34	4.51
1-D	18.34	35.97	42.80	2.87
1-E	4.31	39.22	54.74	1.72
1-F	21.50	50.53	25.80	2.15
1-G	20.51	26.28	51.92	1.28
1-H	8.18	45.45	6.36	...
2-A	8.82	48.23	42.94	...
2-B	4.10	48.83	52.05	...
2-C	...	41.07	58.92	...
2-D	64.58	17.70	17.70	...
Average *:				
Branch 1	13	38	45	4
Branch 2	16	40	44	...

* See note to table 10, page 46.

Relative thickness and trend.—Uniformity of trend around the circuit on all radii combined for both branches in percentage is as follows (see also fig. 67 D):

	A	B	C	D	E	F	G	H	Branch average	T-6	T-7	T-10	T-11
Branch 1	73	75	77	75	72	76	64	61	73	73	78	..	..
Branch 2	72	62	55	60	..	..	..	..	63	..	..	82	79

Branch 1 has very nearly the same amount of uniformity around the circuit as the contiguous trunk sections, and Branch 2 does not. No section of Branch 1 has as great a uniformity as does T-7; however, uniformity in the branch sections is nearly as great as, or greater than, in T-6.

The uniformity in sections of Branch 2 is in all cases much less than in either T-10 or T-11.

TABLE 46.—*Circuit uniformity, three radii on all sections of both branches of OL-S-62. Thicknesses in mm., the three parameters of departure, variation, and departure from mean variation in percent*

Section	Average growth-layer thickness, mm.			Average departure, %			Average variation, %			Average departure from mean variation, %		
	0°	120°	240°	0°	120°	240°	0°	120°	240°	0°	120°	240°
1-A	0.30	0.36	0.38	61.2	55.3	52.1	47.9	53.1	43.6	31.9	32.5	28.0
1-B	0.28	0.36	0.38	46.1	48.6	44.5	48.6	47.3	48.1	30.2	29.9	26.3
1-C	0.28	0.35	0.39	50.6	42.1	54.5	52.2	46.0	57.7	35.3	29.1	40.9
1-D	0.30	0.34	0.37	53.4	43.0	47.4	49.6	53.0	52.5	31.4	30.9	30.7
1-E	0.27	0.36	0.42	44.1	44.0	50.1	53.1	45.7	54.3	31.7	28.3	35.9
1-F	0.33	0.42	0.38	42.6	41.0	40.3	44.4	44.5	44.1	29.3	23.7	24.3
1-G	0.26	0.26	0.33	42.1	38.1	45.6	50.4	44.6	49.1	29.7	29.1	31.9
1-H	0.26	0.37	0.37	40.0	40.2	39.5	42.6	39.9	45.3	26.6	23.0	26.5
Average *	0.287	0.353	0.380	49.2	45.2	47.9	49.1	47.8	49.8	31.3	29.1	31.0
2-A	0.31	0.51	0.52	38.2	41.2	44.2	44.4	45.9	48.3	27.4	26.4	31.5
2-B	0.31	0.50	0.50	41.8	36.2	38.7	45.1	44.9	48.8	27.9	26.3	28.3
2-C	0.22	0.41	0.47	49.8	39.5	39.4	55.5	50.6	47.8	36.1	29.6	28.3
2-D	0.34	0.26	0.24	33.5	36.8	34.2	45.0	45.7	43.6	26.7	28.6	28.6
Average *	0.296	0.440	0.452	40.8	38.6	39.8	47.0	46.6	47.5	29.3	27.4	29.4

* See note to table 10, page 46.

A summation of the total number of years with so-called reversals in thickness for OL-S-62 and its parts comes out as follows:

1781-1947 (167 years)		*1864-1947 (84 years)*	
Trunk (12 sections)	96 reversals, 57.5%	Trunk	50 reversals, 59.5%
Branch 1	98 reversals, 58.7%	Branch 2	44 reversals, 52.4%
T-6	44 reversals, 26.3%	T-10	19 reversals, 22.6%
T-7 (1788)	37 reversals, 23.1%	T-11 (1866)	17 reversals, 20.7%

Here, in contrast to OL-SO-57, trunk and branches show nearly the same tendency toward reversal. No comparisons are involved.

Over a period of 160 years Branch 1 shows 96 reversals (60 percent); section T-6, 41 reversals (26 percent); and section T-7, 37 reversals (23 percent). The branch and sections considered together have 112 separate years when reversals occur on one or the other of them. Seventeen reversals are common to Branch 1 and sections T-6 and T-7; 55 reversals are exclusively on Branch 1; 10 reversals are common to the branch and section T-6; 14 reversals are common to the branch and section T-7; 11 reversals are exclusively on T-6; no reversals are exclusively on T-7; and 5 reversals are common to both T-6 and T-7. Branch 2 gives comparable results. Here, as in OL-SO-57, few reversals are unique to the trunk sections singly or together. Conclusions resemble those of OL-SO-57.

A summary of trends (table 47) emphasizes the fact that the

TABLE 47.—*Summary data for trunk and branches of OL-S-62: Thicknesses in mm.; average departure, average variation, average departure from mean variation, and circuit agreement in percent*

Section	Average growth-layer thickness *mm.*	Maximum difference 3 radii *mm.*	Average departure %	Average variation %	Average departure from mean variation %	Circuit * agreement %
OL-S-62:						
Trunk	0.997	0.195	35.8	35.1	20.9	78
Branch 1	0.341	0.097	44.0	46.1	27.7	73
Branch 2	0.399	0.192	36.1	42.8	26.7	63
Sec. T-6	1.03	0.31	37	31	19	73
Sec. T-7	1.08	0.04	34	32	20	78
Branch 1	0.34	0.10	44	46	28	73
Sec. T-10	1.04	0.38	32	34	20	82
Sec. T-11	0.90	0.13	34	33	20	79
Branch 2	0.40	0.19	36	43	27	63

* Based on thickness measures.

trunk or trunk sections do have a somewhat greater uniformity than the branches.

A comparison of trends between branches, between branches and trunk, and between branches and adjacent trunk sections is set forth in table 48. Trends in the two branches, 18 feet apart, average 69 percent, which is slightly higher than for the branches of OL-SO-57.

Agreement between branches and trunk sections just above and below the branch emergences is mixed, not uniform as in OL-SO-57. In fact, agreement between Branch 1 and nearby sections in OL-S-62 falls short to a marked degree of that in OL-SO-57, whereas

TABLE 48.—*Uniformity of trend around the circuit in trunk and branches of OL-S-62*

	%
Branch 1 vs. T-6 and T-7	30
1 vs. T-6 (below Branch 1)	31
1 vs. T-7 (above Branch 1)	36
Branch 2 vs. T-10 and T-11	38
2 vs. T-10 (below Branch 2)	43
2 vs. T-11 (above Branch 2)	41
Trunk vs. Branch 1 and Branch 2	59
Trunk vs. Branch 1	66
Trunk vs. Branch 2	76
Branch 1 vs. Branch 2	69

(Figures given represent the percentage of years when thickness relations remain the same throughout the area of growth layers examined. A single reversal anywhere on a section or on any section decreases directly the percentage of agreement.)

Branch 2 and the contiguous trunk sections have nearly the same values.

The branches of OL-S-62 show a greater consistency of reversal for consecutive sections (fig. 64) than did OL-SO-57 branches.

If we consider years and sections to correspond to those used in figure 56 of OL-SO-57, results with OL-S-62 (fig. 64) may be compared. Years with opposed trends somewhere on two consecutive sections number 15 out of 123; on three consecutive sections, 5 out of 123; on four, 6 out of 123; and on five, 3 out of 115. Opposed trends isolated on one section out of three on Branch 1 number 24 out of 123 years; on one out of four, 21 out of 123 years; and on one out of five, 17 out of 115 years. These figures emphasize, as in the case of OL-SO-57, the localization of reversals. In the first four sections of Branch 1, 123 years, there are 64 years

FIG. 64.—Lack of circuit uniformity around each section, both branches of OL-S-62. A shaded rectangle indicates a trend disagreement, or reversal, in relative thicknesses between growth layers somewhere on the circuit, as represented by measured radii, of the particular section.

bearing no reversal in any section, duplicating almost exactly the situation in OL-SO-57. In the first five sections of Branch 1 there are 51 years out of 115 bearing no reversal in any section, slightly more than in OL-SO-57. If the sections are considered singly, opposed trends come out as follows (1825-1947):

	%		%
1-A	26.0	1-D	26.0
1-B	25.2	1-E	27.8
1-C	19.5		

The inner portion of the branch does not have the advantage of lack of opposed trends as is the case in OL-SO-57. Reversals are more evenly scattered throughout the branch.

Branch 2 has a record too short, it is thought, to lend itself to detailed analysis.

Figure 65, the skeleton plots of OL-S-62 and its two branches, clearly shows how branches agree with each other and with their trunk in the matter of relative thicknesses of their growth layers. Agreement between branches does not appear to exceed agreement between one or both branches and the trunk. Fifteen growth layers receive attention on the branches and more on the trunk, whereas only three growth layers are marked on the trunk and not on either of the branches.

A certain few of the diagnostic growth layers bear atypical relations to adjacent growth layers. In Branch 1: 1943 is thicker than 1944 on A and B at 240 degrees; 1900 is thicker than 1901 almost throughout; 1868 is thinner than 1867 on B at 120 and 240 degrees, on D at 0 degrees, on E at 240 degrees, and on F on all three radii; 1847 is thicker than 1846 or 1848 on D at 240 degrees; 1845 is thicker than 1846 on A at 240 degrees and on B at 120 degrees; 1818 and 1819 reverse their relationships on C; and 1805 and 1806 reverse on A at 120 degrees and on B at 240 degrees. In Branch 2: 1943 is thicker than 1944 on A and B at 120 degrees; 1900 is thicker than 1901 on D on all three radii; and 1899 and 1900 reverse their relationships on B and C (the same is true on 1-E, F, and H).

Growth-layer thicknesses.—Table 46 gives details of growth-layer thicknesses on the three radii of all branch sections. In all cases the 0-degree radius averages the thinnest sequences with these exceptions: Section 1-G at 120 degrees equals 0 degrees, and section 2-D at 120 and 240 degrees falls short of 0 degrees. A majority of sections have thickest sequences on the 240-degree radius. Average

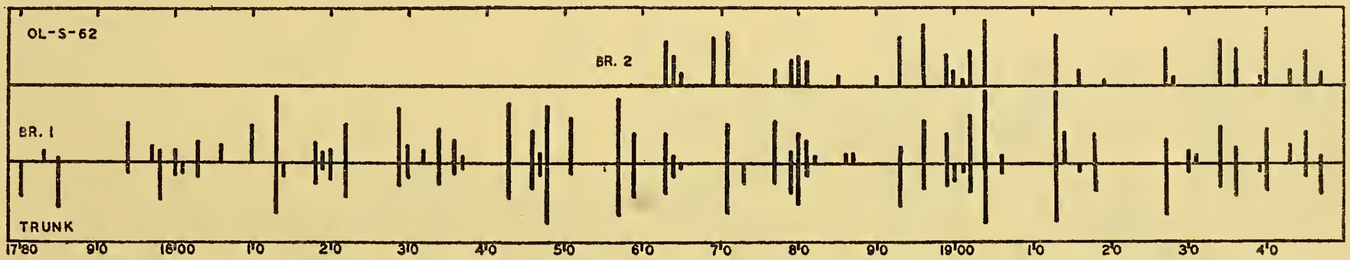


FIG. 65.—Skeleton plots of the two branches of OL-S-62 compared to the trunk. Inked lines appear on the years whose growth layers are strikingly thin; the longer the line the thinner the growth layer.

thickness for Branch 1 is 0.341 mm., and for Branch 2 is 0.399 mm. (table 49).

Average departure.—Figure 66 presents average departures of the branch sections along three radii from the mean of the particular radius for both branches. The contrast with the branches of OL-SO-57 (fig. 58) is striking. Fluctuations on either side of the radius mean are much subdued and, in addition, the averages are considerably less in the branches of OL-S-62. In Branch 1 of OL-SO-57, these

TABLE 49.—*Circuit uniformity, branches of OL-S-62. Sectional averages of thickness, departure, variation, departure from mean variation, and circuit agreement*

Section	Average growth-layer thickness *mm.*	Average departure %	Average variation %	Average departure from mean variation %	Trend agreements *No.*	Trend disagreements *No.*	Circuit agreement %
1-A	0.35	53.0	46.5	28.6	122	45	73
1-B	0.34	43.7	45.5	26.8	120	40	75
1-C	0.34	45.8	49.3	30.6	118	36	77
1-D	0.34	43.9	48.4	27.5	103	35	75
1-E	0.35	42.7	47.8	29.5	84	31	73
1-F	0.38	37.8	42.9	21.7	70	22	76
1-G	0.28	36.8	43.2	29.7	49	28	64
1-H	0.33	36.4	37.2	23.2	33	21	61
2-A	0.45	39.1	43.4	26.4	60	24	72
2-B	0.44	33.4	41.0	25.1	45	27	62
2-C	0.37	38.4	46.8	29.7	38	17	55
2-D	0.28	32.3	39.6	26.0	28	19	60
Average*:							
Branch 1	0.341	44.0	46.1	27.7	...	...	73
Branch 2	0.399	36.1	42.8	26.7	...	...	63

* See note to table 10, page 46.

averages are 64, 57, and 61 percent, whereas in Branch 1 of OL-S-62 they are 49, 45, and 48 percent.

Table 46 gives the average departure of each radius on each section of both OL-S-62 branches. In Branch 1 the least differences around the circuit are on the inner two sections and the outer four; in Branch 2 only the third section has a high difference. Differences in Branch 2 are less than in Branch 1. In general, the differences around the circuit of the various sections are somewhat less than in the branches of OL-SO-57.

Average departures for the branch sections as units and for the entire branches are set forth in table 49. In Branch 1 the outer four sections fall short of the branch average, whereas the inner four alternate above or equal to the branch average; in Branch 2, sections B and D are below the average and A and C above. Figure 67 A illustrates the data of table 49. Branch graphs resemble somewhat the graph for the trunk, section by section, figure 40. Branch 1 has a departure higher than that of the trunk and higher than either T-6 or T-7, although T-6 is higher than the trunk average. Branch 2

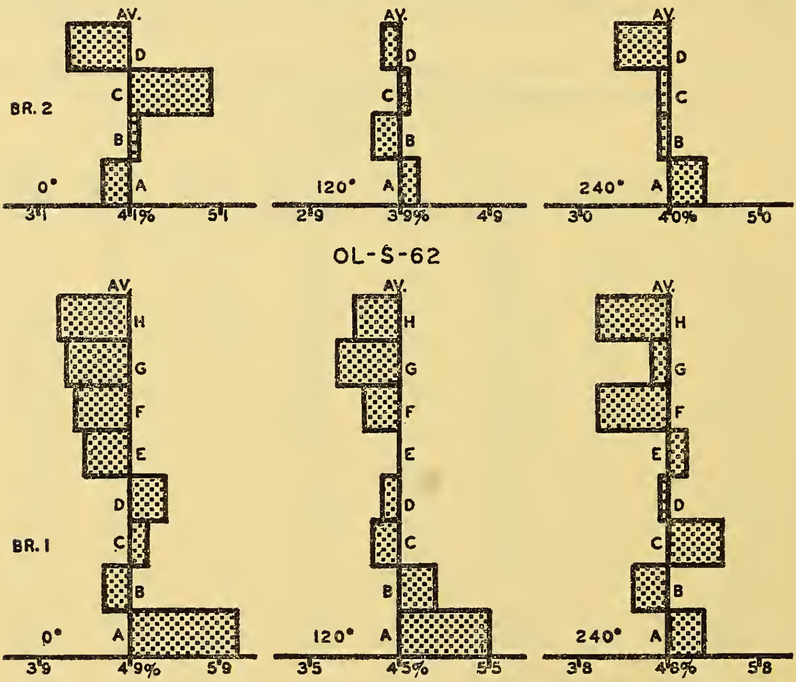


Fig. 66.—Columnar diagrams, three radii all sections of both branches, OL-S-62, to show average departure from the radius mean. Above the mean to the right and below to the left of the vertical mean line.

has a departure somewhat higher than the trunk average and also higher than either T-9 or T-10, both of which are considerably below average. In general form, the graphs of the two branches are nearly identical.

Average departure for Branch 1 is 44 percent and for Branch 2, 36.1 percent (table 49). These exceed average departure for the trunk, 35.8 percent, but not by any excessive amount (table 47).

Average variation.—Figure 68 shows sectional variations from the mean of each radius along three radii for the branches of OL-S-62.

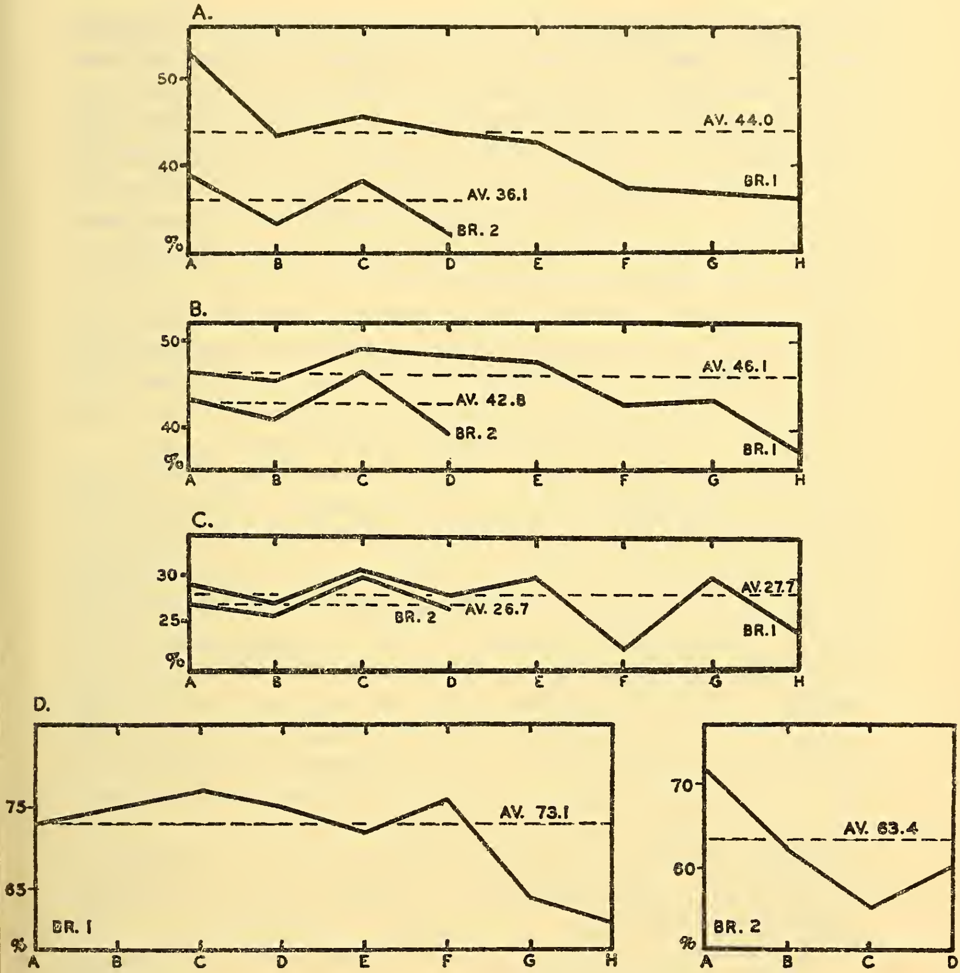


FIG. 67.—Circuit uniformity, all sections both branches, OL-S-62. Graphs of average departure (A), average variation (B), average departure from mean variation (C), trend agreement for both branches of OL-S-62 (D).

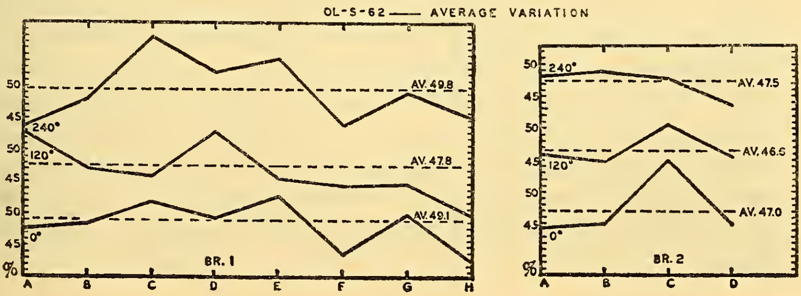


FIG. 68.—Circuit uniformity in average variation, three radii both branches, OL-S-62.

For Branch 1, the graphs for the radii at 0 and 240 degrees resemble each other closely. Sections with the highest variations are near mid-branch and those with lowest are at the inner or outer parts of the branch. The graph for the radius at 120 degrees shows little resemblance to the other two radii. Its highest values fall on sections 1-A and I-D, its lowest on the outer four sections. For Branch 2, the graphs for the radii at 0 and 120 degrees bear a fair resemblance to each other; the graph for the radius at 240 degrees bears only a slight resemblance to the other two.

Table 46 gives the data for the average variation of each radius of each section for both branches. Greatest differences of variation from radius to radius of a section fall on sections 1-A, 1-C, 1-E, and 2-C. Differences among the radii of the branches are greater than among the radii of the trunk sections adjacent to the branches.

Table 49 sets forth average variations for the branch sections as units. The relationships from section to section are not quite so simple in the branches of OL-S-62 as they are in the branches of OL-SO-57. Sections 1-C, 1-D, and 1-E have values higher than the branch mean, the other sections have values lower. In Branch 2, sections A and C have values higher than the branch mean. Figure 67 B shows section variations in the branches. Little or no resemblance exists between these graphs and the graph for the trunk, figure 40 B. Fluctuation from section to section is no greater than it is in the trunk. The average variation of Branch 1 is greater than for trunk sections T-6 and T-7 (fig. 40 B); likewise, the average of Branch 2 is greater than for sections T-10 and T-11.

Average variation for Branch 1 (46.1 percent) and for Branch 2 (42.8 percent), table 49, exceeds the average for the trunk as a whole (35.1 percent), table 47.

Average departure from mean variation.—Figure 69 shows average departure from mean variation of the three radii from the respective radius means for the two branches of OL-S-62. There are certain points of similarity among the graphs. Those for radii at 0 and 240 degrees of Branch 1 resemble each other closely except for the greater amplitude of the 240-degree graph. The graph for the 120-degree radius agrees with the other graphs only in the outer sections. In Branch 2, it is the graphs for the radii at 0 and 120 degrees which resemble each other except for a greater amplitude of the 0-degree radius. Sections closest to the branch mean are not so uniformly placed as in the branches of OL-SO-57. In general, the two inner sections would combine near average values with greater length of record.

Table 46 and figure 69 give the data for each radius of each section for both branches. Greatest differences among the three radii of any one section fall on 1-C, 1-E, and 1-F, and secondarily on the inner two sections of Branch 1. In Branch 2, sections A and C possess marked differences among their three radii. More general statements cannot be made concerning average values from section to section as was done for the branches of OL-SO-57.

Table 49 presents the average departures from mean variation for the branch sections of OL-S-62 as units. Here, as in average variation, relationships are not simple. In Branch 1, sections B, F, and H have values below the branch mean; the remainder of the sections have values higher than the mean. In Branch 2, only section C has a

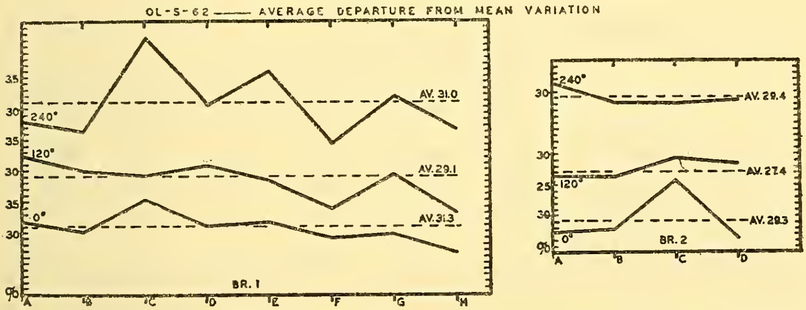


FIG. 69.—Circuit uniformity in average departure from mean variation, three radii both branches, OL-S-62.

value higher than the branch mean. The data of table 49 for both branches are shown on figure 67 C. The graphs are almost identical, Branch 1 resembling the trunk (fig. 40) insofar as both have greatest fluctuations at their extremities.

Average departure from mean variation for Branch 1 is 27.7 percent and for Branch 2, 26.7 percent (table 49). These figures are both higher than the trunk averages of 20.9 percent, a condition unlike that in the branches of OL-SO-57 (table 47).

Summary.—Generalized averages for sections in each branch and for the branches as a whole are contained in table 49, where the branch averages allow for progressively fewer growth layers in the outer sections.

Summary data for the two branches as units are compared with trunk data in table 47. Thicknesses in Branch 1 average less than in Branch 2, but the trunk sections near Branch 1 average greater than those near Branch 2. A maximum difference among the three radii on Branch 1 is lower than that on Branch 2, which corresponds to the relationship between the averages of the pairs of sections in the trunk near the particular branches.

Average departure, average variation, and average departure from mean variation (table 47) are greater than in the trunk; that is, the branches have higher numerical values and less uniformity. These same relationships hold between the branches and adjacent trunk sections. As regards circuit agreement, branches fall short of the trunk as a whole or of the trunk sections adjacent to the branches.

Table 50 carries general data for trees OL-SO-57 and OL-S-62 and their four branches. Growth-layer thicknesses average greater in the trunk of OL-S-62 than in that of OL-SO-57, whereas in the

Table 50.—*Summary data, for comparative purposes, for trunks and branches of OL-SO-57 and OL-S-62*

	OL-SO-57, trunk	OL-S-62, trunk	OL-SO-57, Branch 1	OL-S-62, Branch 1	OL-SO-57, Branch 2	OL-S-62, Branch 2
Average growth-layer thickness, mm.	0.957	0.997	0.414	0.341	0.528	0.399
Average departure, %	49.9	35.8	56.2	44.0	41.9	36.1
Average variation, %	41.4	35.1	48.5	46.1	38.4	42.8
Average departure from mean variation, %	26.2	20.9	30.7	27.7	21.9	26.7
Circuit * agreement, %	79	78	75	73	77	63

* Based on thickness measures.

branches of OL-S-62 they average less than in those of OL-SO-57. Numerical values for average departure, average variation, and average departure from mean variation in OL-S-62, trunk and branches, fall short of the averages for OL-SO-57 and its branches except for average variation and average departure from mean variation in Branch 2. Circuit agreement in all parts of OL-S-62 is less than in OL-SO-57. In general, OL-S-62 has more subdued fluctuations than does OL-SO-57.

It seems clear from a study of table 47 and 48 that the lower branch has higher circuit agreement with the trunk as a unit than does the upper branch, and that the lower branch has slightly higher agreement with adjacent trunk sections. It seems equally clear that no one branch is a completely adequate substitute for the trunk, that no one section is a completely adequate substitute for a branch or a trunk, and that no one radius is identical with any other radius. The closing statement in the summary of OL-SO-57 branches concerning the generalized picture in the trunk and the possibly detailed picture in the branches should perhaps be changed to read *average* picture, because the specific influence of a certain branch at certain times under particular conditions might neutralize rather than subdue or lessen the effect of other branches. From a percentage standpoint, branches possess less uniformity and greater fluctuations than the trunk.

VII. VERTICAL UNIFORMITY

Vertical uniformity refers to the behavior of a growth layer throughout its extent lengthwise of the stem. Much information has already been included under circuit uniformity.

TREE OL-B-42

Absolute thickness.—Average growth-layer thicknesses for sections T-1 to T-9 are plotted on figure 70. The uniformity from section to section from ground level well up into the crown is striking in the general view of the graphs; only details seem to be different.

Three time intervals were selected in order to follow absolute thicknesses from ground level up to T-10; these intervals are 1845-1859, 1875-1884, and 1905-1914 for sectional thicknesses and for radial thicknesses at the southwest. Tables 51 A and 51 B show thickness variations from section T-1 to T-10. Certain years, it can be seen, are represented by widely scattered lenses.

In table 51 A, the average of three radii for years 1845-1859, maximum and minimum thicknesses tend to cluster in the upper half of the trunk with two exceptions: For 1875-1884, maximum thicknesses are rather evenly distributed, whereas minimum thicknesses tend to be in the lower half of the trunk; for 1905-1914, the upper half of the trunk contains twice the number of minima and maxima or more. Along the southwest radius, table 51 B (intermediate in average thickness among the three radii), for 1845-1859, maxima and minima are concentrated in the upper trunk with the exception of four minima in T-4 and T-1; for 1875-1884, more than half the maxima and minima fall in the lower half of the trunk; and for 1905-1914, four times as many maxima and minima fall in the upper half as in the lower half of the trunk. Thicknesses lengthwise of the trunk vary commonly by a factor of 2 and on certain years by as much as 10, taken by trunk averages. Lengthwise along the southwest radius, thicknesses of individual growth layers vary by more than a factor of 2 and commonly by factors of 4, 5, 8, and 9.

Relative thickness and trend.—In spite of the high degree of

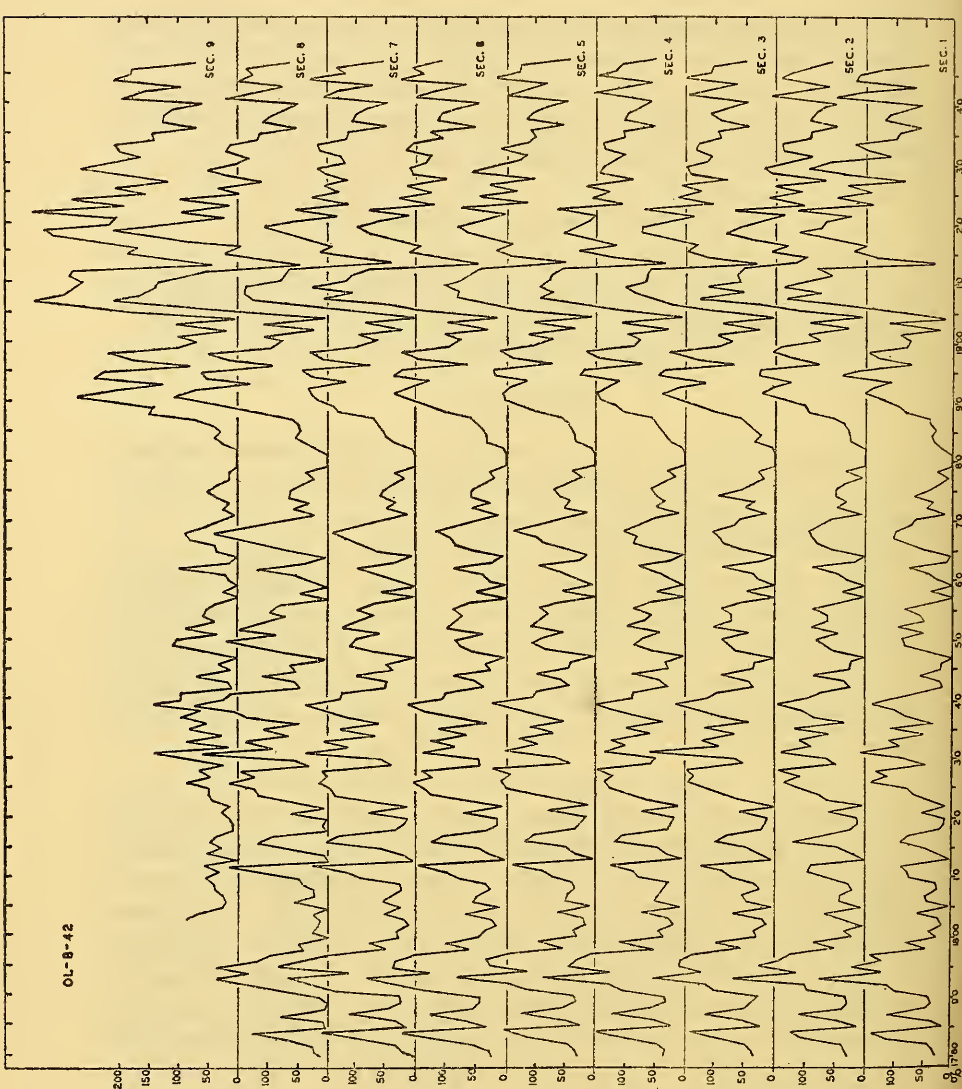


FIG. 70.—Vertical uniformity. Graphs of average growth-layer thicknesses, sections T-1 to T-9, OL-B-42.

visual similarity among the graphs of figure 70, the actual trend uniformity comes out as 73.8 percent for the nine sections when the average sectional thicknesses of the growth layers are compared vertically.

Table 52 shows the effect of vertical trend agreement between the averages of two sections and also the effect of adding more sections. Percentage of agreement decreases from 94 for 2 sections to 63 for

TABLE 51 A.—*Average thicknesses of three radii in the trunk of OL-B-42 for the intervals 1845-59, 1875-84, and 1905-14, in percent*

Section	1845	1846	1847	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858	1859
T-10	76	45	10	41	60	34	09	32	12	25	31	41	0	32	9
T-9	16	30	0	52	105	102	37	86	40	56	55	35	0	22	0
T-8	56	62	0	73	122	169	92	156	104	72	97	77	0	44	0
T-7	42	48	0	67	107	100	61	121	97	71	99	73	0	55	4
T-6	29	31	4	58	75	81	41	97	82	73	85	60	0	47	2
T-5	41	40	3	82	104	90	56	106	93	80	91	66	0	54	7
T-4	30	31	0	57	86	71	44	94	67	56	86	56	0	42	3
T-3	33	31	0	64	78	88	43	101	72	74	89	56	0	45	0
T-2	26	25	0	52	69	81	46	86	63	63	86	52	0	37	0
T-1	20	19	0	40	82	88	53	91	50	57	81	39	0	35	0

Section	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884
T-10	46	47	25	24	0	0	0	6	23	39
T-9	49	33	14	14	0	0	0	0	28	37
T-8	61	43	25	35	0	0	0	11	30	50
T-7	55	39	20	33	0	0	0	5	38	50
T-6	53	36	20	29	0	0	1	3	31	31
T-5	69	46	27	39	0	0	0	7	32	35
T-4	54	37	19	29	0	0	0	7	27	32
T-3	51	35	16	25	0	0	0	2	32	26
T-2	49	36	08	32	0	0	0	0	25	26
T-1	40	24	07	27	0	0	0	20	32	36

Section	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914
T-10	149	194	182	186	174	192	211	175	23	77
T-9	179	251	341	294	279	264	284	281	48	102
T-8	130	248	353	319	292	283	233	208	50	120
T-7	122	185	273	286	285	229	220	212	46	97
T-6	127	187	301	257	320	268	257	228	49	116
T-5	127	176	230	230	251	225	210	194	51	141
T-4	114	166	242	225	243	230	225	207	39	124
T-3	106	174	202	235	250	214	213	207	35	111
T-2	108	171	272	208	262	208	212	204	118	99
T-1	116	192	280	227	283	246	206	230	33	128

TABLE 51 B.—*Average thickness of the southwest radius in the trunk of OL-B-42 for the intervals 1845-59, 1875-84, and 1905-14, in percent*

Section	1845	1846	1847	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858	1859
T-10	108	51	14	32	60	44	0	25	9	32	30	41	0	39	0
T-9	37	26	0	54	88	99	43	65	37	45	57	42	0	27	0
T-8	88	106	0	98	166	255	134	193	131	106	121	90	0	49	0
T-7	50	47	0	73	116	113	60	134	76	69	97	73	0	51	11
T-6	37	37	11	70	89	85	44	101	85	85	90	72	0	74	6
T-5	41	45	0	75	102	78	47	97	83	66	92	62	0	56	0
T-4	29	22	0	67	84	69	27	74	40	42	70	46	0	39	0
T-3	34	33	0	81	86	90	57	99	80	75	84	60	0	51	0
T-2	29	21	0	54	83	80	47	87	65	59	92	44	0	31	0
T-1	10	12	0	43	70	89	53	100	54	45	71	37	0	32	0

Section	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884
T-10	44	41	21	32	0	0	0	18	18	51
T-9	51	35	14	22	0	0	0	0	29	29
T-8	47	40	25	38	0	0	0	20	30	57
T-7	58	47	21	29	0	0	0	6	47	50
T-6	60	40	25	41	0	0	2	10	28	41
T-5	63	39	27	30	0	0	0	13	29	35
T-4	53	28	13	26	0	0	0	20	24	34
T-3	56	42	15	27	0	0	0	5	42	32
T-2	45	35	0	28	0	0	0	0	30	22
T-1	35	28	9	22	0	0	0	24	36	39

Section	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914
T-10	162	171	161	152	170	146	168	161	26	78
T-9	190	340	426	372	311	254	270	287	8	69
T-8	125	209	311	254	280	273	156	166	38	98
T-7	149	206	284	273	275	223	222	212	39	79
T-6	134	157	202	237	253	223	209	201	64	158
T-5	120	160	203	216	220	230	205	198	76	170
T-4	135	162	190	180	205	212	210	183	48	157
T-3	101	162	81	209	234	186	211	195	22	70
T-2	86	158	272	198	244	184	209	182	50	136
T-1	112	173	244	182	275	214	188	243	40	171

12 sections. Among the radii (table 53), the southwest radius has the highest vertical agreement, 63 percent, whereas the average of the three radii is 73 percent. The lower portion of the trunk, T-1 to T-5, has 83 percent agreement, and the upper portion, T-8 to T-13, has 75 percent.

More detailed data on trend agreements vertically in OL-B-42 are given in table 54. In the case of 10 sections, 5 is the maximum

TABLE 52.—*Vertical uniformity, trunk of OL-B-42. Trend agreement with an increasing number of sections, based on average sectional thicknesses of the growth layers*

Comparison of:	Percent
2 sections (267 years)	94
3 sections (254 years)	90
4 sections (238 years)	84
5 sections (225 years)	84
6 sections (220 years)	81
7 sections (193 years)	79
8 sections (178 years)	76
9 sections (146 years)	75
10 sections (104 years)	68
11 sections (49 years)	67
12 sections (30 years)	63

TABLE 53.—*Vertical uniformity, OL-B-42. Trend agreement for the three radii, the average of three radii, and lower, mid, and upper trunk*

	Percent
All sections (267 years):	
North radius	57
Southeast radius	60
Southwest radius	63
Average of 3 radii	73
Average of 3 radii:	
Sections 1-5 (267 years)	83
Sections 5-9 (218 years)	80
Sections 8-13 (146 years)	75

number of possible disagreements. The table shows clearly that disagreements in trend are localized; for instance, the greatest number of disagreements, or reversals, occur on one or two sections only. Out of 104 years in 10 sections, reversals occur in 5 sections on 3 years on the north radius, 1 year on the southeast radius, and 2 years on the southwest radius. This contrasts with the figures for reversals on 1 section out of 10: 17 on the north radius, 14 on the southeast radius, and 17 on the southwest radius.

Specific years experiencing reversals of relative thicknesses where

TABLE 54.—*Vertical uniformity, trunk of OL-B-42. Number and percentage of opposed trends on each of three radii using 10 and 6 to 8 sections*

	North		Southeast		Southwest	
	years	*%*	*years*	*%*	*years*	*%*
Out of 10 sections (104 years)—						
Reversals on:						
5 sections	3	2.9	1	1.0	2	1.9
4 sections	9	8.6	6	5.7	7	6.7
3 sections	6	5.7	8	7.6	4	3.8
2 sections	12	11.5	13	12.5	12	11.5
1 section	17	16.3	14	13.5	17	16.3
Out of 6 to 8 sections (218 years)—						
Reversals on:						
4 sections	6	2.7	3	1.3	5	2.2
3 sections	11	5.0	17	7.7	10	4.5
2 sections	25	11.4	22	10.0	26	11.9
1 section	30	13.7	39	17.9	25	11.4

10 or 6 to 8 sections are considered for the three radii are listed as follows:

Out of 10 sections (1844-1947)—104 years—north radius:

Reversals on:				
5 sections	4 sections	3 sections	2 sections	1 section
1846	1854	1850	1855	1852
1921	1884	1875	1866	1853
1935	1885	1912	1870	1856
	1895	1919	1873	1861
	1908	1929	1878	1864
	1909	1946	1882	1867
	1916		1889	1868
	1933		1892	1869
	1945		1901	1872
			1910	1876
			1911	1887
			1931	1890
				1898
				1900
				1907
				1920
				1939

*Out of 6 to 8 sections (1730-1947)**—*218 years—north radius:*

Reversals on:

4 sections	3 sections	2 sections	1 section
1807	1768	1734	1732
1809	1771	1744	1735
1846	1801	1745	1737
1884	1885	1759	1757
1895	1908	1776	1760
1916	1912	1777	1770
	1919	1781	1772
	1921	1782	1774
	1933	1803	1779
	1935	1819	1780
	1946	1827	1790
		1828	1792
		1830	1796
		1843	1797
		1854	1799
		1870	1810
		1873	1812
		1875	1817
		1882	1820
		1892	1826
		1901	1850
		1909	1853
		1929	1855
		1931	1867
		1945	1872
			1887
			1898
			1900
			1920
			1939

* 8 sections, 1770——.
7 sections, 1755——.
6 sections, 1730——.

Out of 10 sections (1844-1947)—104 years—southeast radius:

Reversals on:

5 sections	4 sections	3 sections	2 sections	1 section
1895	1846	1850	1868	1856
	1854	1875	1873	1867
	1884	1882	1878	1877
	1885	1887	1886	1890
	1889	1893	1891	1907
	1935	1929	1892	1911
		1933	1898	1912
		1938	1900	1916
			1908	1920
			1909	1921
			1910	1930
			1919	1932
			1931	1946
				1947

Out of 6 to 8 sections (1730-1947)—218 years maximum—southeast radius:*

Reversals on:				
4 sections	3 sections	2 sections	1 section	
1841	1732	1734	1744	1873
1884	1737	1735	1759	1890
1895	1768	1738	1767	1908
	1790	1760	1770	1909
	1792	1771	1772	1910
	1796	1781	1773	1911
	1809	1789	1774	1912
	1820	1807	1775	1916
	1826	1808	1776	1920
	1846	1825	1780	1930
	1850	1827	1782	1932
	1854	1875	1786	1938
	1882	1885	1797	1946
	1889	1886	1799	1947
	1929	1887	1803	
	1933	1891	1804	
	1935	1892	1805	
		1893	1806	
		1898	1811	
		1900	1814	
		1919	1819	
		1931	1833	
			1843	
			1856	
			1867	

* 8 sections, 1770——.
7 sections, 1755——.
6 sections, 1730——.

Out of 10 sections (1844-1947)—104 years—southwest radius:

Reversals on:				
5 sections	4 sections	3 sections	2 sections	1 section
1875	1846	1884	1882	1855
1919	1850	1892	1886	1856
	1854	1908	1887	1866
	1868	1912	1893	1867
	1885		1900	1869
	1911		1907	1870
	1938		1910	1873
			1921	1881
			1929	1883
			1933	1889
			1935	1891
			1946	1895
				1909
				1915
				1932
				1934
				1942

Out of 6 to 8 sections (1730-1947)—218 years maximum—southwest radius:*

Reversals on:			
4 sections	3 sections	2 sections	1 section
1774	1790	1732	1747
1768	1796	1734	1760
1777	1820	1738	1776
1846	1830	1745	1782
1875	1841	1759	1784
	1850	1775	1801
	1868	1797	1803
	1892	1807	1808
	1908	1809	1812
	1919	1819	1843
		1825	1867
		1826	1869
		1827	1870
		1828	1873
		1854	1881
		1884	1882
		1885	1891
		1886	1895
		1887	1900
		1893	1907
		1910	1915
		1911	1921
		1912	1934
		1929	1938
		1933	1946
		1935	

* 8 sections, 1770——.
7 sections, 1755——.
6 sections, 1730——.

Figure 71 gives details on the localization of reversals in time and in position in the trunk for the time interval 1800-1899. Out of 100 years, 12 have reversals in relative thicknesses longitudinally on all three radii of one or more sections; 27 out of 100 have reversals on two radii of one or more sections; and 58 out of 100 have reversals on one radius of one or more sections. In the span 1800-1899 there are 39 years in which the trend in relative thicknesses is uniform throughout the trunk as represented by 8 to 10 sections. A significant fact appears from the reversals as shown on figure 71: growth layers considered to be strictly diagnostic do not appear on the figure. Table 55 summarizes figures 71, 74, and 76.

It is a matter of concern whether or not any annual increment maintains its relative thickness throughout the entire trunk. One would not be surprised if 5 percent or less of the growth layers rigorously maintained their relative thicknesses.

Total reversals on the lower nine sections of OL-B-42 on the three radii for 1800-1899 are:

	T-1	2	3	4	5	6	7	8	9	Total
No.	39	19	28	24	27	17	29	31	56	270
Percent	13	6.3	9.3	8	9	5.7	9.7	10.3	19	10 (average)

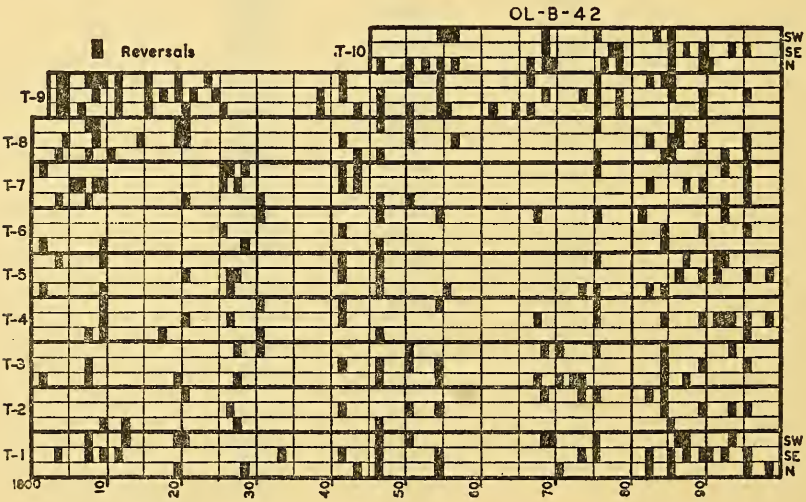


Fig. 71.—Location of specific reversals, or nonuniformity, by radius and by section, 1800-1899, in OL-B-42.

Table 55.—*Vertical uniformity, trunks of OL-B-42, OL-SO-57, and OL-S-62, 1800-1899. Number and percentage of opposed trends (or reversals) on one or more radii for 8 to 10 sections*

	10 sections						8-10 sections	
	All 3 radii		2 radii		1 radius		No reversals	
Tree	*years*	%	*years*	%	*years*	%	*years*	%
OL-B-42	12	1.3	27	5.6	58	15.7	39	39
OL-SO-57	11	1.4	27	4.1	51	14.7	47	47
OL-S-62	15	2.7	25	6.9	48	14.7	45	45

Percentages are based on 300 possibilities—100, the number of years, multiplied by 3, the number of radii. The basal section and the upper sections have the highest percentage of reversals, although this is not uniformly true. Because T-9 has only 98 years, the grand total of possibilities is 2,694; thus, 270 total reversals equals 10 percent, or longitudinal agreement of 90 percent. This 90 percent vertical agreement in trend contrasts with the 80 percent of overall circuit agreement. Time spans of freedom from reversals center for the 8 to 12 years around 1815, 1835, and 1861.

Growth-layer thicknesses.—Table 10 (p. 46) gives differences in growth-layer thicknesses along the trunk. Among sections T-1 to T-11, no overall maximum occurs, though there are peaks on the north radius on T-1, T-4, T-8, and T-10; on the southeast radius on T-1, T-3, T-5, and T-10; on the southwest radius on T-1, T-5, T-8, and T-11; and among the averages on T-1, T-4, T-8, and T-11. Absolute minimum among the first 11 sections does not occur among the three radii of the same section. In general, the lower four or five sections show the greatest average thickness.

Table 56.—*Percentage of thick portions of growth layers on the three radii of all trunk sections of OL-B-42, OL-SO-57, and OL-S-62*

	OL-B-42			OL-SO-57			OL-S-62			Missing gls.		
Section	N. %	SE. %	SW. %	N. %	SE. %	SW. %	N. %	SE. %	SW. %	N. %	SE. %	SW. %
T-10	54.4	37.9	4.1	90.1	1.6	4.9	65.4	31.8	2.7	3.8	3.2	...
T-9	65.6	11.2	17.0	77.9	11.2	8.5	5.2	80.9	13.8	6.1	2.1	...
T-8	55.5	10.6	28.8	75.6	14.3	7.4	70.2	12.4	17.3	5.0	2.6	...
T-7	70.8	11.5	13.9	51.6	38.4	9.2	37.5	31.9	30.4	3.6	0.6	...
T-6	45.7	7.4	45.0	87.2	2.8	8.8	74.7	10.3	14.8	1.8	1.1	...
T-5	56.8	14.9	25.5	85.5	9.9	2.4	6.3	37.6	56.5	2.6	1.9	...
T-4	61.3	23.8	12.6	77.0	11.0	11.0	13.5	52.5	33.4	2.1	0.9	0.4
T-3	76.4	15.1	5.6	74.8	17.9	6.3	41.7	44.0	13.7	2.8	0.8	0.4
T-2	67.7	2.4	27.0	76.2	10.8	11.2	45.9	35.6	17.5	2.8	2.0	0.8
T-1	58.0	9.8	30.4	84.4	5.6	8.6	50.4	41.9	7.2	1.6	1.2	0.4
Average * ..	61.3	13.2	21.9	77.8	12.4	8.1	40.2	37.9	21.3	3.2	1.4	0.2

* See note to table 10, page 46.

Table 56 shows the percentage of thick growth layers in the first 10 sections of the three trees and supplements tables 10, 18, and 27. In tree OL-B-42, the thickest portions of growth layers occur most often on the north radius, the only exception being on T-6, where the southwest radius nearly equals the north. The north radius has 61.3 percent of the thick portions of growth layers, the southwest, 21.9, and the southeast, 13.2 percent. Figure 72 illustrates the relation of the thicknesses of the three radii of each section of the three trees. On all sections of OL-B-42, except T-6 and T-10, the area representing the north radius dominates.

Average departure, average variation, and average departure from mean variation have been dealt with under the heading of circuit uniformity.

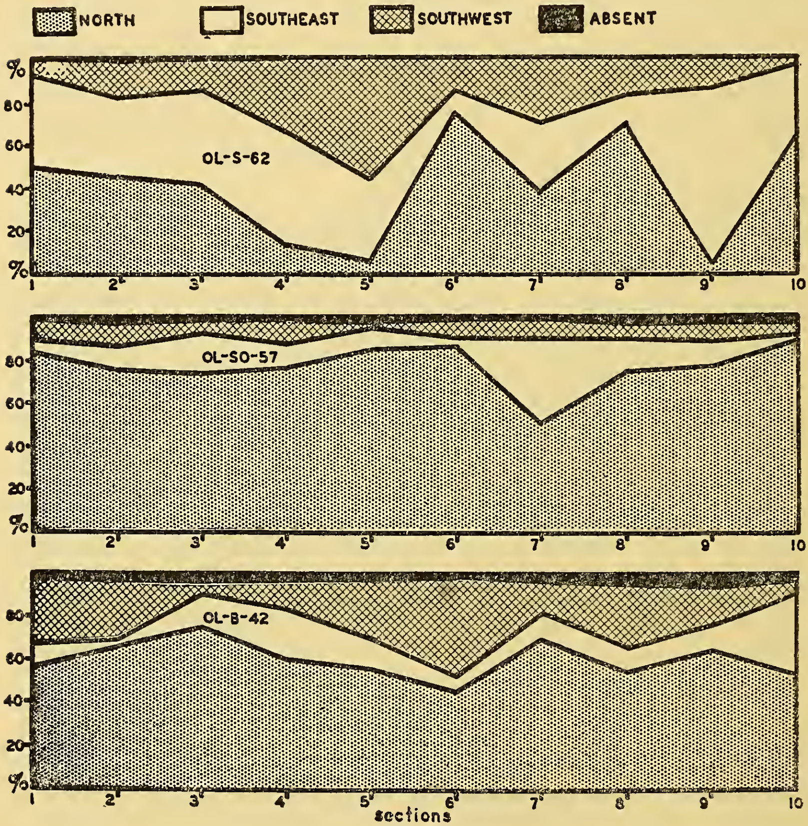


Fig. 72.—Area graphs of growth-layer thicknesses on three radii for 10 sections of OL-B-42, OL-SO-57, and OL-S-62.

TREE OL-SO-57

Absolute thickness.—Figure 73 shows growth-layer thicknesses for sections T-1 to T-9. The overall similarity is striking; slight differences in detail occur from base of tree well up into the crown.

As in tree OL-B-42, three time intervals, 1845-1859, 1875-1884, and 1905-1914, were chosen and the thicknesses of corresponding growth layers arranged to show differences lengthwise of the trunk, tables 57 A and 57 B. Within the range of dates, tree OL-B-42 had seven years represented by scattered lenses, whereas tree OL-SO-57 had two. The average of three radii, tables 57 A and 58, for 1845-1859 shows: Maximum thicknesses dominate the upper four sections and minimum thicknesses the lower four, although T-8 does have

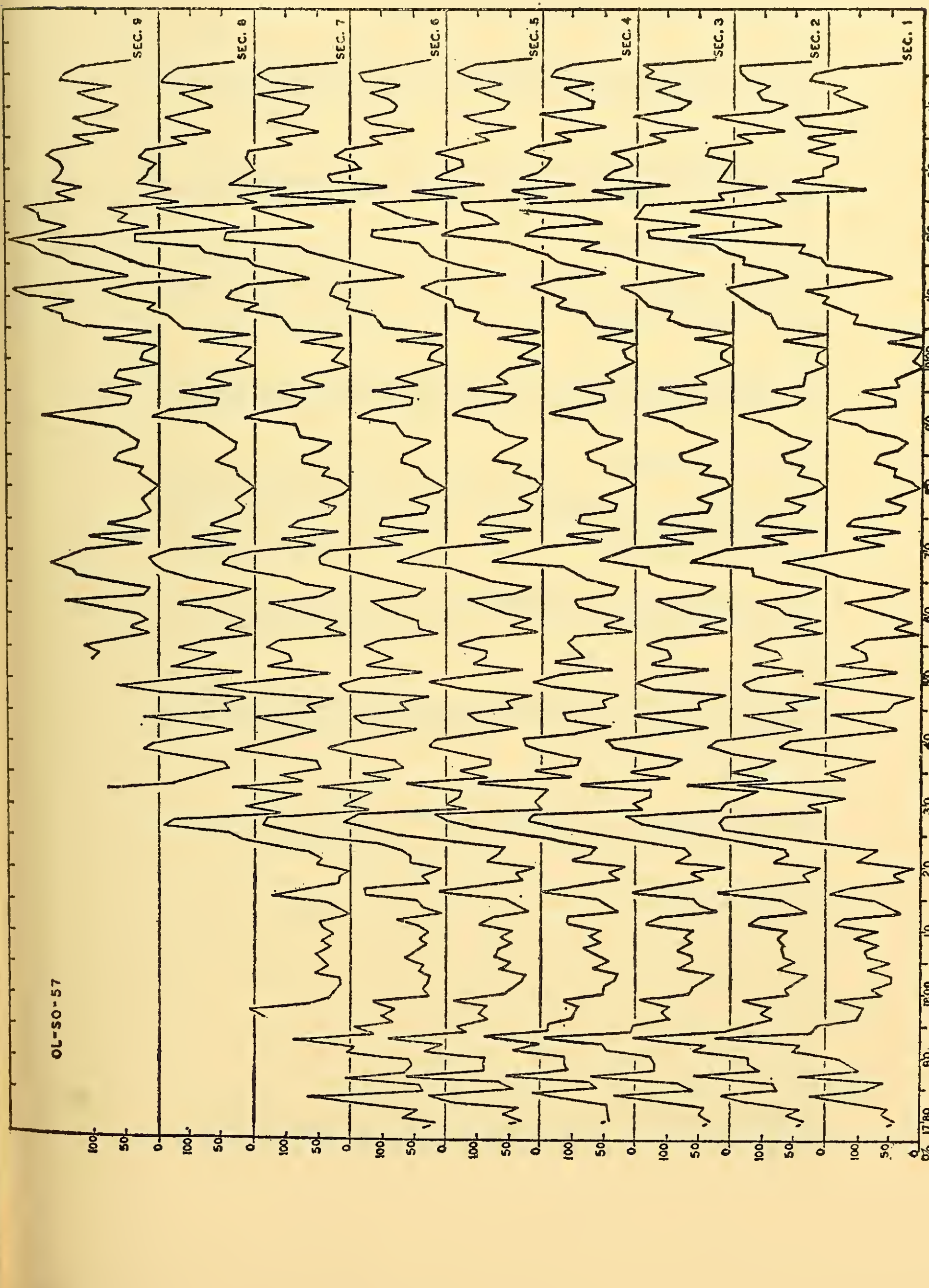


FIG. 73.—Vertical uniformity. Graphs of average growth-layer thicknesses, sections T-1 to T-9, OL-SO-57.

TABLE 57 A.—*Average thicknesses of three radii in the trunk of OL-SO-57 for intervals 1845-1859, 1875-1884, and 1905-1914, in percent*

Section	1845	1846	1847	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858	1859
T-8	40	43	17	147	212	111	17	129	87	62	116	83	4	41	17
T-7	58	68	28	154	210	131	31	125	95	97	127	112	9	37	22
T-6	60	68	29	152	163	126	39	121	83	98	126	98	11	46	46
T-5	44	50	16	119	170	133	28	102	85	84	128	91	4	42	15
T-4	44	47	21	124	159	116	34	122	78	90	103	93	6	45	15
T-3	44	45	6	118	133	107	30	110	84	89	119	91	2	40	6
T-2	42	55	8	113	130	101	35	110	68	74	109	87	...	43	8
T-1	49	39	9	110	164	114	37	125	81	82	105	85	4	36	12

Section	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884
T-8	41	22	17	28	10	...	9	24	29	59
T-7	82	31	26	46	12	1	14	42	36	74
T-6	100	33	29	55	14	...	12	36	41	69
T-5	83	21	17	37	7	...	10	42	34	73
T-4	83	34	30	56	17	...	14	47	47	72
T-3	85	30	27	46	18	...	9	43	32	69
T-2	92	47	37	61	19	...	14	43	37	63
T-1	106	36	25	54	21	3	19	44	44	73

Section	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914
T-8	108	123	132	164	151	204	235	179	69	105
T-7	92	100	108	164	146	192	184	160	65	102
T-6	98	103	112	154	151	180	179	170	69	106
T-5	83	105	100	137	140	167	189	162	59	103
T-4	67	75	81	122	112	146	162	125	52	83
T-3	70	93	91	123	130	141	161	116	46	87
T-2	77	83	92	111	130	146	156	123	57	85
T-1	68	108	106	123	157	151	184	103	50	72

TABLE 57 B.—*Average thickness of the southwest radius in the trunk of OL-SO-57 for intervals 1845-1859, 1875-1884, and 1905-1914, in percent*

Section	1845	1846	1847	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858	1859
T-8	70	94	30	247	329	153	41	176	114	97	143	99	...	46	27
T-7	64	76	35	180	270	153	31	140	114	115	143	110	14	38	23
T-6	60	65	24	165	195	123	45	118	78	101	128	86	...	56	12
T-5	47	49	18	80	168	119	28	108	92	99	131	106	...	33	31
T-4	41	39	11	117	133	98	29	111	64	79	106	84	...	46	...
T-3	51	40	7	128	141	114	20	110	76	92	116	97	...	39	11
T-2	51	50	19	112	123	99	38	107	70	74	123	99	...	38	12
T-1	73	45	15	129	196	101	35	110	68	74	109	87	...	43	8

Section	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884
T-8	41	26	21	34	9	...	...	13	26	53
T-7	85	28	24	38	9	...	9	34	33	66
T-6	68	19	21	38	10	...	15	32	28	55
T-5	74	22	18	39	11	...	16	40	29	47
T-4	80	16	16	43	12	...	9	41	46	68
T-3	58	20	15	35	10	...	...	34	29	54
T-2	87	19	19	49	12	...	15	43	38	69
T-1	79	19	19	39	38	...	21	42	44	62

Section	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914
T-8	106	123	124	147	126	184	164	130	34	64
T-7	92	87	96	167	153	182	182	150	59	92
T-6	100	109	95	128	122	150	173	165	69	111
T-5	78	88	89	120	140	151	178	155	51	101
T-4	72	79	97	177	155	225	235	159	62	117
T-3	76	101	76	152	148	160	216	132	42	103
T-2	70	62	67	116	138	153	145	140	62	83
T-1	73	127	118	149	194	172	218	138	66	70

TABLE 58.—*Vertical uniformity studies. Distribution of maximum and minimum growth-layer thicknesses along the whole trunk on an average and along one radius whose average growth-layer thickness is intermediate among the three radii. Figures in parentheses give the number of maxima, or minima, as the case may be, in relation to the other extreme of the particular dominance*

	Sections averages			SW. radii (B-42 and S-62)	SE. radius (SO-57)	
	1845-1859	1875-1884	1905-1914	1845-1959	1875-1884	1905-1914
OL-B-42:						
10 sections......	Evenly distributed (10 to 10 upper) (2 to 2 lower)	Max. evenly distributed (4 upper, 4 lower) Min. lower half (2 upper, 6 lower)	Evenly distributed upper half (7 to 7) Lower half: 2 max. 3 min.	Upper half: 12 max. 9 min. Lower half 4 min.	Max. upper half (4 to 3) Min. lower half (7 to 3)	Upper half: 8 max. 8 min. Lower half: 2 max. 2 min.
OL-SO-57:						
8 sections.......	Max. upper half (16 to 5) Min. lower half (10 to 0)	Min. upper half (10 to 1) Max. lower half (9 to 1)	Max. upper half (11 to 0) Min. lower half (10 to 1)	Max. upper half (17 to 2) Min. lower half (13 to 1)	Min. upper half (8 to 2) Max. lower half (7 to 3)	Evenly distributed (5 to 5) (5 to 5)
OL-S-62:						
10 sections......	Max. upper half (18 to 3) Min. lower half (12 to 0)	Max. upper half (10 to 0) Min. lower half (11 to 1)	Max. upper half (7 to 1) Min. lower half (8 to 5)	Max. upper half (16 to 6) Min. lower half (10 to 0)	Max. upper half (7 to 2) Min. lower half (10 to 4)	Max. evenly distributed (6 upper, 5 lower) Min. lower half (10 to 5)

four minima and two maxima; for 1875-1884, minima dominate (10 to 1) the upper sections and maxima dominate (9 to 1) the lower four sections; for 1905-1914, maxima dominate (11 to 0) the upper four sections and minima (10 to 1) the lower four, only T-5 failing to show either. These distributions contrast with those of OL-B-42 (table 59) in that for OL-B-42 the first and third time intervals concentrate maxima and minima in the upper half of the trunk, whereas in OL-SO-57 maxima are concentrated in the upper half and minima in the lower half.

TABLE 59.—*Vertical uniformity, trunk of OL-SO-57. Trend agreement with an increasing number of sections, based on average sectional thicknesses of the growth layers*

Comparison of:	Percent
2 sections (256 years)	94
3 sections (236 years)	85
4 sections (221 years)	81
5 sections (200 years)	80
6 sections (175 years)	76
7 sections (150 years)	73
8 sections (114 years)	76
9 sections (94 years)	72
10 sections (60 years)	64
11 sections (38 years)	55
12 sections (25 years)	60
13 sections (19 years)	42
14 sections (11 years)	45

Along the southeast radius (intermediate in average thickness among the three radii) of OL-SO-57 for 1845-1859, tables 57 B and 58 show: Maximum thicknesses dominate (17 to 2) the four upper sections, and minimum (13 to 1) dominate the lower four, with all sections having at least one minimum or maximum; for 1875-1884, minima dominate (8 to 2) the four upper sections, and maxima (7 to 3) the four lower, only T-6 failing to carry either a minimum or maximum; and for 1905-1914, maxima and minima are uniformly distributed (5 to 5 and 5 to 5) between the upper and lower parts of the trunk, with sections T-3, T-5, and T-7 failing to show either a maximum or a minimum. These distributions along a single radius contrast with those of tree OL-B-42 (table 58). OL-SO-57 appears to have a more uniform distribution of thick and thin portions of growth layers throughout its trunk than does OL-B-42.

Thicknesses along the trunk (table 57) commonly vary by a factor of 1½ and on certain years by as much as 5 or 7, taken by trunk averages. Along the southeast radius, thicknesses commonly vary by a factor of 1½ to 2 and individual growth layers by 3, 4, or 5. Overall differences in absolute thickness in OL-B-42 exceed those of OL-SO-57 even though average thickness throughout the trunk of OL-B-42 is less than in OL-SO-57.

Relative thickness and trend.—A trend analysis of the graphs on figure 73 yields an agreement of 71.4 percent. Hence, the visual similarity among the graphs is greater than the actual.

Trend agreements among an increasing number of sections beginning with the two lowest are given in table 59. Percentage of agreement decreases from 94 in a 2-section comparison to 55 for a comparison of 11 sections, a decrease more rapid and of a greater degree than in OL-B-42.

Among the radii (table 60) the north radius has the highest vertical agreement, 68 percent, and the southwest radius the lowest, 62 percent, a condition exactly the opposite to that in OL-B-42 (table 53). An average of the three radii (table 60) comes to 75 percent agreement. The lower trunk, T-1 to T-5, has a vertical trend agreement of 80 percent, whereas the upper, T-7 to T-12, has 85 percent, a situation the reverse of that in OL-B-42 (table 53). In OL-SO-57, the presence of Branch 1 does not decrease agreement, but section T-10, just above Branch 2, adds two years of disagreement to those found in T-1 to T-9.

Table 60.—*Vertical uniformity, OL-SO-57. Trend agreement for the three radii, the average of three radii, and lower, mid, and upper trunk*

	Percent
All sections (255 years):	
North radius	68
Southeast radius	66
Southwest radius	62
Average of 3 radii	75
Average of 3 radii:	
Sections 1-5 (255 years)	80
Sections 5-9 (175 years)	85
Sections 7-12 (114 years)	85

Table 61 gives more detailed information on trend disagreements longitudinally. In 10 sections, 5 is the maximum number of disagreements. It is clear that disagreements in trend, or reversals, are rather severely localized as they were in OL-B-42. Such localization is emphasized by comparing the number of reversals spread over five sections with the number on one section; also by comparing tables 60 and 61.

TABLE 61.—*Vertical uniformity, trunk of OL-SO-57. Number and percentage of opposed trends on each of three radii using 8 to 10 and 4 to 8 sections*

	North		Southeast		Southwest	
	years	*%*	*years*	*%*	*years*	*%*
Out of 8 to 10 sections (108 years)—						
Reversals on:						
5 sections	3	2.8	5	4.6	2	1.8
4 sections	6	5.5	7	6.5	8	11.1
3 sections	4	3.7	6	5.5	6	5.5
2 sections	12	11.1	6	5.5	12	11.1
1 section	20	18.5	12	11.1	16	14.8
Out of 4 to 8 sections (218 years)—						
Reversals on:						
4 sections	4	1.8	5	2.3	6	2.8
3 sections	12	5.5	15	6.9	13	6.0
2 sections	20	9.2	21	9.6	23	10.6
1 section	36	16.5	30	13.8	42	19.3

Years having reversals of relative thicknesses on each of the three radii for either 10 or 8 sections of OL-SO-57 are as follows:

Out of 8-10 sections (1840-1947)—108 years—north radius:*

Reversals on:

5 sections	4 sections	3 sections	2 sections	1 section
1909	1883	1840	1846	1855
1924	1885	1869	1854	1856
1930	1894	1875	1862	1864
	1931	1916	1887	1870
	1945		1890	1877
	1946		1898	1878
			1907	1888
			1920	1889
			1923	1897
			1932	1901
			1935	1902
			1940	1917
				1918
				1926
				1929
				1933
				1934
				1938
				1942
				1943

* 10 sections, 1888——.
9 sections, 1854——.
8 sections, 1840——.

*Out of 4 to 8 sections (1730-1947)**—218 years—north radius:*

Reversals on:				
4 sections	3 sections	2 sections	1 section	
1883	1779	1760	1740	1870
1885	1801	1790	1741	1887
1909	1823	1795	1744	1888
1946	1828	1797	1747	1889
	1837	1803	1750	1890
	1840	1807	1754	1897
	1869	1812	1767	1898
	1875	1832	1770	1902
	1924	1846	1772	1917
	1930	1854	1776	1918
	1931	1862	1792	1923
	1945	1894	1799	1933
		1907	1805	1934
		1916	1822	1938
		1920	1830	1942
		1926	1835	1943
		1929	1839	
		1932	1855	
		1935	1856	
		1940	1864	

* 8 sections, 1834——.
7 sections, 1798——.
6 sections, 1773——.
5 sections, 1748——.
4 sections, 1730——.

*Out of 8-10 sections (1840-1947)**—108 years—southeast radius:*

Reversals on:				
5 sections	4 sections	3 sections	2 sections	1 section
1877	1846	1869	1840	1854
1901	1885	1883	1875	1867
1929	1894	1909	1881	1887
1933	1898	1911	1890	1897
1945	1907	1918	1892	1910
	1923	1942	1906	1916
	1924			1920
				1926
				1930
				1931
				1940
				1941

* 10 sections, 1888——.
9 sections, 1854——.
8 sections, 1840——.

Out of 4 to 8 sections (1730-1947)—218 years maximum—southeast radius:*

Reversals on:

4 sections	3 sections	2 sections	1 section	
1837	1795	1741	1747	1867
1877	1807	1744	1751	1890
1885	1823	1772	1758	1897
1901	1831	1776	1765	1910
1933	1836	1789	1782	1916
	1846	1790	1784	1920
	1869	1798	1786	1930
	1883	1801	1792	1940
	1894	1802	1797	1941
	1907	1812	1799	
	1911	1819	1806	
	1918	1830	1808	
	1924	1832	1810	
	1929	1840	1815	
	1945	1875	1817	
		1881	1822	
		1892	1826	
		1898	1827	
		1906	1828	
		1923	1835	
		1942	1854	

* 8 sections, 1834——.
7 sections, 1798——.
6 sections, 1773——.
5 sections, 1748——.
4 sections, 1730——.

Out of 8-10 sections (1840-1947)—108 years—southwest radius:*

Reversals on:

5 sections	4 sections	3 sections	2 sections	1 section
1890	1854	1883	1844	1840
1945	1894	1885	1846	1862
	1911	1901	1849	1869
	1920	1906	1868	1870
	1923	1907	1875	1876
	1929	1909	1877	1878
	1931		1898	1889
	1933		1916	1897
			1917	1910
			1918	1921
			1922	1924
			1932	1926
				1930
				1940
				1942
				1943

* 10 sections, 1888——.
9 sections, 1854——.
8 sections, 1840——.

Out of 4 to 8 sections (1730-1947)—218 years maximum—southwest radius:*

Reversals on:				
4 sections	3 sections	2 sections	1 section	
1854	1786	1743	1733	1862
1890	1807	1760	1739	1868
1911	1812	1770	1741	1869
1920	1831	1772	1744	1870
1929	1883	1789	1754	1876
1945	1885	1792	1757	1877
	1901	1797	1758	1878
	1906	1798	1776	1897
	1907	1801	1782	1898
	1909	1809	1790	1910
	1923	1817	1795	1916
	1931	1819	1799	1917
	1933	1822	1803	1924
		1823	1805	1926
		1828	1806	1930
		1837	1808	1932
		1844	1810	1940
		1846	1811	1942
		1849	1826	1943
		1875	1830	
		1894	1832	
		1918	1835	
		1922	1840	

* 8 sections, 1834——.
7 sections, 1798——.
6 sections, 1773——.
5 sections, 1748——.
4 sections, 1730——.

Figure 74 gives details on the localization of reversals in time and in position in the trunk of OL-SO-57 from 1800 to 1899. Out of 100 years, 11 have reversals in relative thicknesses along all three radii of one or more sections; 27 out of 100 have reversals on two radii; and 51 out of 100 have reversals on one radius.

From 1800-1899, there are 47 years in which the trend in relative thicknesses is uniform throughout the trunk as represented by 7 to 10 sections. Here, as in OL-B-42, strictly diagnostic growth layers do not show reversals. A comparison of the dates bearing reversals in OL-SO-57 with those in OL-B-42 brings out a lack of agreement among the dates with reversals. A common factor may exist but its identification would be extremely difficult. Table 55 summarizes figure 74 and also figures 71 and 76.

The total number of reversals on the first nine sections of OL-SO-57 on the three radii for 1800-1899 are:

	T-1	2	3	4	5	6	7	8	9	Total
No.	34	21	23	28	17	32	30	21	11	217
Percent ..	11.3	7.0	7.7	9.3	5.7	10.7	10.0	10.6	8.1	8.9 (average)

Percentages here, as with OL-B-42, are based on the number of years multiplied by the number of radii; they come to 300 each for T-1 to T-7, 198 for T-8, and 135 for T-9, or a total of 2,433. Sections T-2, T-3, T-5, and T-9 have the least reversals, with T-5 having half the number of T-1. In OL-B-42, it is T-6 that has the minimum. The average percentage of total reversals, 8.9 percent, is somewhat less than for OL-B-42—10 percent. In OL-SO-57 time spans free of reversals are far less evident than in OL-B-42.

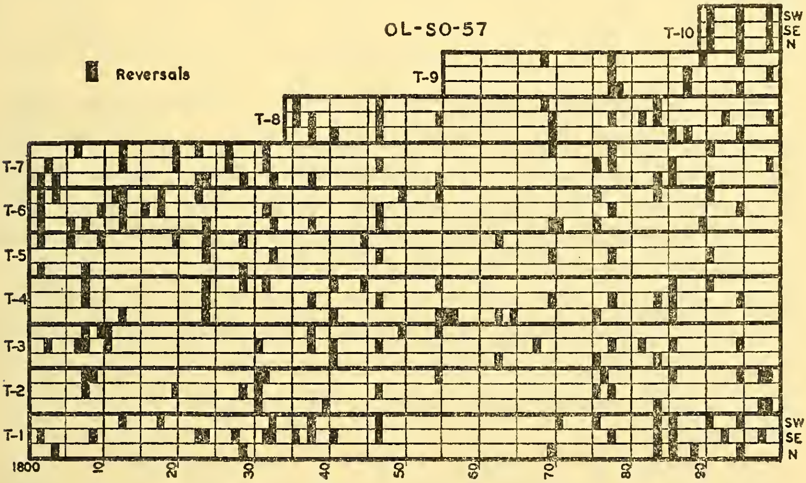


FIG. 74.—Vertical uniformity. Location of specific reversals, or nonuniformity, by radius and by section, 1800-1899, in OL-SO-57.

There are suggestions of fewer reversals centering on 1817 or 1818 and on 1861 or 1862 for something like 10 years at the first interval and 15 to 20 at the second.

Growth-layer thicknesses.—These thicknesses considered longitudinally are given in table 18 (p. 68). No single maximum or minimum occurs on any radius or on the average in sections T-1 to T-12. Maxima exist on the north radius on T-1, T-4, T-8, and T-10; on the southeast radius on T-3, T-4, T-7, T-9, and T-11; on the southwest radius on T-4, T-6, and T-11; and among the averages on T-1, T-5, T-8, and T-10. Absolute maxima and minima do not occur in the same sections on any of the three radii. In general, the lower sections of the north and southwest radii show the greatest average thickness and the lower sections of the southeast radius and of the section averages show the least. This varies from the incidence of thickest growth layers in OL-B-42 (p. 159 and table 10, p. 46).

Table 56 shows the percentage of thick growth layers in the lower 10 sections of OL-SO-57 and supplements table 18. Here, as in tree OL-B-42, growth layers are thickest on the north radius. The north radius carries 77.8 percent of the thick portions of the growth layers, the southeast 12.4 percent, and the southwest 8.1 percent. In OL-B-42 the southwest radius held the intermediate position. Figure 72 shows to what an extent the north radius of OL-SO-57 dominates in thickness.

TREE OL-S-62

Absolute thickness.—Figure 75 shows average growth-layer thicknesses for sections T-1 to T-10. The graphs show a great similarity but at the same time give the impression that the similarity among the graphs of OL-S-62 is not so great as among those of OL-SO-57.

Three time intervals, 1845-1859, 1875-1884, and 1905-1914, were used to show differences longitudinally in the trunk of OL-S-62, tables 62 A and 62 B. The term "scattered lenses" cannot be applied to OL-S-62 within the range of dates used. In contrast with OL-B-42 and OL-SO-57, OL-S-62 has two years with lenticular growth layers that are nearly entire in their areal extent rather than widely scattered.

The average of three radii, table 62 A, for 1845-1859 and 1905-1914 shows: Maximum thicknesses dominate (18 to 3) the upper half of the first time interval and also the third time interval (7 to 1), whereas minimum thicknesses dominate the lower half of the first interval (12 to 0) and also the third time interval (8 to 5). Section T-7 for both intervals contains neither maxima nor minima for any year. For the intermediate time interval, 1875-1884, in contrast with OL-SO-57 (table 58), maxima dominate (10 to 0) the upper sections, and minima the lower (11 to 1), with T-2 and T-7 having neither minima nor maxima.

The southwest radius varies somewhat from the average of the three radii. Table 62 B shows that for 1845-1859 and 1875-1884, maximum thicknesses dominate in the upper five sections, 16 to 6 and 7 to 2; and that for 1905-1914, maxima are spread rather evenly, 6 in the upper and 5 in the lower half, whereas minima are exclusively in the lower sections. Neither maxima nor minima occur on T-1 and T-5 of 1845-1859, on T-7 of 1875-1884, and on T-5, T-6, and T-7 of 1905-1914. Minima predominate, 10 to 0, during

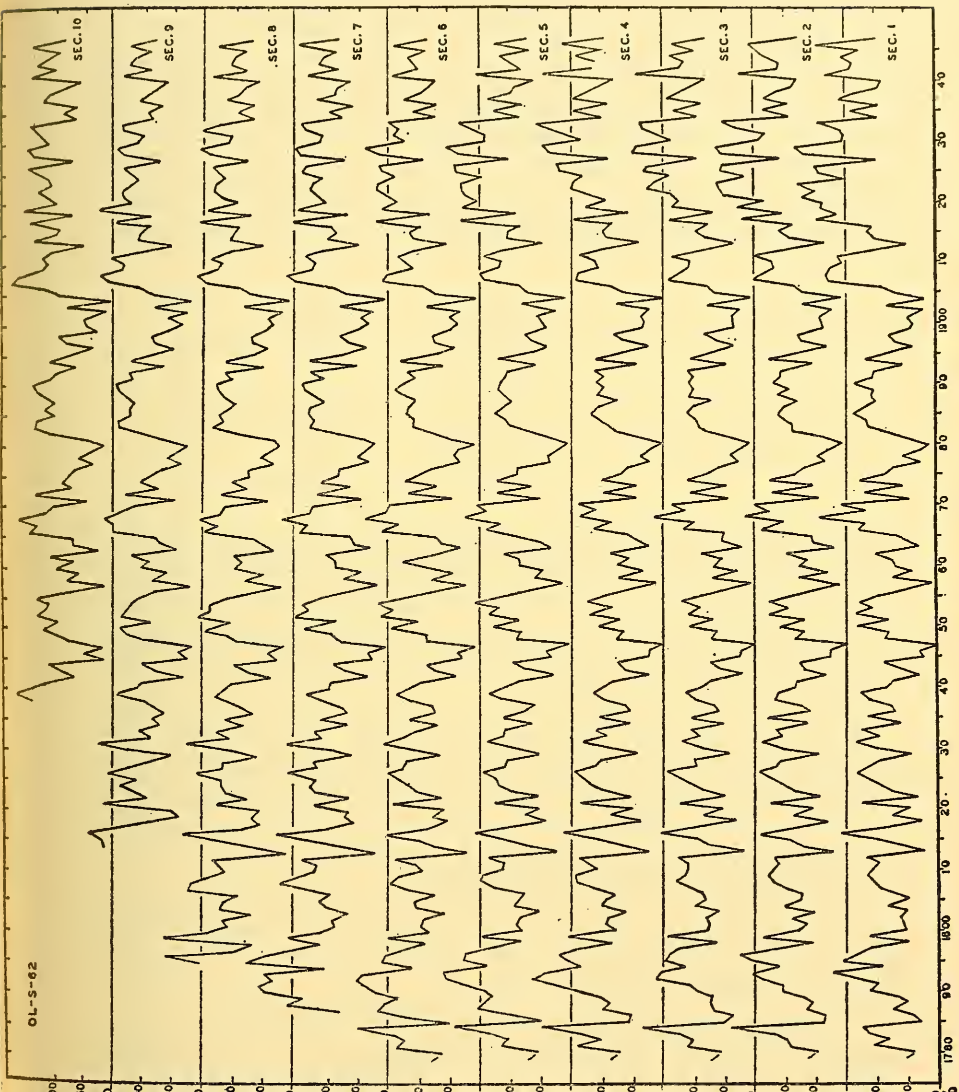


Fig. 75.—Vertical uniformity. Graphs of average growth-layer thicknesses, sections T-1 to T-10, OL-S-62.

1845-1859 for the lower five sections; 10 to 4 during 1875-1884; and 10 to 5 during 1905-1914.

Data gained by a study of the three time intervals are summarized in table 58. Although the trunks of the three trees were divided into upper and lower for comparative purposes, it must be pointed out that maxima or minima may inhabit one section almost to the exclusion of others; for instance, 7 out of 10 minima are on T-4 on the southwest radius for 1905-1914.

It should also be noted that the intervals 1845-1859 and 1905-1914 cover high areas on the graphs, and that 1875-1884 covers a low area (fig. 75). No significance can be read into the gross amounts of growth in OL-S-62, and very little if any in the other two trees. If averages for eight sections for the three trees are summarized, we find the following number of maximum and minimum thicknesses:

Sections	Tree	Maxima	Minima
5-8	OL-B-42	22	1
	OL-SO-57	28	15
	OL-S-62	18	2
1-4	OL-B-42	2	10
	OL-SO-57	10	21
	OL-S-62	4	29

In general, maxima predominate, 68 to 18, in the upper four sections and minima, 60 to 16, in the lower four. Section T-7 is the only section common to the three trees not bearing either maximum or minimum growth-layer thicknesses. Maxima and minima appear to be fairly well distributed over the trunks insofar as they are represented by a series of sections.

Average thicknesses along the trunk (table 62) commonly vary by a factor of 1½ with certain years ranging up to 3 and 4. Along the southwest radius thicknesses vary commonly by a factor of 2 to 2½, certain years ranging up to 3, 4, and more. These values equal or fall short of those for tree OL-SO-57.

Relative thickness and trend.—Trend analysis of the graphs on figure 75 along the trunk, T-1 to T-9, gives an agreement of 69.6 percent. Thus, of the three trees, OL-S-62 has the least general uniformity longitudinally.

Trend agreements decline in number as the averages of more sections are compared (table 63). A comparison of 2 sections gives 90 percent agreement, whereas a comparison of 11 gives 62 percent. For OL-S-62, compared with OL-SO-57, the decline in agreement is not so great.

Among the three radii, as shown on table 64, the north and southwest radii have the same vertical agreement, 59 percent, whereas the southeast has the lowest, 57 percent. There appears to be no common agreement among the three radii of the three trees (tables 53 and 60). The average of the three radii of OL-S-62, 65 percent,

TABLE 62 A.—*Average thicknesses of three radii in the trunk of OL-S-62 for the intervals 1845-1859, 1875-1884, and 1905-1914, in percent*

Section	1845	1846	1847	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858	1859
T-10	16	46	17	69	98	113	92	130	118	110	130	80	11	72	57
T-9	24	34	15	94	123	131	83	130	124	118	105	79	20	79	59
T-8	27	41	17	93	110	142	105	155	140	139	113	68	23	77	50
T-7	28	29	4	77	90	130	88	144	130	132	111	66	19	67	48
T-6	32	33	10	88	89	142	107	160	142	162	126	74	25	79	48
T-5	31	37	4	87	82	123	88	132	120	154	114	69	17	58	49
T-4	26	26	...	76	69	104	73	117	88	123	93	60	12	71	36
T-3	26	24	...	70	64	105	70	106	91	119	91	51	9	67	32
T-2	28	27	...	83	73	107	70	126	99	125	97	61	12	74	36
T-1	23	26	...	83	80	127	82	129	108	124	96	49	07	70	41

Section	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884
T-10	72	64	37	58	40	17	45	110	135	134
T-9	79	68	31	55	41	25	55	101	135	135
T-8	77	77	39	55	44	27	37	95	134	120
T-7	79	79	33	48	39	23	37	88	123	122
T-6	93	78	34	40	36	9	43	78	108	107
T-5	87	85	35	36	26	7	40	74	97	106
T-4	69	58	22	31	20	...	31	75	86	101
T-3	77	57	27	35	23	7	31	77	90	95
T-2	81	68	32	44	23	8	35	83	88	100
T-1	86	70	30	54	27	12	48	82	112	114

Section	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914
T-10	95	120	186	174	128	118	123	110	53	138
T-9	81	105	156	170	136	133	151	110	56	106
T-8	71	94	149	160	130	121	139	107	58	105
T-7	67	91	152	162	124	121	133	109	53	99
T-6	70	90	154	152	112	123	133	110	56	106
T-5	71	87	143	144	119	117	140	110	51	103
T-4	62	81	140	139	108	111	131	103	41	90
T-3	63	78	139	123	106	106	131	90	38	80
T-2	67	84	147	133	119	120	146	105	34	87
T-1	69	91	175	177	173	152	157	107	50	99

Table 62 B.—*Average thickness of the southwest radius in the trunk of OL-S-62 for the intervals 1845-1859, 1875-1884, and 1905-1914, in percent*

Section	1845	1846	1847	1848	1849	1850	1851	1852	1853	1854	1855	1856	1857	1858	1859
T-10	13	44	16	64	76	68	80	120	110	103	114	65	12	78	64
T-9	17	25	17	106	139	155	85	139	138	105	115	93	15	99	61
T-8	26	43	21	96	95	134	81	131	141	132	96	63	25	65	60
T-7	25	25	2	75	85	136	107	153	131	143	117	60	21	61	50
T-6	40	28	17	100	102	168	100	161	165	176	124	74	29	99	52
T-5	25	32	...	72	79	113	103	149	129	168	103	69	25	82	53
T-4	32	29	...	87	78	104	66	91	66	97	80	51	17	69	39
T-3	33	30	...	75	66	110	56	97	81	112	89	46	13	73	37
T-2	22	25	...	71	71	118	75	126	109	126	113	58	...	80	25
T-1	25	30	...	102	98	147	77	135	104	130	99	54	6	79	52

Section	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884
T-10	76	56	32	55	39	20	57	105	136	152
T-9	84	66	28	52	52	31	65	123	179	173
T-8	70	70	37	65	44	32	36	84	115	101
T-7	74	85	36	51	51	23	38	88	121	116
T-6	97	74	22	38	40	7	48	76	106	112
T-5	77	94	48	44	33	16	48	84	105	119
T-4	69	63	15	23	15	...	26	76	57	79
T-3	88	72	20	37	18	16	37	72	78	85
T-2	69	69	22	25	27	...	31	86	80	85
T-1	96	82	42	65	34	25	67	114	165	139

Section	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914
T-10	99	121	202	191	138	139	137	116	53	115
T-9	83	121	178	183	149	127	144	101	54	98
T-8	71	93	124	137	111	106	134	110	63	105
T-7	55	80	143	153	123	124	132	113	53	93
T-6	57	87	135	147	103	125	119	118	61	114
T-5	73	90	144	153	127	128	164	123	56	105
T-4	51	56	93	98	73	91	114	86	36	79
T-3	56	66	115	107	89	100	131	85	39	72
T-2	56	71	149	126	101	107	150	109	34	76
T-1	82	114	194	213	193	194	168	128	56	95

falls short of the percentage agreement in the other two trees. If the sections are grouped into lower, T-1 to T-5, mid, T-5 to T-9, and upper, T-8 to T-13, percentage agreement decreases upward (table 64), a progression resembling that of OL-B-42 (table 53),

TABLE 63.—*Vertical uniformity, trunk of OL-S-62. Trend agreement with an increasing number of sections, based on average sectional thicknesses of the growth layers*

	Percent
Comparison of:	
2 sections (252 years)	90
3 sections (235 years)	84
4 sections (217 years)	84
5 sections (197 years)	79
6 sections (187 years)	75
7 sections (160 years)	74
8 sections (152 years)	74
9 sections (133 years)	73
10 sections (109 years)	71
11 sections (82 years)	62
12 sections (65 years)	63
13 sections (49 years)	55
14 sections (23 years)	48

TABLE 64.—*Vertical uniformity, OL-S-62. Trend agreement for the three radii, the average of three radii, and lower, mid, and upper trunk*

	Percent
All sections (252 years):	
North radius	59
Southeast radius	57
Southwest radius	59
Average of 3 radii	65
Average of 3 radii:	
Sections 1-5 (248 years)	80
Sections 5-9 (188 years)	79
Sections 8-13 (133 years)	76

and differing from that of OL-SO-57 (table 60). In OL-S-62, the values are lower than in the other two trees. The branches have little effect on the sections taken closest to them.

Table 65 gives detailed information on trend disagreements longitudinally. Although the reversals appear to be localized, they are not so localized as in OL-SO-57 (table 61). Reversals are more

TABLE 65.—*Vertical uniformity, trunk of OL-S-62. Number and percentage of opposed trends on each of three radii using 10 sections and 4 to 8 sections*

	North		Southeast		Southwest	
	years	*%*	*years*	*%*	*years*	*%*
Out of 10 sections (108 years)—						
Reversals on:						
5 sections	1	0.9	9	8.3	3	2.8
4 sections	10	9.2	6	5.5	9	8.3
3 sections	7	6.5	7	6.5	9	8.3
2 sections	14	13.0	6	5.5	15	13.9
1 section	12	11.1	20	18.5	9	8.3
Out of 4 to 8 sections (218 years)—						
Reversals on:						
4 sections	12	5.5	16	7.3	7	3.2
3 sections	14	6.4	14	6.4	17	7.8
2 sections	20	9.2	24	11.0	31	14.2
1 section	33	15.1	29	13.3	27	12.4

widespread in the trunk of OL-S-62 than in either OL-SO-57 or OL-B-42 (table 54).

Years having reversals of relative thicknesses on each of the three radii for 10 sections of OL-S-62 are as follows:

Out of 10 sections (1840-1947)—108 years—north radius:

Reversals on:				
5 sections	4 sections	3 sections	2 sections	1 section
1915	1849	1846	1854	1841
	1870	1885	1865	1855
	1884	1898	1867	1861
	1889	1923	1878	1874
	1890	1924	1886	1875
	1891	1926	1887	1876
	1892	1939	1888	1879
	1908		1900	1910
	1933		1901	1919
	1943		1916	1925
			1920	1944
			1929	1945
			1931	
			1932	

Out of 4 to 8 sections (1730-1947)—218 years—north radius:*

Reversals on:				
4 sections	3 sections	2 sections	1 section	
1789	1777	1741	1744	1861
1793	1786	1745	1754	1867
1796	1806	1750	1759	1879
1801	1811	1751	1760	1885
1802	1846	1758	1766	1887
1809	1884	1762	1770	1900
1825	1889	1767	1771	1901
1849	1890	1768	1772	1911
1870	1892	1788	1775	1919
1891	1908	1791	1784	1925
1915	1923	1792	1785	1931
1933	1926	1808	1805	1932
	1939	1865	1810	1945
	1943	1878	1824	
		1888	1826	
		1898	1827	
		1916	1833	
		1920	1837	
		1924	1839	
		1929	1854	

* 8 sections, 1796——.
7 sections, 1788——.
6 sections, 1759——.
5 sections, 1750——.
4 sections, 1730——.

Out of 10 sections (1840-1947)—108 years—southeast radius:

Reversals on:					
5 sections	4 sections	3 sections	2 sections	1 section	
1849	1854	1846	1861	1841	1883
1870	1890	1876	1879	1844	1887
1885	1892	1878	1884	1850	1891
1886	1922	1901	1921	1853	1900
1889	1923	1916	1929	1855	1909
1908	1926	1933	1943	1859	1920
1910		1944		1862	1924
1915				1863	1932
1931				1865	1945
				1880	
				1881	

Out of 4 to 8 sections (1730-1947)—218 years—southeast radius:*

Reversals on:

4 sections	3 sections	2 sections	1 section	
1788	1767	1744	1733	1909
1801	1768	1750	1734	1920
1811	1771	1751	1741	1929
1833	1772	1762	1745	1932
1837	1777	1782	1753	1945
1846	1789	1796	1754	
1849	1793	1802	1757	
1870	1809	1805	1760	
1889	1828	1806	1764	
1908	1845	1810	1769	
1910	1846	1812	1770	
1915	1878	1825	1779	
1922	1890	1839	1786	
1923	1901	1854	1791	
1926		1861	1841	
1931		1876	1844	
		1879	1853	
		1884	1862	
		1892	1863	
		1916	1880	
		1921	1881	
		1933	1883	
		1943	1891	
		1944	1900	

* 8 sections, 1796——.
7 sections, 1788——.
6 sections, 1759——.
5 sections, 1750——.
4 sections, 1730——.

Out of 10 sections (1840-1947)—108 years—southwest radius:

Reversals on:

5 sections	4 sections	3 sections	2 sections	1 section
1849	1846	1854	1853	1850
1870	1876	1861	1855	1851
1931	1879	1885	1865	1875
	1884	1886	1883	1878
	1889	1891	1892	1883
	1890	1908	1898	1926
	1916	1911	1900	1932
	1923	1915	1901	1940
	1944	1929	1910	1945
			1920	
			1921	
			1922	
			1933	
			1939	
			1943	

Out of 4 to 8 sections (1730-1947)—218 years—southwest radius:*

Reversals on: 4 sections	3 sections	2 sections	1 section
1828	1759	1741	1732
1846	1768	1745	1744
1849	1786	1750	1754
1876	1789	1751	1762
1916	1796	1758	1764
1923	1801	1760	1770
1931	1802	1767	1771
	1806	1777	1780
	1861	1782	1783
	1870	1791	1803
	1879	1792	1811
	1884	1793	1812
	1890	1808	1820
	1891	1809	1824
	1915	1833	1825
	1929	1837	1826
	1944	1852	1854
		1883	1865
		1886	1878
		1889	1885
		1892	1888
		1898	1910
		1900	1922
		1901	1926
		1908	1932
		1911	1940
		1920	1945
		1921	
		1933	
		1939	
		1943	

* 8 sections, 1796——.
7 sections, 1788——.
6 sections, 1759——.
5 sections, 1750——.
4 sections, 1730——.

Figure 76 gives details on the localization of reversals in time and in position in OL-S-62 for 1800-1899. Out of 100 years, 15 have reversals in relative thicknesses longitudinally on all three radii of one or more sections; 25 out of 100 have reversals on two radii; and 48 out of 100 have reversals on one radius. From 1800 to 1899 there are 45 years in which the trend in relative thicknesses is uniform throughout the trunk as represented by 10 sections. Strictly diagnostic growth layers, in OL-S-62 as in OL-B-42 and OL-SO-57, appear seldom if at all on figure 76 or in lists setting forth reversals. A comparison of the dates bearing reversals in OL-S-62 with those in OL-B-42 and OL-SO-57 emphasizes the lack of coincidence among the three sets of dates and the radii affected by reversals. It is thus clear from the evidence of these trees that reversals are not due wholly to a cause common to the three trees; perhaps the reversals depend upon a variation in some micro-site factor or upon characteristics inherent in the individual tree.

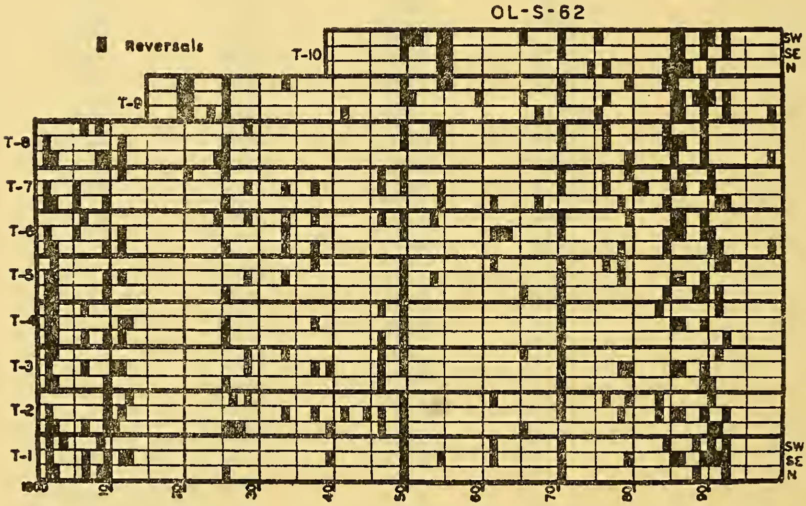


FIG. 76.—Vertical uniformity. Location of specific reversals, or nonuniformity, by radius and by section, 1800-1899, in OL-S-62.

Table 55 summarizes figure 76 and also figures 71 and 74.

The following table sets forth the total number of reversals on the three radii of the lower 10 sections of OL-S-62 for 1800-1899:

	T-1	2	3	4	5	6	7	8	9	10	Total
No.	37	41	32	29	33	39	38	32	39	30	350
Percent	12.3	13.7	10.7	9.7	11.0	13.0	12.7	10.7	15.3	16.4	12.3 (average)

Percentages are based upon the number of years multiplied by the number of radii; this number comes to 300 each for T-1 to T-8, 255 for T-9, and 183 for T-10, or a total of 2,838. In all sections the percentages are higher for OL-S-62 than for OL-SO-57. Section T-4 has the minimum number of reversals, whereas in OL-B-42 it is T-6 and in OL-SO-57 it is T-5. The percentage of total reversals, 12.3, is greater than that for either of the other two trees. Time spans free of reversals appear to be better defined in OL-S-62 than in OL-SO-57 but not as well as in OL-B-42. An interval of 10 to 12 years free of reversals centers on 1818; a second of some 8 years centers on 1842; a third of 14 to 20 years centers about 1860; a fourth, relatively free of reversals, of some 14 years centers on 1876; and a fifth of 7 years centers at 1896. Centers of particularly numerous reversals are near 1807, at 1849, at 1870, and near 1888.

Growth-layer thicknesses.—Such thicknesses longitudinally are given on table 27 (p. 90). No single maximum or minimum exists on any radius or on the mean in the first 12 sections. On the north radius, maxima exist on T-1, T-3, T-6, T-8, and T-10; for the southeast radius on T-1, T-4, T-5, and T-9; for the southwest radius on T-5, T-7, and T-8; and for the average on T-1, T-5, and T-8. Absolute maxima and minima do not exist on the same sections on any of the three radii. In general, the upper half of the 12 sections shows the greatest average thickness on all radii and on the average. A summary of maxima and minima is given in table 66. It is clear that a majority of the maxima occur in the lower trunk and a majority of the minima in the upper trunk. The table shows that average maximum thickness or average minimum do not occur consistently on any one section for a single tree or for two or three trees, or on any one radius.

TABLE 66.—*Location by section of maximum and minimum growth-layer thicknesses in the trunks of the three trees, OL-B-42, OL-SO-57, and OL-S-62. (Taken from tables 10, 18, and 27.)*

	OL-B-42		OL-SO-57		OL-S-62	
	Max.	Min.	Max.	Min.	Max.	Min.
North	T-1	T-11	T-1	T-11	T-6, 8	T-4
Southeast	T-3	T-9	T-7	T-10	T-9	T-12
Southwest	T-1	T-10	T-4	T-8	T-5	T-1
Average	T-1	T-9	T-10	T-12	T-8	T-12

Table 56 gives the percentage of thick growth layers existing along each radius of the lower 10 sections of OL-S-62 and supplements table 27. Out of the 10 sections, 6 have the thickest portions of their growth layers on the north radius. Of the remaining 4 sections, 3 have their thickest portions on the southeast radius and 1 on the southwest. Here, the averages are closer together than they are for the other two trees, the north radius having 40.2 percent of the thickest portions of the growth layers, southeast 37.9 percent, and the southwest 21.3 percent. Figure 72 substantiates these percentages and emphasizes the areal contrasts among the three trees.

Summary.—Much material by way of summary of vertical uniformity has been discussed previously. Here, tables and figures carrying summaries will be mentioned and additional material discussed briefly.

Table 58 treats of the maxima and minima of average growth-layer thicknesses. Maximum thicknesses occur more plentifully in

TABLE 67.—*Percentage agreement vertically, based on average sectional thicknesses, to show decrease as more sections are added, OL-B-42, OL-SO-57, and OL-S-62*

	OL-B-42 %	OL-SO-57 %	OL-S-62 %
Comparison of:			
2 sections	94	94	90
3 sections	90	85	84
4 sections	84	81	84
5 sections	84	80	79
6 sections	81	76	75
7 sections	79	73	74
8 sections	76	76	74
9 sections	75	72	73
10 sections	68	64	71
11 sections	67	55	62
12 sections	63	60	63
13 sections	...	42	55
14 sections	...	45	48

the upper trunk, and minimum thicknesses are more apt to occur in the lower. This is especially evident in OL-S-62, whereas in OL-B-42 maxima and minima are somewhat more evenly distributed. Tabular material (p. 174) emphasizes even more clearly the distribution of growth maxima and minima.

Table 67 shows the trend agreement between the two lowest sections of the three trees and the decline in that percentage as more sections are added. The decline is from some 90 percent to the low 60's at T-12, and even lower above T-12. Figure 77 illustrates the decreasing amount of trend agreement as sections are added. Agreement among the trees is rather close.

Materials on trend agreement concerning the different radii and different portions of the three trunks are summarized in table 68.

In general, the averages of the three radii are higher than any single radius. The lower portion of the trunks of OL-B-42 and OL-S-62 have a higher percentage of agreement than the middle or upper portions, whereas the middle and upper portions of the trunk of OL-SO-57 have the higher percentage of agreement.

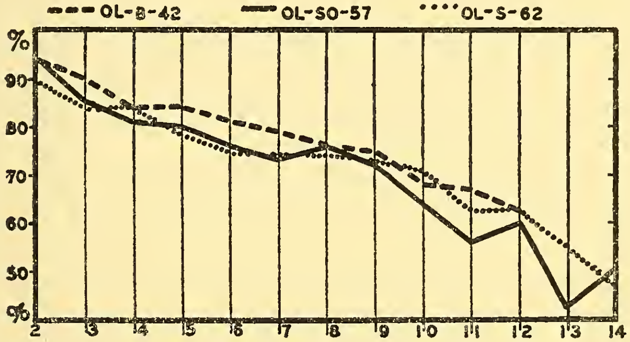


FIG. 77.—Percentage agreement vertically, based on average sectional thicknesses, to show graphically the decrease in agreement as more sections are added, OL-B-42, OL-SO-57, and OL-S-62.

TABLE 68.—*Vertical uniformity, OL-B-42, OL-SO-57, and OL-S-62. Trend agreement for the three radii, average of three radii, and lower, mid, and upper trunks*

	OL-B-42 %	OL-SO-57 %	OL-S-62 %
All sections:	(267 years)	(255 years)	(252 years)
North radius	57	68	59
Southeast radius	60	66	57
Southwest radius	63	62	59
Average of 3 radii	73	75	65
Average of 3 radii:			
T-1 to T-5	83 (267 years)	80 (255 years)	80 (248 years)
T-5 to T-9	80 (218 years)	85 (175 years)	79 (188 years)
T-8 to T-13	75 (146 years)	85 (T-7 to T-12) (114 years)	76 (133 years)

The number of reversals in the interval 1800-1899, for three radii, for two radii, and for one radius, plus the years without reversals longitudinally, is set forth in table 55. Results are mixed: there appears to be no consistent response in one tree compared with the other two. Tree OL-B-42 has the least number of years without reversals and tree OL-SO-57 the most.

For the interval 1800 to 1899 dates have been tabulated for the three trees to show times of no reversals. There are 16 years out of the 100 when no tree showed a reversal; 28 years out of 100 when two trees showed no reversal on the same dates; and 27 years out of 100 when one tree only showed no reversal on particular dates. That leaves 29 years out of 100 when none of the trees showed a uniformity of trend.

Table 66 shows which section and which radius carries maximum and minimum growth-layer thicknesses for the three trees. This table shows a lack of complete consistency in the particular position within the trunk of maxima or minima.

Table 56 details the percentage of thick parts of growth layers occurring on each radius of each tree for sections T-1 to T-10. In OL-B-42, the north radius carries a preponderance of the thick portions of growth layers on all 10 sections; in comparing the southeast and southwest radii, the southeast has the preponderance on 3 sections and the southwest on 7 sections. In OL-SO-57, the north radius has the preponderance of thick portions of growth layers on all 10 sections; in comparing the southeast and the southwest radii the southeast has the majority on 5 sections and the southwest on 4. In OL-S-62, the north radius has the majority of thick portions of growth layers on 6 sections; in comparing the southeast and the southwest radii the southeast has the majority on 7 sections and the southwest on 3, which is the reverse of the relationships in OL-B-42. Figure 72 (p. 160) illustrates table 56. It is clear that the three trees lack consistency. The north radius appears to dominate, and certainly does in two of the trees, but not in the third. The differences cannot be explained by visible differences in site conditions, because they were to the eye as similar as natural conditions can be. In fact, OL-SO-57 should have been the odd tree (fig. 72), not OL-S-62.

OL-SO-57 BRANCHES

The average growth-layer thicknesses of the sections from the two branches of OL-SO-57 are plotted on figures 78 and 79. Similarity among the graphs is of high degree except for section E on Branch 1. On Branch 2 the likeness is not quite so obvious among the sections as it is on Branch 1. Trend agreement among graphs of figure 78, 1840-1947, comes to 75 percent; that for the graphs of figure 79 is 73 percent.

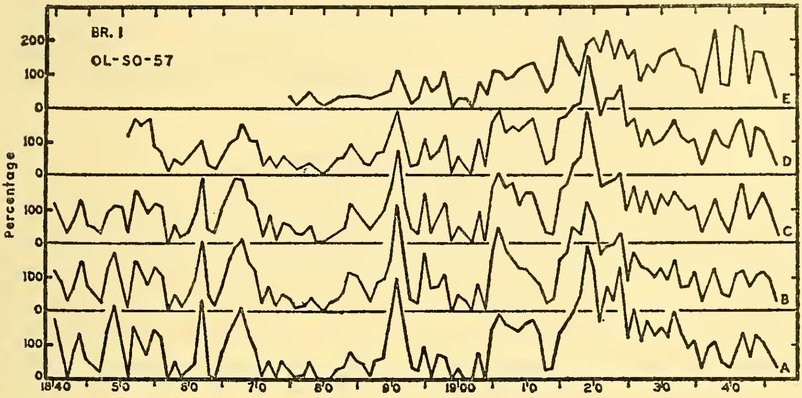


FIG. 78.—Vertical uniformity. Graphs of average growth-layer thicknesses, five sections, Branch 1, OL-SO-57.

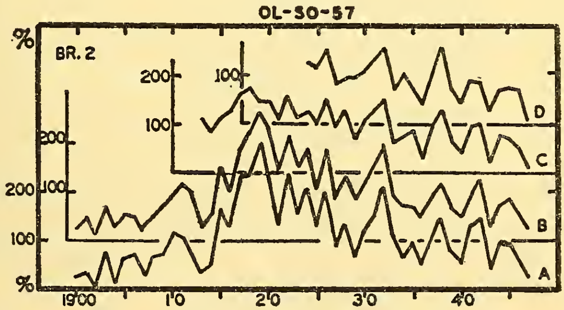


FIG. 79.—Vertical uniformity. Graphs of average growth-layer thicknesses, four sections, Branch 2, OL-SO-57.

Trend agreements in the branches of OL-SO-57 for different dates are as follows:

		%
Branch 1:	1825-1947 (all six sections)	74
	1840-1947 (five sections)	75
	1825-1899 (five sections)	87
	1900-1947 (five sections)	62
Branch 2:	1895-1947 (all sections)	69
	1900-1947 (four sections)	73

It is clear that the division of Branch 1 into two time intervals, 1825-1899 and 1900-1947, has brought out two different trends, namely, 87 percent for the earlier interval and 62 percent for the later one. Although the early interval is about 50 percent longer than the later interval, the difference in percentage of agreement appears to be significant of some change in factors which influence the disposition of xylem on the branch.

OL-S-62 BRANCHES

The average growth-layer thicknesses of the sections from the two branches are plotted on figures 80 and 81. A high degree of similarity exists along Branch 1. Differences of amplitude appear to be more conspicuous than reversals of trend; even so, agreement among the first six graphs on figure 80 is 67 percent. Although the graphs of figure 81 appear to be more dissimilar than any so far shown, the trend is 69 percent.

Trend agreements in the branches for different dates are:

		%
Branch 1:	1810-1947 (all sections)	44
	1810-1947 (six sections)	67
Branch 2:	1875-1947 (all sections)	71
	1880-1947 (all sections)	69
Branch 1:	1825-1899 (seven sections)	52
	1900-1947 (seven sections)	31

In Branch 1, the percentage of reversals increases sharply when all sections are compared rather than when only six sections are compared. Agreements in general in OL-S-62 branches do not measure up to those in OL-SO-57.

If the record is divided into two intervals using those sections whose dates correspond with those used in OL-SO-57, the interval 1825-1899 has much higher agreement than the interval 1900-1947.

SUMMARY COMPARISONS

A summary of longitudinal agreement among branches and between branches and trunk based on average thicknesses is as follows:

	%
OL-SO-57:	
Trunk vs. branches	75
Branch 1 vs. Branch 2	83
Trunk vs. Branch 1	85
Trunk vs. Branch 2	78
OL-S-62:	
Trunk vs. branches	72
Branch 1 vs. Branch 2	82
Trunk vs. Branch 1	83
Trunk vs. Branch 2	82
Branch 1: OL-SO-57 vs. OL-S-62	71
Branch 2: OL-SO-57 vs. OL-S-62	72

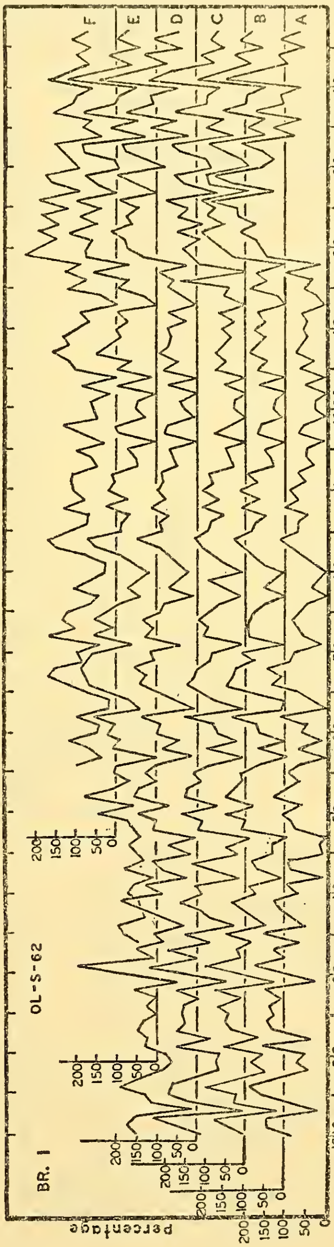


FIG. 80.—Vertical uniformity. Graphs of average growth-layer thicknesses, six sections, Branch 1, OL-S-62.

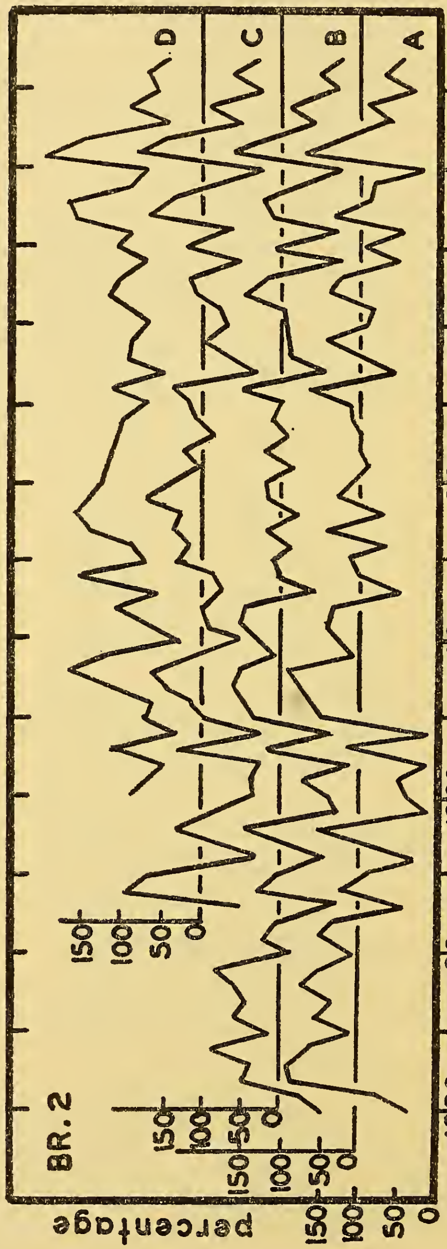


Fig. 81.—Vertical uniformity. Graphs of average growth-layer thicknesses, four sections, Branch 2, OL-S-62.

VIII. PARTIAL AND INTRA-ANNUAL GROWTH LAYERS [4]

INTRODUCTION

In addition to the preceding studies on the uniformity and general trends of growth that exist among growth layers, considerable attention was given to the occurrence and character of those growth layers which were "atypical" in the sense of being uncommonly thin or partial as lenses, or of being intra-annual. Irregularities occur in the manner in which the layers of xylem are laid down among ponderosa pine of northern Arizona, and more or less in all gymnosperms from all regions. This part of the report, in addition to increasing our knowledge of growth layers, is an attempt to add further insight into the behavior of the cambium during critical growing periods.

Much of the work of dendrochronologists is based upon the occurrence, character, and interpretation of the atypical growth layers that have become landmarks in the construction of long chronologies. These landmarks, or diagnostic layers, are part of the entire chronological sequence. Their recognition and proper interpretation determine the accuracy of dates assigned to specific growth layers. Proper recognition of all anomalies of wood structure is possible only when the physiological aspects of growth are considered. Although the cambium may commonly be active only once every year, it cannot be assumed that this is always the case. Growing seasons and chronological years are not necessarily synonymous when interpreting xylem increments.

Attention here is centered on the following two general varieties of atypical growth layers: 1, Lenses or partial growth layers, and 2, "false" or "double" rings, occurring as bands of densewood within the lightwood of the annual increment.

The first of these two types has been designated a lens or partial growth layer. The degree of partiality varies greatly, some layers being present over 99 percent of the stem, whereas others may be present as little as 1 percent. Whatever the area covered by the lens, it indicates the areal extent of the cambial activity that laid down xylem cells.

The second general type of atypical growth layer is commonly referred to as a double or an intra-annual. Difficulties in the analy-

[4] This part of the report was prepared by Paul J. Germann.

sis of intra-annuals arise because these layers may form a continuous series from one whose band of densewood is weakly developed and whose border is hazy, to one whose band of densewood is so definite in its characteristics and so sharply bordered as to be indistinguishable from a true annual increment.

Because both types form a continuous series of variations from one extreme to the other, any decision as to whether they are intra-annual or annual is necessarily arbitrary in the present work. If a line is to be drawn in the series, where should it be drawn? What criteria should be used in deciding whether one type, both types, or neither type is to be considered annual?

METHODS USED IN ANALYZING PARTIAL GROWTH LAYERS

Studies of partial growth layers made by other workers have given diverse results leaning a little perhaps toward more lenticularity at the base of the trunk. Such diversity is illustrated by the following examples, which vary according to the condition of the tree and its geographical location.

Glock (1937), in a study of the partial rings of one ponderosa pine in the Flagstaff region, gives much evidence that more partial growth layers are missing at the base of the trunk than elsewhere and that those present cover a smaller area. He observed further that the last remaining lenses of a growth layer exist in the midsection of the trunk and that the extreme upper portion of the tree resembles the lower.

Hartig (1870), working with trees in Germany, observed that suppressed trees of a stand frequently showed a greater number of growth layers in the upper bole than in the lower. In an extreme case, in a white pine for example, he noted that wood at the trunk base, 21 years old, showed only 14 growth layers.

Haasis (1933) made ring counts in a California redwood in which he noted a decrease in diameter for several years. He stated that there was a greater number of distinguishable growth layers at certain heights on the trunk than at places lower down. He believed his results substantiated the supposition that growth layers may be formed in the upper bole in a year in which they are not produced farther down.

On the contrary, Shreve (1924) found no evidence of partial growth layers in morphological studies of Monterey pine in California. Marr (1948), working with white spruce from the northern forest border in the Hudson Bay area, did not find a single instance of a layer that was partial in any of the sections or cores studied. He therefore assumed perfect horizontal and vertical continuity of growth layers to be the general rule.

In the first analysis of the sections of the three ponderosa pine here studied, while the chronological sequence was being worked out, all partial growth layers were noted and recorded. Later each growth layer was analyzed individually by following it around the entire circuit at the level of each section. The exact location where these rings appeared and disappeared was recorded on a data sheet which was marked off according to compass direction. For the trunk sections, the figures illustrating location start with north and make the circuit in a clockwise direction through east, south, west, and return to north. For the branches, the figures begin at the "up" radius progressing in a clockwise manner, with 180 degrees directly downward, and terminating at "up." Thus the clockwise sequence of inspection was used for both the upper surface of the trunk sections and the distal surface of the branch sections.

Figures 82 to 93 show the distribution of the lenses as they exist at each level in the three trees. The lines in the graphs indicate the *presence* of a recognizable growth layer. Wherever a growth layer is alternately present and absent, the lenses consist of one or two cells in radial thickness.

For comparative purposes all the lines indicating growth layers were made the same length. Thus the comparable vertical positions in the tree would be found one above the other in the figures. At any one level the length of the circuit of the more recent growth layers was longer than the circuit of earlier growth layers nearer the pith. The circuit of the same growth layer was also longer at the base of the tree than in the upper sections. It was essential, however, in the determination of longitudinal and circuit uniformity to compare the characteristics of the growth layers along the same directional radii in order to compare cambial activity in the same absolute positions in the tree. Because it had been determined that there was no spiraling of the xylem in the three trees, the assumption of relative and absolute direction should be valid.

As an illustration, figure 82 shows the location of partial rings as recorded in a straight-line graph, whereas figure 83 shows these same growth layers more in accord with their actual positions in the tree.

A growth layer is partial if it is not visible for a portion of its course around the circuit at any one level. In the original analyses

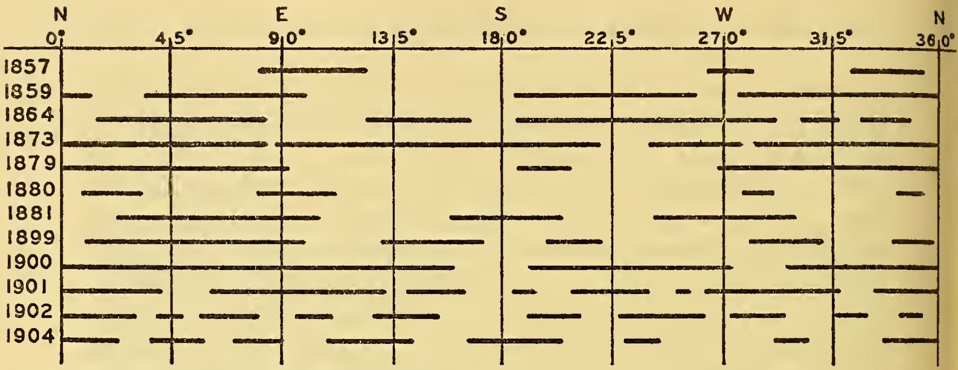


FIG. 82.—Partial growth layers, or lenses, as represented by a straight-line chart. A composite of several trunk sections from tree OL-SO-57.

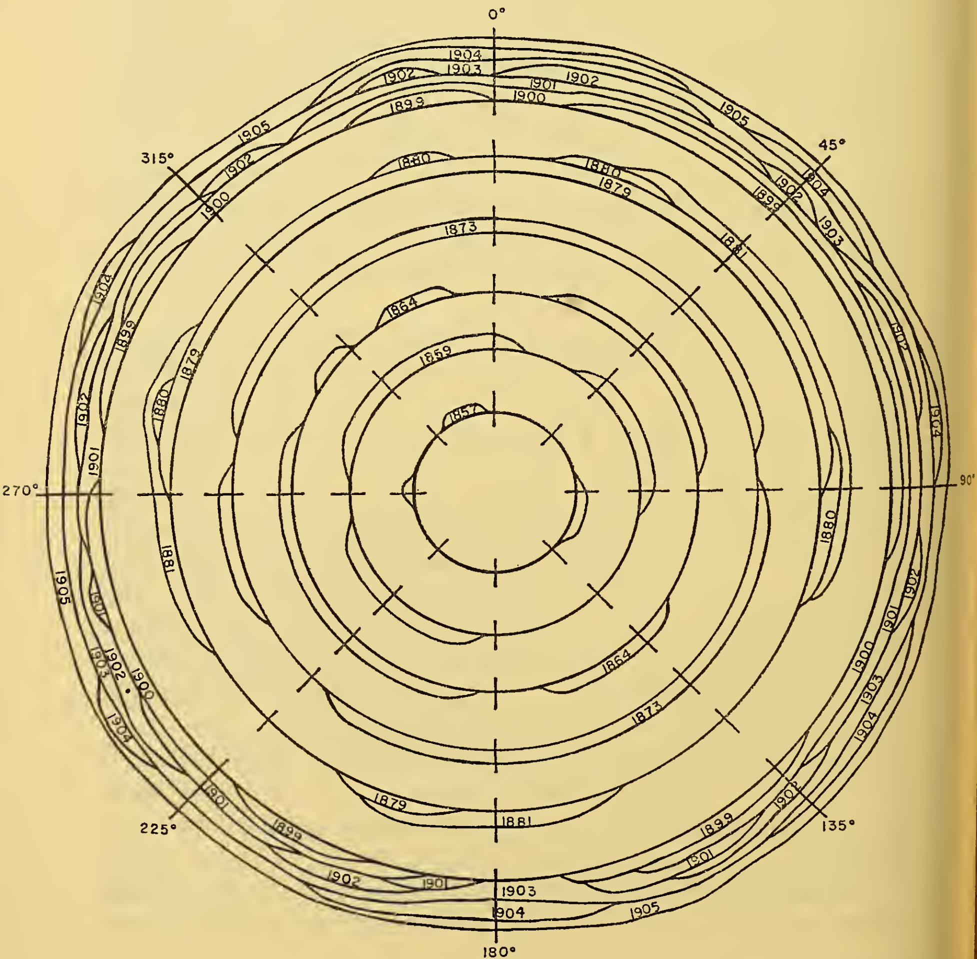


FIG. 83.—Partial growth layers, or lenses, as they actually exist in tree OL-SO-57. A composite of several trunk sections (same as fig. 82), diagrammatically expressed.

of each of the three trees, every growth layer that was partial even for a very short arc, on any one of the sections, was recorded and mapped. In the final data, however, certain partial growth layers were omitted. These were isolated cases of abnormality caused by a local injury or an absence restricted to a small area on one section, the bulk of the growth layer being of average or even above average thickness. Their existence suggests that the problem of cambial activity is a complex one, frequently involving localized cytological factors.

In order to illustrate and discuss circuit distribution of lenticularity in the trunks of the three ponderosa pine, three sections were chosen at similar heights in each trunk.

Sections chosen and their corresponding figures are:

	Section	Figure No.
Tree OL-B-42	T-2, T-6, T-9	84
Tree OL-SO-57	T-2, T-5, T-8	85
Tree OL-S-62	T-2, T-6, T-9	86

Sections and figures for the branches are:

		Figure No.
Tree OL-B-42	Abnormalities so great that the sequences were unreadable.	
Tree OL-SO-57	Branch 1 A, C, E; Branch 2 A	87
Tree OL-S-62	Branch 1 A, C, E; Branch 2 A	88

The figures here included adequately illustrate the distribution and amount of lenticularity. Although no additional information was derived from the sections not illustrated, they were included in all considerations (table 69) and served to confirm the tendencies and principles to be discussed.

TABLE 69.—*Number and percentage of partial growth layers in trunks and branches of the three trees*

	OL-B-42			OL-SO-57			OL-S-62		
	Years used	No. of partial growth layers	Percent	Years used	No. of partial growth layers	Percent	Years used	No. of partial growth layers	Percent
Section:									
T-15	...	...	...	...	...	...	9	0	...
T-14	...	...	...	12	0	...	24	3	12.5
T-13	17	1	5.8	20	0	...	50	0	...
T-12	29	1	3.4	26	0	...	66	1	1.5
T-11	50	0	...	39	0	...	83	1	1.2
T-10	105	15	14.2	61	2	3.2	110	2	1.8
T-9	147	22	14.9	95	8	8.4	134	3	2.2
T-8	179	24	13.4	115	11	9.5	153	3	1.9
T-7	194	16	8.2	151	10	6.6	161	7	4.3
T-6	221	17	7.6	176	10	5.6	188	8	4.2
T-5	227	16	7.0	201	12	5.9	198	8	4.0
T-4	237	17	7.1	222	14	6.3	218	11	5.0
T-3	255	19	7.4	237	16	6.7	236	9	3.8
T-2	267	24	8.9	256	16	6.2	253	13	5.1
T-1	303	31	10.2	282	17	6.0	274	10	3.6
Branch:									
1-A	Branches of OL-B-42 were not identifiable			165	22	13.3	168	33	19.6
1-B				124	19	15.3	152	33	21.7
1-C				111	16	14.4	155	27	17.4
1-D				97	8	8.2	139	25	17.9
1-E				73	9	12.3	116	12	10.3
1-F				29	0	...	93	3	3.2
1-G				...	...	...	78	9	11.5
1-H				...	...	...	55	2	3.6
2-A				68	5	7.3	85	6	7.0
2-B				52	3	5.7	73	3	4.1
2-C				35	0	...	56	3	5.3
2-D				27	1	3.7	48	1	2.0
2-E				15	0	...	...	...	...

The lines in the graphs of figures 84-88, representing lenses in cross section, give an idea as to the numbers and areas of the many lenses scattered over the surface of the trunks. Actual count revealed that some growth layers "appeared" and "disappeared" as many as 50 times around the circuit at certain levels, indicating the presence of tens of thousands of "patches" or lenses spread over the vascular cylinder and indicating possibly the presence of one or more growth flushes. Lenses vary in area from a square millimeter or less up to a sheath covering all but a small portion of the stem. Isolated lenses, and the cambial activity giving rise to them, may vary from a square millimeter to more than a square meter.

CIRCUIT UNIFORMITY AMONG PARTIAL GROWTH LAYERS

The lenses in the trunk sections of OL-B-42, as shown in figure 84, possess little circuit uniformity. Because no definitely clear areas (absence) appear on the figures in a vertical direction, no general tendency toward either absence or presence of growth layers is indicated along any one radius on any of the three sections. The east to south area, however, possesses a slightly greater amount of absence than do the other areas. In general, this east to south area has the thinnest growth layers within the trunk.

At all levels the number of partial growth layers is greater in the last half of the 19th century than at any other time. Section T-2 (fig. 84) has 9 lenticular growth layers, T-6 has 8, and T-9 has 12; thus in one out of five growth periods cambial activity was sufficiently localized to produce partial growth layers.

Although as a rule slightly more absence exists in the southeast quadrant, the first portions of a growth layer to be absent do not always occur in this quadrant and the last small portions to be present do not always occur in the west to north segment. The position of partial growth layers within the trunk follows no general tendency. Characteristics found on one radius for one growth layer or sequence of growth layers are not necessarily duplicated on the same radius for other growth layers at the same level. In addition, no general consistency was found in the length or extent of the lenses at any one level or on any one radius. Growth layers with many small lenses in certain areas might be expected to be the same throughout, but this is not the case. Spotty growth, with short lenses, is intermingled with long lenses both as regards one growth layer in its course around the circuit and all growth layers on any one radius.

FIG. 84.—Circuit uniformity among partial growth layers, or lenses, in sections T-2, T-6, and T-9, tree OL-B-42.

Figures 85 (trunk) and 87 (branches) give the circuit distribution of the lenses or partial growth layers in tree OL-SO-57. One of the striking features of this series, particularly in the lower sections, is the great number of very short lenses visible in the plane

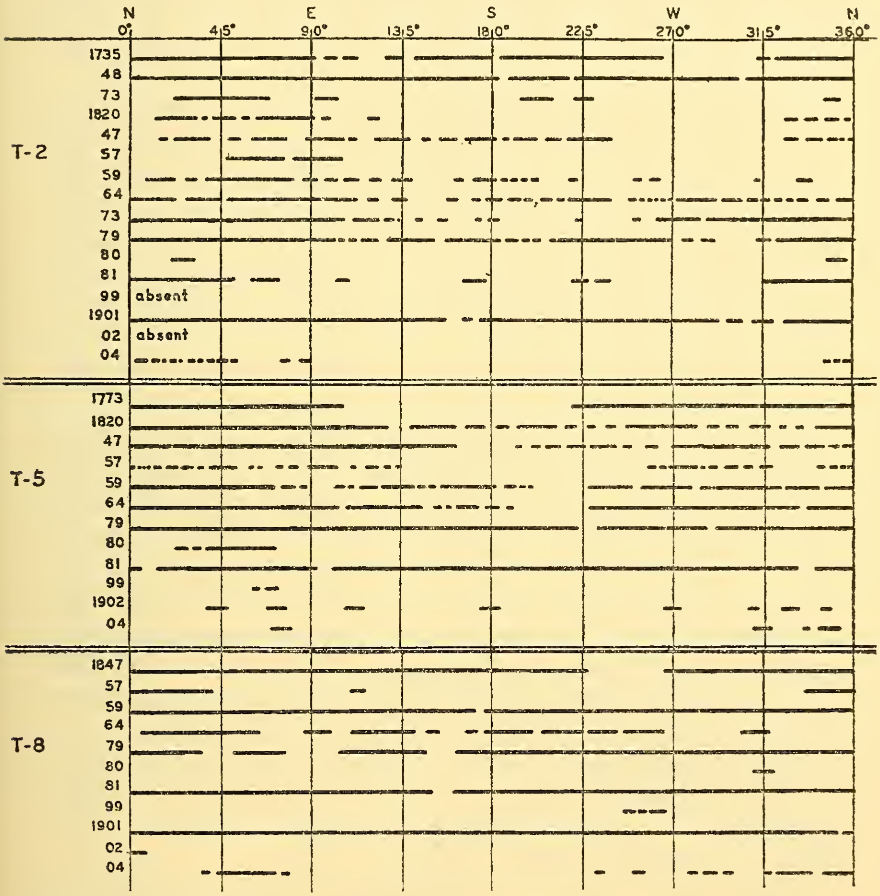


Fig. 85.—Circuit uniformity among partial growth layers, or lenses, in sections T-2, T-5, and T-8, tree OL-SO-57.

of the sections and indicated by short lines on the charts. The factors or stimuli which either promote or inhibit cambial activity are very localized and thus result in areas of activity as small as several square millimeters.

No definite clear areas exist on the charts, indicating a lack of a general tendency toward either absence or presence along any one radius on any one of the three sections. Section T-2 (fig. 85) shows some small decrease in overall presence centered near the west radius, but this is not evident in T-5 or T-8. At all three levels it is again apparent that the number of partial growth layers is greater in the second half of the 19th century (table 70). An average of over seven years was recorded as partial in this tree from 1850 to 1899, whereas only one or two growth layers per section were partial from 1800 to 1849.

In general the partial growth layers in the trunk of this tree do not show circuit uniformity. Absent layers or characteristic sequences are not the same from one radius to the other at the same level. The absent portions of partial growth layers are scattered indiscriminately over the circumference of the stem. These facts are important if cores rather than sections are studied. An entire section of a trunk seems necessary if accurate knowledge of the true characteristics of cambial growth is to be gained. A core gives but one of many histories of cambial activity registered in xylem growth at any one level.

Figure 87, showing the lenses in the branches of OL-SO-57, reveals not only many more partial growth layers than in the trunk, but also the prevalence of totally absent rings. The lower branch (Branch 1) was extremely difficult to study and to match with the chronology of the trunk. Valuable clues as to the identity of growth layers were derived, not from ring sequences or from thickness relationships, but from other structural characteristics, such as thickness of densewood, color or distribution of pigmentation of densewood, regularity of outside margin, and character and number of resin ducts. This was made possible by familiarity with the structural details of a given tree after thorough study of many sections, and only then was their "individuality" and exact position in the sequence known. It seems evident that dating of branch material would be very questionable if not impossible unless great amounts of both branch and trunk material were available for intensive study.

Table 71 shows that of the 165 growth layers in Branch 1, 23 are included in the lenticular record. This contrasts with 13 growth layers which are included for the same span of years in the trunk. In addition, a greater number of growth layers, not included here, had absent regions for only a very small percentage of the circuit. Of the 22 years recorded (fig. 87), 8 are *totally* absent.

In the branches the pith is consistently above center and the average growth-layer thicknesses in the down radii for all branch sections are 20 to 50 percent greater than the average of the thick-

TABLE 70.—*Summary of partial growth layers in the three trees.* x *refers to partial;* a *refers to absent completely around the circuit*

	OL-B-42														OL-SO-57											OL-S-62														
	No. of	Sections													No. of	Sections										No. of	Sections													
Year	yrs.	1	2	3	4	5	6	7	8	9	10	11	12	13	yrs.	1	2	3	4	5	6	7	8	9	10	yrs.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1947														x																										
1944																																								x
1936	10												x																											
1929																										14														x
1928																																								x
1913	22		x	x	x		x			x																														
1904	8	x	x	x	x	x	x	x	x	x	x					x	x	x	x	x	x	x	x	x		23	x	x	x	x	x	x	x	x	x	x	x	x		
1902	1										x				1	x	a	x	x	x	x	x	x	x	x	1		x		x										
1901																x	x	x					x	x																
1900																x		x																						
1899																x	a	x	a	x	x	x	x	x	x															
1885	16										x																													
1882	2	x	x	x	x	x	x	x	x	x	x																													
1881		x	a	x	a	a	x	x	a	a	a				18	x	x	x	x	x	x	x	x																	
1880		a	a	a	a	a	a	a	a	a	a					x	x	a	a	x	x	x	x	x		23	x	x	x	x	x	x	x							
1879		a	a	a	a	a	a	a	a	a	a					x	x	x	x	x	x	x	x	x						x	x	x	x							
1878																												x	x	x	x	x	x							
1877		x	x							x	x																x	x	x	x	x	x	x	x						
1873	3									x	x				5	x	x	x	x																					
1871	1	x	x	x	x	x	x	x	x	x	x																													
1864	6	x	x	x	x	x	x	x	x	a	x				8	x	x	x	x	x		x	x	x																
1863		x								x																														
1860	2									x																														
1859		x	x	x	x	x	x	x	x	a	x				4	x	x	x	x	x	x		x																	
1857	1	a	a	a	a	a	a	a	a	a	a				1	x	x	x	x	x	x	x	x	x		19	x	x	x	x	x	x	x		x	x				
1853	3										x																													
1851	1										x																													
1847	3	a	a	a	x	x	x	a	x	x					9	x	x	x	x	x			x			9	x	x	x	x	x	x	x		x					
1845	1								x	x																														
1842	2									x																														
1832	9									x																														
1822	9	x	x	x	x	x	x	x	x																															
1821										x																														
1820					x				x	x					26	x	x	x	x	x	x	x																		
1819		x							x																															
1818									x	x																														

TABLE 70.—*Continued*

OL-B-42

Year	No. of yrs.	Sections 1	2	3	4	5	6	7	8	9	10	11	12	13
1814	3		x						x					
1813		x	x	x	x	x	x	x	a	a				
1808	4		x											
1805	2	x	x	x		x	x	x	x					
1803	1	x												
1802		x	x	x					x					
1800	1								x					
1790			x											
1789									x					
1788									x					
1786	1								x					
1785		x	x					x	x					
1780	4							x						
1773	6	x	x	x	x	x	x	x						
1772														
1770														
1769														
1766														
1752	20	x					x							
1748	3	x	x	x	x	x	x							
1735	12	x	x	x										
1729	5	x	x	x	x	x								
1716	12	x												
1709	6	x												
1703	5	x												
1670	32	x												
1668	1	x												
1666	1	x												
1660	5	x												

OL-SO-57

Year	No. of yrs.	Sections 1	2	3	4	5	6	7	8	9	10
1814											
1813	6						x	x			
1808											
1805											
1803											
1802											
1800											
1790											
1789											
1788											
1786											
1785											
1780											
1773	39	x	x	x	x	x					
1772											
1770											
1769											
1766											
1752	20			x	x						
1748	3	x	x								
1735	12	x	x								
1729											
1716											
1709											
1703											
1670											
1668											
1666											
1660											

OL-S-62

Year	No. of yrs.	Sections 1	2	3	4	5	6	7	8	9	10	11	12	13	14
1814															
1813	33								x						
1808															
1805															
1803															
1802															
1800															
1790															
1789															
1788															
1786	26		x	x	x										
1785															
1780															
1773	12	x	x	x	x	x									
1772			x												
1770	1		x												
1769		x	x	x	x										
1766	2					x									
1752															
1748															
1735	33	x	x												
1729	5	x													
1716	12	x													
1709															
1703															
1670															
1668															
1666															
1660															

TABLE 71.—*Summary of partial growth layers in the branches of OL-SO-57 and OL-SO-62.* x *refers to partial;* a *refers to absent completely around the circuit*

	OL-SO-57													OL-S-62														
	Br. 1							Br. 2						Br. 1									Br. 2					
	No. of yrs.	Sections						No. of yrs.	Sections					No. of yrs.	Sections								No. of yrs.	Sections				
Year		A	B	C	D	E	F		A	B	C	D	E		A	B	C	D	E	F	G	H		A	B	C	D	
1947																					x							
1945														1		x	x	x	x		x			x		x	x	
1943												x		1					x		x		1			x		
1940														2							x		2	x	x	x		
1936				x	x	x																						
1934														5		x	x	x	x		x							
1932														1				x										
1921														10		x												
1918														2	x	x		x										
1917																	x											
1914	21	x	x											2	x	x	x	x	x									
1913		x	x	x	x			29	x	x					x	x	a	x	x	x	x	x						
1906														6	x	x	x	x										
1905																		x										
1904	8	a	x	x	x	x		8	x						a	a	a	x	x	x	a	x	35	x	x			
1902	1	a	x	x	a	x		1	x	x				1	x	a	a	x	x	x	x		1	x	x			
1901			x	x	x				x						x	x	x	x										
1900															x	x												
1899	1	a	x	x	x	x		1	x	x					x	x	a	x	x		x		2	x				
1896	2	x	x	x										2	a	a	x	x	x				2	x				
1894	1	x	x	x										1		x												
1893		x	x	x		x									x	x	x											
1889														3			x											
1887	5	x	x											1		x												
1884														2	x													
1881	5	a	x	x																								

TABLE 71.—*Continued*

	OL-SO-57													OL-S-62													
	Br. 1							Br. 2						Br. 1									Br. 2				
		Sections							Sections						Sections									Sections			
Year	No. of yrs.	A	B	C	D	E	F	No. of yrs.	A	B	C	D	E	No. of yrs.	A	B	C	D	E	F	G	H	No. of yrs.	A	B	C	D
1880		a	a	x	x	x								3	x	x	x	x	x								
1879		a	x	x											x	x	x	x									
1878															x	x											
1877	1	x				x									x	x	x	x									
1876		x	x	x	x	x																					
1875		x				x																					
1873	1	x	x	x	x																						
1871	1	x	x	x										5	x	x	x	x									
1866														4	x												
1864	6	a	x											1	x	x	x										
1863															x	x	x	x									
1859	3	x		x										3	x	x	x										
1858																		x									
1857	1	a	x												a	x	x	x	x								
1852														4	x												
1847														4	a	a	x	x									
1846															x	x											
1845															x	x	x	x									
1842														2	x	x	x	x	x								
1840														1	x												
1836	20	x	x											3	x	x	x	x									
1834														1		x											
1829														4	x	x	x										
1822														6	x												
1818														3	x												
1813														4	x	x	x	x									

nesses of the growth layers on other radii. In Branch 1 the down radius averages 50 percent greater thickness and would be expected to be the location of partial growth layers. Figure 87 shows a slight tendency in this direction with nine growth layers being present for the major percentage of the 90-degree arc using "down" as center; eight growth layers for the arc around "east"; six for "west"; and three for "up." If the "arcs of absence" between the

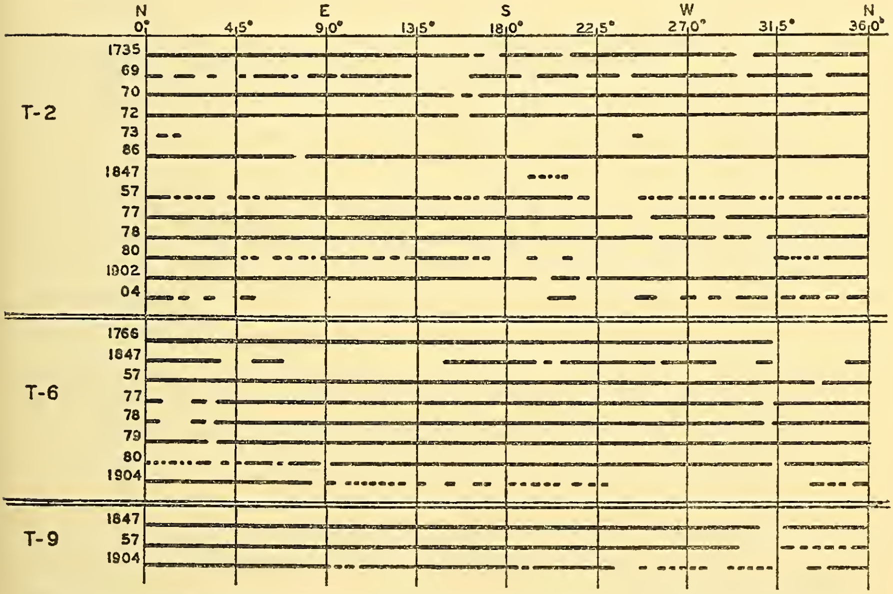


FIG. 86.—Circuit uniformity among partial growth layers, or lenses, in sections T-2, T-6, and T-9, tree OL-S-62.

lenses are noted on figure 87, it is clear that the arcs are dispersed over all radii.

In contrast to the characteristics exhibited by the trunk sections, cambial growth in the branches is more uniformly distributed and less localized. All three sections charted in figure 87 (1-A, 1-E, 1-C) give the impression that growth here is somewhat more consistent. Although there are a number of short lines on the charts indicating small patches of xylem, the longer lines definitely predominate. This is especially true in section 1-C and 1-E (fig. 87).

Branch 2 (fig. 87, 2-A) contained comparatively few growth layers, the earliest dated as 1880. Hence, fewer partial growth layers are recorded. A notable characteristic is the absence of short lenses,

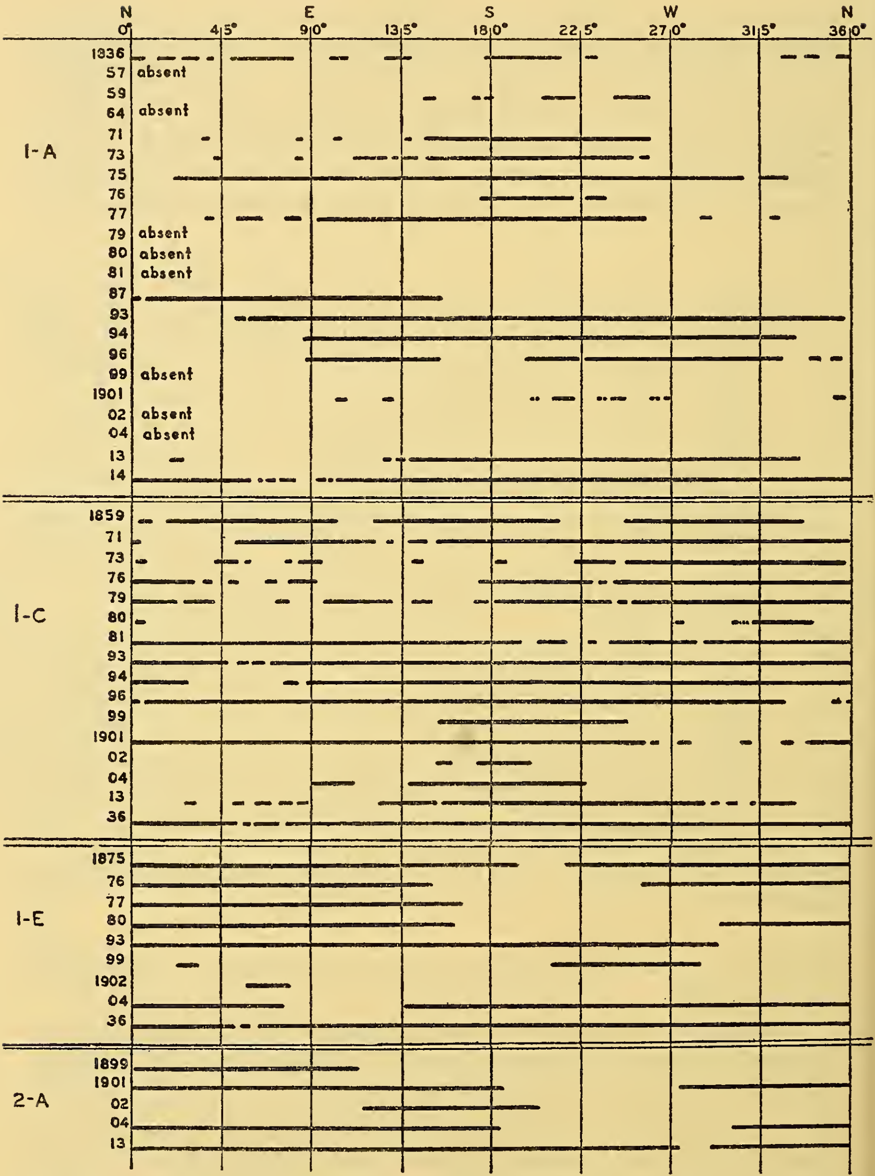


FIG. 87.—Circuit uniformity among partial growth layers, or lenses, in branch sections 1-A, 1-C, 1-E, and 2-A, tree OL-SO-57.

which indicates more consistent areal distribution of growth. But there is no more uniformity in the distribution of segments present here than elsewhere. Lenses are not confined to any one radius.

Since helical grain is not evident in the trunk of OL-SO-57, the absence of circuit uniformity is not related to a possible spiral path of cambial activity. This suggests that growth layers seem to complement each other in thickness through the years on any one radius. Circuit uniformity decreases in the process of compensation which maintains a reasonably uniform cylinder.

Figures 86 (trunk) and 88 (branches) illustrate the circuit distribution of partial growth layers in OL-S-62. The charts show less lenticularity in this tree than in the other two, not only in fewer partial growth layers but also in a smaller percentage of absence per layer. Growth patterns indicate that the activity of the cambium of OL-S-62 was not as localized in time or in space as in the other two trees. With the exception of growth increments labeled 1904 and 1857 there is little evidence of the great number of very short lenses found in the other two trees.

No definite vertical clear areas, indicating uniformity of absence along certain radii, are noticeable in OL-S-62. The distribution of lenticularity is as a rule not the same from one radius to the other. This tree therefore emphasizes that various cores from the same tree at the same height will give different growth histories.

The lenses as shown in figure 88 are in general longer than in the trunk. In this tree, as in the other two, there is more absence in the branches—more layers are classed as lenticular and more layers are completely absent. The upper radii show slightly more absences, but this is by no means consistent, particularly in the later years. The amount of lenticularity in the two branches made it difficult to correlate them with chronologies established by merging the trunk records of these and other trees of the region. Growth layers of branches are highly irregular in certain respects in comparison with those of the trunk and at the same time carry a more intensified ecologic record.

In comparing the lenticular growth layers of the three trees it is apparent that OL-B-42 records the most absence both in the number of layers and in the average amount of absence per growth layer (table 69). For instance in T-2 of OL-B-42 there are 24 partial growth layers (fig. 84); in T-2 of OL-SO-57, 16 partial growth layers (fig. 85); and in T-2 of OL-S-62, 13 partial growth layers (fig. 86). All three trees grew in the lower forest border of the

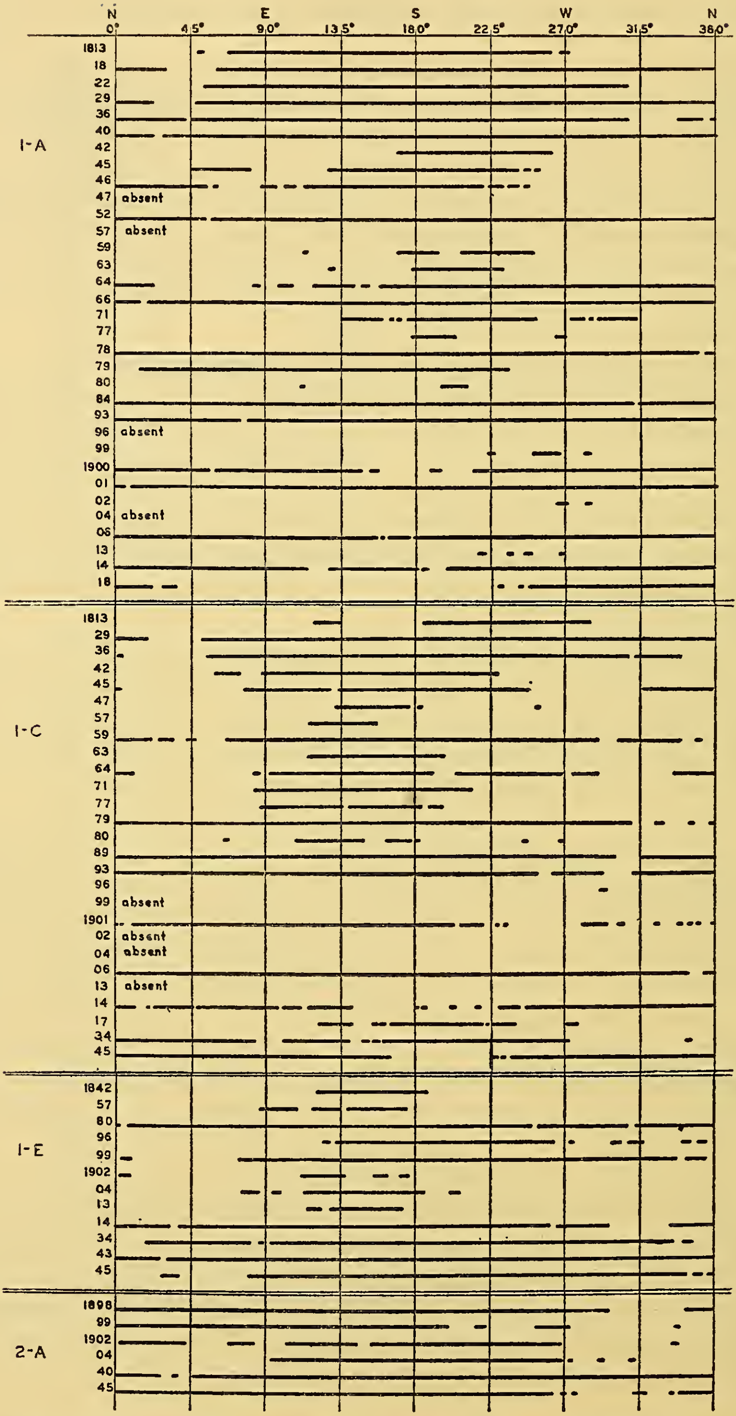


FIG. 88.—Circuit uniformity among partial growth layers, or lenses, in branch sections 1-A, 1-C, 1-E, and 2-A, tree OL-S-62.

ponderosa pine zone, but tree OL-B-42 grew slightly nearer the lower forest border and slightly lower in altitude than the other two. The influence of topography and soil gave soil moisture of greater amount and less intense fluctuation for OL-S-62 than for OL-B-42. Tree OL-SO-57 occupied an intermediate position with respect to soil moisture. As field evidence has suggested, the pattern of growth in the three trees shows that the incidence in time and space of partial growth layers gives a delicate index of growing conditions.

Aside from the above differences, the three trees were much alike in showing little circuit uniformity among partial growth layers and no concentration of absent portions of partial growth layers on any radius or compass direction. It is impossible to predict the radial position of a lens. This lack of uniformity is such that at any one level in a tree, many single growth histories could be derived from as many individual cores.

The cause or causes of lenticularity are not centered on factors that are directional, such as temperature of the bark, source of water from the roots, or competition.

VERTICAL UNIFORMITY AMONG PARTIAL GROWTH LAYERS

Studies of vertical uniformity in partial growth layers were made in two ways: 1, By comparing the lenticularity charts of the sections of each tree, thus noting the collective similarities and differences that exist from one level to another; and 2, by assembling in one chart the characteristics of one specific growth layer for all levels of the tree at which it is present. The original charts (figs. 84-88) are used for the first comparison and a group of typically partial growth layers (figs. 89-93) for the second.

Trunks.—The three sections from OL-B-42 (fig. 84), T-2, T-6, and T-9, vary considerably in the number of partial growth layers (table 70). Section T-2 records 24 of the 50 growth layers that are partial in at least one of the sections. Section T-6 records 17 out of 46 layers, and T-9 records 22 out of 35 layers. The sections, of course, will vary in the number of partial layers that could be present because there are progressively fewer total layers toward the top of the tree. These figures show that mid-tree, as typified by T-6 (fig. 84), possesses lenticularity in only 37 percent of those layers which are partial somewhere in the tree; T-2, representing the lower portion of the tree, contains 48 percent; and T-9, in the upper portion, shows 63 percent lenticularity.

The mid-sections also have fewer completely absent growth layers; only three are recorded for T-6, but five appear in T-2 and seven in T-9. The latter figure is significant because of the relatively small total number, 35, of typically partial layers.

In addition, the charts of the above three sections show other variations. The lower sections (for example, T-2) are characterized by many short lenses, some growth layers appearing and disappearing as many as 24 and 32 times in the course of the circuit (1822 and 1882 respectively). Mid-sections (as T-6) are intermediate, with a moderate number of short lenses combined with longer lenses. Section T-9 shows very few short lenses; the highest number for any one growing period is seven (1904), but most layers average two or three.

These results indicate that the lower levels of the trunk possess many more localized areas of growth and that the higher levels record a higher percentage of lenticular layers and a greater number of totally absent layers.

Further observations indicate that growth was extremely inconsistent in tree OL-B-42. Although the total number of partial growth layers is 54, only 20 of these are lenticular in four or more sections, 25 are lenticular in only one section, and 8 in only two sections (table 70). These figures show that growth varies at different levels of the tree.

In those partial layers represented in sections T-1 to T-10 there is a great difference in the total amount of absence for a single layer. This varies from no absence for layers 1947 and 1936 (lenticular only in T-12 and T-13) to complete absence in all sections for layers 1880, 1879, and 1857. It is difficult to see how the totally absent growth layers, as well as those present over less than 10 percent of the total possible area, can be assumed to be annual increments. In order to be consistent and to reconcile this tree with the chronology of the region, three layers had to be considered totally absent, and two others almost totally absent.

The above observations make it clear that little if any vertical uniformity can be demonstrated in OL-B-42 with respect to partial growth layers because their location changes from one level to the other. The history of growth, as written in the number of xylem layers, varies according to the level studied.

The three sections chosen for specific comparison in OL-SO-57 are T-2, T-5, and T-8 (fig. 85). Tree OL-SO-7, as stated previously, does not possess as many partial layers as does OL-B-42 (table 70). Although the two trees are approximately the same age, OL-SO-57 possesses only 19 layers that are lenticular in at least one section in contrast with OL-B-42 which has 54. Of these 19, T-2 records 16 as lenticular, T-5 has 12 of 18, and T-8 has 11 of 13 layers that could be represented because of age of sections; the respective percentages are 84, 67, and 77.

The record of growth in this tree indicates a more subdued pattern, but the same trends are present here as in OL-B-42. The center section of OL-SO-57, as in OL-B-42, has fewer partial growth layers than the lower or upper sections, but the difference between the sections is not as great. In addition, T-2 has two layers completely absent and six more with only 50 percent or less of the circuit present; T-5 has none completely absent and four with 50 percent or less present; and T-8 has none absent and five with 50 percent or less present. These figures show that OL-SO-57 has a more uniform record of growth vertically than does OL-B-42.

Comparison of the sections in figure 85 shows a tendency toward more short lenses in the lower sections, an intermediate number in the central sections, and fewer but longer lenses in the upper sections. The upper sections also show longer gaps between the long lenses. A higher percentage of absence and more numerous lenses exist in sections from the lower portion of the trunk; the increase in length and decrease in number of lenses are not always directly proportional to the increase in height above the ground.

The amount of absence among partial growth layers ranges from zero (T-2, 1900) to 100 percent (T-2, 1902). The *range* in amount of absence for specific layers is somewhat different for various heights in the trunk, the middle sections of the tree being the most extreme. Section T-4 possesses five entire and two completely absent layers, section T-7 possesses five entire and no absent layers, section T-10 possesses three entire and no absent layers. The fact that the middle sections of the tree show the greatest tendency for partial growth layers to be either entire around the circuit or else wholly absent may possibly be of use in future work in distinguishing annual from intra-annual growth layers; that is, if some lenticular layers are annual and others are intra-annual, one would expect the annual to be entirely present and the intra-annual wholly absent in the mid-portion of the trunk.

The three sections chosen for comparison in OL-S-62 are T-2, T-6, and T-9 (fig. 86). Although this tree is only 8 years younger than OL-SO-57 and 29 years younger than OL-B-42, it possesses less lenticularity than either of the others, both in number of partial layers and in amount of absence in each partial layer (table 70). In at least one section of the tree 21 layers are lenticular, whereas only 9 layers are lenticular in more than three sections. No layer is completely absent on any one section. Of all the partial layers in all sections only three are absent for more than 300 degrees.

Lenticularity decreases from the lower to the upper sections of the tree. In T-2, 13 out of 21 layers are lenticular, or 62 percent; in section T-6, 8 out of 18 layers, or 44 percent; and in section T-9, 3 out of 11 layers, or 27 percent. As in OL-SO-57, comparison of the sections in figure 86 shows a tendency toward fewer short lenses in the upper sections of the tree, with the possible exception of the 1904 growth layer which shows sporadic growth throughout. The upper sections are characterized by longer lenses, whereas the lower sections are characterized by a higher percentage of absence and more numerous lenses. Increase in length and decrease in number of lenses are more directly proportional to increase in height above the ground in OL-S-62 than in either of the other two trees.

The range in the amount of absence for specific layers is not as great in OL-S-62 as in the other trees, a fact one would expect because this tree has more uniform growth and a minimum of lenticularity.

Degree of lenticularity.—The degree of vertical uniformity for specific layers in the trunks of the three trees is illustrated in figures 89-93. In these figures each characteristically partial layer is plotted separately for the presence of lenses for each successive trunk section. Individual layers were thus analyzed without the interference of other layers. All partial layers were plotted on first analysis, but atypical lenses and atypical growth here and there in the trees were eliminated in the final figures here given.

Final data consist of 54 partial layers for tree OL-B-42, 14 of which are illustrated in figures 89 and 90; 19 for tree OL-SO-57, 13 of which are shown in figures 91 and 92; and 21 for tree OL-S-62, 11 of which are shown in figure 93. Five layers (1904, 1880, 1879, 1857, and 1847) are commonly lenticular in all three trees. The area in the tree covered by these lenticular layers ranges from 99 percent to less than 5 percent. The lack of vertical uniformity in the position of the lenses is shown on the charts by the absence of any consistent starting and stopping of the lines at the same radii.

Although vertical uniformity can be of a high order in some instances for several sections in sequence, there are just as many

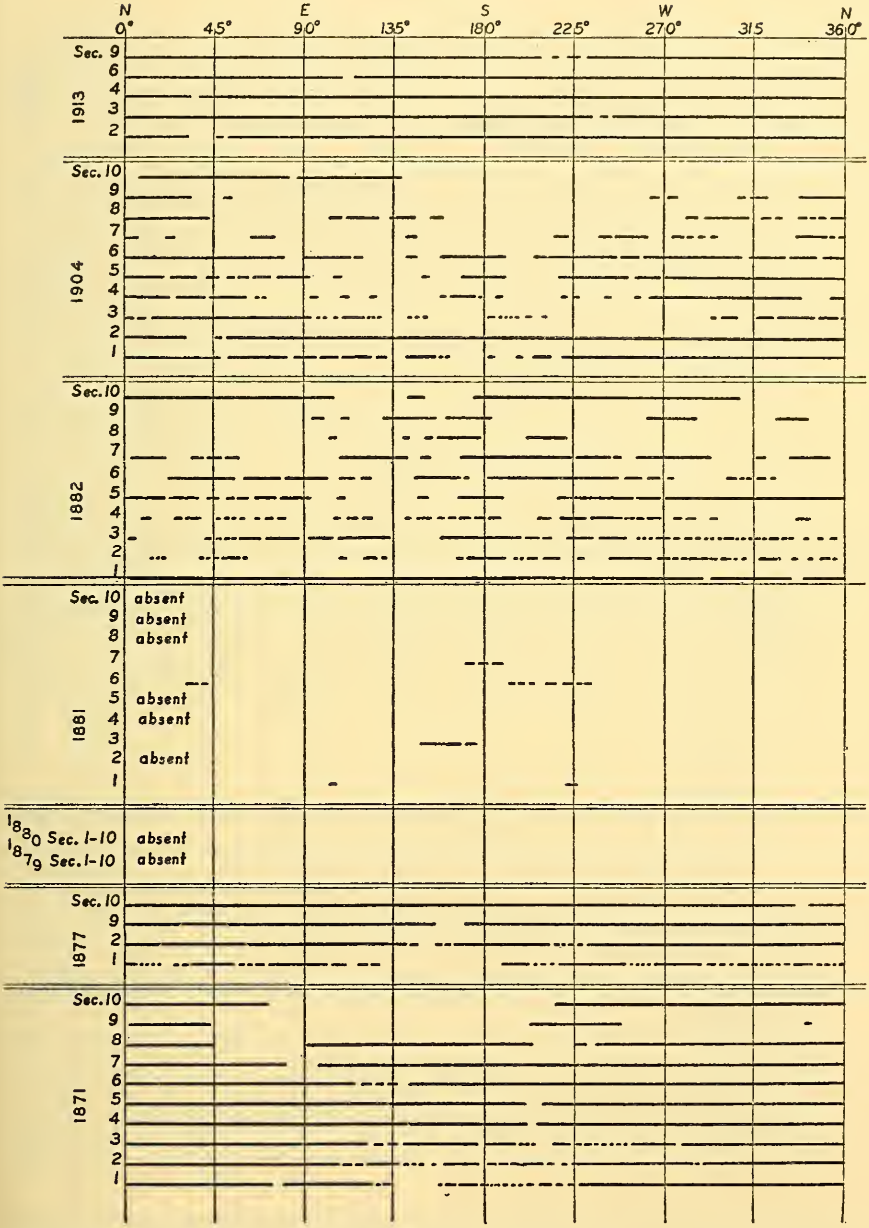


FIG. 89.—Longitudinal uniformity among partial growth layers, or lenses, dated as 1913, 1904, 1882, 1881, 1880, 1879, 1877, and 1871, from designated trunk sections of tree OL-B-42.

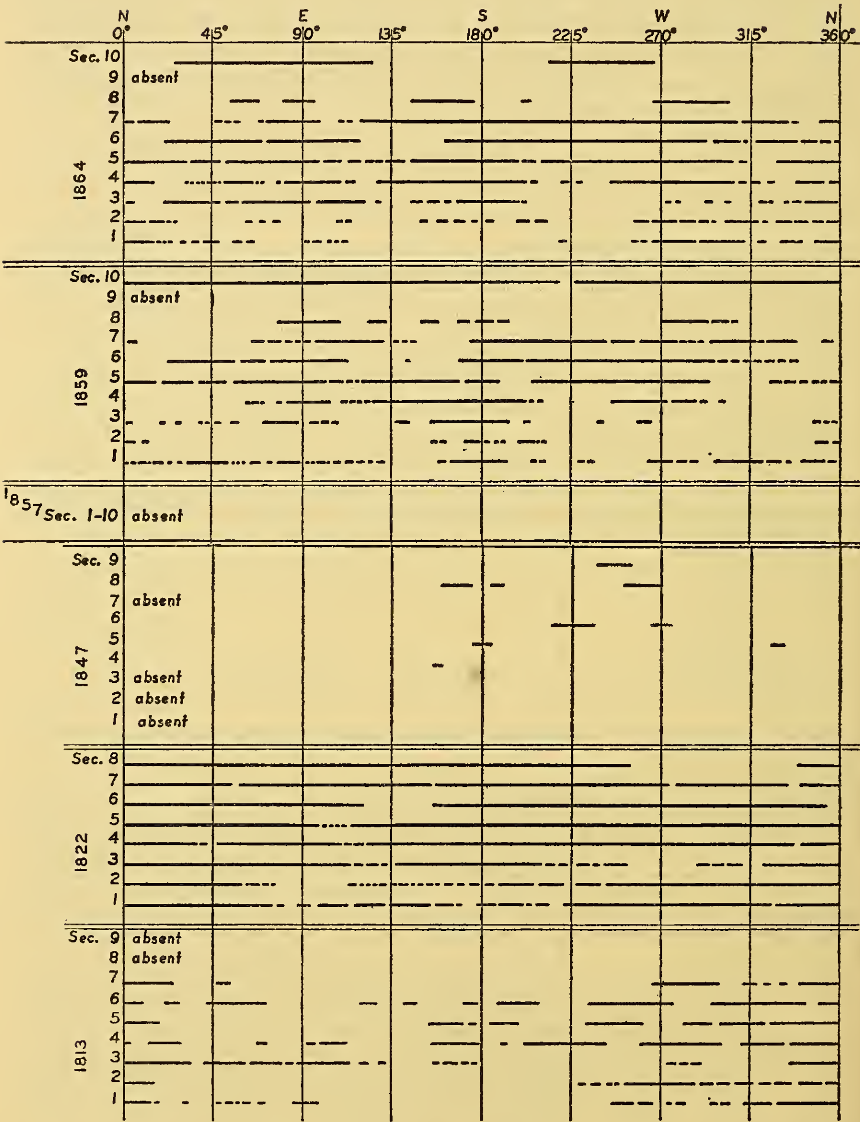


FIG. 90.—Longitudinal uniformity among partial growth layers, or lenses, dated as 1864, 1859, 1857, 1847, 1822, and 1813, from designated trunk sections of tree OL-B-42.

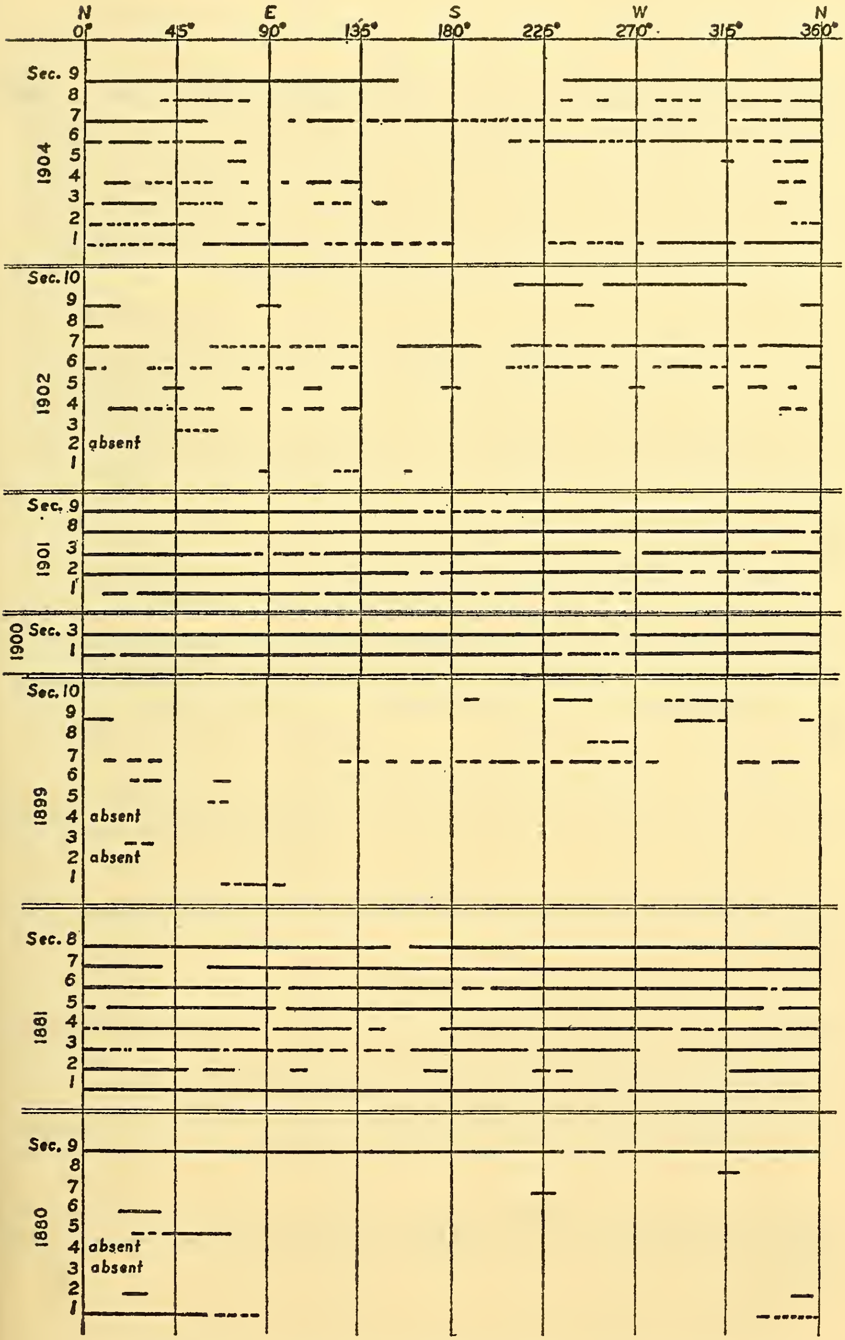


FIG. 91.—Longitudinal uniformity among partial growth layers, or lenses, dated as 1904, 1902, 1901, 1900, 1899, 1881, and 1880, from designated trunk sections of tree OL-SO-57.

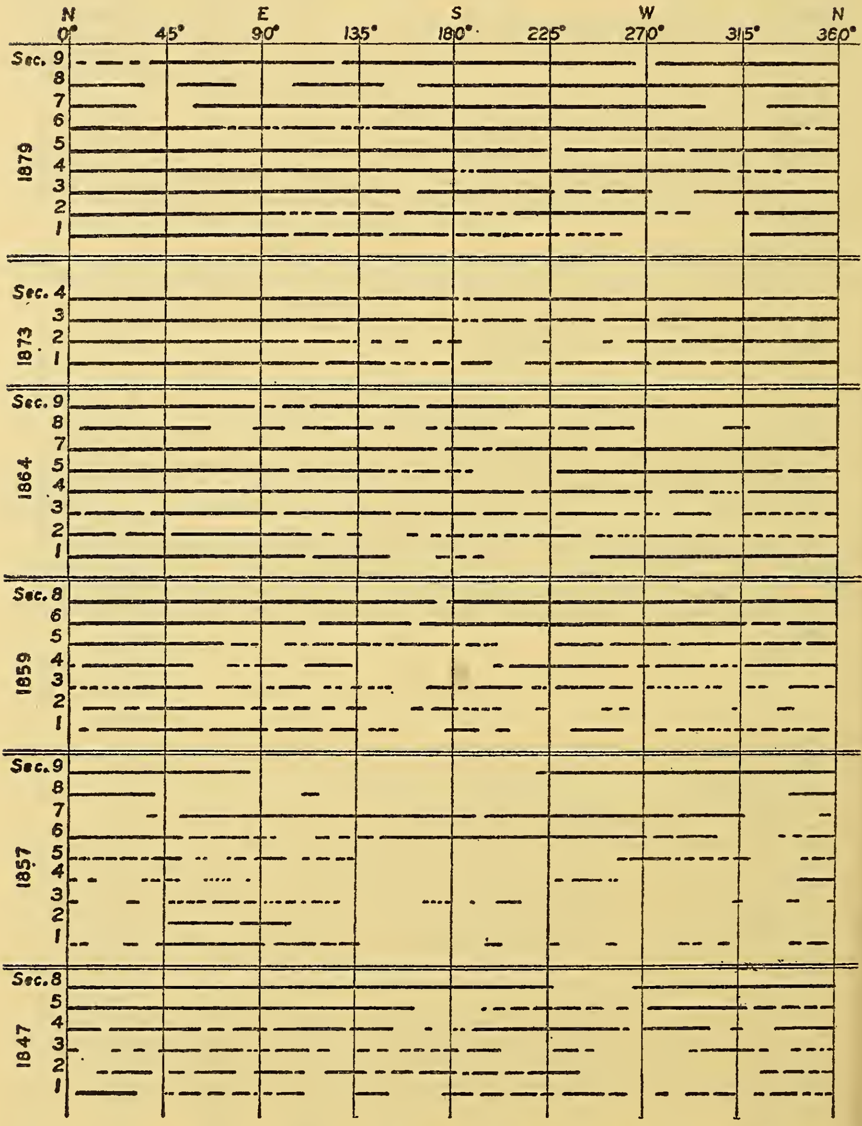


FIG. 92.—Longitudinal uniformity among partial growth layers, or lenses, dated as 1879, 1873, 1864, 1859, 1857, and 1847, from designated trunk sections of tree OL-SO-57.

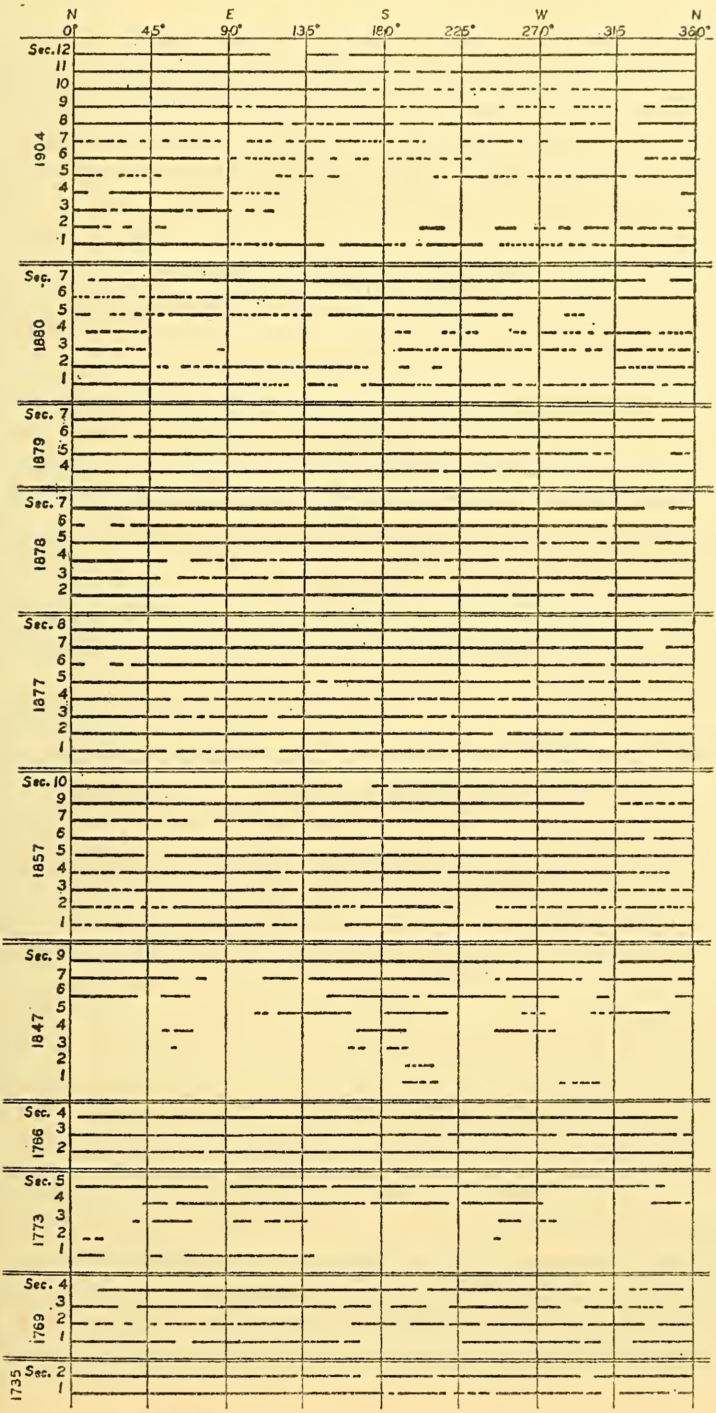


FIG. 93.—Longitudinal uniformity among partial growth layers, or lenses, dated as 1904, 1880, 1879, 1878, 1877, 1857, 1846, 1787, 1773, 1769, and 1735, from designated trunk sections of tree OL-S-62.

cases in which a section has a lens on a certain radius and the next section has none on the same radius. In general, no growth trend was found. Figures 89-93 illustrate the previously mentioned greater degree of absence in the lower sections of the trunk and in the inner sections of the branches. This observation holds true regardless of whether the growth layer was formed early or late in the life of the tree.

The charts of more than a hundred partial layers reveal great variation in the areas of the partial layers present in the trunks of the three trees, areas which vary from 0 to 99 percent. The growth layers that are almost entire are too numerous to be shown on the figures. In contrast, figure 91 shows two growth layers, 1899 and 1880 of tree OL-SO-57, which are absent except for a very small percentage of the trunk. Figures 89 and 90 show even more extreme absence for the growth layers of 1881 and 1847 in OL-B-42. Such absence culminates in figure 89, where the growth layers for 1880 and 1879 in OL-B-42 are entirely absent on all the sections.

Branches.—As mentioned previously, the two branches taken from tree OL-B-42 were not "readable" in terms of their trunk or of the other trees.

Figure 87 and table 71 illustrate the partial growth layers in the branches of OL-SO-57. Comparison of section A from Branch 1 (fig. 87) with section C and with section E reveals another example of the decrease in the amount of absence in partial layers toward the tip. The remaining sections fit into a regular, progressive trend in which the amount of ring absence is inversely related to the distance from the branch base (table 69). Conversely, it can be demonstrated that the number of *entire* growth layers in successive branch sections is directly related to the distance from the branch base. Section A thus has 1 entire ring (4 percent) in the group of 23 layers shown as partial somewhere in the branch, section B has 4 of 23 (17 percent), section C has 6 of 22 (27 percent), D has 14 of 22 (64 percent), E has 10 of 19 (53 percent), and in section F all the layers (2) are entire.

The number of totally absent growth layers decreases with distance from the branch base, but not directly so. For instance, the number of totally absent layers drops suddenly from eight in section A, to one in section B, none in C, one in D, and none in E and F. The sudden drop in section B is partly due to an injury in 1895, visible in the upper radius on this section. The wound stimulus from the injury apparently was effective for several years and appeared to be responsible for the appearance, at this particular place in the circuit, of the layers 1899, 1902, and 1904. These layers were totally absent in section T-4. This same effect was discernible in several other places in the tree, notably in section T-1, where an injury at the east radius in 1899 seems to have been accompanied by the development of a short lens for 1899. Aside from this, 1899 is characteristically absent throughout the lower trunk, being present for only about 1 percent of this entire region.

Comparison of the sections from Branch 1 and from Branch 2 (fig. 87) indicates strongly that lenticularity becomes more frequent toward the base of a branch, as it does toward the base of the trunk, particularly in OL-S-62.

Figure 88 and table 71 illustrate partial and absent growth layers in the branches of OL-S-62. In general, the statements made for the branches of OL-SO-57 hold for those of OL-S-62. Branch 1 shows an arc of less than 45 degrees in 16 percent of the partial growth layers on section A, 7 percent in C, and zero percent in E. Short lenses as exposed on the section surfaces are more numerous toward the base of the branch. If arcs of less than 180 degrees and of more than 315 degrees are examined, the results are not consistent with those of less than 45 degrees: section C has the lowest percentage in each case.

Totally absent growth layers are equal in number on sections A and C—four on each. Section E has more absent. A comparison of sections A and C reveals that only one year, 1904, is common to both sections.

The number of growth layers entire on one or more sections but partial somewhere on at least one of them progresses from 14 (31 percent) on section A, to 20 (43 percent) on C, and to 27 (69 percent) on E. Such increase agrees with that found in Branch 1 of OL-SO-57.

Branch 2 of tree OL-S-62 adds nothing different to the information given by Branch 1. However, the percentage of growth layers that are partial and the average amount of absence among the partial growth layers are decidedly less than in Branch 1. No totally absent growth layer occurred in Branch 2, which was higher on the trunk than Branch 1.

A study of branches emphasizes two things: First, that they possess a certain degree of consistency in the change of lenticularity from base outward, and second, that lack of uniformity of amount and distribution of lenticularity in detail is even more striking than is the consistency.

Discussion.—It is interesting to note that some partial layers with a high degree of absence (1899 and 1880 of OL-SO-57, fig. 91) may record a high degree of presence (1899) in T-7 and 1880 in T-9) in certain sections. Many other growth layers also tend toward a greater degree of presence at the level of section T-7. In fact, the level of section T-7 is a center of moderately greater growth whose average layer thickness is 1.02 mm., approximately 10 percent greater than the average of the sections immediately above and below. The cambium at the level of section T-7 no doubt was active for a longer time or at a greater rate than elsewhere in the tree; whether annual or intra-annual is irrelevant. Perhaps this level was close to a large branch and therefore received a greater supply of food materials and hormones. The greater average thickness of growth layers in section T-7 may add somewhat to the quality of circuit uniformity but would detract from that of vertical uniformity.

One must look for a different explanation for the 1880 growth layer of T-9 in tree OL-SO-57 (fig. 91). This layer is more than 95 percent present at this level but averages far less than 10 percent at all other levels. The growth layers of T-9 do not show a greater average thickness. Obviously the factors that caused this comparatively excessive growth for 1880 in T-9 were active only at this level and only for this one year.

Figure 92 illustrates the growth layers of 1859 and 1847 in tree OL-SO-57. They are characteristically lenticular throughout the tree and may be regarded as typical layers with medium lenticularity. Growth is very sporadic and the "layer" actually consists of hundreds of small patches of xylem. Both growth layers illustrate well the previously mentioned increase of absence in the basal sections. For instance, the layer 1859 especially shows where a single layer is very spotty at the base and almost entire in the upper portions of the tree. The same holds true for the layers 1904 and 1880 and 1847 and 1773 of tree OL-S-62 (fig. 93). Obviously, the same causative factors were active for this tree as for OL-SO-57.

Tree OL-B-42 shows some interesting deviations from the above observations. Although layers 1877 (fig. 89) and 1822 (fig. 90) conform quite well to the pattern of growth found in the other two trees, other layers show very different trends. Attention is drawn to layer 1904 (fig. 89), where presence *increases* in the lower sections of the tree; to 1882, where the longest lenses are found on the first and tenth sections; and to 1871, where growth is more sporadic in the lower sections and more absence exists in the upper sections. Finally, layers 1864 and 1859 and layer 1813 (fig. 90) have longer lenses and more consistent growth in the *center* sections of the tree. The cambium of these three trees obviously reacted differently from each other and from one section to another in the same tree.

The distribution of lenses and their areal variation from almost entire to almost absent makes it difficult to support the supposition that these growth layers represent *annual* increments. This would necessitate holding to the hypothesis that for three consecutive years the entire cambium of the tree put down xylem over only about 3 percent of its total area in one year out of the three-year period, and failed completely to lay down any xylem during the other two summers. Cases are known where certain regions of the cambium have been inactive for some time, but these trees usually were carrying on a marginal existence. Tree OL-B-42, although it appeared to be carrying on such an existence, was healthy and growing well.

The series of growth layers at and near the end of the 19th century became thin, and in many cases lenticular, in all the trees of the area. There can, however, be no positive proof as to whether these thin diagnostic growth layers are annual or intra-annual until such time as a recurrence of conditions will cause the formation of similar growth layers, in the Flagstaff area, in trees under constant observation and annual sampling.

ANNUAL GROWTH LAYERS AND MARGINAL ANALYSES

Since only variable sequences, possessing certain rather isolated diagnostic layers, are "readable" and therefore useful in crossdating and chronology building, dendrochronologists must choose sequences that possess thick and thin rings. Trees with such sequences are commonly found in sites where growth factors seldom reach optimum and where the variable impact of limiting factors causes variability.

Structural variations, which always accompany variable sequences, are sometimes very difficult to interpret. Several of the most difficult questions to be faced are: 1. What actually constitutes a true seasonal growth increment, and are there any objective, definite criteria by which these annual layers may be recognized? 2. Can "missing" layers always be detected? 3. Even if crossdating exists among trees in any area, does this necessarily prove beyond question the annual nature of the layers involved? 4. Does our knowledge of physiology, anatomy, and ecology support the long absolute chronologies built up by dendrochronologists? The whole structure of chronology building depends upon the correct answers to these and other questions. If prehistoric wood specimens from Indian ruins of the Southwest are to be accurately dated, and if prehistoric climate is to be reconstructed, an accurate dating system must be attained. Such a system must assign definite calendar dates to each growth layer with some assurance of accuracy.

All the workers in dendrochronology have not been botanists, and acquaintance with the literature brings with it the conclusion that the botanical problems involved have not always been fully recognized and that analyses and methods of approach to a very complex matter have been oversimplified. There is still belief that crossdating is sufficient proof of the annual nature of an increment and that the formation of a distinct growth layer is necessarily an annual phenomenon. Drought, frosts, distribution of food reserves, and other factors have not been recognized as causes for definite cessation of growth in the middle of an actual growing season.

Crossdating may in some cases help to determine where layers may have failed to form in some sections of a tree. It is very doubtful it any botanist would consider cambial activity to be a simple process which regularly begins over an entire tree at a specific time in spring, runs a steady course, and ends at a definite time in summer or autumn. No exclusively annual rhythm of the cambium has been proved. Trees do not necessarily have only one rest period a year and only one uninterrupted "growing season"; in fact, many investigators have published proof to the contrary.

A failure to understand and to evaluate the basic principles of plant physiology, ecology, and especially the importance of cambial activity as related to the total metabolism and general economy of the tree seems sometimes to make itself evident. An adequate grasp of the concepts that different localities produce different responses and that principles or chronologies gained in one region do not necessarily apply to other regions emerges only from an intensive study in each separate region. Comparisons have been made by some students between records from localities more than 1,000 miles apart, and results were obtained, apparently, by assuming that trees react in the same manner to identical limiting factors regardless of their location.

That trees, even in the same locality, will respond each to its own combination of factors has been shown by Glock (1950) in comparing growth sequences of trees that grew various distances apart. Working with trees that grew near Holman Pass, north-central New Mexico, he found that the disagreement of sequences increased with increasing distance apart, and in this case distance was measured in yards and not in miles.

Much of the basic difficulty appears to arise from the fact that the complete analysis of a dissected tree is necessary to learn its growth history. This is a long and laborious task that is seldom undertaken even in beginning the study of growth responses in one locality. As a result, conclusions have been drawn from relatively meager material, and a true appreciation of the tremendous variability found, even in one tree, is sometimes not realized.

The solution to the problem of positive detection of partial layers can commonly be obtained by a study of an adequate amount of material from the stem of a tree. Even this, however, may not suffice—for example, tree OL-B-42 with its 15 sections.

A second, much less reliable, method of proof for the existence of an absent layer, has been the comparison of specimens from many trees in the same general locality. The reliability of this method is in direct proportion to the number of trees studied and the number of specimens used from each tree. However, this method involves the inclusion of genetic differences in individuals and the differences in response that probably exist among trees. It also includes differences in microclimate and soil, even between individuals that grow very close to each other. This kind of work has usually been based on core samples rather than sections because cores do not require the destruction and dissection of an entire tree.

The most important problem concerns the nature of a true seasonal growth increment and the valid principles and assumptions by which annual or intra-annual growth layers are distinguished. For this, there is no simple solution. Various investigators have obtained absolute dates from tree-ring records by accepting crossdating as final proof.

This method seems to fall short on two counts. First, it is difficult to understand how crossdating has any relation to the annual or intra-annual nature of a layer. Is there any proof that growth factors which commonly produce one sharply bordered growth layer a year cannot on occasion do so two or more times in one calendar year? If these growth factors are widespread, why should not the effects be present in many trees of a stand? Second, when there is such a high degree of structural differences in so-called "sensitive" trees that a continuous series extends from the extreme of variability and lenticularity to that of uniformity and entirety, where may the objective, arbitrary line be drawn in this series separating true annual growth layers from intra-annuals with any degree of certainty?

The resolution of this critical problem is one of the major objectives of the present study. Measurements, detailed morphological analyses, and particularly experimentation and prolonged observation of the same trees over many years will, we hope, permit positive identification of those layers formed during the observation period, thereby giving us a better understanding of the problem.

For those studies which are primarily morphological, the problem of recognizing the annual increment involves the analysis of the outer border of the densewood (or summer wood) and the relationship that various growth increments bear to each other. The problem is as important as the correct determination of absent rings, for it involves making a proper chronology of the years. It is also difficult because the same conditions that bring about readable growth-layer sequences also result in the production of absent layers, partial layers, and false or double rings. What are the definite criteria by which a false or double ring may be distinguished from two annual growth layers? A realization of the variability of marginal definition existing in one tree illustrates the difficulties encountered in assigning definite dates to certain growth layers.

The correct identification of uncertain growth-layer margins has been approached in the past by thorough comparison and crossdating among different specimens from the same tree and from different trees of the same locality. Douglass (1940) used certain principles in order to arrive at absolute dates for the chronology of the Flagstaff area. The criteria used by Douglass were derived from his early work with ponderosa pine. He found that for normal years the spring or lightwood merged into densewood and that the latter terminated abruptly in a sharp outer face against which the next year's lightwood had been placed. When double rings were formed, implying an interruption of growth processes making lightwood at some time during the growing season, he found that the interruption did not result in an abrupt discontinuity but in a gradual transition outward from the premature densewood into lightwood cells again. Thus he thought the infallible criterion for identification of false rings to be a hazy outside boundary for the densewood in contrast with a sharp outer boundary of a true annual.

The above criterion was supported by a secondary one which maintained that the characteristic position of a false densewood is always far out in the annual growth. Therefore if a questionable densewood is just inside a sharply margined densewood, it is intra-annual or false, but if it is just outside a definite boundary and within the next lightwood outward it is an annual.

As was previously stated, the three O'Leary trees were dated on the basis of the Northern Arizona chronology as worked out originally by Douglass. We conscientiously followed his criteria for the identification of all doubtful growth layers. The sequences thus dated agreed in the main with the established chronology (Douglass, 1937).

However, during our studies it was in many cases very difficult to apply the two criteria for the identification of the annual increment because of the great range of variation among our trees and because of complete gradation throughout. For example, growth layers possessed margins that varied from diffuse to very sharp. Certain layers which were at one end of the range of diffuseness had to be called annuals in some cases and intra-annuals in others in order to follow the chronology. The same held true for rings at the other end of the range. The criteria appeared reasonable and decisions seemed logical and valid for about 90 percent of all growth layers. However, since contrasting cases did exist, a definite doubt began to form as to whether these criteria could actually be applied without exception, and, if universally applied, whether the dating is reasonably free from error.

Certain sections from OL-SO-57 were used, although many similar cases of variation calling for doubtful decisions were encountered in all three trees, particularly in OL-B-42, and in their branches. Tree OL-SO-57 was chosen because its characteristics and site factors were intermediate. No attempt was made to illustrate only extreme cases. The following discussion shows the normal difficulties in distinguishing between annual increments and intra-annual growth layers.

The photographs here reproduced were taken directly from the wood surfaces after they were polished. They show the detail of cellular organization as seen through a stereoscopic microscope. The 15 photomicrographs (pls. 6-13) illustrate a few of the variations in growth-layer characteristics brought out by careful analysis.

Plates 6 and 7 show a series of growth layers which are classified as *intra-annual* in accordance with the Arizona chronology. In plate 6, figure 1, layers of densewood with diffuse margins lie within the lightwoods of the increments labeled 1723 and 1724. These densewood bands apparently identify a period of change in growth processes during the growing season when the bands of densewood were laid down. The increment for 1723 shows just a hint of a wide mid-line, whereas that for 1724 has a more definite intra-annual densewood. Although the intra-annual or "false" ring in 1724 is outside, or closer to, the sharp densewood of 1723, it has an outer border which is too diffuse to be considered a true annual. The two cases illustrate the slight structural variations which form the beginning of a continuous series from an unmodified simple layer to an increment which could be two layers. Although the decision concerning 1724 may seem doubtful to some students, the densewood in question appeared clearly intra-annual, based on the characteristics of these layers throughout the entire tree in reference to the standard chronology.

Plate 6, figure 2, and plate 7 show that a decision as to the proper identification of false rings becomes progressively more difficult and may be accompanied by an increasingly greater possibility of error. Plate 6, figure 2, illustrates a more definite mid-line in the lightwood of 1755. The densewood of the false annual ring is heavy and distinct; its outer and inner margins are rather abrupt and distinct, but the transition into and out of the densewood band covers several cells. The outer margin is considered too diffuse to be called the densewood of a true annual. Cases of this kind, however, illustrate that it is not rare for certain growth factors to cause the formation of densewood during a regular growing season. Ordinarily the abruptness terminating the densewood of an intra-annual is less than that which terminates the annual, but the quantitative difference may be difficult to measure at times.

Plate 7, figures 1 and 2, illustrate the same growth layers on section T-3 of OL-SO-57. A comparison shows differences that exist between the northeast radius (pl. 7, fig. 1) and the east radius (pl. 7, fig. 2). On this section and for these years, the actual distance between the two figures on the wood is about 2 inches. The increment labeled 1786 on the northeast radius shows two bands of densewood (pl. 7, fig. 1), the inner one having diffuse inner and outer margins. On the east radius (pl. 7, fig. 2) the inner band has merged completely with the outer. These morphological variations appear and disappear as a ring if followed around its circuit much in the same manner as lenticular layers.

The mid-line or intra-annual band of densewood in 1785 is rather thin and definite on the northeast radius (pl. 7, fig. 1) but very definite and much closer to the chief densewood band of the annual increment on the east radius (pl. 7, fig. 2). The outer margin of this intra-annual of plate 7, figure 2, would be considered sharp enough for an annual because transition from densewood to lightwood occurs within one row of cells. Some students might insist that this band terminates an annual increment, but the densewood in question lies just inside the strong band of densewood and is therefore intra-annual according to the second of our criteria.

The band of densewood in the increment for 1785 on plate 7, figure 2, is very narrow, but this in itself means little since frequently the densewood of an unquestioned annual increment is equally narrow and at places the entire increment may be only several cells thick. The series indicates that a great amount of material from one area is necessary for the proper analysis of certain features in a specific chronology. Even so, it is questionable whether exact dates may be arbitrarily assigned to certain diagnostic growth layers in a long sequence.

The series of densewood bands (pls. 6 and 7) shows that the extreme variability, which exists throughout the tree with regard to grosser characteristics, is also present in very important microscopic details. The intra-annual of 1785 in some portions of its existence has an outer border in some places more distinct, in others less distinct, than in the photographs. The layer was chosen as an example because it was a problem layer with high variability throughout the tree. It illustrates the difficulty of drawing an arbitrary line somewhere in the series of variations, a line to one side of which all less sharp are intra-annuals and to the other side of which all more sharp are true annuals.

Plates 8 and 9 and plate 10, figure 1, illustrate the variations in growth layers which are considered *annual*. Plate 8, figures 1 and 2, and plate 9, figure 1, illustrate the increments dated as 1855-1860 at the levels of sections T-1, T-3, and T-4. Attention is called especially to the growth layers for 1857 and 1859. In plate 8, figure 1, section T-1, the growth for 1857 consists of a layer two to three cells thick which lies against the outer face of 1856. Its presence is revealed here by careful examination, by comparison with other parts of the section and tree, and by the visibility of the individual cells. Because the thin layer for 1857 lies *outside* the heavy band of densewood for 1856, it was interpreted as annual in conformity with the standard Northern Arizona chronology. Is it possible that the thin layer of cells was actually postseasonal growth, that is, cells added on after the chief growth flush of the 1856 season?

The layer for 1857 on section T-3 (pl. 8, fig. 2) is somewhat more distinct and thicker than on section T-1 (pl. 8, fig. 1), but it is still closely allied to the densewood of 1856. Neither figure on plate 8 carries unequivocal evidence of the annual nature of the 1857 layer. In plate 9, figure 1, section T-4, the layer for 1857 possesses definition as sharp as anywhere in tree OL-SO-57. Although two or three lightwood cells separate its densewood from that of the previous growth layer (pl. 9, fig. 1), the 1857 layer could easily be interpreted as intra-annual. This is true except that it lies *outside* the sharply defined densewood of 1856 and should be annual if we follow the criteria of dating previously stated. However, studies at the extreme lower forest border have emphasized the intra-annual character of such "outer thin" growth layers (Glock, Studhalter, and Agerter, 1960).

Plate 9, figure 2, and plate 10, figure 1, also contain examples of narrow growth layers, 1752 on the former photograph showing a relatively thick band of densewood, and 1820 on the latter showing a thin band of densewood. By the standard criteria these growth layers are interpreted as annual because the Northern Arizona chronology was used as a point of departure. However, we believe their annual nature to be in doubt.

In plate 8, figures 1 and 2, plate 9, figure 1, and plate 10, figure 2, the narrow growth layer labeled 1859 must be interpreted as such in order to fit into the regional chronology. This growth layer, it should be emphasized, possesses a heavy band of densewood, lies just outside a less heavy, less sharp band of densewood, and compares favorably with the situation in the increment of 1785 (pl. 7, fig. 2), with its two bands of densewood in one year. The growth layer for 1859 may appear more definite in other trees and its annual nature may seem more certain, but the fact remains that in our three trees the distinguishing characteristics for annual and intra-annual growth layers overlap at the extremities of their range of variation. The arbitrary application of criteria to small amounts of wood material and to regions where the specific nature of tree growth has not been fully investigated seems open to the full possibility of error. The use of a large amount of material, checking and rechecking, and constant crossdating could conceivably establish a reasonably accurate sequence. This procedure, however, cannot be used in a region or between regions until details of growth have been traced day by day for a period of several years. Chronology building comes *after*, not *before*, such investigations.

A rather intensive study of tree growth at the extreme lower forest border has, it is hoped, thrown some light on the status of the doubtful annual increments here discussed (Glock, Studhalter, and Agerter, 1960).

Plate 11 and plate 10, figure 2, sections T-3 and T-1 of tree OL-SO-57, illustrate the manner in which growth layers, labeled 1773 and 1857, disappear by apparently merging with the previous densewood. In fact, lightwood traced tangentially disappears first; densewood may continue for a distance, indistinguishable from the densewood of the previous growth layer, or it may complete the circuit of the section. These particular growth layers were chosen from among many others more characteristically lenticular because the light-wood disappears abruptly and the areas can therefore be photographed. From these illustrations it is apparent that two cores, taken only a short distance from each other, will have different sequences and that one will record the layer while the other will not. Whether lenticular rings as above described are always positively annual increments, or whether they indicate that the cambium has had two periods of activity within a single year, needs to be decided in every region for itself.

Plate 12, figures 1 and 2, and plate 13, sections T-3, T-1, and T-3 of tree OL-SO-57, form a series which illustrates the problem of growth layers possessing a very thin and questionable densewood. In OL-SO-57 the growth layer for 1813 was one that presented a serious problem. Plate 12, figures 1 and 2, show the 1813 layer under different magnifications on different sections and at different radii. The questionable nature of this growth layer proved to be consistent throughout the tree under careful microscopic examination. The question which is difficult to answer is whether, at the end of a growing season, the cambium can lay down such a small amount of densewood and in spots fail to lay down any at all. The intermittent and discontinuous character of the densewood can be seen in both figures on plate 12, although with a higher magnification (fig. 2), every cell is larger, and the characteristic morphology is more apparent. Intermittency is of common occurrence in mid-lines and false growth layers. Does it occur in a true annual as well?

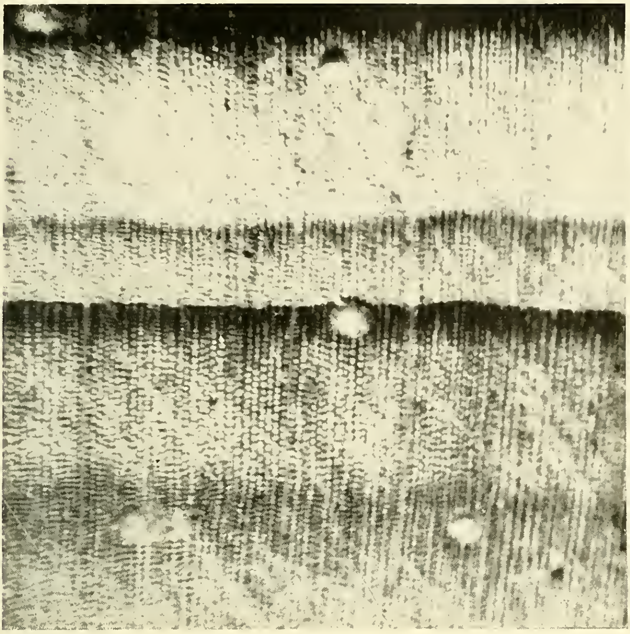
It is significant that where the layer for 1813 can be studied in relation to those layers just inside and outside (pl. 12, fig. 1), the two layers 1813 and 1814 produce a single increment which is very comparable to its neighbors in width, amount of densewood, and general character except that it would possess a very thin mid-line. The thin band of densewood is in all respects a mid-line even though it lies closer to the densewood of 1812 than to that of 1814 and has a fairly sharp outer margin. The repeated occurrence of such morphological characteristics may well cause doubt as to the validity of simple dating criteria for determining an annual increment. Certainly in our three dissected trees it would be very difficult to justify the annual nature of the layer for 1813. Perhaps the study of a great amount of material from the area would lend support to its annual nature, but the decision should ultimately be made, not on simple criteria, but upon strict botanical investigations.

Plate 13, section T-3 from tree OL-SO-57, permits a comparison of a "true" annual increment, 1813, and the intra-annual growth layer of 1809. The two pictures were taken from the same section and are chronologically only four years apart. No doubt exists as to their striking similarity. The simple criteria upon which the Arizona chronology was based here suggest that the increment labeled 1813 and the inner growth layer of 1809 are both annual. Therefore, these criteria cannot always be relied upon to separate annual growth layers from intra-annual. Adequate evidence from observation and experiment over a number of years is needed in each region to establish the principles by which annual increments and intra-annual growth layers may or may not be identified.

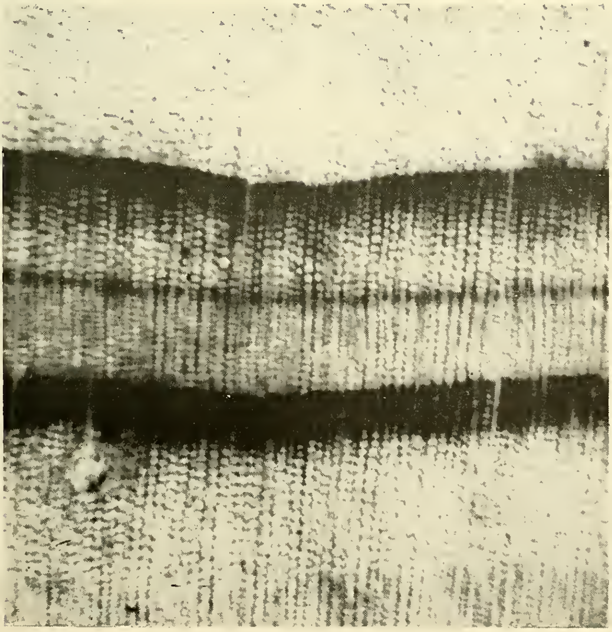
IX. SUMMARIES AND CONCLUSIONS

Summary statements have been made throughout the text; in addition, sections designated as summaries have brought together the chief characteristics of the three trees. These sections appear on the following pages:

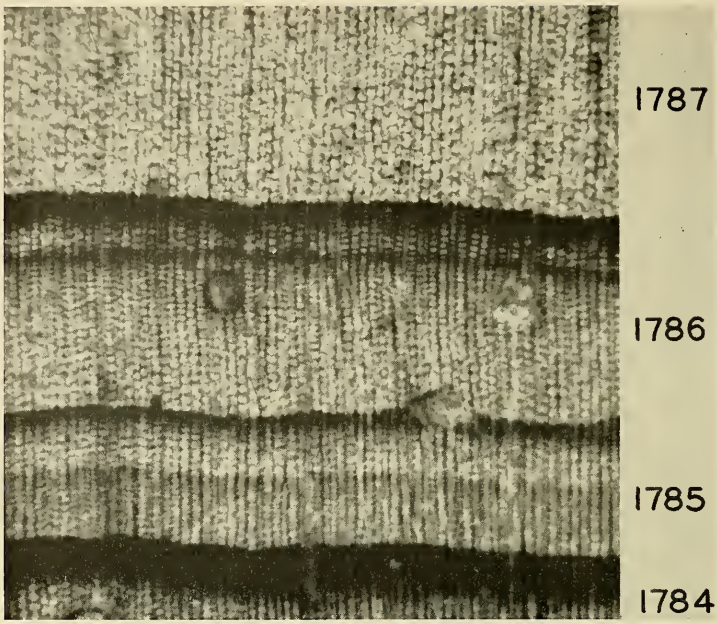
Before remarks are made concerning the objectives of our study, as mentioned in the Introduction, it is well to point out that an increase in the number of radii, of sections, and of trees decreases



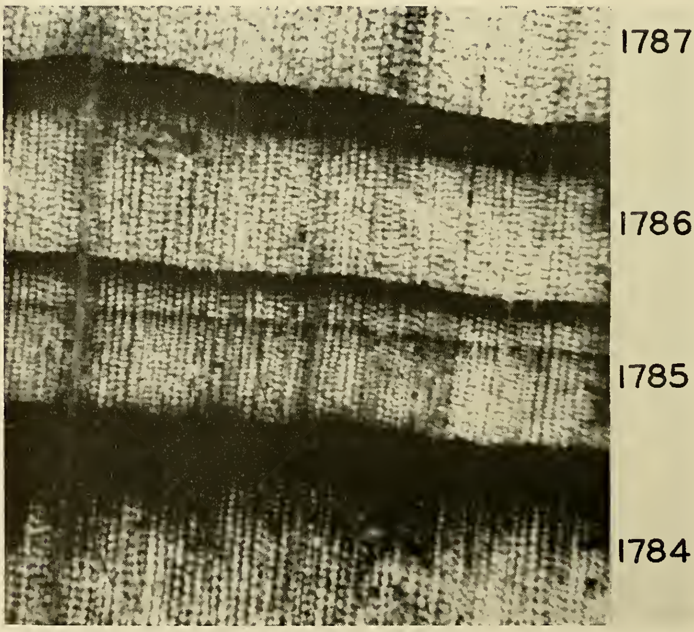
1. Increments dated as 1723 and 1724 on east radius of trunk section T-3 of tree OL-SO-57. Two degrees of diffuseness on the outer margins of two intra-annual growth layers. A mid-line in 1723 and an "outer thin" growth layer in 1724.



2. Increments dated as 1754-1756 on southeast radius of trunk section T-3 of tree OL-SO-57. A mid-line of 1755 more definite than that of 1723, figure 1, above.

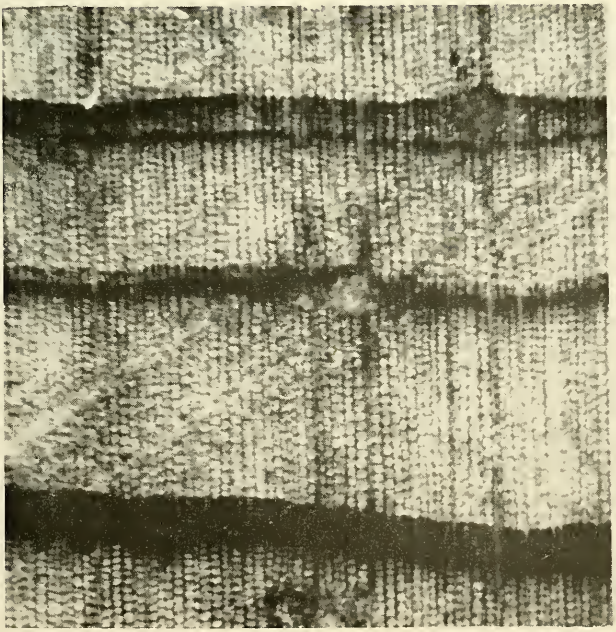


1. Increments dated as 1784-1787 on northeast radius of trunk section T-3 of tree OL-SO-57. Mid-line of 1785 rather thin and weak. Intra-annual densewood of 1786 fairly definite and separated from annual densewood by lightwood cells. Compare with figure 2, below.

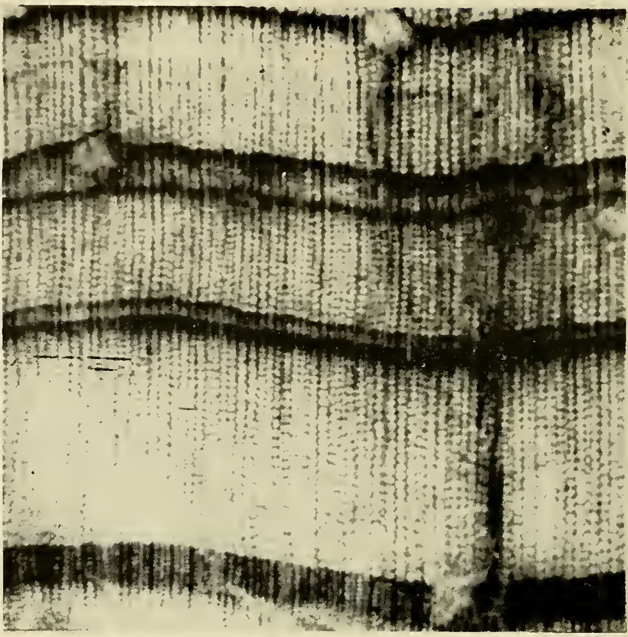


2. Increments dated as 1784-1787 on east radius of trunk section T-3 of tree OL-SO-57. Mid-line of 1785, figure 1, is much more definite and farther out—i.e., closer to the annual densewood—in figure 2. Intra-annual of 1786, figure 1, has in figure 2 moved outward to merge with the annual densewood.

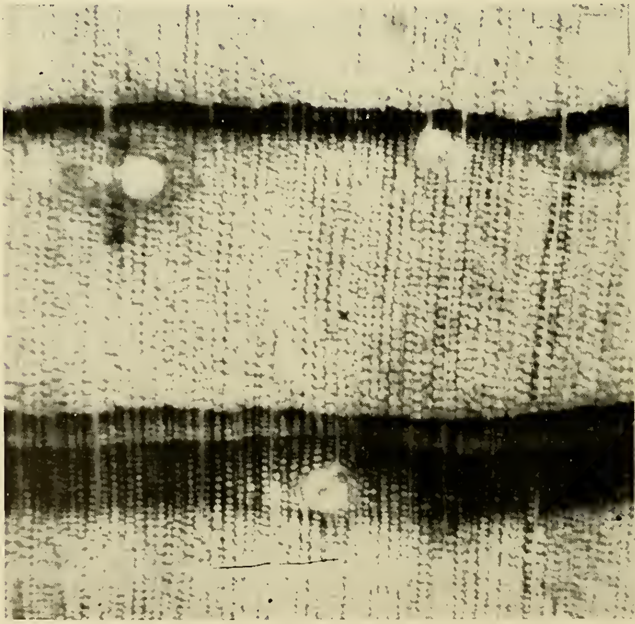
1. Increments dated as 1855-1860 on southeast radius of trunk section T-1 of tree OL-SO-57. This figure and plate 8, figure 2, and plate 9, figure 1, form a series. Layer for 1857 averages two cells in thickness, against the densewood of 1856. Densewood of 1858 closely resembles intra-annual densewood of 1785, plate 7, figure 2. Compare with plate 8, figure 2, and plate 9, figure 1.



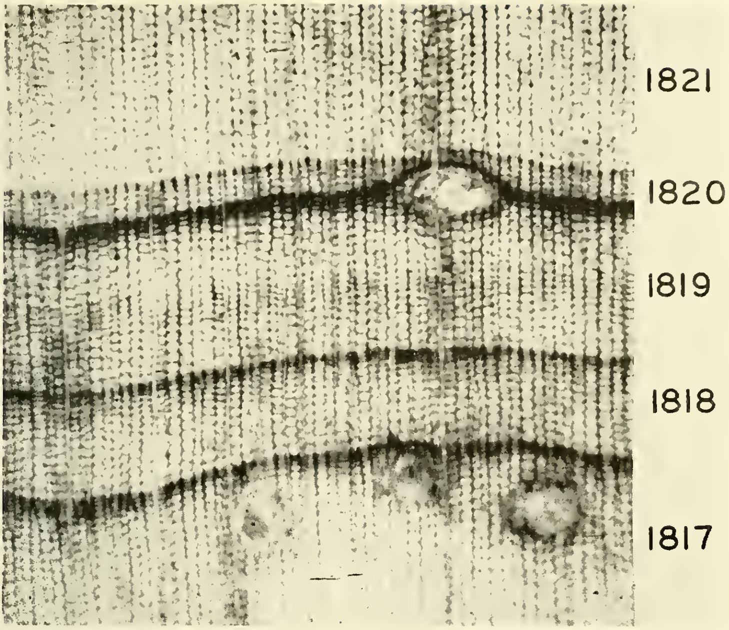
2. Increments dated as 1855-1860 on east radius of trunk section T-3 of tree OL-SO-57. Layer for 1857 slightly thicker and more distinct than it is on figure 1. Densewood of 1858, as in figure 1, resembles that of an intra-annual. Compare with plate 8, figure 1, and plate 9, figure 1.



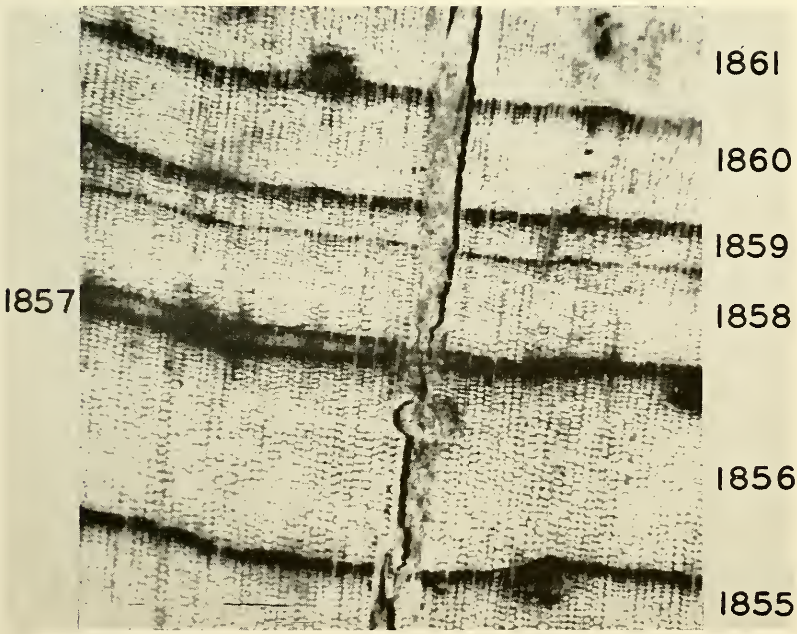
1. Increments dated as 1855-1860 on south-southwest radius of trunk section T-4 of tree OL-SO-57. Layer for 1857 four to five cells thick and more distinct than on plate 8, figures 1 and 2. Densewood of 1858 has not changed from the two previous trunk sections. Compare with plate 8, figures 1 and 2.



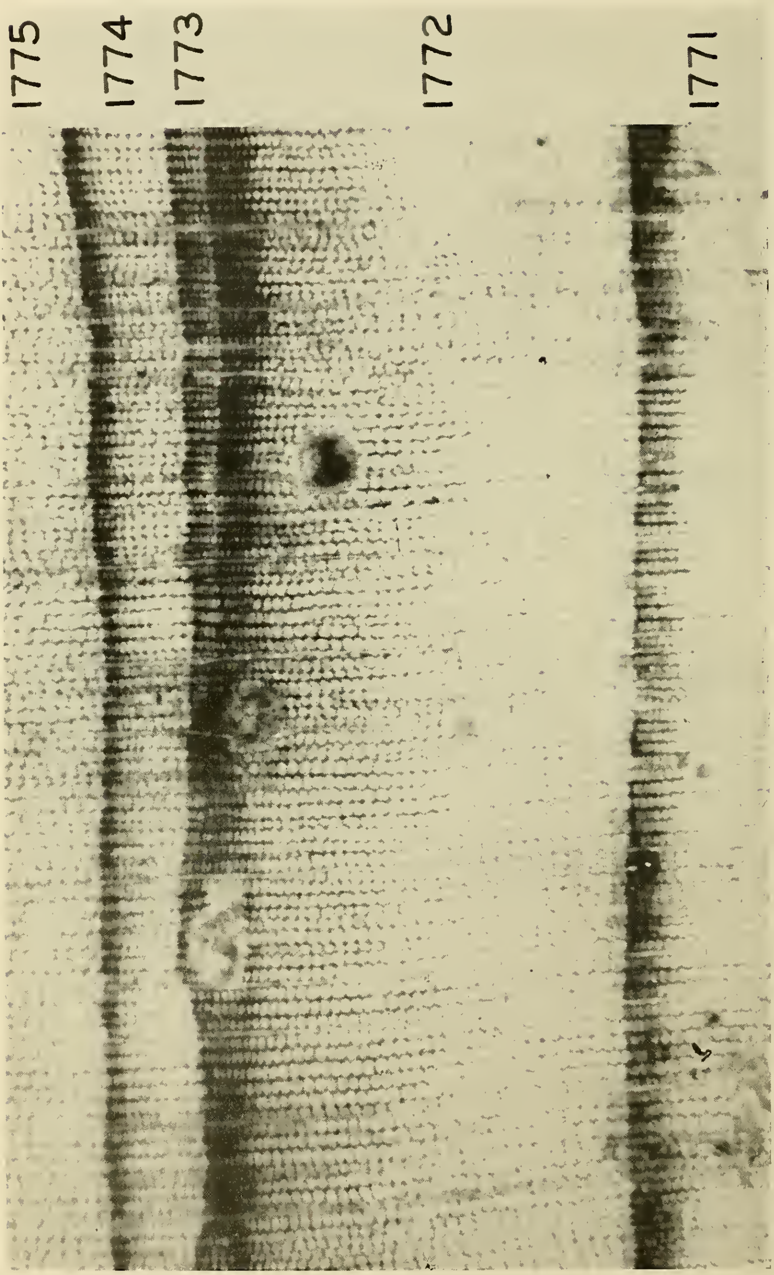
2. Increments dated as 1751-1754 on west radius of trunk section T-4 of tree OL-SO-57. "Outer thin" growth layer, 1752, with relatively thick band of densewood. Compare with plate 10, figure 1.



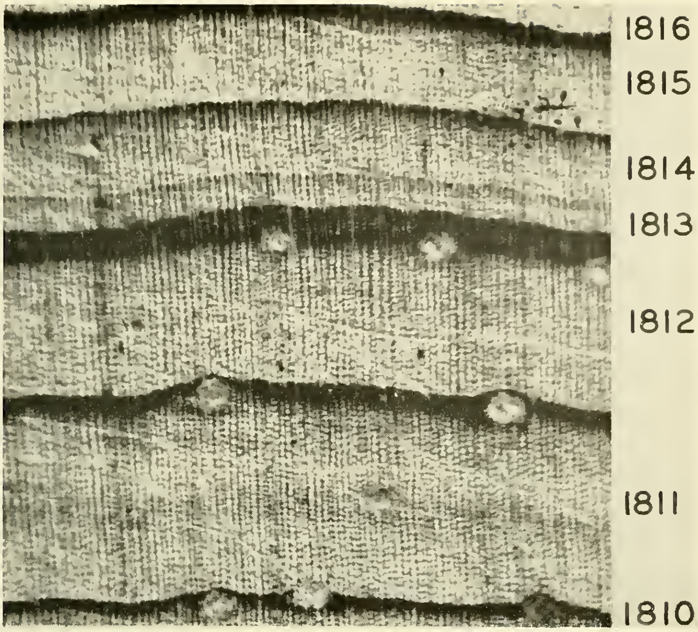
1. Increments dated as 1817-1821 on northeast radius of trunk section T-3 of tree OL-SO-57. "Outer thin" growth layer, 1820, with relatively thin, nearly nonexistent, densewood. Compare with plate 9, figure 2, and plate 6, figure 1.



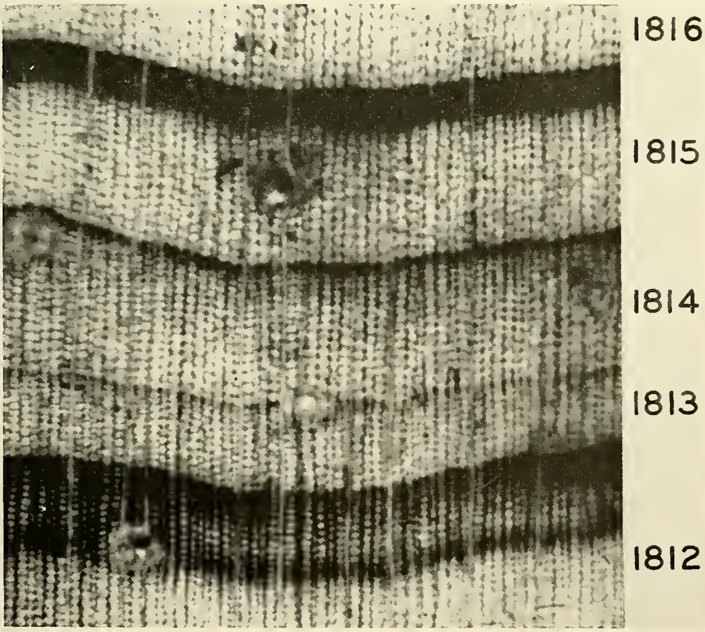
2. Increments dated as 1855-1861 on east radius of trunk section T-1 of tree OL-SO-57. Lightwood of 1857 disappears tangentially and layer for 1857 appears to merge with densewood of 1856. Compare with plate 11. Layer for 1859 resembles layers of same date in plate 8, figures 1 and 2, and plate 9, figure 1, and, because of weak densewood of 1858, answers the description of an intra-annual growth layer.



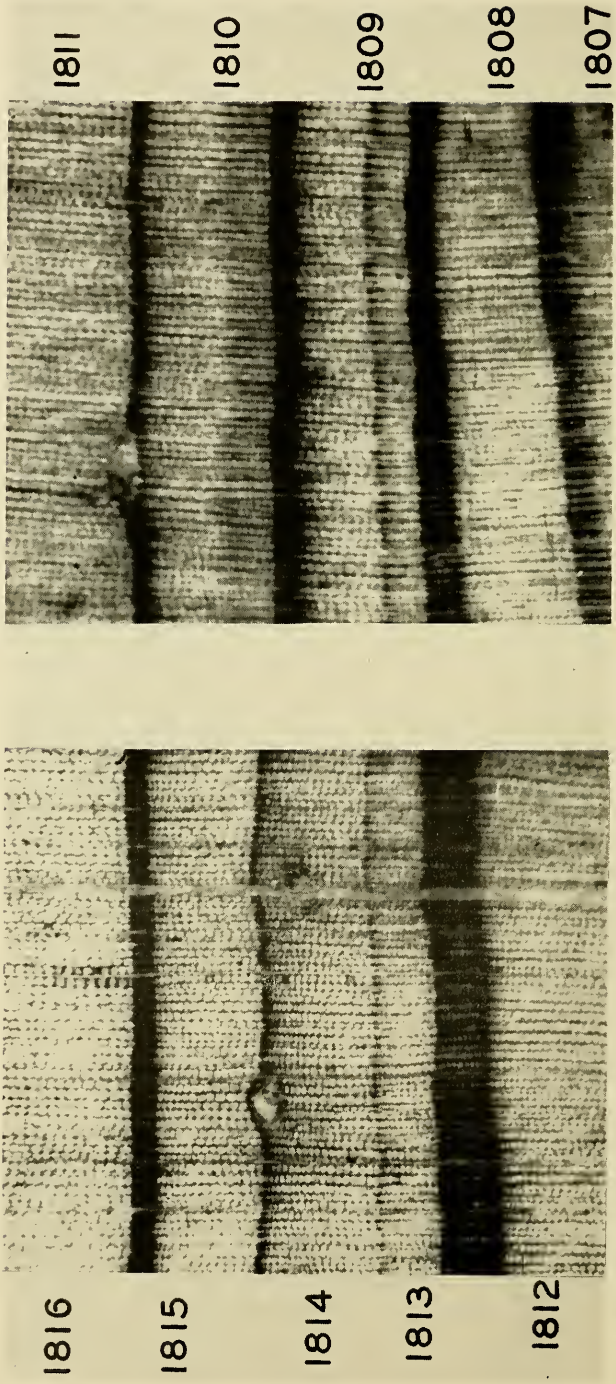
Increments dated as 1771-1775 on south radius of trunk section T-3 of tree OL-SO-57. "Outer thin" growth layer, 1773, with relatively thick densewood. Compare with plate 10, figure 1. Lightwood of 1773 disappears tangentially and layer for 1773 appears to merge with densewood of 1772. Compare with plate 10, figure 2.



1. Increments dated as 1811-1815 on east radius of trunk section T-3 of tree OL-SO-57. Layer for 1813 with weak, nearly nonexistent, densewood. Could be questionable that growth layer dated as 1813 represents an annual increment. See also plate 12, figure 2, and plate 13.



2. Increments dated as 1812-1815 on northeast radius of trunk section T-1 of tree OL-SO-57. Layer for 1813 with densewood weak, nearly nonexistent, and where present, one cell thick. See plate 12, figure 1, and plate 13.



Increments dated as 1812-1816 (left) and 1807-1811 (right) on trunk section T-3 of tree OL-SO-57. Comparison of 1813, an annual, and the intra-annual of 1809 reveals a striking resemblance.

the degree of consistency, or trend, in absolute and relative thicknesses among growth layers if the radii, the sections, and the trees are compared growth layer by growth layer. It is also well to point out that the more radii used to obtain a section average and the more sections used to obtain a tree average, the closer the tree average thus built up will approximate the true volume relationships of the growth layers.

Absolute thickness.—Little uniformity exists around a section or vertically along the trunk. A single growth layer varies by a factor of 2, 4, 8, or even 15. In one tree, on sections studied, there is no growth layer whose thickness is identical on all three radii. A single radius offers little opportunity to measure the true overall thicknesses of growth layers. A full section offers a much better measure of true thicknesses than a single radius, and many sections averaged give the most accurate measure of thicknesses. Although the three trees grew in the lower forest border below what may be considered optimum conditions for ponderosa pine, the three trees have decidedly different average absolute thicknesses of growth layers, OL-B the least and OL-S the greatest.

Relative thicknesses and trend.—Two radii may agree with each other by as much as 90 percent; three by as much as 80 percent; and five by as much as 77 percent. Such decreasing agreement with increasing numbers of radii suggests the strong probability that no growth layer in any tree stem maintains entirely uniform relationships with adjacent growth layers throughout its areal extent. Amount of agreement varies not only from place to place within a tree, but also from one time interval to another. On one section a 60-year period has 100 percent agreement, whereas a 50-year period has but 60 percent. Agreement on individual sections varies from 61 to 84 percent, being least in the upper parts of the trees. If two and more sections are compared, agreement drops rapidly, 11 sections in OL-B having only 41 percent.

Localized comparisons among the three trees yield less agreement than do comparisons among the trees as units. Separate but unified tree records agree with each other to a greater extent than do single radii within a tree or between two or more trees.

Thus, three points should be emphasized: First, a single radius may or may not be a fair representation of a section or of a tree and there is no simple way of determining accurately the degree of representativeness; second, the merging of an increasing number of radii approaches true volume relationships; and third, agreement appears to be least in the upper portions of the trees where the shortest growth-layer sequences exist. In an all-tree average, local differences in relative thicknesses may be subdued or even eliminated.

Growth-layer thicknesses.—The north radii do not consistently contain the thickest portions of the individual growth layers. However, it is to be avoided if only one radius can be taken. If a section can be taken, it should come, where possible, from about mid-tree.

Average departure.—The north radii of the three trees are more representative of the trees as a whole than are the other two, and sections taken from the lower half of the trunks are more representative than those from the upper half. In general, average departures in lower trunks and mid-trunks exceed those in the upper trunks.

Average variation.—The north radii are not the most representative of the trees as a whole; the other radii are almost equally representative, the southeast radius being perhaps slightly less so than the other two. If sections can be taken, they should come from the lower trunks.

Average departure from mean variation.—The conclusions here resemble those for average variation.

Branches—circuit uniformity.—Circuit uniformity in branch sections falls short of that in the trunk as a whole or in the trunk sections contiguous to the branches. In OL-SO-57, the three parameters of average departure, average variation, and average departure from mean variation maintain values roughly equivalent to those of adjacent trunk sections; in OL-S-62 the values of the three parameters exceed those of the trunks and of adjacent trunk sections.

Trunks—vertical uniformity.—No radius in any of the three trees possesses consistent vertical uniformity. With an average of three radii, greatest agreement resides in the basal five sections and exceeds the values for any single radius. Maximum and minimum growth-layer thicknesses are rather well scattered throughout the trunk. The addition of more and more sections increases the number of relative thickness reversals; hence one radius, or one section, taken at any locality in the trunk has small probability of being truly representative.

Branches—longitudinal uniformity.—Longitudinal uniformity in branches resembles vertical uniformity in trunks so closely that it is necessary to emphasize one point only. The branches carry a rather sharp contrast, in the percentage of trend agreements, between the intervals 1825-1899 and 1900-1947. In the trunks, shorter time intervals show similar contrasts.

Partial and intra-annual growth layers.—In general, trunks and branches resemble each other in having near their bases the greatest number of lenses, the greatest amount of lenticularity, and the greatest number of complete absences on the several sections. Branches exceed the trunks in numbers of lenticular growth layers and in numbers of growth layers totally absent on a section.

Conclusions.—In extension of the summary given on page 230, the following points should be listed.

1. A single radius may or may not represent the relationships among growth layers within the total tree; such a radius should be considered, perhaps, as exploratory only.
2. A section exceeds in value any part thereof.
3. A complete tree yields volume relationships, undoubtedly the true measure of tree growth.
4. Whole trees do not necessarily agree with each other to a greater extent than do the various parts of a tree or similar portions of different trees.
5. Overall trend agreement among the averages for the three trees is 52 percent; for the trees two by two it varies from 63 to 74 percent.
6. Tree OL-B-42 has the thinnest growth layers on the average and the highest values for the four parameters, average departure, average variation, average departure from mean variation, and mean sensitivity.
7. Tree OL-S-62 has the thickest growth layers on the average and the lowest values for the four parameters.
8. It is clear that the relationships given under Nos. 6 and 7 indicate slightly more favorable growing conditions for OL-S-62 than for OL-SO-57, and for OL-SO-57 than for OL-B-42, although all three trees grew in the lower forest border near the lower limit of the Transition Zone.
9. Because of the greater amount and the less uniform distribution of lenticularity and absence in the branches than in the trunks, it may be that branches have less value chronologically but more value ecologically than the trunks.
10. Because of the degree of uniformity found to exist among radii, among sections, and among trees, it seems clear that legitimate correlation of growth-layer thicknesses in sequence with pertinent seasonal rainfall intervals cannot exceed the degree of agreement found among radii, sections, or trees, at least in the three trees taken from the lower forest border and here analyzed. Correlations ranging from 0.4 to 0.7 or 0.75, or from less than 50 percent up to 80, are thus quite understandable and may represent the highest to be expected with trees from the lower forest border.

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APPENDIX

GROWTH-LAYER MEASUREMENTS

TABLE 42*-1.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-B-42, trunk section 1, 0.5 feet above ground*

Year	N.	ENE.	SE.	SW.	WNW.	Av.	Year	N.	ENE.	SE.	SW.	WNW.	Av.
1645....	115	120	107	113	15	94	1685....	62	63	41	60	62	58
6....	116	118	103	99	119	111	6....	85	77	72	98	94	85
7....	16	17	18	15	15	16	7....	178	171	228	257	232	215
8....	14	14	10	17	18	15	8....	230	163	174	218	139	185
9....	25	20	25	22	22	23	9....	310	271	302	370	370	325
1650....	73	60	43	63	86	65	1690....	189	172	169	213	166	182
1....	08	11	20	11	49	20	1....	230	186	168	239	255	216
2....	49	45	38	43	23	40	2....	407	415	329	494	347	398
3....	34	23	24	20	07	22	3....	301	263	185	251	273	255
4....	15	10	12	11	15	13	4....	245	242	214	299	250	250
1655....	20	19	12	39	25	23	1695....	298	275	196	213	237	244
6....	21	19	10	25	22	19	6....	82	121	95	95	133	105
7....	18	12	17	26	26	20	7....	141	121	115	174	110	132
8....	22	26	18	19	25	22	8....	154	170	183	233	169	182
9....	69	74	66	16	113	68	9....	287	272	266	373	384	316
1660....	0	0	12	13	25	10	1700....	65	72	54	83	80	71
1....	132	113	103	193	214	151	1....	305	241	215	347	361	294
2....	211	171	178	221	261	208	2....	162	163	138	223	280	193
3....	240	199	215	223	209	217	3....	36	0	24	36	56	30
4....	159	112	148	168	206	159	4....	31	19	40	40	47	35
1665....	67	48	71	105	186	95	1705....	84	56	89	114	135	96
6....	0	0	05	21	12	08	6....	33	53	34	56	59	47
7....	77	51	75	104	120	85	7....	125	105	120	159	185	139
8....	14	16	0	18	17	13	8....	127	134	116	183	172	146
9....	32	14	31	58	41	35	9....	33	43	32	76	54	48
1670....	0	0	12	0	0	02	1710....	144	143	170	224	203	177
1....	20	24	25	23	15	21	1....	214	122	158	204	209	181
2....	64	47	57	159	94	84	2....	238	241	168	226	249	224
3....	67	68	80	298	145	132	3....	146	124	145	182	212	162
4....	128	86	123	194	182	145	4....	165	138	126	194	172	159
1675....	41	24	48	96	76	57	1715....	63	79	58	132	72	81
6....	18	12	21	57	47	31	6....	17	15	11	32	22	19
7....	128	34	106	191	169	126	7....	91	100	80	140	124	107
8....	174	160	179	204	232	190	8....	125	128	108	161	161	137
9....	57	69	54	81	62	65	9....	301	273	217	363	359	303
1680....	156	158	166	190	181	170	1720....	436	341	369	413	510	414
1....	269	267	247	389	284	291	1....	229	266	198	312	220	245
2....	249	237	223	327	251	257	2....	108	80	80	103	107	96
3....	187	170	148	173	174	170	3....	223	180	183	187	214	197
4....	36	44	40	26	32	36	4....	68	65	57	88	106	77

* Table 42 in Appendix is so numbered because it deals throughout with tree OL-B-42.

Table 42-1.—*Continued*

Year	N.	ENE.	SE.	SW.	WNW.	Av.	Year	N.	ENE.	SE.	SW.	WNW.	Av.
1725....	137	111	133	135	160	135	1765....	99	78	70	96	109	90
6....	300	259	259	313	330	292	6....	111	111	116	124	145	121
7....	132	195	114	202	200	169	7....	102	98	110	78	101	98
8....	38	39	36	93	42	50	8....	121	91	96	118	134	112
9....	0	09	0	15	18	08	9....	86	40	46	50	47	54
1730....	33	42	42	29	61	41	1770....	15	67	58	74	75	58
1....	50	53	64	56	61	57	1....	126	78	71	108	109	98
2....	73	57	55	61	90	67	2....	75	77	71	60	79	72
3....	34	32	35	53	48	40	3....	13	07	0	21	10	10
4....	32	43	37	46	45	41	4....	67	53	44	52	48	53
1735....	15	0	0	0	0	03	1775....	166	66	60	74	49	83
6....	70	55	38	57	56	55	6....	91	51	55	65	54	63
7....	49	33	45	158	71	71	7....	112	78	59	59	91	80
8....	106	82	88	107	123	101	8....	38	30	33	39	49	36
9....	43	32	43	57	51	45	9....	51	49	57	48	69	55
1740....	60	61	57	79	70	65	1780....	29	25	32	23	30	28
1....	123	112	104	138	133	122	1....	43	24	30	25	32	31
2....	75	42	57	57	51	56	2....	43	35	46	34	54	42
3....	240	172	208	200	222	208	3....	84	95	141	102	128	110
4....	197	199	177	207	238	204	4....	135	100	171	87	150	129
1745....	277	205	244	233	262	244	1785....	30	15	12	13	28	20
6....	361	289	344	347	452	359	6....	50	37	35	26	54	40
7....	251	238	200	228	300	243	7....	135	100	100	95	132	112
8....	08	12	09	17	19	13	8....	66	49	32	43	53	48
9....	159	147	148	140	165	152	9....	47	30	31	32	49	38
1750....	25	65	55	67	67	56	1790....	43	41	33	50	70	48
1....	129	110	150	141	134	133	1....	143	95	86	66	89	96
2....	21	25	17	28	55	29	2....	143	96	70	130	135	115
3....	48	43	61	65	95	62	3....	199	224	256	198	227	221
4....	110	88	125	116	137	115	4....	170	122	112	92	149	129
1755....	08	15	09	17	17	13	1795....	187	146	158	159	183	167
6....	73	69	68	73	60	69	6....	128	126	121	123	159	131
7....	73	64	80	100	112	86	7....	144	86	124	154	129	127
8....	267	169	186	214	272	222	8....	49	53	40	48	65	51
9....	209	143	142	165	252	182	9....	80	47	67	86	93	75
1760....	219	190	225	192	249	215	1800....	34	18	21	31	31	27
1....	85	59	108	69	100	84	1....	36	35	26	43	32	34
2....	168	112	135	160	198	155	2....	17	05	22	17	15	15
3....	54	44	41	43	46	46	3....	30	17	13	27	10	19
4....	123	127	152	124	149	135	4....	45	57	59	69	60	58

Table 42-1.—*Continued*

Year	N.	ENE.	SE.	SW.	WNW.	Av.	Year	N.	ENE.	SE.	SW.	WNW.	Av.
1805....	09	03	0	10	0	04	1845....	34	20	16	11	22	21
6....	41	36	42	25	39	37	6....	28	21	16	13	11	18
7....	42	37	47	40	40	41	7....	0	0	0	0	0	0
8....	37	12	20	19	19	21	8....	42	41	33	46	51	43
9....	46	34	18	21	24	29	9....	76	48	92	75	101	78
1810....	76	61	79	62	70	70	1850....	98	91	74	95	74	86
1....	105	72	61	70	76	77	1....	50	54	51	57	53	53
2....	137	81	102	21	27	74	2....	101	70	71	107	98	89
3....	13	0	0	0	0	03	3....	59	55	36	58	56	53
4....	25	24	26	27	22	25	4....	82	76	44	48	65	63
1815....	61	45	47	28	31	42	1855....	118	67	56	76	90	81
6....	103	100	88	79	75	89	6....	54	38	28	40	41	40
7....	87	76	77	59	58	71	7....	0	0	0	0	0	0
8....	23	12	24	14	22	19	8....	40	36	30	34	37	35
9....	23	12	09	14	27	17	9....	0	07	0	0	0	01
1820....	15	15	15	10	17	14	1860....	33	21	24	29	21	26
1....	49	53	52	48	41	49	1....	49	41	38	35	33	39
2....	16	11	08	09	17	12	2....	91	56	66	61	69	69
3....	43	54	42	39	43	44	3....	15	16	06	10	16	13
4....	91	61	54	56	78	68	4....	12	0	0	0	11	05
1825....	108	86	58	73	106	86	1865....	51	52	52	51	40	49
6....	205	126	99	122	150	140	6....	77	49	56	90	93	73
7....	171	109	83	93	148	121	7....	135	65	78	96	93	93
8....	153	133	113	127	144	134	8....	144	92	88	67	84	95
9....	80	32	23	48	57	48	9....	86	77	67	73	78	76
1830....	108	69	58	95	64	79	1870....	92	108	49	63	64	75
1....	124	112	160	180	133	142	1....	26	09	04	12	19	14
2....	112	83	87	89	108	96	2....	71	37	20	47	57	46
3....	140	96	65	131	84	103	3....	41	24	29	36	36	33
4....	50	64	42	62	50	54	4....	95	60	55	55	59	65
1835....	106	109	105	109	99	106	1875....	55	37	31	37	43	41
6....	55	28	27	29	26	33	6....	17	09	24	30	23	21
7....	90	72	79	67	60	74	7....	14	11	0	10	05	08
8....	92	81	98	100	85	91	8....	35	25	25	24	30	28
9....	155	102	126	133	140	131	9....	0	0	0	0	0	0
1840....	132	102	94	90	69	97	1880....	0	0	0	0	0	0
1....	67	77	60	58	65	65	1....	0	0	0	0	0	0
2....	21	16	14	19	23	19	2....	10	07	22	26	05	14
3....	16	35	25	32	32	28	3....	32	18	26	38	25	28
4....	46	70	59	59	63	59	4....	36	36	32	42	30	35

TABLE 42-1.—*Continued*

Year	N.	ENE.	SE.	SW.	WNW.	Av.
1885....	23	36	25	43	22	30
6....	39	36	42	41	42	40
7....	51	30	39	39	51	42
8....	75	77	82	90	121	89
9....	90	83	79	123	144	104
1890....	129	140	71	156	148	129
1....	181	117	78	201	232	162
2....	168	112	128	117	156	136
3....	117	88	93	118	104	104
4....	202	129	155	210	144	168
1895....	218	153	90	182	154	159
6....	115	67	48	66	52	70
7....	156	94	108	116	109	117
8....	154	134	129	148	94	132
9....	130	47	47	76	100	80
1900....	98	57	50	84	72	72
1....	90	89	83	100	116	96
2....	46	13	11	18	20	22
3....	122	96	95	111	105	106
4....	36	21	06	09	35	21
1905....	150	110	87	120	121	118
6....	245	134	158	185	146	174
7....	362	234	231	261	240	266
8....	347	246	160	195	277	245
9....	364	278	228	275	361	301
1910....	336	233	190	229	344	266
1....	267	240	162	201	251	224
2....	272	253	174	260	237	239
3....	34	39	24	43	35	35
4....	114	119	94	183	135	129
1915....	195	201	132	184	168	176
6....	220	152	91	161	138	152
7....	259	217	129	234	208	209
8....	361	254	180	263	209	253
9....	191	222	256	211	185	213
1920....	243	207	202	206	174	206
1....	253	126	117	160	165	164
2....	337	302	216	249	257	272
3....	187	143	115	119	114	136
4....	295	207	141	170	142	191
1925....	185	96	106	150	128	133
6....	216	160	153	168	159	171
7....	104	68	48	101	36	71
8....	206	126	145	222	138	167
9....	315	151	202	230	157	211
1930....	259	137	149	224	150	184
1....	147	91	92	92	85	101
2....	186	122	115	145	98	133
3....	246	147	117	149	102	152
4....	124	112	91	86	100	103
1935....	106	90	65	109	105	95
6....	60	38	40	61	60	52
7....	160	71	91	107	97	105
8....	158	81	61	121	112	107
9....	103	62	51	75	87	76
1940....	80	49	34	62	54	56
1....	241	173	141	214	172	188
2....	205	118	102	175	126	145
3....	88	54	40	74	75	66
4....	203	157	126	175	179	168
1945....	219	126	115	157	144	152
6....	157	97	72	146	127	120
7....	63	47	30	40	67	49

TABLE 42-2.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-B-42, trunk section 2, 5.7 feet above ground*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1681.....	124	108	112	115	1720.....	320	228	290	279
2.....	201	184	194	193	1.....	254	190	263	236
3.....	232	184	228	215	2.....	107	78	78	88
4.....	99	74	108	94	3.....	176	124	178	159
					4.....	99	56	83	79
1685.....	99	60	88	82					
6.....	102	72	97	90	1725.....	124	98	126	116
7.....	161	96	157	138	6.....	306	196	258	253
8.....	193	116	152	154	7.....	134	133	161	143
9.....	325	240	203	256	8.....	37	32	59	43
					9.....	05	0	08	04
1690.....	218	130	190	179					
1.....	265	190	282	246	1730.....	25	30	42	32
2.....	406	312	389	369	1.....	49	47	64	53
3.....	340	152	269	254	2.....	70	65	60	65
4.....	437	186	328	317	3.....	47	39	45	44
					4.....	31	28	36	32
1695.....	295	164	183	214					
6.....	152	58	95	102	1735.....	26	0	0	09
7.....	235	110	151	165	6.....	72	51	38	54
8.....	292	186	179	219	7.....	65	42	62	56
9.....	354	210	244	269	8.....	82	68	92	81
					9.....	37	21	50	36
1700.....	86	44	43	58					
1.....	357	206	239	267	1740.....	57	59	100	72
2.....	239	16	149	135	1.....	148	77	133	119
3.....	25	18	30	24	2.....	49	36	46	44
4.....	40	28	43	37	3.....	172	160	182	171
					4.....	176	147	158	160
1705.....	110	98	139	116					
6.....	133	76	107	105	1745.....	213	156	201	190
7.....	187	114	167	156	6.....	261	200	224	228
8.....	162	112	151	142	7.....	230	185	226	214
9.....	84	144	86	105	8.....	0	04	20	08
					9.....	145	130	146	140
1710.....	221	42	190	151					
1.....	240	156	175	190	1750.....	55	56	63	58
2.....	215	168	200	194	1.....	148	116	130	131
3.....	172	130	46	116	2.....	30	15	27	24
4.....	174	112	134	140	3.....	62	56	59	59
					4.....	107	100	114	107
1715.....	133	72	79	95	1755.....	14	11	31	19
6.....	35	18	21	25	6.....	75	66	90	77
7.....	140	210	130	160	7.....	119	85	113	106
8.....	159	122	135	139	8.....	213	158	163	178
9.....	249	180	259	229	9.....	191	140	144	158

TABLE 42-2.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1760.....	235	156	188	193	1800.....	29	13	23	22
1.....	94	58	84	79	1.....	39	25	24	29
2.....	185	114	134	144	2.....	10	0	11	07
3.....	53	33	33	40	3.....	25	15	18	19
4.....	144	136	137	139	4.....	74	51	63	63
1765.....	101	85	71	85	1805.....	10	0	09	06
6.....	128	116	115	120	6.....	43	39	38	40
7.....	113	95	90	99	7.....	48	31	35	38
8.....	94	91	90	92	8.....	33	10	18	20
9.....	79	56	75	70	9.....	33	21	25	26
1770.....	125	56	94	92	1810.....	84	57	51	64
1.....	117	53	103	91	1.....	115	64	87	89
2.....	90	46	86	74	2.....	41	90	109	80
3.....	10	0	10	07	3.....	10	0	0	03
4.....	56	38	52	49	4.....	33	09	21	21
1775.....	61	44	61	55	1815.....	48	44	34	42
6.....	54	50	77	60	6.....	126	101	104	110
7.....	83	48	60	64	7.....	71	69	63	68
8.....	30	22	32	28	8.....	26	14	26	22
9.....	61	50	68	60	9.....	23	07	08	13
1780.....	26	22	31	26	1820.....	19	09	10	13
1.....	38	25	35	33	1.....	71	46	52	56
2.....	48	31	34	38	2.....	15	03	0	06
3.....	96	88	110	98	3.....	58	51	65	58
4.....	120	104	118	114	4.....	84	61	75	73
1785.....	25	05	12	14	1825.....	111	90	107	103
6.....	44	42	45	44	6.....	140	85	158	128
7.....	86	96	113	98	7.....	153	60	105	106
8.....	44	25	44	38	8.....	182	106	119	136
9.....	33	23	26	27	9.....	61	32	52	48
1790.....	41	18	31	30	1830.....	79	41	68	63
1.....	92	95	78	88	1.....	143	92	154	130
2.....	102	79	92	91	2.....	79	70	97	82
3.....	206	188	214	203	3.....	104	73	131	103
4.....	133	87	106	109	4.....	54	45	70	56
1795.....	188	129	180	166	1835.....	124	87	117	109
6.....	146	111	142	133	6.....	41	26	30	32
7.....	139	95	115	116	7.....	98	66	86	83
8.....	53	42	51	49	8.....	127	68	108	101
9.....	104	65	76	82	9.....	159	111	136	135

TABLE 42-2.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1840.....	108	69	98	92	1880.....	0	0	0	0
1.....	74	59	80	71	1.....	0	0	0	0
2.....	24	20	29	24	2.....	0	0	0	0
3.....	37	29	32	33	3.....	11	26	29	22
4.....	86	71	73	77	4.....	30	21	21	24
1845.....	31	15	28	25	1885.....	24	27	26	26
6.....	30	22	20	24	6.....	30	34	35	33
7.....	0	0	0	0	7.....	47	49	54	50
8.....	45	46	52	48	8.....	71	88	94	84
9.....	63	52	80	65	9.....	102	65	118	95
1850.....	82	67	77	75	1890.....	125	110	140	125
1.....	42	40	45	43	1.....	188	112	186	162
2.....	96	64	83	81	2.....	167	103	162	144
3.....	69	47	62	59	3.....	115	105	118	113
4.....	68	53	57	59	4.....	219	108	176	168
1855.....	92	64	88	81	1895.....	200	131	170	167
6.....	57	47	42	39	6.....	89	57	70	72
7.....	0	0	0	0	7.....	139	101	110	117
8.....	44	31	30	35	8.....	157	125	142	141
9.....	0	0	0	0	9.....	95	65	80	80
1860.....	26	28	31	28	1900.....	88	56	72	72
1.....	40	42	34	39	1.....	83	77	98	86
2.....	92	79	65	79	2.....	36	18	24	26
3.....	20	14	18	17	3.....	116	66	74	85
4.....	13	0	0	04	4.....	14	0	0	05
1865.....	58	47	49	51	1905.....	119	100	82	100
6.....	95	61	66	74	6.....	200	134	152	162
7.....	100	72	83	85	7.....	295	211	260	255
8.....	119	76	81	92	8.....	241	158	190	196
9.....	77	75	61	71	9.....	303	205	234	247
1870.....	75	40	51	55	1910.....	266	152	176	198
1.....	17	08	0	08	1.....	217	178	200	197
2.....	58	43	25	42	2.....	227	164	174	188
3.....	42	27	26	32	3.....	33	21	48	34
4.....	67	38	39	48	4.....	91	61	130	94
1875.....	52	42	43	46	1915.....	148	110	180	146
6.....	28	36	34	33	6.....	157	100	112	123
7.....	17	07	0	08	7.....	200	165	180	182
8.....	39	25	27	30	8.....	283	190	210	228
9.....	0	0	0	0	9.....	242	157	192	197

Table 42-2.—*Continued*

Year	N.	SE.	SW.	Av.
1920	161	160	174	165
1	172	99	128	133
2	221	176	208	202
3	109	65	120	98
4	146	136	158	147
1925	127	90	86	101
6	148	129	132	136
7	59	45	88	64
8	184	122	142	149
9	192	131	148	157
1930	144	95	114	118
1	84	70	92	82
2	155	115	114	128
3	142	105	140	129
4	98	74	86	86
1935	75	80	94	83
6	52	36	46	45
7	91	79	82	84
8	82	61	92	78
9	71	54	72	66
1940	50	36	52	46
1	164	117	156	146
2	105	90	102	99
3	67	47	58	57
4	146	120	126	131
1945	156	83	112	117
6	113	58	100	90
7	70	37	62	56

Table 42-3.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-B-42, trunk section 3, 10.2 feet above ground*

Year	N.	SE.	SW.	Av.
1693	110	125	115	117
4	141	129	165	145
1695	139	161	147	149
6	85	84	71	80
7	123	144	156	141
8	148	165	143	152
9	179	187	182	183
1700	57	43	39	46
1	186	243	239	223
2	168	184	210	187
3	49	37	35	40
4	44	46	32	41
1705	119	90	113	107
6	118	84	90	97
7	147	118	110	125
8	121	105	85	104
9	68	91	52	70
1710	165	176	157	166
1	197	194	181	191
2	185	178	155	173
3	175	150	128	151
4	139	129	98	122
1715	75	78	51	68
6	10	58	08	25
7	158	107	133	133
8	225	175	178	192
9	307	286	226	273
1720	344	333	231	303
1	294	265	206	255
2	152	168	100	140
3	233	227	181	214
4	114	115	74	101
1725	215	175	153	181
6	356	288	227	290
7	186	176	137	166
8	94	136	67	99
9	13	13	09	12
1730	45	48	36	43
1	87	80	60	76
2	132	96	66	98
3	65	42	44	50
4	54	41	31	42

TABLE 42-3.—*Continued*

Year	N.	SE.	SW.	Av.
1735.....	24	0	08	11
6.....	117	58	28	68
7.....	118	88	58	88
8.....	148	109	110	122
9.....	62	60	45	56
1740.....	102	125	82	103
1.....	190	161	117	156
2.....	76	70	46	64
3.....	235	210	144	196
4.....	202	153	147	167
1745.....	226	208	167	200
6.....	286	249	215	250
7.....	224	204	169	199
8.....	08	06	10	08
9.....	170	136	158	155
1750.....	65	59	42	55
1.....	148	134	113	132
2.....	23	20	23	22
3.....	69	65	59	64
4.....	104	103	81	96
1755.....	16	22	17	18
6.....	87	105	70	87
7.....	122	118	94	111
8.....	243	198	158	200
9.....	206	143	158	169
1760.....	260	140	167	189
1.....	112	53	77	81
2.....	168	123	97	129
3.....	48	45	33	42
4.....	156	143	132	144
1765.....	102	89	79	90
6.....	122	120	122	121
7.....	115	123	84	107
8.....	155	135	103	131
9.....	107	86	48	80
1770.....	142	88	79	103
1.....	145	105	85	112
2.....	116	68	65	83
3.....	18	19	07	15
4.....	65	59	49	58

Year	N.	SE.	SW.	Av.
1775.....	77	55	45	59
6.....	90	75	58	74
7.....	93	72	66	77
8.....	34	30	31	32
9.....	76	61	60	66
1780.....	39	28	28	32
1.....	44	33	32	36
2.....	50	40	45	45
3.....	111	91	87	96
4.....	154	134	106	131
1785.....	26	18	20	21
6.....	59	44	44	49
7.....	138	86	93	106
8.....	56	38	44	46
9.....	40	38	30	36
1790.....	41	24	14	26
1.....	102	87	94	94
2.....	129	99	97	108
3.....	166	204	186	185
4.....	147	100	101	116
1795.....	219	134	105	153
6.....	188	141	127	152
7.....	171	107	106	128
8.....	72	48	39	53
9.....	108	95	67	90
1800.....	34	30	21	28
1.....	34	32	26	31
2.....	24	10	10	15
3.....	25	14	15	18
4.....	79	61	51	64
1805.....	11	08	0	06
6.....	47	40	46	44
7.....	44	64	38	49
8.....	31	18	15	21
9.....	41	24	30	32
1810.....	90	66	48	68
1.....	93	73	79	82
2.....	159	104	97	120
3.....	06	0	0	02
4.....	27	23	24	25

TABLE 42-3.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1815.....	43	30	56	43	1855.....	103	84	66	84
6.....	104	91	81	92	6.....	64	48	47	53
7.....	79	78	65	74	7.....	0	0	0	0
8.....	28	22	15	22	8.....	45	40	40	42
9.....	31	08	11	17	9.....	0	0	0	0
1820.....	17	13	09	13	1860.....	22	25	30	26
1.....	60	57	46	54	1.....	42	27	32	34
2.....	09	0	0	03	2.....	87	76	76	80
3.....	51	55	65	57	3.....	21	24	17	21
4.....	87	77	70	78	4.....	0	0	0	0
1825.....	141	100	100	114	1865.....	56	44	46	49
6.....	179	130	102	137	6.....	97	82	71	83
7.....	179	108	103	130	7.....	91	88	84	88
8.....	189	123	110	141	8.....	113	109	78	100
9.....	77	38	37	51	9.....	62	79	52	64
1830.....	103	54	35	64	1870.....	73	44	52	56
1.....	178	156	108	147	1.....	41	05	04	17
2.....	91	91	78	87	2.....	36	44	51	44
3.....	136	110	94	113	3.....	38	31	28	32
4.....	72	73	47	64	4.....	69	39	141	83
1835.....	132	93	103	109	1875.....	47	52	44	48
6.....	49	51	21	40	6.....	30	34	33	32
7.....	99	84	75	86	7.....	24	11	12	16
8.....	128	120	106	118	8.....	28	22	21	24
9.....	208	129	129	155	9.....	0	0	0	0
1840.....	140	92	86	106	1880.....	0	0	0	0
1.....	104	83	76	88	1.....	0	0	0	0
2.....	33	37	30	33	2.....	0	0	04	01
3.....	49	40	35	41	3.....	28	26	33	29
4.....	96	82	72	83	4.....	28	21	25	25
1845.....	37	30	27	31	1885.....	29	28	31	29
6.....	38	23	26	29	6.....	53	44	36	44
7.....	0	0	0	0	7.....	52	57	48	52
8.....	60	52	64	59	8.....	110	99	83	97
9.....	86	66	68	73	9.....	152	127	85	121
1850.....	100	77	71	83	1890.....	178	161	111	150
1.....	52	24	45	40	1.....	223	180	126	176
2.....	104	102	78	95	2.....	197	178	90	155
3.....	83	57	63	68	3.....	105	137	90	111
4.....	87	64	59	70	4.....	259	184	119	187

TABLE 42-3.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1895.....	236	179	115	177	2.....	272	185	165	207
6.....	81	82	40	68	3.....	119	107	80	102
7.....	147	146	89	127	4.....	176	144	132	151
8.....	183	179	125	162					
9.....	117	106	54	92	1925.....	146	110	100	119
					6.....	174	152	116	147
1900.....	69	87	53	70	7.....	78	86	76	80
1.....	110	97	63	90	8.....	157	129	114	133
2.....	33	27	20	27	9.....	177	120	125	141
3.....	102	78	65	82					
4.....	05	0	0	02	1930.....	87	128	100	105
					1.....	107	113	83	101
1905.....	116	104	80	100	2.....	153	112	110	125
6.....	191	178	128	166	3.....	95	119	132	115
7.....	310	228	64	201	4.....	90	90	80	87
8.....	313	201	165	226					
9.....	320	211	185	239	1935.....	97	86	82	88
					6.....	43	41	44	43
1910.....	292	175	147	205	7.....	98	85	77	87
1.....	231	208	167	202	8.....	78	162	67	102
2.....	243	194	154	197	9.....	84	62	60	69
3.....	34	48	17	33					
4.....	124	142	55	107	1940.....	61	46	37	48
					1.....	151	123	125	133
1915.....	133	155	117	135	2.....	114	98	84	99
6.....	128	150	93	124	3.....	71	59	56	62
7.....	192	173	140	168	4.....	159	141	121	140
8.....	254	205	170	210					
9.....	265	176	185	209	1945.....	122	115	75	104
1920.....	173	156	162	164	6.....	144	90	73	102
1.....	172	133	93	133	7.....	63	43	37	48

TABLE 42-4.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-B-42, trunk section 4, 15.3 feet above ground*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1711.....	187	165	200	184	1720.....	335	162	315	271
2.....	235	211	199	215	1.....	373	244	398	338
3.....	202	155	141	166	2.....	302	168	269	246
4.....	152	87	83	107	3.....	308	193	204	235
					4.....	141	70	69	93
1715.....	125	68	61	85	1725.....	184	127	120	144
6.....	0	06	06	04	6.....	235	161	155	184
7.....	186	99	131	139	7.....	212	114	127	151
8.....	211	102	157	157	8.....	162	72	92	109
9.....	273	131	217	207	9.....	21	07	09	12

Table 42-4.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1730.....	65	34	46	48	1770.....	149	104	101	118
1.....	131	63	83	92	1.....	154	98	125	126
2.....	175	73	105	118	2.....	120	78	81	93
3.....	95	34	46	58	3.....	15	09	12	12
4.....	93	22	63	59	4.....	52	49	58	53
1735.....	32	22	39	31	1775.....	59	69	57	62
6.....	158	53	164	125	6.....	80	91	68	80
7.....	153	91	128	124	7.....	100	76	82	86
8.....	201	92	145	146	8.....	37	31	26	31
9.....	80	31	61	57	9.....	72	57	60	63
1740.....	147	53	125	108	1780.....	29	39	25	31
1.....	195	103	176	158	1.....	27	34	28	30
2.....	74	35	68	59	2.....	46	42	40	43
3.....	233	150	277	220	3.....	107	100	98	102
4.....	248	141	258	216	4.....	155	128	130	138
1745.....	245	159	192	199	1785.....	38	21	17	25
6.....	325	201	243	256	6.....	56	40	39	45
7.....	274	165	221	220	7.....	125	100	109	111
8.....	10	0	08	06	8.....	61	48	40	50
9.....	218	146	169	178	9.....	32	36	26	31
1750.....	128	48	80	85	1790.....	45	29	30	35
1.....	226	112	137	158	1.....	113	88	95	99
2.....	33	25	21	26	2.....	163	85	121	123
3.....	80	66	73	73	3.....	251	191	220	221
4.....	119	102	115	112	4.....	155	107	102	121
1755.....	38	15	31	28	1795.....	222	161	168	184
6.....	107	90	114	104	6.....	178	153	182	171
7.....	151	115	146	137	7.....	154	131	139	141
8.....	240	155	200	198	8.....	64	44	45	51
9.....	207	132	153	164	9.....	111	87	112	103
1760.....	279	148	194	207	1800.....	35	29	43	36
1.....	114	72	87	91	1.....	38	32	45	38
2.....	191	112	142	148	2.....	19	16	19	18
3.....	49	41	54	48	3.....	27	20	25	24
4.....	185	131	165	160	4.....	64	59	74	66
1765.....	90	79	100	90	1805.....	06	13	12	10
6.....	159	121	170	150	6.....	43	46	47	45
7.....	146	99	117	121	7.....	38	39	40	39
8.....	156	117	116	130	8.....	34	31	33	33
9.....	106	72	73	84	9.....	27	29	27	28

TABLE 42-4.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1810.....	67	76	67	70	1850.....	84	58	61	68
1.....	90	77	74	80	1.....	50	52	24	42
2.....	129	96	118	114	2.....	109	94	66	90
3.....	10	0	12	07	3.....	83	74	36	64
4.....	34	32	24	30	4.....	62	59	37	53
1815.....	37	46	45	43	1855.....	90	91	62	81
6.....	95	115	113	108	6.....	53	64	41	53
7.....	102	94	93	96	7.....	0	0	0	0
8.....	31	21	29	27	8.....	40	44	35	40
9.....	24	17	19	20	9.....	0	07	0	02
1820.....	16	17	12	15	1860.....	21	29	26	25
1.....	61	65	68	65	1.....	38	44	35	39
2.....	08	14	09	10	2.....	53	91	63	69
3.....	54	58	61	58	3.....	20	26	21	22
4.....	90	96	85	90	4.....	07	08	0	05
1825.....	144	108	108	120	1865.....	50	58	36	48
6.....	175	100	112	129	6.....	93	89	59	80
7.....	166	92	93	117	7.....	97	81	60	79
8.....	177	120	117	138	8.....	104	107	74	95
9.....	69	41	45	52	9.....	82	83	42	69
1830.....	59	45	42	49	1870.....	68	54	30	51
1.....	134	139	101	125	1.....	11	15	07	11
2.....	109	89	86	95	2.....	59	51	32	47
3.....	129	107	100	112	3.....	50	29	25	35
4.....	64	58	51	58	4.....	63	54	28	48
1835.....	97	83	83	88	1875.....	53	51	47	50
6.....	39	36	33	36	6.....	34	45	25	35
7.....	100	87	61	83	7.....	21	21	12	18
8.....	130	112	107	116	8.....	27	32	23	27
9.....	175	125	126	142	9.....	0	0	0	0
1840.....	101	72	78	84	1880.....	0	0	0	0
1.....	81	82	79	81	1.....	0	0	0	0
2.....	25	35	19	26	2.....	0	0	18	06
3.....	33	54	26	38	3.....	25	29	21	25
4.....	88	86	68	81	4.....	31	28	30	30
1845.....	29	30	26	28	1885.....	39	33	42	38
6.....	35	34	20	30	6.....	42	47	45	45
7.....	0	0	0	0	7.....	57	52	53	54
8.....	52	49	60	54	8.....	99	105	95	100
9.....	80	88	75	81	9.....	131	108	107	115

TABLE 42-4.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1890.....	170	125	119	138	1920.....	146	168	140	151
1.....	186	110	130	142	1.....	173	141	119	144
2.....	137	113	129	126	2.....	235	217	157	203
3.....	100	115	103	106	3.....	98	115	84	99
4.....	200	147	159	169	4.....	172	131	145	149
1895.....	208	142	143	164	1925.....	152	130	90	124
6.....	74	58	67	66	6.....	166	169	123	153
7.....	142	130	139	137	7.....	80	99	72	84
8.....	183	127	163	158	8.....	134	150	118	134
9.....	75	86	81	81	9.....	143	134	112	130
1900.....	84	62	72	73	1930.....	112	132	103	116
1.....	89	93	93	92	1.....	85	120	84	96
2.....	28	29	32	30	2.....	130	144	109	128
3.....	133	77	91	100	3.....	139	135	115	130
4.....	09	0	05	05	4.....	91	111	87	96
1905.....	108	94	120	107	1935.....	110	94	90	98
6.....	176	152	144	157	6.....	47	52	52	50
7.....	320	211	169	233	7.....	109	88	89	95
8.....	279	206	160	215	8.....	106	79	82	89
9.....	310	208	183	234	9.....	76	70	73	73
1910.....	256	211	189	219	1940.....	52	46	47	48
1.....	212	234	187	211	1.....	170	134	131	145
2.....	197	221	163	197	2.....	102	116	99	106
3.....	31	35	43	36	3.....	57	57	49	54
4.....	93	112	140	115	4.....	144	135	134	138
1915.....	131	179	174	161	1945.....	116	109	105	110
6.....	113	118	100	110	6.....	132	88	92	104
7.....	173	154	152	160	7.....	71	33	44	49
8.....	237	174	172	194					
9.....	227	175	148	183					

TABLE 42-5.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-B-42, trunk section 5, 19.1 feet above ground*

Year	N.	ENE.	SE.	SW.	WNW.	Av.
1721....	265	215	207	255	257	240
2....	225	219	212	243	245	229
3....	252	233	188	220	258	230
4....	115	115	110	95	109	109
1725....	165	155	166	170	171	165
6....	295	256	247	307	301	281
7....	190	157	146	195	207	179
8....	187	168	129	189	215	178
9....	14	10	04	04	09	08
1730....	78	62	52	62	81	67
1....	117	85	66	108	102	96
2....	118	84	50	112	94	92
3....	44	36	30	44	47	40
4....	55	20	21	47	44	37
1735....	42	38	39	28	60	41
6....	139	111	80	105	210	129
7....	72	90	66	72	95	79
8....	79	91	58	60	100	78
9....	19	26	07	34	33	24
1740....	84	30	24	89	97	65
1....	102	94	57	143	144	108
2....	29	31	25	53	44	36
3....	197	168	138	193	198	179
4....	167	153	122	152	159	151
1745....	192	154	138	155	189	166
6....	273	206	184	233	289	237
7....	224	184	139	211	251	202
8....	0	0	0	0	23	05
9....	188	127	123	195	217	170
1750....	71	40	46	114	129	80
1....	141	105	95	172	179	138
2....	28	25	23	28	25	26
3....	70	58	73	86	84	74
4....	105	64	90	114	129	100
1755....	12	15	22	41	39	26
6....	71	69	90	101	86	83
7....	134	157	148	142	173	151
8....	236	179	171	193	240	204
9....	227	175	146	163	223	187
1760....	260	170	188	184	262	213
1....	81	71	74	102	116	89
2....	137	120	112	145	178	138
3....	34	44	44	48	58	46
4....	152	132	147	158	181	154
1765....	94	76	92	103	104	94
6....	167	142	142	154	190	159
7....	164	100	114	123	153	131
8....	164	110	125	134	126	132
9....	83	72	79	84	93	82
1770....	142	108	125	140	160	135
1....	147	117	133	162	176	147
2....	107	81	81	98	110	95
3....	07	0	05	11	30	11
4....	39	47	57	55	64	52
1775....	57	57	68	71	68	64
6....	78	63	77	90	100	82
7....	75	85	81	90	113	89
8....	28	28	34	32	41	33
9....	52	52	65	60	76	61
1780....	21	23	26	36	27	27
1....	24	26	32	33	32	29
2....	39	41	41	50	35	41
3....	97	95	107	106	122	105
4....	154	134	123	148	167	145
1785....	32	18	18	20	48	27
6....	55	48	45	39	59	49
7....	121	110	110	106	127	115
8....	56	54	45	45	70	54
9....	33	34	23	30	46	33
1790....	37	34	23	30	52	35
1....	117	87	91	113	124	106
2....	156	136	97	152	175	143
3....	287	217	158	208	268	228
4....	146	130	75	112	152	123
1795....	207	178	118	172	211	177
6....	179	202	135	188	163	173
7....	154	137	113	137	177	144
8....	60	51	42	55	78	57
9....	105	101	70	92	104	94

TABLE 42-5.—*Continued*

Year	N.	ENE.	SE.	SW.	WNW.	Av.	Year	N.	ENE.	SE.	SW.	WNW.	Av.
1800....	37	37	21	31	28	31	1840....	118	84	88	88	114	98
1....	37	37	24	39	42	36	1....	102	98	88	90	93	94
2....	23	18	08	19	20	18	2....	45	31	40	41	40	39
3....	27	22	15	16	26	21	3....	50	41	55	55	59	52
4....	68	57	39	64	60	58	4....	111	75	68	88	97	88
1805....	13	11	06	12	10	10	1845....	41	37	38	38	32	37
6....	46	48	42	49	50	47	6....	36	43	36	42	34	38
7....	54	43	35	38	30	40	7....	0	0	08	0	0	02
8....	46	26	21	31	17	28	8....	60	59	97	70	62	70
9....	26	33	49	26	28	32	9....	98	95	99	95	75	92
1810....	87	70	59	57	80	71	1850....	107	79	76	73	73	82
1....	112	82	63	81	101	88	1....	56	57	57	44	53	53
2....	159	131	91	138	133	130	2....	108	109	101	90	86	99
3....	10	0	07	0	09	05	3....	100	64	86	77	84	82
4....	27	27	32	35	26	29	4....	93	62	72	61	77	73
1815....	55	54	40	45	39	47	1855....	88	91	83	86	83	86
6....	121	100	95	112	102	106	6....	57	74	69	58	58	63
7....	115	102	83	89	95	97	7....	0	0	0	0	0	0
8....	35	29	25	34	34	31	8....	45	58	55	52	52	52
9....	33	19	17	21	19	22	9....	05	11	14	0	0	06
1820....	26	17	15	09	18	17	1860....	33	44	28	37	26	34
1....	76	59	60	75	57	65	1....	60	45	49	43	38	47
2....	08	14	11	12	17	12	2....	82	90	92	80	90	87
3....	56	59	54	64	61	59	3....	27	33	26	25	20	26
4....	140	100	101	94	98	107	4....	10	13	10	13	09	11
1825....	192	102	112	118	128	130	1865....	55	57	50	48	54	53
6....	191	121	109	138	160	144	6....	98	69	88	64	85	81
7....	165	116	117	119	128	129	7....	102	84	97	82	84	90
8....	208	148	124	147	166	159	8....	159	109	130	100	110	122
9....	50	38	35	44	56	45	9....	104	68	85	74	75	81
1830....	67	46	42	70	65	58	1870....	73	53	48	42	50	53
1....	140	120	138	138	145	138	1....	15	16	16	12	10	14
2....	109	105	77	96	104	98	2....	47	59	46	47	65	53
3....	140	91	104	113	105	111	3....	50	41	35	35	49	42
4....	83	56	58	65	69	66	4....	56	50	60	55	69	58
1835....	111	100	99	94	117	104	1875....	62	58	73	59	57	62
6....	55	38	51	42	48	47	6....	35	40	55	36	43	42
7....	106	89	79	88	81	89	7....	25	34	26	25	25	27
8....	155	111	111	113	130	124	8....	33	56	47	28	31	39
9....	193	116	146	145	152	150	9....	0	0	0	0	0	0

TABLE 42-5.—*Continued*

Year	N.	ENE.	SE.	SW.	WNW.	Av.
1880....	0	0	0	0	0	0
1....	0	0	0	0	0	0
2....	07	07	0	12	0	05
3....	32	25	31	27	34	30
4....	32	31	33	33	26	31
1885....	48	46	35	32	36	39
6....	56	46	32	43	42	44
7....	65	48	57	41	65	55
8....	111	102	106	81	97	99
9....	122	108	135	105	129	120
1890....	155	116	140	131	165	141
1....	176	117	135	121	179	146
2....	143	127	127	136	181	143
3....	127	97	99	105	123	110
4....	194	156	131	155	219	171
1895....	181	164	145	153	189	166
6....	76	66	65	79	89	75
7....	136	125	139	121	170	138
8....	161	153	139	145	183	156
9....	100	76	87	107	112	96
1900....	68	70	76	68	94	75
1....	93	81	122	95	112	101
2....	36	32	32	35	34	34
3....	108	87	79	109	106	98
4....	19	10	0	08	12	10
1905....	129	96	127	112	115	116
6....	184	155	163	149	190	168
7....	267	197	199	189	280	226
8....	275	211	178	201	294	232
9....	320	208	194	204	316	248
1910....	242	190	182	214	252	216
1....	214	200	188	191	248	208
2....	195	180	168	184	250	195
3....	23	40	48	71	50	46
4....	104	90	132	158	143	125
1915....	135	128	176	155	135	146
6....	117	110	142	134	142	129
7....	181	156	174	153	193	171
8....	258	202	181	174	200	203
9....	289	208	207	160	224	218
1920....	193	170	199	145	178	177
1....	155	137	131	147	159	146
2....	226	172	200	198	216	202
3....	119	101	117	95	124	111
4....	185	162	180	171	178	175
1925....	118	104	135	121	144	124
6....	162	146	176	153	148	157
7....	93	74	99	100	86	90
8....	162	124	165	236	149	167
9....	157	134	156	169	136	150
1930....	105	109	127	129	131	120
1....	103	102	110	119	117	110
2....	140	143	132	158	134	141
3....	145	141	119	50	106	112
4....	104	97	104	75	99	96
1935....	103	102	99	102	105	102
6....	46	52	53	60	60	54
7....	103	84	103	120	91	100
8....	93	79	97	102	76	89
9....	82	68	81	68	70	74
1940....	44	48	48	40	58	48
1....	135	119	139	131	156	136
2....	105	105	107	104	105	105
3....	87	54	73	71	70	71
4....	180	124	146	142	159	150
1945....	114	93	124	122	106	112
6....	158	87	107	93	105	110
7....	43	33	43	35	57	42

Table 42-6.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-B-42, trunk section 6, 22.8 feet above ground*

Year	N.	SE.	SW.	Av.
1727.....	81	119	114	105
8.....	172	193	207	191
9.....	23	33	33	30
1730.....	85	75	75	78
1.....	95	86	98	93
2.....	72	67	67	69
3.....	50	51	52	51
4.....	56	71	51	59
1735.....	59	65	47	57
6.....	108	120	107	112
7.....	66	82	65	71
8.....	92	63	90	82
9.....	19	14	12	15
1740.....	53	17	33	34
1.....	94	60	60	71
2.....	23	18	19	20
3.....	191	110	118	140
4.....	170	123	118	137
1745.....	130	150	118	133
6.....	250	270	219	246
7.....	200	197	107	168
8.....	0	0	0	0
9.....	190	141	193	175
1750.....	106	62	108	92
1.....	133	126	153	137
2.....	05	24	13	14
3.....	50	70	70	63
4.....	106	97	111	105
1755.....	32	34	24	30
6.....	100	92	81	91
7.....	164	136	144	148
8.....	226	141	156	174
9.....	234	157	166	186
1760.....	198	169	263	210
1.....	78	87	125	97
2.....	114	114	147	125
3.....	38	46	43	42
4.....	142	145	229	172
1765.....	92	82	105	93
6.....	208	163	206	192
7.....	132	90	120	114
8.....	236	100	142	159
9.....	90	75	105	90
1770.....	130	111	117	119
1.....	30	117	138	95
2.....	72	82	94	83
3.....	06	08	09	08
4.....	36	35	37	36
1775.....	63	70	60	64
6.....	74	84	81	80
7.....	81	94	105	93
8.....	30	36	43	36
9.....	54	56	76	62
1780.....	16	20	25	20
1.....	11	29	31	24
2.....	28	46	51	42
3.....	93	98	107	99
4.....	138	140	149	142
1785.....	16	26	45	29
6.....	40	54	66	53
7.....	90	107	112	103
8.....	37	42	62	47
9.....	28	35	48	37
1790.....	33	32	44	36
1.....	114	103	115	111
2.....	156	149	141	149
3.....	207	192	176	192
4.....	103	102	115	107
1795.....	142	144	182	156
6.....	168	153	146	156
7.....	145	96	157	133
8.....	53	41	61	52
9.....	87	60	102	83
1800.....	32	14	30	25
1.....	29	21	38	29
2.....	12	06	17	12
3.....	14	17	20	17
4.....	52	52	51	52

TABLE 42-6.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1805.....	04	08	12	08	1845.....	26	17	33	25
6.....	37	44	48	43	6.....	30	19	33	27
7.....	39	34	41	38	7.....	0	0	10	03
8.....	29	15	23	22	8.....	48	38	62	49
9.....	22	23	37	27	9.....	72	44	78	65
1810.....	71	45	75	64	1850.....	95	42	75	71
1.....	103	65	79	82	1.....	42	25	39	35
2.....	158	95	114	122	2.....	100	62	89	84
3.....	08	0	0	03	3.....	90	49	75	71
4.....	30	21	20	24	4.....	71	44	75	63
1815.....	42	40	31	38	1855.....	85	55	79	73
6.....	107	99	98	101	6.....	50	40	63	51
7.....	105	82	80	89	7.....	0	0	0	0
8.....	31	21	28	27	8.....	24	31	65	40
9.....	20	09	13	14	9.....	0	0	05	02
1820.....	18	12	11	14	1860.....	29	16	28	24
1.....	57	48	65	57	1.....	35	23	42	33
2.....	04	0	10	05	2.....	73	59	85	72
3.....	56	48	66	57	3.....	25	09	28	21
4.....	113	90	106	103	4.....	0	0	15	05
1825.....	145	82	115	114	1865.....	52	39	45	45
6.....	183	84	140	136	6.....	80	56	84	73
7.....	138	70	112	107	7.....	93	62	80	78
8.....	132	98	128	119	8.....	126	67	100	98
9.....	38	24	47	36	9.....	92	42	80	71
1830.....	40	28	46	38	1870.....	56	21	53	43
1.....	96	100	144	113	1.....	11	07	18	12
2.....	73	57	89	73	2.....	49	38	49	45
3.....	122	80	114	105	3.....	29	15	31	25
4.....	59	37	77	58	4.....	57	32	52	47
1835.....	100	65	110	92	1875.....	40	44	53	46
6.....	30	14	44	29	6.....	32	26	35	31
7.....	88	57	80	75	7.....	20	11	22	18
8.....	135	83	126	115	8.....	23	15	36	25
9.....	178	96	142	139	9.....	0	0	0	0
1840.....	114	55	100	90	1880.....	0	0	0	0
1.....	102	64	90	85	1.....	0	0	02	01
2.....	33	20	48	34	2.....	0	0	09	03
3.....	48	23	63	45	3.....	28	25	25	26
4.....	70	55	96	74	4.....	17	24	36	26

Table 42-6.—*Continued*

Year	N.	SE.	SW.	Av.
1885	33	28	33	31
6	40	45	35	40
7	50	47	48	48
8	99	82	82	88
9	118	82	116	105
1890	174	91	148	138
1	206	110	152	156
2	160	95	160	138
3	135	79	111	108
4	209	103	170	161
1895	176	113	157	149
6	60	51	60	57
7	136	109	134	126
8	156	130	152	146
9	82	55	102	80
1900	64	55	80	66
1	86	62	100	83
2	22	19	40	27
3	82	62	103	82
4	17	0	18	12
1905	110	95	118	108
6	205	137	138	160
7	380	218	178	259
8	278	176	209	221
9	404	204	223	277
1910	345	158	197	233
1	291	186	184	220
2	250	159	177	195
3	45	26	56	42
4	112	53	139	101
1915	145	97	166	136
6	140	98	126	121
7	195	135	160	163
8	252	140	200	197
9	300	167	175	214
1920	240	148	170	186
1	198	86	150	145
2	258	141	185	195
3	142	75	97	105
4	183	117	153	151
1925	123	86	108	106
6	174	122	119	138
7	100	73	82	85
8	153	106	142	134
9	154	109	143	135
1930	129	85	122	112
1	136	87	100	108
2	167	123	127	139
3	161	120	119	133
4	89	80	101	90
1935	119	90	102	104
6	47	36	47	43
7	103	84	93	93
8	99	81	88	89
9	72	59	73	68
1940	39	35	47	40
1	122	117	127	122
2	97	91	96	95
3	64	39	60	54
4	154	143	134	144
1945	113	120	112	115
6	179	108	108	132
7	78	137	40	85

Table 42-7.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-B-42, trunk section 7, 28.3 feet above ground*

Year	N.	SE.	SW.	Av.
1754	121	136	100	119
1755	64	59	70	64
6	61	48	64	58
7	121	104	109	111
8	205	144	167	172
9	316	203	182	233
1760	343	189	148	227
1	181	99	87	122
2	213	101	103	139
3	67	43	38	49
4	194	150	145	163

TABLE 42-7.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1765.....	77	47	40	55	1805.....	04	38	09	17
6.....	235	154	134	174	6.....	41	32	47	40
7.....	118	85	52	85	7.....	36	15	37	29
8.....	115	69	49	78	8.....	22	22	13	19
9.....	100	53	43	65	9.....	37	08	20	22
1770.....	144	59	59	87	1810.....	98	54	70	74
1.....	135	81	86	101	1.....	128	72	74	91
2.....	61	32	45	46	2.....	164	120	118	134
3.....	0	0	0	0	3.....	03	0	0	01
4.....	31	23	18	24	4.....	05	20	21	15
1775.....	61	30	38	43	1815.....	44	36	57	46
6.....	86	44	56	62	6.....	140	93	118	117
7.....	107	54	47	69	7.....	128	79	100	102
8.....	24	13	11	16	8.....	36	25	22	28
9.....	33	26	22	27	9.....	16	11	20	16
1780.....	0	0	0	0	1820.....	16	13	13	14
1.....	29	12	18	20	1.....	62	56	65	61
2.....	30	23	22	25	2.....	16	08	17	14
3.....	99	69	59	76	3.....	74	64	67	68
4.....	174	106	91	124	4.....	114	86	119	106
1785.....	36	09	0	15	1825.....	137	85	119	114
6.....	39	18	20	26	6.....	165	102	118	128
7.....	133	68	65	89	7.....	136	108	113	119
8.....	70	21	20	37	8.....	142	115	109	122
9.....	34	14	13	21	9.....	49	25	27	34
1790.....	36	11	12	20	1830.....	48	35	56	46
1.....	168	80	91	113	1.....	155	125	150	143
2.....	197	89	111	132	2.....	107	77	88	91
3.....	228	132	149	170	3.....	141	98	122	120
4.....	134	68	80	94	4.....	65	47	60	57
1795.....	220	139	179	179	1835.....	96	100	91	96
6.....	205	111	164	160	6.....	48	35	67	50
7.....	144	95	108	116	7.....	107	73	90	90
8.....	57	27	45	43	8.....	156	101	104	120
9.....	71	25	85	60	9.....	165	122	146	144
1800.....	21	12	36	23	1840.....	125	90	84	100
1.....	22	24	25	24	1.....	108	86	100	98
2.....	15	08	06	10	2.....	46	41	30	39
3.....	15	13	13	14	3.....	55	35	28	39
4.....	49	31	41	40	4.....	85	67	78	77

TABLE 42-7.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1845.....	33	29	36	33	1885.....	30	50	40	40
6.....	43	36	34	38	6.....	35	60	50	48
7.....	0	0	0	0	7.....	43	60	52	52
8.....	54	49	53	52	8.....	98	100	104	101
9.....	94	76	84	85	9.....	104	103	107	105
1850.....	90	65	82	79	1890.....	145	121	114	127
1.....	50	50	43	48	1.....	171	124	115	137
2.....	98	88	97	94	2.....	173	121	131	142
3.....	103	76	55	78	3.....	117	75	90	94
4.....	60	56	50	56	4.....	207	110	111	143
1855.....	91	73	70	78	1895.....	216	106	137	153
6.....	63	55	53	57	6.....	91	39	54	61
7.....	0	0	0	0	7.....	172	97	113	127
8.....	41	50	37	43	8.....	193	101	138	144
9.....	0	0	08	03	9.....	100	46	78	75
1860.....	19	28	22	23	1900.....	62	39	56	52
1.....	39	45	42	42	1.....	85	70	68	74
2.....	63	70	86	73	2.....	22	13	25	20
3.....	26	26	29	27	3.....	78	56	66	67
4.....	04	08	08	07	4.....	12	0	05	06
1865.....	48	52	49	50	1905.....	108	74	108	97
6.....	65	68	69	67	6.....	167	122	149	146
7.....	90	90	87	89	7.....	311	149	205	222
8.....	112	103	108	108	8.....	376	138	197	237
9.....	83	74	73	77	9.....	355	152	199	235
1870.....	45	35	42	41	1910.....	281	121	161	188
1.....	14	08	11	11	1.....	224	144	160	176
2.....	39	38	32	36	2.....	222	136	153	170
3.....	25	24	26	25	3.....	51	33	28	37
4.....	55	42	42	46	4.....	118	63	57	79
1875.....	42	44	42	43	1915.....	122	130	117	123
6.....	24	31	34	30	6.....	143	106	90	113
7.....	17	15	15	16	7.....	205	124	120	150
8.....	28	29	21	26	8.....	240	142	146	176
9.....	0	0	0	0	9.....	280	172	167	206
1880.....	0	0	0	0	1920.....	232	137	142	170
1.....	0	0	0	0	1.....	173	69	101	114
2.....	0	07	04	04	2.....	218	126	139	161
3.....	24	30	34	29	3.....	117	84	75	93
4.....	28	49	36	38	4.....	193	123	100	139

TABLE 42-7.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1925.....	127	98	90	105	7.....	83	90	76	83
6.....	138	115	106	120	8.....	78	78	72	76
7.....	100	90	78	89	9.....	74	63	60	66
8.....	158	100	105	121					
9.....	150	117	127	131	1940.....	38	37	34	36
1930.....	102	94	87	94	1.....	122	117	115	118
1.....	100	107	80	96	2.....	100	107	103	103
2.....	134	122	117	124	3.....	56	62	58	59
3.....	132	121	124	126	4.....	137	136	135	136
4.....	106	84	84	91					
					1945.....	100	91	92	94
1935.....	105	96	70	90	6.....	107	99	101	102
6.....	42	46	34	41	7.....	58	38	42	46

TABLE 42-8.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-B-42, trunk section 8, 32.5 feet above ground*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1769.....	116	102	89	102	2.....	137	69	122	109
					3.....	229	98	128	152
1770.....	52	66	35	51	4.....	181	67	100	116
1.....	70	90	55	72					
2.....	56	34	65	52	1795.....	223	94	137	151
3.....	49	36	46	44	6.....	131	74	83	96
4.....	34	18	31	28	7.....	100	63	64	76
					8.....	48	22	38	36
1775.....	41	29	46	39	9.....	43	23	51	39
6.....	43	45	50	46					
7.....	27	25	45	32	1800.....	0	0	0	0
8.....	07	07	14	09	1.....	23	15	22	20
9.....	07	10	15	11	2.....	16	10	09	12
					3.....	07	12	11	10
1780.....	07	12	12	10	4.....	29	08	24	20
1.....	16	19	16	17					
2.....	11	12	31	18	1805.....	0	0	0	0
3.....	37	40	72	50	6.....	43	42	38	41
4.....	71	84	128	94	7.....	30	10	15	18
					8.....	24	15	15	18
1785.....	08	0	11	06	9.....	38	25	33	32
6.....	10	0	13	08					
7.....	62	67	48	59	1810.....	37	33	39	36
8.....	09	0	10	06	1.....	108	74	82	88
9.....	06	0	0	02	2.....	168	85	145	133
1790.....	15	06	18	13	3.....	0	0	0	0
1.....	61	53	47	54	4.....	14	0	11	08

TABLE 42-8.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1815.....	65	33	34	44	1855.....	93	50	92	78
6.....	119	73	86	93	6.....	62	50	68	60
7.....	77	65	70	70	7.....	0	0	0	0
8.....	09	0	0	03	8.....	31	32	37	33
9.....	07	12	0	06	9.....	0	0	0	0
1820.....	0	06	0	02	1860.....	13	22	27	21
1.....	48	49	41	46	1.....	16	39	54	36
2.....	07	10	0	06	2.....	89	77	94	87
3.....	65	35	56	52	3.....	29	21	33	28
4.....	116	69	95	93	4.....	0	0	09	03
1825.....	121	76	97	98	1865.....	40	51	44	45
6.....	153	88	147	129	6.....	96	55	83	78
7.....	110	72	116	99	7.....	177	88	100	122
8.....	122	88	134	115	8.....	232	90	152	158
9.....	36	18	24	26	9.....	162	77	103	114
1830.....	54	32	47	44	1870.....	77	47	73	66
1.....	192	104	203	166	1.....	17	22	15	18
2.....	96	41	98	78	2.....	28	40	52	40
3.....	150	57	129	112	3.....	16	28	25	23
4.....	107	22	51	60	4.....	45	38	60	48
1835.....	131	48	91	90	1875.....	52	52	36	47
6.....	69	13	51	44	6.....	38	33	30	34
7.....	107	57	157	107	7.....	16	20	19	18
8.....	137	73	159	123	8.....	21	27	29	26
9.....	184	95	251	177	9.....	0	0	0	0
1840.....	175	70	184	143	1880.....	0	0	0	0
1.....	147	77	162	129	1.....	0	0	0	0
2.....	39	28	48	38	2.....	0	07	15	07
3.....	22	39	59	40	3.....	13	29	23	22
4.....	72	59	118	83	4.....	13	47	43	34
1845.....	31	30	67	43	1885.....	07	45	45	32
6.....	29	31	80	47	6.....	15	40	43	33
7.....	0	0	0	0	7.....	25	52	52	43
8.....	41	49	74	55	8.....	78	77	97	84
9.....	106	59	126	97	9.....	99	98	138	112
1850.....	157	62	193	137	1890.....	145	127	175	149
1.....	91	33	102	75	1.....	230	143	226	200
2.....	158	75	147	127	2.....	256	117	164	179
3.....	98	52	99	83	3.....	148	64	110	107
4.....	50	38	80	56	4.....	217	100	176	164

TABLE 42-8.—*Continued*

Year	N.	SE.	SW.	Av.
1895.....	242	112	159	171
6.....	135	42	63	80
7.....	183	109	107	133
8.....	246	124	121	164
9.....	110	60	68	79
1900.....	81	50	52	61
1.....	107	67	75	83
2.....	14	27	19	20
3.....	75	88	78	80
4.....	07	05	0	04
1905.....	140	80	95	105
6.....	341	128	159	209
7.....	504	163	236	301
8.....	420	183	193	265
9.....	340	164	220	241
1910.....	334	155	207	232
1.....	275	168	118	187
2.....	250	131	126	169
3.....	50	39	29	39
4.....	104	97	74	92
1915.....	159	128	115	134
6.....	183	89	96	123
7.....	324	131	132	199
8.....	373	167	160	233
9.....	496	200	206	301
1920.....	336	161	139	212
1.....	253	100	100	151
2.....	311	150	137	199
3.....	260	87	89	145
4.....	334	132	146	204
1925.....	194	88	89	124
6.....	224	95	129	149
7.....	136	79	63	93
8.....	230	110	91	144
9.....	280	124	97	167
1930.....	210	99	76	128
1.....	188	75	74	112
2.....	198	111	97	135
3.....	184	111	98	131
4.....	142	76	72	97
1935.....	141	68	71	93
6.....	62	32	34	43
7.....	134	64	65	88
8.....	114	60	64	79
9.....	84	51	48	61
1940.....	56	33	30	40
1.....	189	103	114	135
2.....	128	74	93	98
3.....	93	48	46	62
4.....	168	102	89	120
1945.....	155	83	76	105
6.....	146	78	98	107
7.....	65	39	49	51

TABLE 42-9.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of ponderosa pine, OL-B-42, trunk section 9, 36.4 feet above ground*

Year	N.	ENE.	SE.	SW.	WNW.	Av.
1801....	122	121	120	118	120	120
2....	90	94	86	83	85	88
3....	57	55	56	46	51	53
4....	43	53	45	37	43	44
1805....	30	17	09	12	21	18
6....	08	13	13	17	13	13
7....	15	12	18	17	17	16
8....	15	15	31	23	13	19
9....	18	20	34	22	12	21
1810....	24	26	38	34	20	28
1....	15	36	23	21	09	21
2....	31	21	32	43	15	28
3....	0	0	0	0	0	0
4....	18	35	29	45	09	27
1815....	14	26	18	22	12	18
6....	25	10	26	35	18	23
7....	21	29	26	21	21	24
8....	08	17	05	04	0	07
9....	05	05	06	04	09	06
1820....	06	0	18	0	0	05
1....	19	30	12	21	19	20
2....	09	16	05	13	14	11
3....	25	26	28	27	29	27
4....	49	29	23	27	43	34
1825....	39	25	29	32	71	39
6....	89	48	38	45	77	59
7....	43	28	27	25	22	29
8....	70	36	30	31	53	44
9....	11	06	20	15	13	13
1830....	73	31	36	27	27	39
1....	160	91	66	67	146	106
2....	20	09	07	11	15	12
3....	70	60	56	44	77	61
4....	37	15	13	12	19	19
1835....	94	45	44	32	57	54
6....	81	23	21	21	25	34
7....	134	52	42	36	58	64
8....	62	43	32	37	46	44
9....	162	101	66	66	121	103
1840....	129	44	31	54	88	69
1....	87	48	46	70	98	70
2....	19	05	0	13	09	09
3....	13	13	07	16	18	13
4....	42	30	42	48	81	49
1845....	10	0	0	23	25	12
6....	25	23	19	17	21	21
7....	0	0	0	0	0	0
8....	50	25	26	34	30	33
9....	118	59	49	56	88	74
1850....	117	43	39	62	112	75
1....	48	14	07	27	26	24
2....	102	50	41	41	66	60
3....	60	25	08	23	30	29
4....	64	24	26	28	32	35
1855....	41	29	35	32	55	38
6....	27	18	17	26	33	24
7....	0	0	0	0	0	0
8....	08	14	15	17	27	16
9....	0	0	0	0	0	0
1860....	08	0	09	12	06	07
1....	07	16	15	16	19	15
2....	33	48	45	38	60	45
3....	0	0	07	14	23	09
4....	0	0	0	0	0	0
1865....	17	29	23	31	30	26
6....	17	31	28	30	65	34
7....	52	53	45	60	95	61
8....	75	51	41	62	91	64
9....	50	26	20	47	56	40
1870....	38	12	15	23	27	23
1....	0	0	0	14	0	03
2....	13	10	08	24	18	15
3....	05	09	13	10	05	08
4....	18	20	31	19	19	21
1875....	42	31	26	32	21	30
6....	32	22	15	22	22	23
7....	12	09	08	09	12	10
8....	10	05	07	14	11	09
9....	0	0	0	0	0	0

TABLE 42-9.—*Continued*

Year	N.	ENE.	SE.	SW.	WNW.	Av.
1880....	0	0	0	0	0	0
1....	0	0	0	0	0	0
2....	0	0	0	0	0	0
3....	15	23	20	18	18	19
4....	27	29	27	18	30	26
1885....	33	26	14	17	27	23
6....	49	26	21	24	35	31
7....	94	43	34	26	61	52
8....	174	93	64	79	183	119
9....	167	70	48	93	180	112
1890....	252	80	62	146	221	152
1....	295	76	70	211	288	188
2....	167	62	60	206	187	136
3....	104	37	43	118	130	86
4....	206	70	79	211	277	169
1895....	190	83	100	166	230	154
6....	58	37	57	50	60	52
7....	112	120	104	130	133	120
8....	176	115	105	161	245	160
9....	90	46	53	61	85	67
1900....	62	41	33	51	80	53
1....	93	61	52	59	28	59
2....	19	10	11	13	16	14
3....	96	47	51	63	61	64
4....	12	0	0	0	0	02
1905....	160	85	88	119	137	118
6....	203	110	97	213	244	173
7....	269	149	154	267	294	227
8....	231	140	131	233	228	193
9....	229	136	141	195	182	177
1910....	258	135	129	159	150	166
1....	261	148	150	169	164	178
2....	256	162	142	180	171	182
3....	65	55	33	05	14	34
4....	108	106	61	43	73	78

Year	N.	ENE.	SE.	SW.	WNW.	Av.
1915....	177	142	99	107	153	136
6....	179	124	90	84	137	123
7....	215	188	137	135	198	175
8....	266	242	195	163	169	207
9....	273	310	204	170	178	227
1920....	178	225	138	117	113	154
1....	184	162	111	116	115	138
2....	318	241	191	189	173	222
3....	189	124	105	101	123	128
4....	279	170	147	149	206	190
1925....	140	89	86	92	121	106
6....	167	154	123	115	140	140
7....	110	87	62	72	81	82
8....	173	123	95	123	153	133
9....	223	153	153	153	188	174
1930....	209	134	120	110	133	141
1....	134	79	96	100	115	105
2....	146	132	144	98	112	126
3....	140	150	139	120	120	134
4....	105	105	99	79	97	97
1935....	125	110	81	87	95	100
6....	58	52	38	46	44	48
7....	107	87	64	78	87	85
8....	97	85	72	80	73	81
9....	96	71	55	69	62	71
1940....	49	38	35	43	34	40
1....	165	120	100	125	126	127
2....	123	107	98	95	99	104
3....	85	67	52	63	65	66
4....	157	151	122	127	100	131
1945....	168	135	94	106	99	120
6....	197	162	91	85	110	129
7....	58	60	48	37	34	47

TABLE 42-10.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-B-42, trunk section 10, 39.7 feet above ground*

Year	N.	SE.	SW.	Av.
1843.....	77	92	88	86
4.....	72	69	68	70
1845.....	46	62	61	56
6.....	32	43	29	35
7.....	09	06	08	08
8.....	45	38	18	34
9.....	61	48	34	48
1850.....	21	30	25	25
1.....	14	11	0	08
2.....	12	49	14	25
3.....	0	22	05	09
4.....	18	20	18	19
1855.....	19	37	17	24
6.....	47	28	23	33
7.....	0	0	0	0
8.....	35	17	22	25
9.....	14	11	0	08
1860.....	39	28	17	28
1.....	64	37	29	43
2.....	109	56	56	74
3.....	38	18	17	24
4.....	0	0	12	04
1865.....	40	40	40	40
6.....	38	49	59	49
7.....	119	69	62	83
8.....	77	69	54	67
9.....	146	27	43	72
1870.....	98	25	35	53
1.....	20	0	11	10
2.....	64	25	26	38
3.....	28	0	15	14
4.....	60	13	26	33
1875.....	59	28	25	37
6.....	68	24	23	38
7.....	19	30	12	20
8.....	18	19	18	18
9.....	0	0	0	0
1880.....	0	0	0	0
1.....	0	0	0	0
2.....	0	0	10	03
3.....	27	19	10	19
4.....	32	27	29	29
1885.....	23	14	0	12
6.....	54	38	17	36
7.....	73	30	20	41
8.....	131	67	35	78
9.....	96	58	31	62
1890.....	93	71	53	72
1.....	221	122	62	135
2.....	146	91	40	92
3.....	114	92	37	81
4.....	300	155	73	176
1895.....	249	142	70	154
6.....	89	49	22	53
7.....	170	106	59	112
8.....	234	128	68	143
9.....	94	61	19	58
1900.....	26	43	29	33
1.....	69	74	45	63
2.....	0	08	0	03
3.....	71	60	47	59
4.....	0	08	0	03
1905.....	145	115	92	117
6.....	222	153	97	157
7.....	200	150	91	147
8.....	202	165	86	151
9.....	155	162	96	138
1910.....	216	173	83	157
1.....	244	177	95	172
2.....	233	102	91	142
3.....	14	24	15	18
4.....	73	65	44	61
1915.....	117	120	79	105
6.....	142	87	66	98
7.....	197	148	88	144
8.....	201	169	113	161
9.....	207	192	119	173

TABLE 42-10.—*Continued*

Year	N.	SE.	SW.	Av.
1920.....	156	167	106	143
1.....	178	217	131	175
2.....	261	336	196	264
3.....	131	176	108	138
4.....	184	321	132	212
1925.....	124	151	80	118
6.....	170	243	134	182
7.....	98	110	65	91
8.....	154	227	121	167
9.....	140	282	132	185
1930.....	97	223	122	147
1.....	83	150	105	113
2.....	128	173	120	140
3.....	152	146	134	144
4.....	97	116	85	99
1935.....	104	118	87	103
6.....	59	81	53	64
7.....	103	96	78	92
8.....	85	103	86	91
9.....	78	77	83	79
1940.....	50	50	35	45
1.....	118	159	100	126
2.....	106	132	103	114
3.....	66	130	75	90
4.....	132	159	139	143
1945.....	135	143	130	136
6.....	152	106	112	123
7.....	58	56	46	53

TABLE 42-11.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-B-42, trunk section 11, 43.7 feet above ground*

Year	N.	SE.	SW.	Av.
1898.....	160	265	143	189
9.....	62	58	83	68
1900.....	46	85	60	64
1.....	32	137	47	72
2.....	07	12	10	10
3.....	58	44	46	49
4.....	10	19	25	18
1905.....	81	66	87	78
6.....	76	95	87	86
7.....	68	110	90	89
8.....	93	102	99	98
9.....	54	70	44	56
1910.....	94	113	98	102
1.....	192	122	188	167
2.....	118	102	157	126
3.....	22	30	35	29
4.....	62	45	50	52
1915.....	161	110	136	136
6.....	105	85	133	108
7.....	140	115	146	134
8.....	138	123	135	132
9.....	139	69	82	97
1920.....	122	79	123	108
1.....	95	85	127	102
2.....	91	188	160	146
3.....	61	92	105	86
4.....	139	115	120	125
1925.....	63	60	75	66
6.....	113	107	164	128
7.....	29	30	56	38
8.....	85	78	75	79
9.....	34	142	177	118
1930.....	123	74	150	116
1.....	51	60	98	70
2.....	77	86	115	93
3.....	82	72	150	101
4.....	63	79	99	80
1935.....	63	54	60	59
6.....	36	29	41	35
7.....	69	48	53	57
8.....	62	68	73	68
9.....	37	42	84	54
1940.....	17	30	34	27
1.....	101	112	139	117
2.....	70	68	121	86
3.....	39	46	76	54
4.....	86	98	121	102
1945.....	81	69	90	80
6.....	78	62	89	76
7.....	46	45	55	49

Table 42-12.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-B-42, trunk section 12, 47.2 feet above ground*

Year	N.	SE.	SW.	Av.
1917.....	237	253	256	249
8.....	139	149	134	141
9.....	88	84	85	86
1920.....	141	90	82	104
1.....	85	62	78	75
2.....	52	55	60	56
3.....	54	31	34	40
4.....	118	63	67	83
1925.....	102	26	36	55
6.....	98	47	63	69
7.....	25	23	18	22
8.....	106	35	43	61
9.....	124	43	69	79
1930.....	89	30	36	52
1.....	70	41	44	52
2.....	77	49	52	59
3.....	62	40	52	51
4.....	56	28	46	43
1935.....	30	22	31	28
6.....	17	19	0	12
7.....	42	40	36	39
8.....	62	44	33	46
9.....	41	43	40	41
1940.....	29	07	15	17
1.....	156	79	89	108
2.....	117	49	56	74
3.....	43	28	23	31
4.....	89	62	69	73
1945.....	71	51	43	55
6.....	57	39	32	43
7.....	23	36	25	28

Table 42-13.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-B-42, trunk section 13, 49.9 feet above ground*

Year	N.	SE.	SW.	Av.
1927.....	73	62	68	68
8.....	135	112	129	125
9.....	105	121	120	115
1930.....	83	110	61	85
1.....	32	24	32	29
2.....	40	36	38	38
3.....	35	42	37	38
4.....	40	30	27	32
1935.....	28	24	20	24
6.....	27	15	13	18
7.....	53	24	27	35
8.....	47	30	39	39
9.....	15	22	18	18
1940.....	20	12	09	14
1.....	78	47	33	53
2.....	36	31	28	32
3.....	13	09	17	13
4.....	51	31	39	40
1945.....	37	33	30	33
6.....	30	16	24	23
7.....	0	11	13	08

TABLE 57 *—1.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, trunk section 1, 1.2 feet above ground*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1666.....	110	100	120	110	1705.....	129	96	135	120
7.....	106	108	100	105	6.....	59	47	78	61
8.....	72	55	47	58	7.....	72	25	62	53
9.....	109	74	59	81	8.....	74	37	43	51
					9.....	37	20	30	29
1670.....	57	72	35	55					
1.....	71	57	69	66	1710.....	98	72	96	89
2.....	46	42	44	44	1.....	202	110	106	139
3.....	79	51	64	65	2.....	135	81	137	118
4.....	123	71	81	92	3.....	116	96	118	110
					4.....	90	46	43	60
1675.....	54	17	29	33					
6.....	45	34	36	38	1715.....	35	19	25	26
7.....	85	43	53	60	6.....	16	14	08	13
8.....	117	66	53	79	7.....	88	44	68	67
9.....	51	28	26	35	8.....	206	149	193	183
					9.....	202	152	186	180
1680.....	145	84	90	106					
1.....	163	81	72	105	1720.....	234	215	192	214
2.....	197	75	76	116	1.....	145	118	147	137
3.....	128	82	97	102	2.....	38	32	36	35
4.....	18	13	11	14	3.....	85	73	59	72
					4.....	49	35	39	41
1685.....	89	28	25	47					
6.....	66	36	31	44	1725.....	106	90	92	96
7.....	88	51	27	55	6.....	196	131	103	143
8.....	107	53	48	69	7.....	100	77	105	94
9.....	233	105	110	149	8.....	56	33	20	36
					9.....	44	15	14	24
1690.....	180	56	67	101	1730.....	113	64	80	86
1.....	85	36	42	54	1.....	50	55	37	47
2.....	124	70	95	96	2.....	97	69	44	70
3.....	133	62	78	91	3.....	72	57	60	63
4.....	200	59	91	117	4.....	132	86	88	102
1695.....	168	59	77	101	1735.....	19	05	08	11
6.....	101	46	70	72	6.....	54	36	56	49
7.....	128	33	78	80	7.....	26	15	13	18
8.....	198	89	137	141	8.....	83	50	67	67
9.....	144	43	87	91	9.....	127	52	84	88
1700.....	80	44	61	62	1740.....	112	97	102	104
1.....	157	88	107	117	1.....	113	70	88	90
2.....	184	72	103	120	2.....	30	22	20	24
3.....	101	47	85	78	3.....	31	34	49	38
4.....	112	64	83	86	4.....	17	35	20	24

* Table 57 in Appendix is so numbered because it deals throughout with tree OL-SO-57.

TABLE 57-1.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1745.....	39	37	51	42	1785.....	115	46	59	73
6.....	109	77	86	91	6.....	46	55	51	51
7.....	138	82	82	101	7.....	237	161	112	170
8.....	07	11	12	10	8.....	120	62	73	85
9.....	87	74	74	78	9.....	136	71	82	96
1750.....	64	44	32	47	1790.....	184	69	89	114
1.....	104	36	57	66	1.....	274	155	119	183
2.....	19	0	0	06	2.....	253	117	142	171
3.....	99	51	70	73	3.....	439	206	239	295
4.....	131	59	54	81	4.....	244	109	114	156
1755.....	48	24	16	29	1795.....	214	85	148	149
6.....	229	135	141	168	6.....	124	43	95	87
7.....	170	77	78	108	7.....	122	51	73	82
8.....	196	136	128	153	8.....	90	55	99	81
9.....	84	58	83	75	9.....	141	75	141	119
1760.....	74	81	57	71	1800.....	71	37	55	54
1.....	36	25	21	27	1.....	100	47	43	63
2.....	123	88	85	99	2.....	60	23	39	41
3.....	56	26	26	36	3.....	67	19	34	40
4.....	122	94	75	97	4.....	121	46	50	72
1765.....	105	59	56	73	1805.....	55	27	43	42
6.....	151	86	69	102	6.....	101	51	65	72
7.....	98	76	84	86	7.....	115	50	60	75
8.....	169	108	103	127	8.....	73	52	48	58
9.....	97	81	66	81	9.....	108	79	76	88
1770.....	104	46	62	71	1810.....	63	63	54	60
1.....	165	83	82	110	1.....	160	105	90	119
2.....	125	87	85	99	2.....	137	84	109	110
3.....	12	10	14	12	3.....	21	26	27	25
4.....	48	21	25	31	4.....	48	45	48	47
1775.....	81	60	63	68	1815.....	65	62	62	63
6.....	88	69	55	71	6.....	163	122	106	130
7.....	69	42	47	53	7.....	85	91	109	95
8.....	36	25	38	33	8.....	22	23	18	21
9.....	87	54	92	78	9.....	47	30	22	33
1780.....	38	26	29	31	1820.....	0	16	08	08
1.....	51	46	46	48	1.....	119	83	52	85
2.....	47	42	40	43	2.....	98	85	40	74
3.....	125	82	92	100	3.....	75	58	41	58
4.....	192	148	124	155	4.....	168	115	92	125

TABLE 57-1.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1825.....	322	177	123	207	1865.....	79	66	48	62
6.....	450	237	161	283	6.....	169	90	101	120
7.....	531	162	176	290	7.....	195	122	114	144
8.....	530	155	171	285	8.....	239	186	170	198
9.....	270	94	68	144	9.....	258	151	77	162
1830.....	274	103	99	159	1870.....	160	79	107	115
1.....	196	64	74	111	1.....	81	40	40	54
2.....	260	86	113	153	2.....	159	67	58	95
3.....	434	145	222	267	3.....	60	28	10	33
4.....	159	83	89	110	4.....	178	92	52	107
1835.....	182	80	149	137	1875.....	169	56	75	100
6.....	151	52	82	95	6.....	68	14	19	34
7.....	87	58	51	65	7.....	43	14	11	23
8.....	219	97	135	150	8.....	93	28	32	51
9.....	282	146	173	200	9.....	21	27	10	19
1840.....	270	187	111	189	1880.....	08	0	0	03
1.....	131	93	89	104	1.....	25	15	14	18
2.....	23	42	36	34	2.....	64	30	30	41
3.....	91	45	58	65	3.....	53	31	39	41
4.....	145	125	110	127	4.....	111	44	53	69
1845.....	38	52	47	46	1885.....	77	58	58	64
6.....	40	32	40	37	6.....	58	21	30	36
7.....	0	11	12	08	7.....	43	18	12	24
8.....	109	92	109	103	8.....	41	35	44	40
9.....	198	139	125	154	9.....	94	72	76	81
1850.....	135	99	87	107	1890.....	124	99	66	96
1.....	51	25	29	35	1.....	196	102	121	140
2.....	144	109	99	117	2.....	148	105	94	116
3.....	99	67	61	76	3.....	50	44	25	40
4.....	93	81	57	77	4.....	55	40	29	41
1855.....	116	92	88	99	1895.....	91	81	86	86
6.....	97	72	71	80	6.....	41	36	31	36
7.....	0	12	0	04	7.....	48	26	42	39
8.....	39	40	22	34	8.....	19	12	24	18
9.....	20	12	0	11	9.....	0	0	0	0
1860.....	65	34	38	46	1900.....	12	16	15	14
1.....	90	71	50	70	1.....	0	12	10	07
2.....	154	109	71	111	2.....	0	0	0	0
3.....	42	38	33	38	3.....	60	51	44	52
4.....	32	22	0	18	4.....	0	0	0	0

Table 57-1.—*Continued*

Year	N.	SE.	SW.	Av.
1905.....	72	52	67	64
6.....	117	90	99	102
7.....	123	84	94	100
8.....	146	106	95	116
9.....	169	138	136	148
1910.....	181	122	124	142
1.....	238	155	127	173
2.....	105	98	88	97
3.....	61	47	34	47
4.....	103	50	52	68
1915.....	195	136	113	148
6.....	195	135	130	153
7.....	197	192	168	186
8.....	298	112	127	179
9.....	548	205	295	349
1920.....	425	181	288	298
1.....	264	146	228	213
2.....	293	150	265	236
3.....	517	218	306	347
4.....	466	190	212	289
1925.....	355	92	176	208
6.....	369	128	161	219
7.....	105	57	117	93
8.....	269	107	212	196
9.....	193	96	164	151
1930.....	229	88	136	151
1.....	157	72	177	135
2.....	57	97	238	131
3.....	219	112	192	174
4.....	220	65	135	140
1935.....	253	93	180	175
6.....	177	44	96	106
7.....	283	101	152	179
8.....	260	108	206	191
9.....	235	53	109	132
1940.....	131	48	100	93
1.....	164	92	106	121
2.....	200	74	134	136
3.....	205	60	101	122
4.....	259	105	145	170
1945.....	263	94	147	168
6.....	198	80	100	126
7.....	49	36	29	38

Table 57-2.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, trunk section 2, 5.4 feet above ground*

Year	N.	SE.	SW.	Av.
1692.....	101	112	105	106
3.....	126	138	138	134
4.....	51	58	41	50
1695.....	51	65	49	55
6.....	56	51	54	54
7.....	65	60	73	66
8.....	103	90	89	94
9.....	82	91	66	80
1700.....	62	76	59	66
1.....	134	150	110	131
2.....	184	166	137	162
3.....	109	112	91	104
4.....	155	121	108	128
1705.....	166	164	149	160
6.....	105	100	110	105
7.....	90	96	98	95
8.....	76	79	69	75
9.....	46	56	45	49
1710.....	137	120	145	134
1.....	194	215	171	193
2.....	146	147	149	147
3.....	138	170	143	150
4.....	67	86	77	77
1715.....	52	62	58	57
6.....	27	50	44	40
7.....	119	149	161	143
8.....	203	207	251	220
9.....	212	198	215	208

TABLE 57-2.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1720.....	272	227	236	245	1760.....	94	68	55	72
1.....	157	168	153	159	1.....	50	46	30	42
2.....	43	48	59	50	2.....	142	82	78	101
3.....	108	137	115	120	3.....	54	36	33	41
4.....	55	80	75	70	4.....	131	111	79	107
1725.....	123	144	119	129	1765.....	94	67	55	72
6.....	160	182	157	166	6.....	121	105	91	106
7.....	124	98	116	113	7.....	126	66	44	79
8.....	67	57	55	60	8.....	149	103	92	115
9.....	31	40	27	33	9.....	116	77	75	89
1730.....	98	102	84	95	1770.....	88	61	69	73
1.....	66	78	81	75	1.....	143	95	85	108
2.....	98	85	112	98	2.....	111	97	85	98
3.....	97	81	97	92	3.....	08	0	13	07
4.....	119	97	121	113	4.....	40	26	23	30
1735.....	22	06	22	17	1775.....	70	57	51	59
6.....	56	61	69	62	6.....	78	72	54	68
7.....	29	24	34	29	7.....	50	50	49	50
8.....	92	89	94	92	8.....	24	27	29	27
9.....	124	111	91	109	9.....	91	57	78	75
1740.....	146	126	132	135	1780.....	36	18	27	27
1.....	126	128	117	124	1.....	55	52	47	51
2.....	43	35	35	38	2.....	31	19	43	31
3.....	52	51	27	43	3.....	119	104	109	111
4.....	47	40	24	37	4.....	203	126	117	149
1745.....	59	75	40	58	1785.....	92	47	56	65
6.....	117	134	113	121	6.....	111	45	50	69
7.....	97	101	92	97	7.....	270	154	157	194
8.....	10	21	14	15	8.....	135	73	84	97
9.....	109	109	70	96	9.....	159	80	90	110
1750.....	96	59	55	70	1790.....	147	76	108	110
1.....	76	76	69	74	1.....	266	149	166	194
2.....	07	0	0	02	2.....	250	147	127	175
3.....	125	88	84	99	3.....	438	200	231	290
4.....	129	91	81	100	4.....	227	90	122	146
1755.....	75	37	28	47	1795.....	183	69	107	120
6.....	256	177	151	195	6.....	112	54	65	77
7.....	188	125	116	143	7.....	126	60	87	91
8.....	208	137	127	157	8.....	96	57	80	78
9.....	129	44	62	78	9.....	137	91	126	118

TABLE 57-2.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1800.....	65	40	48	51	1840.....	207	150	130	162
1.....	80	35	46	54	1.....	109	50	77	79
2.....	49	32	23	35	2.....	26	41	29	32
3.....	31	22	16	23	3.....	104	85	74	88
4.....	67	54	62	61	4.....	141	121	108	123
1805.....	41	31	49	40	1845.....	38	44	41	41
6.....	73	50	50	58	6.....	63	43	55	54
7.....	75	50	52	59	7.....	0	16	08	08
8.....	64	44	58	55	8.....	130	96	107	111
9.....	94	50	61	68	9.....	133	106	144	128
1810.....	68	44	49	54	1850.....	114	85	98	99
1.....	152	106	118	125	1.....	33	33	36	34
2.....	117	73	98	96	2.....	130	92	102	108
3.....	30	21	21	24	3.....	90	60	52	67
4.....	58	35	42	45	4.....	84	64	72	73
1815.....	77	58	57	64	1855.....	128	106	88	107
6.....	186	155	129	157	6.....	88	85	83	85
7.....	91	87	97	92	7.....	0	0	0	0
8.....	21	14	27	21	8.....	56	33	36	42
9.....	36	14	33	28	9.....	0	10	14	08
1820.....	0	0	0	0	1860.....	66	55	49	57
1.....	106	51	66	74	1.....	82	74	58	71
2.....	80	34	46	53	2.....	132	92	83	102
3.....	51	67	57	58	3.....	32	31	35	33
4.....	132	92	97	107	4.....	15	0	11	09
1825.....	164	174	168	169	1865.....	77	78	66	74
6.....	289	196	231	239	6.....	119	104	112	112
7.....	385	213	232	277	7.....	133	111	105	116
8.....	499	233	168	300	8.....	231	192	198	207
9.....	286	85	104	158	9.....	219	151	159	176
1830.....	246	75	104	142	1870.....	212	136	101	150
1.....	152	100	131	128	1.....	73	62	50	62
2.....	158	86	60	101	2.....	159	64	62	95
3.....	293	165	166	208	3.....	37	13	0	17
4.....	108	75	67	83	4.....	169	69	75	104
1835.....	216	104	92	137	1875.....	140	75	56	90
6.....	157	68	52	92	6.....	59	16	64	46
7.....	114	55	53	74	7.....	47	16	45	36
8.....	214	120	91	142	8.....	93	42	45	60
9.....	209	154	161	175	9.....	24	10	23	19

TABLE 57-2.—*Continued*

Year	N.	SE.	SW.	Av.
1880	0	0	0	0
1	15	13	15	14
2	67	37	21	42
3	57	33	17	36
4	110	59	18	62
1885	126	53	23	67
6	66	39	14	40
7	44	18	12	25
8	74	42	45	54
9	112	51	61	75
1890	122	76	72	90
1	194	105	108	136
2	153	66	88	102
3	79	39	27	48
4	61	23	28	37
1895	118	80	61	86
6	54	37	26	39
7	48	40	24	37
8	55	14	27	32
9	0	0	0	0
1900	20	13	18	17
1	18	13	18	16
2	0	0	0	0
3	77	42	79	66
4	08	0	0	03
1905	84	60	82	75
6	126	53	64	81
7	134	58	78	90
8	142	100	85	109
9	158	119	104	127
1910	181	132	117	143
1	216	125	117	153
2	139	120	102	120
3	84	53	32	56
4	125	71	53	83

Year	N.	SE.	SW.	Av.
1915	174	109	103	129
6	173	110	105	129
7	192	164	133	163
8	253	126	151	177
9	390	213	238	280
1920	393	204	253	283
1	308	135	170	204
2	472	189	237	299
3	506	188	174	289
4	488	149	216	284
1925	292	96	121	170
6	271	127	188	195
7	154	68	75	99
8	251	101	169	174
9	167	135	186	163
1930	237	104	142	161
1	190	126	148	155
2	213	148	206	189
3	209	164	189	187
4	167	97	112	125
1935	157	137	143	146
6	87	73	67	76
7	166	112	119	132
8	222	137	178	179
9	114	83	90	96
1940	73	73	66	71
1	154	73	98	108
2	143	109	92	115
3	106	96	93	98
4	152	119	117	129
1945	157	124	130	137
6	181	119	124	141
7	29	26	43	33

TABLE 57-3.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, trunk section 3, 9.7 feet above ground*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1711.....	163	151	171	162	1750.....	87	80	97	88
2.....	187	148	158	164	1.....	93	92	113	99
3.....	163	128	106	132	2.....	0	14	11	08
4.....	74	93	70	79	3.....	111	96	111	106
					4.....	104	100	91	98
1715.....	55	52	46	51	1755.....	51	49	50	50
6.....	36	35	44	38	6.....	230	203	181	205
7.....	171	179	192	180	7.....	159	142	129	143
8.....	218	226	225	223	8.....	162	148	148	153
9.....	206	202	194	201	9.....	129	74	46	83
1720.....	266	254	231	250	1760.....	120	78	44	81
1.....	196	187	173	185	1.....	49	45	41	45
2.....	46	69	66	60	2.....	109	91	94	98
3.....	153	163	153	156	3.....	42	45	40	42
4.....	95	95	100	97	4.....	123	98	97	106
1725.....	167	192	133	164	1765.....	93	82	62	79
6.....	190	240	181	204	6.....	123	110	101	111
7.....	105	144	107	119	7.....	102	90	88	93
8.....	60	103	89	84	8.....	120	114	118	117
9.....	36	66	46	49	9.....	113	86	91	97
1730.....	117	157	125	133	1770.....	95	82	91	89
1.....	92	117	85	98	1.....	120	92	105	106
2.....	115	135	123	124	2.....	103	98	91	97
3.....	112	126	105	114	3.....	17	08	06	10
4.....	141	177	142	153	4.....	38	36	32	35
1735.....	57	30	18	35	1775.....	82	80	57	73
6.....	67	82	56	68	6.....	93	77	72	81
7.....	24	28	26	26	7.....	51	46	48	48
8.....	95	106	72	91	8.....	24	22	22	23
9.....	136	132	106	125	9.....	90	80	79	83
1740.....	148	158	131	146	1780.....	23	24	26	24
1.....	138	131	107	125	1.....	38	41	30	36
2.....	50	48	36	45	2.....	38	22	32	31
3.....	67	51	35	51	3.....	118	88	85	97
4.....	57	59	40	52	4.....	223	119	129	157
1745.....	85	112	67	88	1785.....	65	39	41	48
6.....	141	173	145	153	6.....	94	51	54	66
7.....	125	134	117	125	7.....	232	169	168	190
8.....	25	26	22	24	8.....	140	88	76	101
9.....	156	150	128	145	9.....	128	94	84	102

TABLE 57-3.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1790.....	135	100	91	109	1830.....	216	74	114	135
1.....	236	137	136	170	1.....	129	102	106	112
2.....	268	148	117	178	2.....	155	89	90	111
3.....	372	205	191	256	3.....	271	170	182	208
4.....	220	90	99	136	4.....	98	77	77	84
1795.....	202	77	119	133	1835.....	184	111	114	136
6.....	113	49	85	82	6.....	126	58	69	84
7.....	119	76	78	91	7.....	83	58	62	68
8.....	92	62	93	82	8.....	164	110	110	128
9.....	135	103	105	114	9.....	213	140	139	164
1800.....	66	46	49	54	1840.....	244	144	132	173
1.....	68	32	46	49	1.....	136	85	69	97
2.....	44	32	22	33	2.....	39	27	28	31
3.....	20	13	21	18	3.....	93	93	80	89
4.....	77	53	64	65	4.....	158	125	108	130
1805.....	57	37	49	48	1845.....	46	47	39	44
6.....	62	32	54	49	6.....	52	37	45	45
7.....	94	50	57	67	7.....	13	06	0	06
8.....	58	41	50	50	8.....	106	118	127	117
9.....	89	43	41	58	9.....	164	130	103	132
1810.....	57	48	43	49	1850.....	116	105	98	106
1.....	147	103	95	115	1.....	40	18	32	30
2.....	120	86	75	94	2.....	120	101	106	109
3.....	15	17	15	16	3.....	112	70	67	83
4.....	43	37	38	39	4.....	100	85	78	88
1815.....	45	48	52	48	1855.....	136	107	111	118
6.....	149	131	121	134	6.....	97	89	84	90
7.....	105	87	80	91	7.....	06	0	0	02
8.....	78	16	14	36	8.....	41	36	44	40
9.....	93	31	20	48	9.....	09	10	0	06
1820.....	06	0	0	02	1860.....	60	50	56	55
1.....	89	57	64	70	1.....	106	74	71	84
2.....	71	55	39	55	2.....	106	106	100	104
3.....	65	62	57	61	3.....	38	45	28	37
4.....	153	98	104	118	4.....	28	25	12	22
1825.....	246	174	154	191	1865.....	92	81	75	83
6.....	347	225	181	251	6.....	132	114	106	117
7.....	433	231	192	285	7.....	134	112	112	119
8.....	472	188	175	278	8.....	206	174	171	184
9.....	207	84	87	126	9.....	194	164	145	168

TABLE 57-3.—*Continued*

Year	N.	SE.	SW.	Av.
1870.....	170	135	108	138
1.....	73	54	37	55
2.....	134	70	94	99
3.....	34	13	10	19
4.....	139	76	90	102
1875.....	141	53	57	84
6.....	52	18	21	30
7.....	47	14	20	27
8.....	78	32	27	46
9.....	23	09	21	18
1880.....	0	0	0	0
1.....	24	0	02	09
2.....	63	31	35	43
3.....	51	27	19	32
4.....	98	50	57	68
1885.....	107	59	49	72
6.....	52	40	27	40
7.....	28	22	12	21
8.....	64	41	50	52
9.....	98	69	57	75
1890.....	99	79	79	86
1.....	159	112	108	126
2.....	97	83	89	90
3.....	57	32	31	40
4.....	55	38	26	40
1895.....	122	106	79	102
6.....	52	37	32	40
7.....	57	50	47	51
8.....	38	30	34	34
9.....	0	0	0	0
1900.....	22	17	12	17
1.....	11	23	14	16
2.....	0	0	0	0
3.....	56	42	60	53
4.....	05	0	0	02
1905.....	79	70	58	69
6.....	101	93	81	92
7.....	112	70	89	90
8.....	121	140	106	122
9.....	146	136	105	129
1910.....	159	147	114	140
1.....	164	199	117	160
2.....	125	121	99	115
3.....	68	39	31	46
4.....	105	95	59	86
1915.....	156	160	114	143
6.....	189	163	140	164
7.....	224	252	171	216
8.....	278	162	156	199
9.....	373	273	248	298
1920.....	369	256	233	286
1.....	286	158	137	194
2.....	368	200	135	234
3.....	498	233	192	308
4.....	447	201	243	297
1925.....	215	127	149	164
6.....	240	180	187	202
7.....	104	83	100	96
8.....	194	167	197	186
9.....	173	154	198	175
1930.....	169	127	151	149
1.....	153	152	159	155
2.....	200	164	161	175
3.....	154	128	152	145
4.....	117	104	87	103
1935.....	141	125	103	123
6.....	71	38	62	57
7.....	107	107	123	112
8.....	166	160	132	153
9.....	97	64	83	81
1940.....	78	55	70	68
1.....	80	83	83	82
2.....	122	109	102	111
3.....	78	93	78	83
4.....	118	142	123	128
1945.....	110	134	118	121
6.....	172	119	116	136
7.....	28	39	30	32

TABLE 57-4.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, trunk section 4, 14.7 feet above ground*

Year	N.	SE.	SW.	Av.
1726.....	183	203	190	192
7.....	173	179	170	174
8.....	186	197	154	179
9.....	118	111	96	108
1730.....	219	192	192	201
1.....	127	107	132	122
2.....	191	202	208	200
3.....	154	185	173	171
4.....	205	227	237	223
1735.....	14	22	15	17
6.....	73	94	105	91
7.....	27	39	28	31
8.....	100	100	102	101
9.....	130	109	114	118
1740.....	162	131	137	143
1.....	153	136	149	146
2.....	43	42	46	44
3.....	88	83	99	90
4.....	88	76	78	81
1745.....	144	123	120	129
6.....	237	176	169	194
7.....	103	134	115	117
8.....	23	26	26	25
9.....	188	158	128	158
1750.....	121	110	85	105
1.....	145	123	108	125
2.....	15	07	17	13
3.....	104	86	100	97
4.....	116	98	85	100
1755.....	71	70	49	63
6.....	199	203	192	198
7.....	133	149	148	143
8.....	140	145	135	140
9.....	97	88	83	89
1760.....	121	97	107	108
1.....	47	50	61	53
2.....	106	106	128	113
3.....	47	38	45	44
4.....	134	92	128	118
1765.....	115	93	107	105
6.....	150	115	128	131
7.....	111	71	95	92
8.....	149	128	132	136
9.....	114	96	95	102
1770.....	109	95	88	97
1.....	129	105	112	115
2.....	108	95	78	94
3.....	11	19	10	13
4.....	28	41	51	40
1775.....	75	99	67	80
6.....	104	70	73	82
7.....	80	66	58	68
8.....	58	35	31	41
9.....	72	71	82	75
1780.....	38	37	31	35
1.....	57	41	48	49
2.....	45	45	31	40
3.....	90	79	94	88
4.....	163	130	188	160
1785.....	57	49	56	54
6.....	76	52	79	69
7.....	209	177	221	202
8.....	120	96	93	103
9.....	149	97	79	108
1790.....	132	107	84	108
1.....	256	161	149	189
2.....	192	141	126	153
3.....	302	214	207	241
4.....	207	105	114	142
1795.....	195	111	120	142
6.....	131	61	100	97
7.....	121	58	93	91
8.....	93	78	90	87
9.....	136	85	104	108
1800.....	58	46	38	47
1.....	66	28	35	43
2.....	29	22	28	26
3.....	23	19	21	21
4.....	65	58	57	60

TABLE 57-4.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1805.....	44	32	34	37	1845.....	55	38	45	46
6.....	71	53	49	58	6.....	60	36	50	49
7.....	91	66	66	74	7.....	33	10	23	22
8.....	61	40	50	50	8.....	160	108	118	129
9.....	82	47	62	64	9.....	235	122	138	165
1810.....	53	40	49	47	1850.....	165	90	107	121
1.....	129	95	89	104	1.....	56	27	22	35
2.....	151	88	74	104	2.....	171	102	108	127
3.....	26	19	24	23	3.....	113	59	70	81
4.....	55	39	38	44	4.....	127	73	81	94
1815.....	67	44	57	56	1855.....	118	98	104	107
6.....	182	116	141	146	6.....	126	77	90	98
7.....	136	78	95	103	7.....	18	0	0	06
8.....	38	16	14	23	8.....	56	42	42	47
9.....	46	19	41	35	9.....	26	0	21	16
1820.....	13	13	07	11	1860.....	69	58	56	61
1.....	131	79	79	96	1.....	115	65	78	86
2.....	83	47	62	64	2.....	100	86	99	95
3.....	85	42	54	60	3.....	45	29	25	33
4.....	151	115	118	128	4.....	48	26	14	29
1825.....	236	144	139	173	1865.....	82	74	71	76
6.....	322	231	220	258	6.....	125	75	99	100
7.....	410	237	268	305	7.....	130	109	105	115
8.....	496	193	276	322	8.....	285	199	210	231
9.....	223	84	138	148	9.....	240	199	151	197
1830.....	237	90	144	157	1870.....	205	113	122	147
1.....	181	122	146	150	1.....	79	50	41	57
2.....	211	90	110	137	2.....	138	100	93	110
3.....	379	173	203	252	3.....	37	23	16	25
4.....	128	75	101	101	4.....	108	82	75	88
1835.....	230	112	127	156	1875.....	115	74	70	86
6.....	158	52	57	89	6.....	66	15	24	35
7.....	122	60	79	87	7.....	56	15	23	31
8.....	210	116	127	151	8.....	88	40	46	58
9.....	211	143	167	174	9.....	20	11	22	18
1840.....	222	142	169	178	1880.....	0	0	0	0
1.....	114	77	89	93	1.....	17	08	19	15
2.....	56	27	35	39	2.....	45	38	63	49
3.....	134	80	107	107	3.....	57	42	47	49
4.....	145	89	104	113	4.....	105	63	56	75

TABLE 57-4.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1885.....	95	69	67	77	7.....	230	219	105	185
6.....	55	32	46	44	8.....	266	226	144	212
7.....	32	13	28	24	9.....	453	301	200	318
8.....	59	58	63	60					
9.....	74	60	83	72	1920.....	419	252	202	291
					1.....	348	177	162	229
1890.....	84	79	77	80	2.....	394	178	167	246
1.....	169	127	125	140	3.....	461	188	200	283
2.....	105	110	75	97	4.....	416	224	224	288
3.....	62	54	42	53					
4.....	54	66	39	53	1925.....	194	115	143	151
					6.....	275	163	175	204
1895.....	128	92	75	98	7.....	145	89	87	107
6.....	45	50	22	39	8.....	262	147	158	189
7.....	62	51	32	48	9.....	204	168	119	164
8.....	32	45	23	33					
9.....	0	0	11	04	1930.....	183	125	140	149
					1.....	177	127	125	143
1900.....	20	21	19	20	2.....	212	177	167	185
1.....	17	21	25	21	3.....	201	140	148	163
2.....	0	0	0	0	4.....	147	92	96	112
3.....	43	72	62	59					
4.....	16	0	0	05	1935.....	176	103	118	132
					6.....	70	41	54	55
1905.....	72	66	71	70	7.....	147	92	84	108
6.....	86	73	76	78	8.....	194	130	149	158
7.....	92	89	70	84	9.....	100	63	60	74
8.....	130	163	89	127					
9.....	127	142	78	116	1940.....	102	62	69	78
					1.....	105	70	116	97
1910.....	153	207	96	152	2.....	147	97	119	121
1.....	165	216	122	168	3.....	96	64	67	76
2.....	145	146	99	130	4.....	172	129	127	143
3.....	70	57	36	54					
4.....	101	108	50	86	1945.....	163	124	118	135
					6.....	143	97	78	106
1915.....	155	146	98	133	7.....	33	31	30	31
6.....	176	150	109	145					

TABLE 57-5.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, trunk section 5, 21.3 feet above ground*

Year	N.	SE.	SW.	Av.
1747.....	229	190	202	207
8.....	62	60	59	61
9.....	147	125	129	134
1750.....	101	94	90	95
1.....	129	116	113	119
2.....	24	18	17	20
3.....	93	84	80	86
4.....	140	104	96	113
1755.....	50	43	41	45
6.....	236	199	156	197
7.....	182	147	158	162
8.....	187	165	180	177
9.....	137	146	132	138
1760.....	194	232	245	224
1.....	80	71	50	67
2.....	117	126	124	122
3.....	48	61	37	49
4.....	171	152	141	155
1765.....	145	130	102	126
6.....	180	154	133	156
7.....	128	102	94	108
8.....	166	118	123	136
9.....	135	96	97	109
1770.....	118	95	99	104
1.....	125	114	112	117
2.....	103	46	79	76
3.....	30	18	07	18
4.....	67	49	47	54
1775.....	118	84	92	98
6.....	167	105	132	135
7.....	84	43	59	62
8.....	23	27	39	30
9.....	101	75	88	88
1780.....	33	21	26	27
1.....	70	50	43	54
2.....	47	23	22	31
3.....	110	166	112	129
4.....	192	165	127	161
1785.....	53	46	35	45
6.....	78	51	44	58
7.....	217	196	172	195
8.....	103	83	63	83
9.....	103	72	77	84
1790.....	81	92	68	80
1.....	194	199	109	167
2.....	187	141	101	143
3.....	249	248	170	222
4.....	135	109	84	109
1795.....	137	123	93	118
6.....	92	63	80	78
7.....	99	89	76	88
8.....	87	85	54	75
9.....	127	136	110	124
1800.....	66	56	24	49
1.....	62	30	28	40
2.....	34	27	20	27
3.....	30	22	10	21
4.....	78	58	27	54
1805.....	54	45	35	45
6.....	84	60	55	66
7.....	77	57	44	59
8.....	41	38	40	40
9.....	62	66	36	55
1810.....	43	46	29	39
1.....	102	105	58	88
2.....	84	60	55	66
3.....	21	10	19	17
4.....	34	30	24	29
1815.....	61	46	39	49
6.....	170	155	106	144
7.....	131	105	63	100
8.....	25	29	23	26
9.....	46	32	20	33
1820.....	14	08	0	07
1.....	92	76	58	75
2.....	70	63	45	59
3.....	53	62	44	53
4.....	150	130	88	123

TABLE 57-5.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1825.....	233	221	164	206	1865.....	90	65	72	76
6.....	296	230	199	242	6.....	154	101	76	110
7.....	353	287	229	290	7.....	194	123	89	135
8.....	297	237	263	266	8.....	308	178	143	210
9.....	160	86	81	109	9.....	269	192	113	191
1830.....	204	97	113	138	1870.....	235	123	96	151
1.....	164	101	94	120	1.....	77	36	30	48
2.....	175	109	69	118	2.....	138	65	62	88
3.....	254	186	147	196	3.....	31	10	05	15
4.....	123	50	61	78	4.....	149	78	53	93
1835.....	169	87	85	114	1875.....	119	67	48	78
6.....	114	77	34	75	6.....	30	20	11	20
7.....	96	64	59	73	7.....	25	16	09	17
8.....	171	110	81	121	8.....	45	35	24	35
9.....	247	143	103	164	9.....	12	10	0	07
1840.....	218	140	97	152	1880.....	0	0	0	0
1.....	120	60	57	79	1.....	10	14	02	09
2.....	61	18	25	35	2.....	38	36	42	39
3.....	133	76	70	93	3.....	42	26	27	32
4.....	147	97	66	103	4.....	109	42	47	66
1845.....	48	42	32	41	1885.....	110	37	42	63
6.....	62	44	35	47	6.....	55	29	26	37
7.....	19	16	10	15	7.....	34	16	16	22
8.....	156	72	107	112	8.....	66	38	45	50
9.....	218	151	110	160	9.....	89	68	53	70
1850.....	179	107	88	125	1890.....	100	58	75	78
1.....	38	25	15	26	1.....	168	109	116	131
2.....	129	97	61	96	2.....	133	103	102	113
3.....	117	83	41	80	3.....	63	48	39	50
4.....	109	89	39	79	4.....	46	46	25	39
1855.....	175	118	68	120	1895.....	105	84	81	90
6.....	113	96	50	86	6.....	42	43	33	39
7.....	12	0	0	04	7.....	64	52	45	54
8.....	44	30	42	39	8.....	51	32	37	40
9.....	13	28	0	14	9.....	0	0	0	0
1860.....	67	60	36	54	1900.....	25	40	25	30
1.....	122	70	56	83	1.....	17	29	11	19
2.....	154	101	54	103	2.....	0	0	0	0
3.....	54	33	25	37	3.....	68	61	58	62
4.....	29	15	0	15	4.....	0	0	0	0

TABLE 57-5.—*Continued*

Year	N.	SE.	SW.	Av.
1905.....	93	70	71	78
6.....	142	79	75	99
7.....	134	80	69	94
8.....	183	108	97	129
9.....	173	126	96	132
1910.....	199	136	135	157
1.....	244	160	127	177
2.....	193	139	125	152
3.....	81	46	35	55
4.....	135	91	61	96
1915.....	189	132	88	136
6.....	242	144	110	165
7.....	239	171	122	177
8.....	265	149	135	183
9.....	325	213	216	251
1920.....	312	201	240	251
1.....	223	114	132	156
2.....	281	129	186	199
3.....	340	149	180	223
4.....	332	240	185	252
1925.....	168	101	104	125
6.....	191	144	140	158
7.....	143	56	77	92
8.....	217	141	107	155
9.....	174	134	122	143
1930.....	146	108	99	118
1.....	171	109	79	120
2.....	224	124	117	155
3.....	148	119	122	130
4.....	96	76	76	83
1935.....	94	91	106	97
6.....	40	44	41	42
7.....	98	86	93	92
8.....	123	104	117	115
9.....	48	60	62	57
1940.....	48	58	53	53
1.....	89	72	69	77
2.....	110	103	87	100
3.....	70	64	57	64
4.....	115	100	106	107
1945.....	160	112	108	127
6.....	127	86	94	102
7.....	21	17	18	19

TABLE 57-6.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, trunk section 6, 27.6 feet above ground*

Year	N.	SE.	SW.	Av.
1772.....	84	107	97	96
3.....	67	56	68	64
4.....	72	81	79	77
1775.....	132	108	111	117
6.....	145	130	136	137
7.....	89	65	77	77
8.....	36	24	27	29
9.....	85	65	64	71
1780.....	27	12	12	17
1.....	60	58	62	60
2.....	45	44	35	41
3.....	146	114	86	115
4.....	276	167	157	200
1785.....	58	29	17	35
6.....	68	34	17	40
7.....	211	133	90	145
8.....	100	50	29	60
9.....	83	43	22	49
1790.....	75	51	31	52
1.....	181	132	115	143
2.....	162	104	134	133
3.....	240	222	197	220
4.....	119	112	90	107

TABLE 57-6.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1795.....	156	136	105	132	1835.....	137	110	99	115
6.....	97	78	54	76	6.....	77	73	33	61
7.....	115	90	70	92	7.....	89	72	60	74
8.....	93	75	63	77	8.....	159	120	111	130
9.....	114	114	80	103	9.....	214	153	138	168
1800.....	41	22	14	26	1840.....	182	130	107	140
1.....	41	27	26	31	1.....	110	73	78	87
2.....	36	23	18	26	2.....	57	37	35	43
3.....	31	19	24	25	3.....	116	91	98	102
4.....	46	40	32	39	4.....	175	116	117	136
1805.....	55	25	29	36	1845.....	74	47	48	56
6.....	79	51	48	59	6.....	73	51	65	63
7.....	62	38	36	45	7.....	30	19	32	27
8.....	38	18	28	28	8.....	169	129	126	141
9.....	60	18	33	37	9.....	176	152	125	151
1810.....	39	13	32	28	1850.....	156	96	99	117
1.....	61	28	32	40	1.....	39	35	34	36
2.....	104	46	61	70	2.....	129	92	115	112
3.....	14	0	0	05	3.....	111	61	59	77
4.....	36	35	30	34	4.....	109	79	84	91
1815.....	52	27	33	37	1855.....	155	100	96	117
6.....	158	87	104	116	6.....	113	67	94	91
7.....	134	111	105	117	7.....	10	0	19	10
8.....	26	26	28	27	8.....	42	44	44	43
9.....	36	30	31	32	9.....	27	09	16	17
1820.....	07	0	12	06	1860.....	74	51	50	58
1.....	86	37	26	50	1.....	128	68	70	89
2.....	81	34	38	51	2.....	141	71	107	106
3.....	91	48	56	65	3.....	54	31	42	42
4.....	146	50	105	100	4.....	35	24	30	30
1825.....	205	152	187	181	1865.....	89	54	63	69
6.....	230	211	224	222	6.....	111	91	105	102
7.....	275	230	277	261	7.....	125	123	155	134
8.....	283	228	269	260	8.....	178	171	201	183
9.....	115	99	105	106	9.....	209	155	190	185
1830.....	179	127	137	148	1870.....	224	119	160	168
1.....	150	119	134	134	1.....	84	52	60	65
2.....	145	102	75	107	2.....	117	90	98	102
3.....	217	175	167	186	3.....	36	22	24	27
4.....	95	73	78	82	4.....	139	63	83	95

TABLE 57-6.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1875.....	141	53	84	93	2.....	195	129	150	158
6.....	47	15	30	31	3.....	76	54	62	64
7.....	39	16	27	27	4.....	131	87	79	99
8.....	74	30	49	51					
9.....	12	08	18	13	1915.....	199	97	128	141
					6.....	238	124	138	166
1880.....	0	0	0	0	7.....	273	180	156	203
1.....	09	12	12	11	8.....	255	197	190	214
2.....	41	25	32	33	9.....	358	259	353	323
3.....	50	22	42	38					
4.....	79	43	70	64	1920.....	340	267	353	320
					1.....	230	119	239	196
1885.....	89	37	59	62	2.....	247	164	234	215
6.....	48	27	46	40	3.....	336	167	227	243
7.....	31	09	32	24	4.....	359	192	290	280
8.....	68	47	62	59					
9.....	68	57	74	66	1925.....	182	86	146	138
					6.....	317	113	189	206
1890.....	92	58	73	74	7.....	114	73	75	87
1.....	157	119	111	129	8.....	260	100	138	166
2.....	139	92	85	105	9.....	282	107	122	170
3.....	60	37	53	50					
4.....	47	52	49	49	1930.....	150	91	114	128
					1.....	187	102	105	131
1895.....	128	94	89	104	2.....	209	119	156	161
6.....	60	39	37	45	3.....	166	124	143	144
7.....	75	67	70	71	4.....	117	87	81	95
8.....	57	38	40	45					
9.....	0	0	0	0	1935.....	127	102	103	111
					6.....	59	40	46	48
1900.....	31	19	29	26	7.....	129	100	92	107
1.....	18	22	21	20	8.....	151	107	100	119
2.....	11	0	0	04	9.....	93	71	65	76
3.....	74	54	72	67					
4.....	17	0	0	06	1940.....	70	66	51	62
					1.....	99	70	79	83
1905.....	101	78	94	91	2.....	145	72	99	105
6.....	132	85	71	96	3.....	91	66	53	70
7.....	150	74	88	104	4.....	150	98	111	120
8.....	202	100	128	143					
9.....	197	95	128	140	1945.....	162	116	95	124
1910.....	214	117	171	167	6.....	115	86	65	89
1.....	205	135	157	166	7.....	27	21	17	22

TABLE 57-7.—*Growth-layer thicknesses, in hundredths of a millimeter along designated radii of the ponderosa pine, OL-SO-57, trunk section 7, 32.3 feet above ground*

Year	N.	SE.	SW.	Av.
1797	161	121	143	142
8	170	171	139	160
9	53	50	85	63
1800	34	36	32	34
1	25	22	29	25
2	16	23	16	18
3	23	20	15	19
4	59	56	43	53
1805	33	34	42	36
6	49	59	42	50
7	59	56	40	52
8	39	37	17	31
9	46	50	39	45
1810	30	26	33	30
1	54	45	37	45
2	53	53	38	48
3	04	0	0	01
4	24	20	19	21
1815	35	44	39	39
6	110	135	126	123
7	74	82	88	81
8	16	24	20	20
9	17	20	18	18
1820	0	0	0	0
1	32	76	49	52
2	46	40	60	49
3	68	47	82	66
4	90	142	108	113
1825	157	198	169	175
6	257	197	133	196
7	336	390	167	298
8	327	360	160	282
9	127	153	58	113
1830	214	187	90	165
1	143	147	91	127
2	109	84	46	80
3	213	225	119	186
4	102	89	48	80
1835	119	118	81	106
6	57	71	23	50
7	63	64	39	55
8	147	142	78	122
9	217	220	110	182
1840	163	183	89	145
1	110	125	71	102
2	65	59	37	54
3	99	143	76	106
4	156	195	101	151
1845	62	70	48	60
6	74	83	55	70
7	32	38	17	29
8	170	196	110	159
9	224	295	128	216
1850	159	167	80	135
1	35	34	28	32
2	126	152	108	129
3	92	124	77	98
4	100	125	74	100
1855	131	156	107	131
6	129	120	96	115
7	0	15	11	09
8	41	41	33	38
9	26	25	17	23
1860	47	65	40	51
1	84	111	67	87
2	136	160	87	128
3	60	51	31	47
4	38	32	12	27
1865	81	75	64	73
6	119	118	67	101
7	176	222	119	172
8	209	247	158	205
9	183	242	165	197
1870	179	159	149	162
1	60	57	61	59
2	129	103	100	111

TABLE 57-7.—*Continued*

Year	N.	SE.	SW.	Av.
1873.....	19	34	20	24
4.....	118	88	77	94
1875.....	96	93	62	84
6.....	44	31	22	32
7.....	30	26	26	27
8.....	50	42	50	47
9.....	14	10	13	12
1880.....	0	0	03	01
1.....	17	10	14	14
2.....	45	37	46	43
3.....	40	36	36	37
4.....	92	72	63	76
1885.....	80	85	61	75
6.....	59	38	41	46
7.....	44	33	27	35
8.....	78	63	58	66
9.....	99	85	76	87
1890.....	97	104	73	91
1.....	191	169	138	166
2.....	180	131	114	142
3.....	103	70	75	83
4.....	84	65	73	74
1895.....	121	112	118	117
6.....	59	55	38	51
7.....	93	59	68	73
8.....	56	63	49	56
9.....	0	07	0	02
1900.....	32	26	26	28
1.....	22	28	20	23
2.....	10	11	08	10
3.....	101	73	63	78
4.....	19	10	14	14
1905.....	131	100	54	95
6.....	139	95	76	103
7.....	139	105	90	111
8.....	167	182	157	169
9.....	148	167	138	151
1910.....	196	199	200	198
1.....	198	199	170	189
2.....	187	164	143	165
3.....	68	64	69	67
4.....	113	100	103	105
1915.....	154	166	132	151
6.....	176	193	127	165
7.....	208	268	214	230
8.....	235	246	235	239
9.....	328	380	326	345
1920.....	356	362	313	344
1.....	213	142	189	181
2.....	227	189	237	218
3.....	340	246	243	275
4.....	387	276	267	310
1925.....	165	126	163	151
6.....	222	157	164	181
7.....	152	80	87	106
8.....	270	157	157	195
9.....	238	144	136	173
1930.....	223	123	123	156
1.....	232	124	132	163
2.....	210	154	138	167
3.....	188	155	149	164
4.....	138	82	77	99
1935.....	158	112	91	120
6.....	71	39	53	54
7.....	112	102	89	101
8.....	177	117	104	133
9.....	104	70	65	80
1940.....	98	54	60	71
1.....	120	93	69	94
2.....	160	90	96	115
3.....	102	60	49	70
4.....	163	115	110	129
1945.....	205	125	106	145
6.....	212	100	74	129
7.....	25	22	22	23

TABLE 57-8.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, trunk section 8, 37.8 feet above ground*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1833.....	221	188	209	206	1870.....	149	99	110	119
4.....	103	111	119	111	1.....	31	29	24	28
					2.....	101	69	81	84
1835.....	92	78	71	80	3.....	22	22	16	20
6.....	32	41	34	36	4.....	79	47	53	60
7.....	43	48	35	42					
8.....	98	87	104	96	1875.....	55	29	28	37
9.....	131	179	149	153	6.....	24	18	17	20
					7.....	13	15	16	15
1840.....	131	174	120	142	8.....	29	24	23	25
1.....	78	92	73	81	9.....	08	06	13	09
2.....	18	41	36	32					
3.....	75	71	76	74	1880.....	0	0	0	0
4.....	135	184	141	153	1.....	11	0	14	08
					2.....	34	09	22	22
1845.....	30	49	29	36	3.....	37	18	23	26
6.....	22	66	28	39	4.....	82	37	41	53
7.....	12	21	11	15					
8.....	112	173	110	132	1885.....	60	26	34	40
9.....	207	230	136	191	6.....	35	18	27	27
					7.....	35	14	22	24
1850.....	110	107	84	100	8.....	46	23	42	37
1.....	17	29	0	15	9.....	60	39	51	50
2.....	137	123	89	116					
3.....	90	80	63	78	1890.....	83	49	77	70
4.....	54	68	45	56	1.....	181	89	143	138
					2.....	159	91	103	118
1855.....	121	100	91	104	3.....	73	29	57	53
6.....	96	69	61	75	4.....	73	24	45	47
7.....	11	0	0	04					
8.....	47	32	33	37	1895.....	125	72	107	101
9.....	12	19	13	15	6.....	52	23	31	35
					7.....	80	48	58	62
1860.....	41	22	28	30	8.....	58	48	47	51
1.....	65	44	58	56	9.....	0	0	0	0
2.....	152	82	80	105					
3.....	42	18	39	33	1900.....	25	12	25	21
4.....	0	09	12	07	1.....	14	10	15	13
					2.....	0	0	0	0
1865.....	66	33	47	49	3.....	88	63	66	72
6.....	117	65	112	98	4.....	11	0	0	04
7.....	164	73	145	127					
8.....	193	96	140	143	1905.....	119	74	98	97
9.....	205	119	111	145	6.....	146	86	97	110

TABLE 57-8.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1907.....	162	87	105	118	8.....	257	93	130	160
8.....	215	103	122	147	9.....	234	82	131	149
9.....	226	88	92	135					
1910.....	312	129	134	192	1930.....	234	92	115	147
1.....	355	115	164	211	1.....	187	100	126	138
2.....	261	91	130	161	2.....	232	127	120	160
3.....	117	24	44	62	3.....	196	119	125	147
4.....	173	45	68	95	4.....	146	78	65	96
1915.....	267	93	94	151	1935.....	172	79	81	111
6.....	297	109	105	170	6.....	80	44	49	58
7.....	353	120	128	200	7.....	118	88	73	93
8.....	389	133	154	225	8.....	180	94	92	122
9.....	530	185	192	302	9.....	115	59	50	75
1920.....	324	128	179	210	1940.....	85	47	41	58
1.....	215	100	130	148	1.....	115	81	51	82
2.....	271	125	169	188	2.....	142	83	78	100
3.....	271	97	173	180	3.....	94	51	34	60
4.....	292	126	192	203	4.....	181	108	90	126
1925.....	144	77	101	107	1945.....	178	110	75	121
6.....	216	98	147	154	6.....	180	80	52	104
7.....	178	74	100	117	7.....	27	32	26	28

TABLE 57-9.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, trunk section 9, 41.7 feet above ground*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1853.....	91	102	88	94	1865.....	76	56	39	57
4.....	92	83	83	86	6.....	150	105	101	119
1855.....	99	98	106	101	7.....	204	127	128	153
6.....	82	56	57	65	8.....	213	129	122	155
7.....	13	15	10	13	9.....	145	127	101	124
8.....	36	33	42	37					
9.....	15	16	18	16	1870.....	112	119	87	106
1860.....	41	29	24	31	1.....	18	30	19	22
1.....	84	65	67	72	2.....	100	113	76	96
2.....	161	136	106	134	3.....	21	08	15	15
3.....	31	17	16	21	4.....	85	68	59	71
4.....	23	10	11	15					

TABLE 57-9.—*Continued*

Year	N.	SE.	SW.	Av.
1875.....	50	18	32	33
6.....	16	10	09	12
7.....	24	12	18	18
8.....	24	17	22	21
9.....	10	10	07	09
1880.....	0	0	06	02
1.....	09	11	11	10
2.....	25	29	28	27
3.....	36	10	24	23
4.....	64	52	72	63
1885.....	65	48	54	56
6.....	38	20	41	33
7.....	38	20	39	32
8.....	46	36	53	45
9.....	58	61	49	56
1890.....	97	104	92	98
1.....	213	173	151	179
2.....	143	104	100	115
3.....	66	40	28	45
4.....	67	35	29	44
1895.....	116	66	66	83
6.....	56	11	13	27
7.....	92	30	50	57
8.....	75	40	47	56
9.....	0	0	0	0
1900.....	32	19	20	24
1.....	35	13	11	20
2.....	0	0	0	0
3.....	92	59	71	74
4.....	24	12	0	12
1905.....	143	83	93	106
6.....	170	129	112	137
7.....	192	109	118	140
8.....	204	155	132	164
9.....	163	101	108	124
1910.....	266	139	157	187
1.....	282	173	182	212
2.....	173	109	121	134
3.....	82	27	30	46
4.....	116	59	61	79
1915.....	197	123	108	143
6.....	201	158	116	158
7.....	254	174	164	197
8.....	298	164	177	213
9.....	373	189	208	257
1920.....	261	132	164	186
1.....	218	97	123	146
2.....	250	123	152	175
3.....	251	118	159	176
4.....	280	138	166	195
1925.....	161	98	109	123
6.....	220	96	138	151
7.....	140	88	110	113
8.....	176	108	160	148
9.....	159	119	147	142
1930.....	193	109	120	141
1.....	182	112	138	144
2.....	215	144	128	162
3.....	169	133	148	150
4.....	124	88	80	97
1935.....	150	112	100	121
6.....	80	46	52	59
7.....	129	79	96	101
8.....	160	96	107	121
9.....	93	63	67	74
1940.....	81	46	60	62
1.....	101	84	93	93
2.....	123	103	117	114
3.....	90	55	65	70
4.....	142	143	131	139
1945.....	172	110	122	135
6.....	134	87	112	111
7.....	39	43	40	41

TABLE 57-10.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, trunk section 10. 45.6 feet above ground*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1887.....	116	117	121	118	8.....	178	75	108	120
8.....	75	63	70	69	9.....	278	134	143	185
9.....	95	104	99	99					
1890.....	56	47	48	50	1920.....	246	100	119	155
1.....	99	79	84	87	1.....	208	93	130	144
2.....	76	46	52	58	2.....	230	115	177	174
3.....	34	12	12	19	3.....	203	102	159	155
4.....	37	21	21	26	4.....	263	87	164	171
1895.....	77	44	67	63	1925.....	167	48	111	109
6.....	31	20	32	28	6.....	186	74	116	125
7.....	44	26	42	37	7.....	97	48	73	73
8.....	56	38	43	46	8.....	173	68	119	120
9.....	0	0	0	0	9.....	167	74	104	115
1900.....	18	12	14	15	1930.....	168	60	98	109
1.....	16	11	11	13	1.....	177	73	95	115
2.....	0	0	0	0	2.....	221	99	142	154
3.....	73	42	53	56	3.....	170	99	105	125
4.....	17	14	19	17	4.....	131	51	77	86
1905.....	90	55	57	67	1935.....	170	80	94	115
6.....	124	59	78	87	6.....	66	37	46	50
7.....	133	60	89	94	7.....	119	68	82	90
8.....	146	66	105	106	8.....	130	71	103	101
9.....	149	64	93	102	9.....	88	52	64	68
1910.....	198	89	115	134	1940.....	68	50	59	59
1.....	280	99	129	169	1.....	111	90	100	100
2.....	168	72	79	106	2.....	141	82	117	113
3.....	42	17	18	26	3.....	103	32	73	69
4.....	102	39	42	61	4.....	193	97	120	137
1915.....	158	72	97	109	1945.....	178	80	130	129
6.....	144	77	93	105	6.....	153	48	94	98
7.....	158	95	93	115	7.....	32	25	40	32

TABLE 57-11 AND 12.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, trunk section 11, 47.9 feet above ground, and trunk section 12, 49.9 feet above ground*

T-11

Year	N.	SE.	SW.	Av.
1909.....	121	77	66	88
1910.....	133	125	114	124
1.....	151	156	137	148
2.....	94	96	99	96
3.....	14	14	13	14
4.....	64	47	43	51
1915.....	73	63	42	59
6.....	65	57	40	54
7.....	90	150	123	121
8.....	82	89	100	90
9.....	117	145	116	126
1920.....	120	193	144	152
1.....	105	111	87	101
2.....	130	137	90	119
3.....	113	123	91	109
4.....	118	156	107	127
1925.....	84	136	74	98
6.....	107	129	81	106
7.....	71	99	59	76
8.....	90	193	84	122
9.....	81	149	78	103
1930.....	66	121	76	88
1.....	92	136	75	101
2.....	123	200	99	141
3.....	91	142	86	106
4.....	102	131	55	96
1935.....	105	153	98	119
6.....	29	82	41	51
7.....	74	109	104	96
8.....	93	136	107	112
9.....	41	70	45	52
1940.....	31	63	48	47
1.....	81	92	111	95
2.....	56	127	102	95
3.....	39	75	38	51
4.....	86	148	131	122
1945.....	85	121	121	106
6.....	65	114	91	90
7.....	17	26	23	22

T-12

Year	N.	SE.	SW.	Av.
1922.....	89	112	82	94
3.....	115	130	109	118
4.....	70	82	79	77
1925.....	74	74	60	69
6.....	94	85	86	88
7.....	78	67	78	74
8.....	113	162	136	137
9.....	86	145	98	110
1930.....	102	119	79	100
1.....	109	101	94	101
2.....	131	151	118	133
3.....	89	134	85	103
4.....	80	130	85	98
1935.....	95	147	83	108
6.....	46	69	31	49
7.....	98	190	113	134
8.....	133	158	86	126
9.....	52	59	46	52
1940.....	38	45	44	42
1.....	93	115	88	99
2.....	117	104	82	101
3.....	36	47	37	40
4.....	127	123	86	112
1945.....	92	100	82	91
6.....	69	57	70	65
7.....	40	23	19	27

Table 57-13 and 14.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, trunk section 13, 51.2 feet above ground, and trunk section 14, 52.6 feet above ground*

T-13

Year	N.	SE.	SW.	Av.
1928.....	106	129	125	120
9.....	89	113	106	103
1930.....	68	88	69	75
1.....	78	115	98	97
2.....	115	127	105	116
3.....	81	75	81	79
4.....	83	77	75	78
1935.....	72	94	61	76
6.....	18	44	21	28
7.....	62	81	77	73
8.....	88	84	112	95
9.....	28	30	38	32
1940.....	26	31	33	30
1.....	70	68	109	82
2.....	81	75	86	81
3.....	38	36	29	34
4.....	88	102	96	95
1945.....	72	83	62	72
6.....	70	65	52	62
7.....	16	23	22	20

T-14

Year	N.	SE.	SW.	Av.
1935.....	189	183	199	190
6.....	89	100	79	89
7.....	69	67	73	70
8.....	64	65	65	65
9.....	19	21	20	20
1940.....	26	26	22	25
1.....	64	65	83	71
2.....	57	81	53	64
3.....	21	61	18	33
4.....	57	81	56	65
1945.....	67	92	72	77
6.....	61	60	43	55
7.....	09	19	19	16

Table 57-1-A.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, branch section 1-A, 1.2 feet out from the trunk*

Year	Down	Up-E.	Up-W.	Av.
1783.....	25	25	26	25
4.....	80	96	85	87
1785.....	25	42	31	33
6.....	33	22	22	26
7.....	47	45	42	45
8.....	25	31	34	30
9.....	29	22	38	30
1790.....	32	30	36	33
1.....	61	66	80	69
2.....	51	54	62	56
3.....	63	51	79	64
4.....	19	14	20	18
1795.....	35	28	53	39
6.....	07	07	07	07
7.....	21	14	18	18
8.....	08	06	06	07
9.....	12	12	13	12
1800.....	0	06	0	02
1.....	06	07	09	07
2.....	08	07	07	07
3.....	0	0	0	0
4.....	18	16	20	18

TABLE 57-1-A.—*Continued*

Year	Down	Up-E.	Up-W.	Av.
1805.....	20	20	22	21
6.....	32	35	41	36
7.....	15	17	17	16
8.....	11	12	09	11
9.....	22	26	21	23
1810.....	15	14	10	13
1.....	52	59	79	63
2.....	61	81	134	92
3.....	0	0	07	02
4.....	20	29	19	23
1815.....	18	37	18	24
6.....	60	87	63	70
7.....	40	54	43	46
8.....	0	08	08	05
9.....	17	22	22	20
1820.....	0	13	10	08
1.....	45	75	56	59
2.....	59	60	56	58
3.....	58	60	45	54
4.....	69	88	74	77
1825.....	126	132	99	119
6.....	136	123	89	116
7.....	104	122	81	102
8.....	117	128	69	105
9.....	23	32	13	23
1830.....	79	71	45	65
1.....	66	61	43	57
2.....	30	12	23	22
3.....	62	61	54	59
4.....	30	38	25	31
1835.....	50	66	43	53
6.....	06	0	0	02
7.....	15	20	12	16
8.....	25	45	25	32
9.....	70	90	61	74
1840.....	75	85	47	69
1.....	49	45	32	42
2.....	04	0	0	01
3.....	37	34	22	31
4.....	46	52	43	47

Year	Down	Up-E.	Up-W.	Av.
1845.....	23	19	17	20
6.....	20	14	14	16
7.....	10	0	12	07
8.....	58	48	44	50
9.....	87	72	82	80
1850.....	63	36	50	50
1.....	06	0	0	02
2.....	69	48	50	56
3.....	51	35	50	45
4.....	37	26	14	26
1855.....	76	46	41	54
6.....	68	37	39	48
7.....	0	0	0	0
8.....	31	08	10	16
9.....	06	0	0	02
1860.....	13	06	12	10
1.....	30	07	10	16
2.....	74	46	35	52
3.....	15	07	0	07
4.....	0	0	0	0
1865.....	34	34	22	30
6.....	59	53	36	49
7.....	90	62	49	67
8.....	113	62	60	78
9.....	72	32	39	48
1870.....	46	25	35	35
1.....	07	0	0	02
2.....	34	12	16	21
3.....	10	0	0	03
4.....	35	08	18	20
1875.....	16	08	04	09
6.....	04	0	0	01
7.....	05	0	0	02
8.....	21	18	12	17
9.....	0	0	0	0
1880.....	0	0	0	0
1.....	0	0	0	0
2.....	14	08	06	09
3.....	17	08	07	11
4.....	44	28	18	30

Table 57-1-A.—*Continued*

Year	Down	Up-E.	Up-W.	Av.
1885.....	28	23	09	20
6.....	15	21	15	17
7.....	0	10	0	03
8.....	23	23	15	20
9.....	26	32	19	26
1890.....	75	51	35	54
1.....	227	54	55	112
2.....	74	30	46	50
3.....	31	0	10	14
4.....	17	0	11	09
1895.....	48	27	26	34
6.....	0	0	12	04
7.....	35	19	30	28
8.....	31	08	31	23
9.....	0	0	0	0
1900.....	15	07	09	10
1.....	0	0	0	0
2.....	0	0	0	0
3.....	44	22	21	29
4.....	0	0	0	0
1905.....	90	25	48	54
6.....	141	29	44	71
7.....	110	29	43	61
8.....	112	22	44	59
9.....	95	28	35	53
1910.....	104	32	48	61
1.....	120	25	58	67
2.....	83	24	42	50
3.....	14	0	09	08
4.....	16	12	15	14
1915.....	81	19	54	51
6.....	100	27	57	61

Year	Down	Up-E.	Up-W.	Av.
7.....	108	50	70	76
8.....	137	43	98	93
9.....	239	64	141	148
1920.....	240	42	100	127
1.....	115	24	54	64
2.....	202	37	67	102
3.....	175	33	60	89
4.....	238	43	98	126
1925.....	80	22	35	46
6.....	127	43	60	77
7.....	76	27	31	45
8.....	102	29	57	63
9.....	93	21	38	51
1930.....	92	41	38	57
1.....	84	30	34	49
2.....	136	46	44	75
3.....	83	32	36	50
4.....	59	26	26	37
1935.....	90	18	24	44
6.....	23	11	12	15
7.....	69	20	20	36
8.....	81	33	29	48
9.....	34	13	08	18
1940.....	30	07	08	15
1.....	76	19	17	37
2.....	86	33	33	51
3.....	37	14	19	23
4.....	86	25	28	46
1945.....	70	21	27	39
6.....	58	13	19	30
7.....	20	05	06	10

TABLE 57-1-B.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, branch section 1-B, 3.7 feet out from the trunk*

Year	Down	Up-E.	Up-W.	Av.
1824	84	91	87	87
1825	81	82	70	78
6	83	70	79	77
7	77	71	81	76
8	89	84	81	85
9	64	47	61	57
1830	92	90	79	87
1	78	71	70	73
2	18	16	09	14
3	48	61	38	49
4	15	20	16	17
1835	31	33	25	30
6	07	09	06	07
7	08	14	11	11
8	46	43	36	42
9	95	84	88	89
1840	65	51	52	56
1	53	33	36	41
2	25	04	12	14
3	41	34	33	36
4	81	58	62	67
1845	45	26	30	34
6	28	19	27	25
7	10	11	15	12
8	71	49	59	60
9	101	60	71	77
1850	53	36	41	43
1	08	0	0	03
2	70	54	71	65
3	60	54	50	55
4	52	31	29	37
1855	64	48	67	60
6	51	43	48	47
7	0	0	0	0
8	25	26	23	25
9	08	05	11	08
1860	22	16	20	19
1	40	33	46	40
2	97	78	101	92
3	21	16	19	19
4	11	0	13	08
1865	42	31	29	34
6	82	64	67	71
7	110	64	83	86
8	114	70	111	98
9	80	45	71	65
1870	66	45	49	53
1	15	07	07	10
2	36	23	29	29
3	06	05	11	07
4	21	17	26	21
1875	16	16	21	18
6	06	0	07	04
7	09	10	06	08
8	21	13	21	18
9	09	0	0	03
1880	0	0	0	0
1	10	13	07	10
2	16	14	16	15
3	32	26	14	24
4	57	69	37	54
1885	62	42	42	49
6	38	20	26	28
7	37	0	11	16
8	58	26	32	39
9	66	33	28	42
1890	112	57	50	73
1	214	70	137	140
2	58	36	61	52
3	21	0	24	15
4	12	0	21	11
1895	129	41	61	77
6	47	09	34	30
7	49	23	36	36
8	65	41	34	47
9	0	0	0	0

Table 57-1-B.—*Continued*

Year	Down	Up-E.	Up-W.	Av.	Year	Down	Up-E.	Up-W.	Av.
1900.....	29	21	10	20	3.....	191	31	45	89
1.....	19	14	08	14	4.....	212	48	58	106
2.....	0	0	0	0					
3.....	65	20	27	37	1925.....	72	22	27	40
4.....	0	03	01	01	6.....	137	41	52	77
					7.....	129	27	31	62
					8.....	98	27	47	57
1905.....	151	50	44	82	9.....	96	16	27	46
6.....	230	51	59	113					
7.....	184	27	37	83	1930.....	97	40	32	56
8.....	148	23	33	68	1.....	88	16	29	44
9.....	113	26	36	58	2.....	145	34	31	70
					3.....	113	15	27	52
1910.....	117	21	33	57	4.....	67	13	21	34
1.....	99	20	36	52					
2.....	59	15	33	35	1935.....	127	14	19	53
3.....	28	0	04	11	6.....	29	0	11	13
4.....	30	0	15	15	7.....	76	17	16	36
					8.....	128	21	22	57
					9.....	52	05	20	26
1915.....	149	26	36	70					
6.....	152	26	56	78	1940.....	35	05	16	19
7.....	217	46	77	113	1.....	97	21	27	48
8.....	222	37	62	107	2.....	101	27	36	55
9.....	314	46	81	147	3.....	59	25	14	33
					4.....	93	26	31	50
1920.....	285	36	60	127	1945.....	101	29	31	54
1.....	149	36	45	77	6.....	88	13	20	40
2.....	179	28	48	85	7.....	16	08	07	10

Table 57-1-C.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, branch section 1-C, 5.6 feet out from the trunk*

Year	Down	Up-E.	Up-W.	Av.	Year	Down	Up-E.	Up-W.	Av.
1837.....	32	51	46	43	8.....	34	29	57	40
8.....	34	68	84	62	9.....	52	47	59	53
9.....	85	69	92	82					
					1850.....	51	42	63	52
1840.....	57	54	50	54	1.....	20	12	12	15
1.....	36	32	41	36	2.....	75	58	73	69
2.....	21	07	18	15	3.....	57	56	46	53
3.....	34	34	26	31	4.....	50	32	43	42
4.....	54	68	51	58					
					1855.....	57	48	58	54
					6.....	49	47	51	49
1845.....	22	19	24	22	7.....	0	0	0	0
6.....	25	17	18	20	8.....	20	24	22	22
7.....	23	07	10	13	9.....	09	06	08	08

TABLE 57-1-C.—*Continued*

Year	Down	Up-E.	Up-W.	Av.
1860.....	22	08	18	16
1.....	42	36	39	39
2.....	100	89	69	86
3.....	16	18	14	16
4.....	25	11	10	15
1865.....	64	39	36	46
6.....	112	58	39	70
7.....	101	82	84	89
8.....	77	96	92	88
9.....	55	55	73	61
1870.....	52	35	59	49
1.....	12	0	15	09
2.....	30	34	46	37
3.....	0	05	10	05
4.....	22	31	28	27
1875.....	20	22	37	26
6.....	09	08	17	11
7.....	11	14	15	13
8.....	20	14	30	21
9.....	05	0	07	04
1880.....	0	08	03	04
1.....	07	08	10	08
2.....	15	16	16	16
3.....	24	20	14	19
4.....	67	44	51	54
1885.....	55	27	43	42
6.....	33	23	34	30
7.....	19	15	22	19
8.....	42	27	35	35
9.....	50	45	37	44
1890.....	101	55	65	74
1.....	160	81	132	124
2.....	71	33	61	55
3.....	29	08	26	21
4.....	26	0	18	15
1895.....	77	45	56	59
6.....	25	14	13	17
7.....	42	32	32	35
8.....	75	36	37	49
9.....	11	0	0	04
1900.....	24	18	16	19
1.....	14	16	0	10
2.....	08	0	0	03
3.....	45	39	36	40
4.....	14	0	0	05
1905.....	94	67	62	74
6.....	150	64	64	93
7.....	130	43	59	77
8.....	144	37	63	81
9.....	60	43	61	55
1910.....	96	39	68	68
1.....	88	41	71	67
2.....	50	36	38	41
3.....	25	0	20	15
4.....	19	10	11	13
1915.....	103	34	62	66
6.....	125	53	52	77
7.....	180	63	80	108
8.....	217	69	69	118
9.....	343	80	105	176
1920.....	229	63	111	134
1.....	127	37	67	77
2.....	147	38	60	82
3.....	161	40	53	85
4.....	173	58	65	99
1925.....	55	41	43	46
6.....	111	50	63	75
7.....	67	33	35	45
8.....	138	37	43	73
9.....	77	22	23	41
1930.....	110	43	40	64
1.....	82	33	45	53
2.....	98	60	50	69
3.....	106	28	36	57
4.....	81	27	30	46

TABLE 57-1-C.—*Continued*

Year	Down	Up-E.	Up-W.	Av.	Year	Down	Up-E.	Up-W.	Av.
1935.....	106	15	28	50	2.....	131	64	40	78
6.....	31	06	16	18	3.....	49	28	15	31
7.....	76	18	21	38	4.....	82	49	28	53
8.....	117	29	33	60					
9.....	60	17	19	32	1945.....	106	54	40	67
					6.....	90	30	28	49
1940.....	33	15	08	19	7.....	16	11	10	12
1.....	89	44	32	55					

TABLE 57-1-D.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, branch section 1-D, 7.4 feet out from the trunk*

Year	Down	Up-E.	Up-W.	Av.	Year	Down	Up-E.	Up-W.	Av.
1851.....	42	51	50	48	1880.....	04	0	0	01
2.....	55	74	73	67	1.....	05	04	15	08
3.....	59	59	64	61	2.....	11	15	30	19
4.....	66	64	68	66	3.....	17	20	24	20
					4.....	24	32	50	35
1855.....	40	40	18	33					
6.....	26	26	28	27	1885.....	27	27	23	26
7.....	04	05	09	06	6.....	15	13	17	15
8.....	15	21	23	20	7.....	15	11	13	13
9.....	11	17	18	15	8.....	27	24	26	26
					9.....	30	29	21	27
1860.....	19	20	31	23					
1.....	25	31	39	32	1890.....	49	43	56	49
2.....	34	42	50	42	1.....	88	79	57	75
3.....	14	12	11	12	2.....	49	52	32	44
4.....	08	08	07	08	3.....	16	08	09	11
					4.....	13	10	13	12
1865.....	19	24	23	22					
6.....	29	43	47	40	1895.....	51	39	33	41
7.....	32	46	54	44	6.....	16	18	26	20
8.....	41	68	67	59	7.....	26	29	28	28
9.....	41	44	44	43	8.....	44	41	53	46
					9.....	13	0	0	04
1870.....	42	39	47	43					
1.....	10	14	14	13	1900.....	15	21	21	19
2.....	22	28	20	23	1.....	11	10	16	12
3.....	07	07	11	08	2.....	0	0	0	0
4.....	21	24	23	23	3.....	31	40	52	41
					4.....	10	10	17	12
1875.....	20	12	15	16					
6.....	0	10	10	07	1905.....	60	63	67	63
7.....	11	13	10	11	6.....	86	71	68	75
8.....	12	17	20	16	7.....	66	45	49	53
9.....	09	11	13	11	8.....	69	46	60	58
					9.....	54	60	49	54

TABLE 57-1-D.—*Continued*

Year	Down	Up-E.	Up-W.	Av.	Year	Down	Up-E.	Up-W.	Av.
1910.....	66	57	64	62	1929.....	71	21	25	39
1.....	82	50	68	67	1930.....	60	35	32	42
2.....	56	38	27	40	1.....	87	35	38	53
3.....	21	07	10	13	2.....	90	65	41	65
4.....	26	15	19	20	3.....	86	33	23	47
1915.....	88	59	51	66	4.....	77	27	17	40
6.....	104	52	57	71	1935.....	92	30	13	45
7.....	88	78	81	82	6.....	25	09	07	14
8.....	114	76	71	87	7.....	73	24	07	35
9.....	209	117	112	146	8.....	113	40	13	55
1920.....	171	75	88	111	9.....	95	16	05	39
1.....	109	57	51	72	1940.....	78	19	05	34
2.....	137	61	76	91	1.....	98	57	19	58
3.....	137	60	72	90	2.....	119	50	22	64
4.....	149	75	90	105	3.....	52	15	07	25
1925.....	100	43	39	61	4.....	123	36	12	57
6.....	91	54	57	67	1945.....	101	45	14	53
7.....	52	30	25	36	6.....	67	20	09	32
8.....	86	37	43	55	7.....	19	14	06	13

TABLE 57-1-E.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, branch section 1-E, 9.2 feet out from the trunk*

Year	Down	Up-E.	Up-W.	Av.	Year	Down	Up-E.	Up-W.	Av.
1871.....	62	57	59	59	8.....	08	12	19	13
2.....	81	72	84	79	9.....	12	16	15	14
3.....	29	33	26	29	1890.....	12	19	16	16
4.....	70	72	80	74	1.....	28	45	36	36
1875.....	10	13	14	12	2.....	18	19	25	21
6.....	0	05	05	03	3.....	04	12	0	05
7.....	08	15	0	08	4.....	10	11	09	10
8.....	12	16	19	16	1895.....	46	30	16	31
9.....	10	08	04	07	6.....	17	17	14	16
1880.....	0	08	04	04	7.....	26	18	20	21
1.....	06	08	05	06	8.....	41	31	31	34
2.....	12	10	06	09	9.....	0	0	0	0
3.....	14	09	10	11	1900.....	08	12	13	11
4.....	15	09	11	12	1.....	06	12	11	10
1885.....	08	10	19	12	2.....	0	0	0	0
6.....	07	08	18	11	3.....	18	24	29	24
7.....	04	07	16	09	4.....	13	15	15	14

TABLE 57-1-E.—*Continued*

Year	Down	Up-E.	Up-W.	Av.	Year	Down	Up-E.	Up-W.	Av.
1905.....	39	39	36	38	7.....	38	17	30	28
6.....	46	26	32	35	8.....	65	35	30	43
7.....	25	35	23	28	9.....	62	26	18	35
8.....	30	28	34	31					
9.....	35	39	42	39	1930.....	86	33	37	52
					1.....	85	43	37	55
1910.....	31	56	43	43	2.....	63	52	53	56
1.....	31	55	50	45	3.....	54	43	27	41
2.....	26	29	29	28	4.....	56	35	28	40
3.....	15	15	15	15					
4.....	23	31	18	24	1935.....	51	30	26	36
					6.....	28	08	09	15
1915.....	51	80	74	68	7.....	60	42	39	47
6.....	44	62	51	52	8.....	103	59	69	77
7.....	38	50	42	43	9.....	34	20	22	25
8.....	34	31	28	31					
9.....	102	33	50	62	1940.....	26	22	19	22
1920.....	117	39	49	68	1.....	107	64	69	80
1.....	89	38	45	57	2.....	92	72	62	75
2.....	136	32	61	76	3.....	37	26	14	26
3.....	57	41	47	48	4.....	85	47	34	55
4.....	100	34	60	65					
					1945.....	69	44	45	53
1925.....	56	51	41	49	6.....	44	19	25	29
6.....	87	22	56	55	7.....	18	10	09	12

TABLE 57-1-F.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, branch section 1-F, 11.9 feet out from the trunk*

Year	Down	Up-E.	Up-W.	Av.	Year	Down	Up-E.	Up-W.	Av.
1919.....	86	82	75	81	3.....	20	24	27	24
					4.....	39	39	34	37
1920.....	91	62	78	77					
1.....	75	78	78	77	1935.....	53	25	44	41
2.....	84	80	76	80	6.....	27	17	11	18
3.....	61	54	76	64	7.....	92	52	67	70
4.....	61	56	79	65	8.....	95	58	76	76
					9.....	17	16	21	18
1925.....	58	52	50	53					
6.....	80	81	64	75	1940.....	23	17	26	22
7.....	30	38	61	43	1.....	66	50	53	56
8.....	38	42	91	57	2.....	74	49	52	58
9.....	51	26	67	48	3.....	30	17	18	22
					4.....	55	42	42	46
1930.....	49	44	47	47	1945.....	50	33	46	43
1.....	52	54	57	54	6.....	30	32	30	31
2.....	50	38	38	42	7.....	22	14	11	16

Table 57-2-A.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, branch section 2-A, 0.4 foot out from the trunk*

Year	Down	Up-E.	Up-W.	Av.	Year	Down	Up-E.	Up-W.	Av.
1880.....	41	42	36	40	1915.....	99	62	83	81
1.....	56	36	58	50	6.....	78	41	80	66
2.....	42	45	41	43	7.....	155	79	122	119
3.....	60	49	45	51	8.....	151	101	113	122
4.....	44	46	36	42	9.....	165	163	134	154
1885.....	38	34	23	32	1920.....	128	116	106	117
6.....	16	21	09	15	1.....	76	64	66	69
7.....	30	36	13	26	2.....	126	114	103	114
8.....	36	25	32	31	3.....	81	80	81	81
9.....	57	62	35	51	4.....	109	119	96	108
1890.....	59	42	14	38	1925.....	65	59	78	67
1.....	86	72	63	74	6.....	110	100	92	101
2.....	47	41	36	41	7.....	45	47	47	46
3.....	29	39	10	26	8.....	53	76	65	65
4.....	30	26	20	25	9.....	50	29	35	38
1895.....	54	50	41	48	1930.....	61	68	61	63
6.....	20	37	17	25	1.....	83	74	68	75
7.....	32	52	30	38	2.....	116	123	72	104
8.....	44	51	34	43	3.....	78	47	49	58
9.....	0	14	0	05	4.....	51	39	40	43
1900.....	09	23	13	15	1935.....	51	53	34	46
1.....	10	31	06	16	6.....	27	31	17	25
2.....	08	0	0	03	7.....	62	66	36	55
3.....	20	60	35	38	8.....	89	78	48	72
4.....	08	09	07	08	9.....	41	46	32	40
1905.....	18	41	31	30	1940.....	33	30	26	30
6.....	32	41	31	35	1.....	62	58	67	62
7.....	16	25	16	19	2.....	87	75	57	73
8.....	49	28	24	34	3.....	28	21	16	22
9.....	51	25	25	34	4.....	55	44	47	49
1910.....	78	42	57	59	1945.....	58	48	35	47
1.....	63	38	65	56	6.....	35	30	29	31
2.....	47	21	52	40	7.....	13	10	11	11
3.....	14	21	11	15					
4.....	28	27	26	27					

TABLE 57-2-B.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, branch section 2-B, 1.8 feet out from the trunk*

Year	Down	Up-E.	Up-W.	Av.
1895.....	129	112	119	120
6.....	67	48	39	51
7.....	59	39	39	46
8.....	79	39	40	53
9.....	0	16	13	10
1900.....	27	14	12	18
1.....	20	17	28	22
2.....	0	08	09	06
3.....	37	32	30	33
4.....	11	18	15	15
1905.....	30	32	26	29
6.....	25	28	27	27
7.....	12	07	15	11
8.....	29	23	28	27
9.....	49	32	29	37
1910.....	61	34	39	45
1.....	66	63	40	56
2.....	56	54	33	48
3.....	24	13	06	14
4.....	42	31	21	31
1915.....	97	79	50	75
6.....	60	49	53	54
7.....	133	67	93	98
8.....	152	87	103	114
9.....	185	101	120	135
1920.....	178	102	86	122
1.....	103	68	63	78
2.....	144	102	90	112
3.....	104	88	55	82
4.....	143	81	68	97
1925.....	71	43	46	53
6.....	129	86	69	95
7.....	77	39	32	49
8.....	90	62	42	65
9.....	73	34	28	45
1930.....	61	68	51	60
1.....	99	76	67	81
2.....	124	99	77	100
3.....	56	29	55	47
4.....	54	27	39	40
1935.....	50	33	34	39
6.....	28	23	16	22
7.....	56	52	34	47
8.....	88	54	36	59
9.....	48	26	27	34
1940.....	32	21	30	28
1.....	63	38	52	51
2.....	88	33	67	63
3.....	31	11	15	19
4.....	69	25	20	38
1945.....	68	20	37	42
6.....	48	15	19	27
7.....	15	09	08	31

TABLE 57-2-C.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, branch section 2-C, 3.9 feet out from the trunk*

Year	Down	Up-E.	Up-W.	Av.
1913.....	78	76	61	72
4.....	60	63	49	57
1915.....	75	84	62	74
6.....	94	71	82	82
7.....	106	91	111	103
8.....	115	95	110	107
9.....	109	88	102	100
1920.....	105	82	90	92
1.....	76	74	62	71
2.....	107	97	83	96
3.....	84	81	56	74
4.....	91	78	68	79

TABLE 57-2-C.—*Continued*

Year	Down	Up-E.	Up-W.	Av.	Year	Down	Up-E.	Up-W.	Av.
1925.....	72	70	59	67	7.....	59	58	59	59
6.....	106	90	87	94	8.....	84	78	71	78
7.....	57	59	59	58	9.....	40	41	39	40
8.....	92	69	75	79					
9.....	57	36	46	46	1940.....	29	26	27	27
1930.....	79	62	63	68	1.....	60	53	66	60
1.....	91	65	82	79	2.....	67	60	65	64
2.....	116	82	77	92	3.....	17	11	12	13
3.....	41	42	47	43	4.....	43	53	47	48
4.....	52	40	42	45					
1935.....	58	56	50	55	1945.....	57	43	42	47
6.....	23	21	27	24	6.....	37	44	29	37
					7.....	08	09	11	09

TABLE 57-2-D AND 2-E.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-SO-57, branch section 2-D, 5.0 feet out from the trunk, and branch section 2-E, 7.0 feet out from the trunk*

2-D

Year	Down	Up-E.	Up-W.	Av.
1920.....	118	103	106	109
1.....	77	68	69	71
2.....	71	63	66	67
3.....	66	56	66	63
4.....	80	64	63	69
1925.....	73	64	45	61
6.....	86	72	69	76
7.....	55	39	38	44
8.....	54	46	43	48
9.....	58	44	46	49
1930.....	70	49	52	57
1.....	76	59	66	67
2.....	91	64	78	78
3.....	48	34	35	39
4.....	62	36	56	51
1935.....	49	33	30	37
6.....	30	16	17	21
7.....	59	40	29	43
8.....	96	72	76	81
9.....	33	36	36	35
1940.....	30	27	25	27
1.....	53	46	47	49
2.....	48	52	45	48
3.....	16	17	12	15
4.....	36	35	24	32

2-D—*Continued*

Year	Down	Up-E.	Up-W.	Av.
1945.....	42	39	34	38
6.....	39	26	33	33
7.....	06	06	06	06

2-E

Year	Down	Up-E.	Up-W.	Av.
1931.....	138	92	107	112
2.....	87	69	51	69
3.....	75	59	65	66
4.....	51	71	27	50
1935.....	71	37	16	41
6.....	25	20	23	23
7.....	68	45	44	52
8.....	97	75	63	78
9.....	24	27	17	23
1940.....	38	13	19	23
1.....	52	31	20	34
2.....	36	23	17	25
3.....	11	11	16	13
4.....	41	23	31	32
1945.....	33	42	43	39
6.....	11	23	15	16
7.....	0	09	06	05

TABLE 62 *-1.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, trunk section 1, 1.2 feet above ground*

Year	N.	ENE.	SE.	SW.	WNW.	Av.
1674....	77	81	79	88	107	86
1675....	88	82	91	85	101	89
6....	45	45	45	50	42	45
7....	74	73	74	63	70	71
8....	118	106	105	101	114	109
9....	54	59	41	41	40	47
1680....	108	100	111	123	119	112
1....	94	76	86	85	83	85
2....	54	61	64	62	56	59
3....	70	65	66	83	65	70
4....	52	37	39	48	38	43
1685....	66	38	33	50	52	48
6....	45	85	84	87	78	76
7....	80	85	87	105	78	87
8....	88	117	117	97	87	101
9....	82	167	156	119	127	130
1690....	70	93	127	77	76	89
1....	100	140	164	112	97	123
2....	157	230	239	155	113	179
3....	94	142	173	92	78	116
4....	122	221	233	163	139	176
1695....	69	132	138	80	70	98
6....	59	82	68	45	30	57
7....	106	118	75	54	55	81
8....	163	225	207	107	119	164
9....	135	228	189	99	94	149
1700....	64	126	161	42	49	88
1....	135	211	259	81	67	151
2....	107	171	197	76	70	124
3....	35	90	104	50	30	62
4....	93	176	176	41	60	109
1705....	120	187	206	63	78	131
6....	65	137	152	48	72	95
7....	83	214	184	51	84	123
8....	52	87	94	21	44	60
9....	78	139	146	52	43	92
1710....	135	203	221	71	91	144
1....	125	179	182	63	63	122
2....	117	131	149	78	59	107
3....	114	155	170	74	64	115
4....	119	157	181	70	61	118
1715....	77	145	169	57	55	101
6....	31	47	54	08	08	30
7....	123	145	164	55	54	108
8....	191	242	212	114	120	176
9....	189	269	229	109	116	182
1720....	194	311	325	128	127	217
1....	152	227	212	119	104	163
2....	56	84	90	27	27	57
3....	118	125	133	66	66	102
4....	85	107	92	44	36	73
1725....	165	233	184	98	80	152
6....	194	266	247	128	134	194
7....	75	136	113	90	71	97
8....	56	67	100	44	24	58
9....	18	38	35	07	06	21
1730....	70	104	107	55	45	76
1....	114	143	159	68	87	114
2....	103	154	156	49	58	104
3....	48	105	109	30	38	66
4....	98	125	152	63	65	101
1735....	25	24	45	13	15	24
6....	109	126	140	61	63	100
7....	65	63	78	20	30	51
8....	127	158	147	62	69	113
9....	81	94	121	47	68	82
1740....	128	120	142	72	64	105
1....	122	169	123	63	65	108
2....	82	117	90	42	51	76
3....	146	187	155	96	118	140
4....	121	160	166	109	109	133
1745....	149	200	224	111	95	156
6....	208	230	258	139	139	195
7....	122	160	171	85	98	127
8....	48	37	41	09	14	30
9....	170	141	164	91	94	132
1750....	128	98	142	70	62	100
1....	146	141	132	57	72	110
2....	62	36	38	23	18	35
3....	75	56	28	53	30	48
4....	111	93	171	60	52	97

* Table 62 in Appendix is so numbered because it deals throughout with tree OL-S-62.

TABLE 62-1.—*Continued*

Year	N.	ENE.	SE.	SW.	WNW.	Av.	Year	N.	ENE.	SE.	SW.	WNW.	Av.
1755....	32	39	29	21	06	25	1795....	148	128	191	111	133	142
6....	104	103	111	68	70	91	6....	118	137	150	112	150	133
7....	130	132	129	79	69	108	7....	92	113	138	85	99	105
8....	128	196	167	135	121	149	8....	50	63	67	38	48	53
9....	143	163	161	93	102	132	9....	102	127	123	89	134	115
1760....	167	138	165	124	117	142	1800....	70	68	52	40	73	61
1....	88	85	96	66	74	82	1....	70	74	59	43	82	66
2....	135	129	127	84	86	112	2....	73	78	67	45	85	70
3....	44	49	53	26	23	39	3....	53	59	59	47	70	58
4....	124	116	128	101	93	112	4....	85	98	82	64	71	80
1765....	75	78	57	46	45	60	1805....	48	71	63	35	66	57
6....	100	110	84	83	57	87	6....	83	70	77	57	65	70
7....	108	99	82	65	55	82	7....	111	102	79	84	93	94
8....	88	73	62	48	59	66	8....	105	120	115	81	122	109
9....	24	33	44	0	10	22	9....	143	157	120	75	118	123
1770....	26	47	58	21	22	35	1810....	126	145	102	74	121	114
1....	52	55	46	22	26	40	1....	96	131	106	76	110	104
2....	50	42	52	12	15	34	2....	150	159	102	82	119	122
3....	05	24	12	0	0	08	3....	30	37	20	30	38	31
4....	35	42	38	21	28	33	4....	62	102	52	54	84	71
1775....	35	53	54	26	21	38	1815....	129	124	82	71	89	99
6....	170	80	91	48	41	86	6....	183	178	152	115	140	154
7....	90	94	107	46	48	77	7....	68	95	62	52	81	72
8....	50	108	83	32	28	60	8....	37	34	31	21	28	30
9....	63	90	65	31	49	60	9....	98	105	64	49	65	76
1780....	41	77	58	32	40	50	1820....	61	81	51	29	38	52
1....	97	134	121	83	70	101	1....	138	163	107	103	127	128
2....	79	143	100	57	82	92	2....	53	71	43	20	51	48
3....	113	181	131	79	92	119	3....	69	110	79	59	82	80
4....	30	250	214	108	147	150	4....	105	102	91	66	81	89
1785....	55	65	24	20	31	39	1825....	132	114	107	80	98	106
6....	55	64	49	20	47	47	6....	131	166	120	117	133	133
7....	77	73	84	54	70	72	7....	141	104	100	79	117	108
8....	48	88	82	30	52	60	8....	94	122	90	76	99	96
9....	76	79	85	36	58	67	9....	47	44	48	37	53	46
1790....	125	141	151	52	82	110	1830....	127	119	80	72	120	104
1....	100	135	113	76	101	105	1....	143	140	113	109	144	130
2....	136	148	182	88	136	138	2....	86	88	109	83	94	92
3....	165	157	189	132	140	157	3....	131	144	112	102	128	123
4....	98	107	121	62	115	101	4....	67	72	68	51	60	64

TABLE 62-1.—*Continued*

Year	N.	ENE.	SE.	SW.	WNW.	Av.	Year	N.	ENE.	SE.	SW.	WNW.	Av.
1835....	115	100	118	87	105	105	1865....	70	58	53	62	80	65
6....	86	86	67	50	58	69	6....	137	138	122	98	136	126
7....	87	75	69	61	86	76	7....	127	124	115	94	111	114
8....	113	134	116	88	100	110	8....	181	177	193	163	215	186
9....	141	140	100	104	140	125	9....	143	156	99	92	125	123
1840....	91	90	80	72	86	84	1870....	169	162	140	125	159	151
1....	73	93	63	66	68	73	1....	53	84	43	41	61	56
2....	31	49	27	31	40	36	2....	132	110	85	105	129	112
3....	57	62	52	58	74	61	3....	69	83	48	44	62	61
4....	81	107	81	76	96	88	4....	127	120	110	108	132	119
1845....	27	29	19	20	30	25	1875....	94	103	73	76	81	85
6....	29	29	21	24	36	28	6....	79	83	51	65	92	74
7....	0	0	0	0	0	0	7....	41	34	06	33	25	28
8....	90	97	60	81	92	84	8....	87	37	12	59	26	44
9....	71	73	74	77	91	77	9....	32	15	17	27	19	22
1850....	124	106	114	116	115	115	1880....	12	14	0	20	12	12
1....	94	88	78	61	89	82	1....	52	35	26	53	28	39
2....	138	142	121	107	142	130	2....	84	76	50	90	57	71
3....	116	99	110	82	103	102	3....	91	98	85	130	69	95
4....	139	123	108	103	181	131	4....	119	73	90	110	78	94
1855....	117	96	75	78	109	95	1885....	138	103	90	137	77	109
6....	40	52	55	43	67	51	6....	113	96	88	110	100	101
7....	14	21	0	05	27	13	7....	116	82	72	93	83	89
8....	71	70	64	62	72	68	8....	106	99	95	92	96	98
9....	44	36	28	41	52	40	9....	87	98	113	87	106	98
1860....	85	63	49	57	82	67	1890....	132	80	110	120	120	112
1....	75	71	66	59	89	72	1....	95	100	110	88	125	104
2....	105	97	81	88	109	96	2....	109	105	109	69	115	101
3....	30	26	22	30	33	28	3....	56	65	58	53	85	63
4....	57	64	32	38	61	50	4....	124	145	85	106	134	119

TABLE 62-1.—*Continued*

Year	N.	ENE.	SE.	SW.	WNW.	Av.
1895....	94	85	65	65	89	80
6....	51	42	46	27	47	43
7....	75	58	56	55	78	64
8....	77	74	78	57	90	75
9....	42	50	38	36	48	43
1900....	45	34	28	35	40	36
1....	46	46	34	42	56	45
2....	26	24	15	17	20	20
3....	96	84	51	73	73	75
4....	15	09	20	24	0	14
1905....	65	63	63	65	69	65
6....	77	78	85	90	66	79
7....	173	125	168	153	138	151
8....	172	148	155	168	140	157
9....	165	120	170	152	118	145
1910....	160	124	107	153	132	135
1....	175	179	136	133	178	160
2....	100	134	97	101	123	111
3....	52	46	46	44	57	49
4....	117	109	91	75	133	105
1915....	107	111	92	107	135	110
6....	108	93	93	90	122	101
7....	180	156	196	164	187	177
8....	172	151	167	127	133	150
9....	170	204	196	161	212	189
1920....	173	191	170	178	217	186
1....	193	283	169	230	281	231
2....	210	240	127	211	282	214
3....	228	290	175	217	283	239
4....	152	183	140	134	224	167
1925....	147	242	163	210	283	209
6....	155	211	163	211	303	209
7....	85	142	88	100	183	120
8....	187	196	179	221	278	212
9....	194	237	202	235	302	234
1930....	149	173	120	155	277	175
1....	153	170	122	143	173	152
2....	191	190	104	136	222	169
3....	176	227	152	187	247	198
4....	124	129	76	76	152	111
1935....	174	162	79	123	173	142
6....	111	88	72	85	145	100
7....	184	171	118	129	159	152
8....	135	135	100	126	146	128
9....	100	108	79	85	125	99
1940....	95	134	61	86	84	92
1....	196	268	150	150	219	195
2....	184	172	114	103	121	139
3....	150	155	109	124	155	139
4....	160	139	145	119	135	140
1945....	143	114	70	133	123	117
6....	224	162	142	170	174	174
7....	108	128	90	71	123	104

Table 62-2.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, trunk section 2, 5.4 feet above ground*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1695.....	47	55	42	48	1735.....	26	09	09	15
6.....	96	51	65	71	6.....	104	116	78	99
7.....	135	94	116	115	7.....	46	38	39	41
8.....	165	153	169	162	8.....	108	126	99	111
9.....	180	143	168	164	9.....	85	65	77	76
1700.....	111	83	116	103	1740.....	112	87	94	98
1.....	176	138	166	160	1.....	121	103	90	105
2.....	159	132	151	147	2.....	84	70	66	73
3.....	79	59	72	70	3.....	150	158	102	137
4.....	127	84	94	102	4.....	149	156	116	140
1705.....	183	138	138	153	1745.....	152	131	140	141
6.....	154	121	124	133	6.....	180	185	165	177
7.....	171	104	116	130	7.....	139	112	98	116
8.....	118	64	85	89	8.....	27	22	17	22
9.....	192	136	155	161	9.....	121	93	105	106
1710.....	247	189	175	204	1750.....	125	104	106	112
1.....	245	200	160	202	1.....	139	107	110	119
2.....	174	107	89	123	2.....	32	20	31	28
3.....	173	148	114	145	3.....	43	62	67	57
4.....	167	111	112	130	4.....	78	93	85	85
1715.....	151	96	68	105	1755.....	37	32	36	35
6.....	96	64	44	68	6.....	85	102	95	94
7.....	205	164	145	171	7.....	103	102	115	107
8.....	221	250	196	222	8.....	139	127	162	143
9.....	206	173	177	185	9.....	107	111	120	113
1720.....	220	210	175	202	1760.....	124	171	131	142
1.....	183	187	168	179	1.....	81	95	75	84
2.....	89	93	63	82	2.....	88	130	89	102
3.....	121	145	105	124	3.....	24	47	42	38
4.....	94	112	59	88	4.....	77	131	94	101
1725.....	150	175	142	156	1765.....	48	71	52	57
6.....	152	195	172	173	6.....	133	112	80	108
7.....	80	108	93	94	7.....	33	79	72	61
8.....	86	97	63	82	8.....	69	63	68	67
9.....	28	31	23	27	9.....	23	0	14	12
1730.....	100	121	91	104	1770.....	57	28	43	43
1.....	113	128	105	115	1.....	44	25	33	34
2.....	111	103	88	101	2.....	38	22	27	29
3.....	88	73	53	71	3.....	0	0	0	0
4.....	112	121	90	108	4.....	20	20	18	19

TABLE 62-2.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1775.....	44	27	33	35	1815.....	93	91	86	90
6.....	57	47	47	50	6.....	123	126	145	131
7.....	72	46	63	60	7.....	80	83	73	79
8.....	49	25	47	40	8.....	31	30	36	32
9.....	53	46	57	52	9.....	95	78	69	81
1780.....	42	41	55	46	1820.....	57	51	57	55
1.....	86	82	91	86	1.....	122	124	97	114
2.....	74	95	102	90	2.....	52	40	38	43
3.....	106	114	112	111	3.....	87	72	86	82
4.....	161	184	181	175	4.....	96	110	94	100
1785.....	43	27	34	35	1825.....	123	130	109	121
6.....	26	24	51	34	6.....	145	149	107	134
7.....	57	29	90	59	7.....	127	126	85	113
8.....	57	41	67	55	8.....	100	118	91	103
9.....	70	50	77	66	9.....	45	56	36	46
1790.....	100	79	113	97	1830.....	107	105	82	98
1.....	98	89	105	97	1.....	115	164	110	130
2.....	147	102	143	131	2.....	106	120	77	101
3.....	163	117	144	141	3.....	111	109	96	105
4.....	103	97	118	106	4.....	53	71	60	61
1795.....	127	157	153	146	1835.....	109	145	110	121
6.....	159	185	139	161	6.....	55	74	50	60
7.....	105	114	107	109	7.....	73	73	60	69
8.....	51	50	57	53	8.....	107	132	86	108
9.....	135	131	111	126	9.....	94	139	87	107
1800.....	80	74	65	73	1840.....	81	85	75	80
1.....	70	62	48	60	1.....	77	86	62	75
2.....	89	76	73	79	2.....	28	41	30	33
3.....	51	41	53	48	3.....	55	92	52	66
4.....	91	70	97	86	4.....	68	77	68	71
1805.....	67	61	77	68	1845.....	25	34	20	26
6.....	68	58	78	68	6.....	25	29	22	25
7.....	95	95	92	94	7.....	0	0	0	0
8.....	112	117	110	113	8.....	78	95	63	79
9.....	112	127	119	119	9.....	66	77	63	69
1810.....	119	118	105	114	1850.....	97	100	105	101
1.....	90	110	112	104	1.....	58	71	67	65
2.....	114	111	105	110	2.....	117	126	112	118
3.....	19	25	26	23	3.....	91	91	97	93
4.....	66	57	77	67	4.....	115	125	112	117

TABLE 62-2.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1855.....	88	86	101	92	1895.....	80	63	53	65
6.....	55	66	52	58	6.....	45	23	21	30
7.....	14	22	0	12	7.....	77	62	59	66
8.....	73	64	71	69	8.....	80	63	63	69
9.....	35	44	22	34	9.....	47	25	26	33
1860.....	73	83	58	71	1900.....	37	35	27	33
1.....	55	77	60	64	1.....	50	30	23	34
2.....	104	93	85	94	2.....	26	15	16	19
3.....	27	27	16	23	3.....	73	55	53	60
4.....	56	58	31	48	4.....	25	0	0	08
1865.....	54	66	46	55	1905.....	78	63	50	64
6.....	123	157	102	127	6.....	100	75	63	79
7.....	98	114	82	98	7.....	164	121	133	139
8.....	153	163	151	156	8.....	138	126	112	125
9.....	127	139	97	121	9.....	137	112	90	113
1870.....	118	173	133	141	1910.....	127	119	95	114
1.....	45	52	38	45	1.....	142	136	133	137
2.....	106	138	86	110	2.....	92	107	97	99
3.....	62	50	46	53	3.....	23	41	30	31
4.....	134	124	86	115	4.....	80	100	68	83
1875.....	90	79	61	77	1915.....	121	104	76	100
6.....	53	76	61	63	6.....	90	72	73	78
7.....	34	37	20	30	7.....	135	154	175	155
8.....	72	34	22	43	8.....	92	98	94	95
9.....	26	15	24	22	9.....	139	182	161	161
1880.....	12	12	0	08	1920.....	139	170	172	160
1.....	43	29	28	33	1.....	161	210	188	186
2.....	84	74	77	78	2.....	174	195	202	190
3.....	113	67	71	84	3.....	182	205	188	192
4.....	123	86	76	95	4.....	149	161	155	155
1885.....	126	91	86	101	1925.....	163	178	224	188
6.....	110	92	79	94	6.....	177	191	193	187
7.....	90	73	63	75	7.....	94	95	93	94
8.....	116	104	89	103	8.....	184	180	205	190
9.....	113	84	66	88	9.....	198	164	220	194
1890.....	110	107	111	109	1930.....	134	120	144	133
1.....	120	105	76	100	1.....	111	98	158	122
2.....	107	81	105	98	2.....	186	143	172	167
3.....	53	55	48	52	3.....	189	151	219	186
4.....	128	115	104	116	4.....	107	62	92	87

TABLE 62-2.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1935.....	153	101	119	124	2.....	129	69	112	103
6.....	93	70	101	88	3.....	107	83	113	101
7.....	140	109	120	123	4.....	157	91	123	124
8.....	123	84	97	101					
9.....	92	66	83	80	1945.....	96	101	109	102
					6.....	144	148	139	144
1940.....	82	63	75	73	7.....	75	63	81	73
1.....	200	119	163	161					

TABLE 62-3.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, trunk section 3, 9.9 feet above ground*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1712.....	84	71	80	78	2.....	127	99	89	105
3.....	175	176	157	169	3.....	212	147	175	178
4.....	145	156	149	150	4.....	225	186	183	198
1715.....	153	157	110	140	1745.....	214	164	164	181
6.....	101	118	89	103	6.....	225	209	184	206
7.....	227	261	202	230	7.....	172	158	132	154
8.....	235	273	232	247	8.....	45	40	14	33
9.....	212	215	164	197	9.....	157	160	128	148
1720.....	292	290	207	263	1750.....	174	174	147	165
1.....	249	232	180	220	1.....	169	182	159	170
2.....	136	103	94	111	2.....	31	33	27	30
3.....	182	143	150	158	3.....	50	93	96	80
4.....	158	106	100	121	4.....	95	119	122	112
1725.....	242	206	145	197	1755.....	49	61	47	52
6.....	220	208	153	194	6.....	120	124	104	116
7.....	80	85	74	80	7.....	137	156	116	136
8.....	133	118	102	118	8.....	166	206	148	173
9.....	75	77	44	65	9.....	118	148	111	129
1730.....	125	132	100	119	1760.....	144	186	171	167
1.....	165	149	118	144	1.....	81	92	82	85
2.....	146	103	134	128	2.....	82	117	98	99
3.....	101	73	102	92	3.....	28	44	50	41
4.....	141	126	130	132	4.....	81	100	138	106
1735.....	42	29	25	32	1765.....	52	56	70	59
6.....	123	156	139	139	6.....	94	92	126	104
7.....	77	67	63	69	7.....	84	81	96	87
8.....	160	136	138	145	8.....	84	72	85	80
9.....	106	94	99	100	9.....	26	10	23	20
1740.....	147	107	122	125					
1.....	160	118	125	134					

TABLE 62-3.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1770.....	54	45	47	49	1810.....	103	126	92	107
1.....	61	43	48	51	1.....	97	117	107	107
2.....	46	45	36	42	2.....	118	120	123	121
3.....	0	06	0	02	3.....	15	23	32	23
4.....	24	27	27	26	4.....	55	77	77	70
1775.....	36	53	37	42	1815.....	81	90	100	90
6.....	88	82	79	83	6.....	125	167	149	147
7.....	70	86	65	74	7.....	78	77	87	81
8.....	68	68	38	58	8.....	33	38	32	34
9.....	70	81	52	68	9.....	88	76	74	79
1780.....	41	69	44	51	1820.....	64	53	47	55
1.....	97	118	103	106	1.....	123	110	119	117
2.....	94	128	76	99	2.....	50	53	51	51
3.....	128	139	96	121	3.....	87	87	79	84
4.....	181	190	160	177	4.....	116	100	94	103
1785.....	55	40	40	45	1825.....	122	118	115	118
6.....	15	76	23	38	6.....	147	1 19	149	138
7.....	47	102	55	68	7.....	115	81	93	96
8.....	57	102	47	69	8.....	106	82	100	96
9.....	71	93	42	69	9.....	40	44	46	43
1790.....	102	122	62	95	1830.....	88	69	88	82
1.....	107	125	84	105	1.....	122	109	116	116
2.....	173	170	127	157	2.....	85	85	97	89
3.....	152	152	138	147	3.....	97	107	96	100
4.....	102	126	107	112	4.....	43	63	50	52
1795.....	138	154	136	143	1835.....	97	106	97	100
6.....	153	136	119	136	6.....	60	64	55	60
7.....	110	133	110	118	7.....	68	63	70	67
8.....	70	74	55	66	8.....	97	96	97	97
9.....	137	155	121	138	9.....	108	94	119	107
1800.....	75	70	69	71	1840.....	84	89	79	84
1.....	75	65	73	71	1.....	76	75	65	72
2.....	82	89	56	76	2.....	24	28	26	26
3.....	60	62	55	59	3.....	53	60	59	57
4.....	96	92	90	93	4.....	68	67	75	70
1805.....	70	90	74	78	1845.....	23	22	29	25
6.....	69	94	78	80	6.....	22	22	27	24
7.....	110	118	87	105	7.....	0	0	0	0
8.....	121	138	109	123	8.....	67	69	67	68
9.....	115	121	98	111	9.....	72	55	59	62

TABLE 62-3.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1850.....	95	113	98	102	1890.....	119	110	81	103
1.....	73	83	50	69	1.....	116	95	82	98
2.....	110	114	86	103	2.....	111	116	83	103
3.....	92	102	72	89	3.....	45	51	46	47
4.....	120	129	100	116	4.....	114	97	84	98
1855.....	93	95	79	89	1895.....	89	58	58	68
6.....	53	56	41	50	6.....	52	35	18	35
7.....	16	0	12	09	7.....	65	57	55	59
8.....	63	67	65	65	8.....	84	67	72	74
9.....	32	28	33	31	9.....	46	30	31	36
1860.....	70	68	60	66	1900.....	41	27	29	32
1.....	63	58	49	57	1.....	46	26	29	34
2.....	92	86	72	83	2.....	28	20	16	21
3.....	34	23	18	25	3.....	90	56	64	70
4.....	59	42	62	54	4.....	18	0	0	06
1865.....	61	50	43	51	1905.....	84	50	50	61
6.....	110	116	110	112	6.....	89	81	59	76
7.....	96	110	88	98	7.....	171	138	102	137
8.....	156	176	143	158	8.....	150	118	95	121
9.....	121	124	103	116	9.....	132	100	80	104
1870.....	127	151	121	133	1910.....	120	103	89	104
1.....	39	46	40	42	1.....	136	130	116	127
2.....	107	99	93	100	2.....	89	100	76	88
3.....	53	55	35	48	3.....	39	38	35	37
4.....	113	104	95	104	4.....	89	85	64	79
1875.....	74	71	78	74	1915.....	116	85	82	94
6.....	48	52	64	55	6.....	82	75	70	76
7.....	36	27	18	27	7.....	133	166	103	134
8.....	47	22	33	34	8.....	68	96	37	67
9.....	27	25	16	23	9.....	115	167	107	130
1880.....	05	0	14	06	1920.....	107	155	102	121
1.....	33	24	33	30	1.....	114	158	120	131
2.....	86	76	64	75	2.....	158	200	151	170
3.....	113	83	69	88	3.....	131	195	147	158
4.....	119	86	76	94	4.....	131	168	128	142
1885.....	140	94	84	106	1925.....	157	215	150	174
6.....	119	98	75	97	6.....	149	212	157	173
7.....	94	64	56	71	7.....	85	95	103	94
8.....	121	100	85	102	8.....	178	196	195	190
9.....	122	89	84	98	9.....	174	205	180	186

Table 62-3.—*Continued*

Year	N.	SE.	SW.	Av.
1930.....	116	155	136	136
1.....	149	176	136	154
2.....	170	194	168	177
3.....	160	215	166	180
4.....	105	79	93	92
1935.....	142	131	118	130
6.....	82	95	86	88
7.....	129	140	139	136
8.....	117	107	114	113
9.....	93	105	97	98
1940.....	82	71	80	78
1.....	180	188	190	186
2.....	122	120	117	120
3.....	103	113	117	111
4.....	129	140	127	132
1945.....	87	87	109	94
6.....	131	102	154	129
7.....	68	88	78	78

Table 62-4.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, trunk section 4, 14.4 feet above ground*

Year	N.	SE.	SW.	Av.
1724.....	141	139	90	123
1725.....	405	288	188	294
6.....	446	323	205	325
7.....	216	260	80	185
8.....	233	260	108	200
9.....	62	90	45	66
1730.....	100	193	122	138
1.....	200	318	158	225
2.....	197	257	83	179
3.....	129	265	58	151
4.....	179	260	101	180
1735.....	47	81	20	49
6.....	150	254	108	171
7.....	65	90	33	63
8.....	117	178	72	122
9.....	72	85	33	63
1740.....	120	119	75	105
1.....	90	162	97	116
2.....	81	116	74	90
3.....	144	254	137	178
4.....	143	243	159	182
1745.....	128	219	143	163
6.....	159	328	180	222
7.....	103	210	178	164
8.....	35	48	28	37
9.....	125	233	176	178
1750.....	159	218	191	189
1.....	150	215	200	188
2.....	16	29	35	27
3.....	56	107	101	88
4.....	100	143	129	124
1755.....	40	65	60	55
6.....	96	145	122	121
7.....	99	185	138	141
8.....	105	196	137	146
9.....	96	157	139	131
1760.....	135	181	173	163
1.....	70	91	83	81
2.....	83	101	88	91
3.....	36	43	45	41
4.....	99	107	113	106
1765.....	51	55	58	55
6.....	100	77	89	89
7.....	67	79	88	78
8.....	82	83	98	88
9.....	0	31	27	19
1770.....	31	62	63	52
1.....	46	66	75	62
2.....	33	56	47	45
3.....	0	17	0	06
4.....	33	43	42	39

TABLE 62-4.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1775.....	50	63	58	57	1815.....	96	86	122	101
6.....	79	102	111	97	6.....	146	167	152	155
7.....	83	93	91	89	7.....	94	94	79	89
8.....	56	69	81	69	8.....	27	41	48	39
9.....	75	75	100	83	9.....	73	68	100	80
1780.....	59	63	84	69	1820.....	51	47	55	51
1.....	98	124	174	132	1.....	122	111	145	126
2.....	67	117	118	101	2.....	45	62	62	56
3.....	116	122	141	126	3.....	84	108	99	97
4.....	166	212	187	188	4.....	104	123	115	114
1785.....	49	31	84	55	1825.....	117	120	135	124
6.....	0	81	80	54	6.....	127	141	150	139
7.....	57	118	116	97	7.....	110	100	112	107
8.....	60	125	75	87	8.....	96	83	111	97
9.....	60	143	98	100	9.....	41	36	57	45
1790.....	91	170	144	135	1830.....	78	62	96	79
1.....	119	185	200	168	1.....	118	104	143	122
2.....	166	233	216	205	2.....	84	86	102	91
3.....	148	214	201	188	3.....	95	109	114	106
4.....	85	161	153	133	4.....	53	66	50	56
1795.....	119	193	154	155	1835.....	100	99	95	98
6.....	116	175	192	161	6.....	54	67	50	57
7.....	101	142	163	135	7.....	56	67	62	62
8.....	59	87	97	81	8.....	82	104	103	96
9.....	113	158	170	147	9.....	98	124	117	113
1800.....	59	79	91	76	1840.....	82	107	97	95
1.....	78	85	104	89	1.....	72	84	80	79
2.....	82	83	93	86	2.....	23	27	27	26
3.....	40	66	73	60	3.....	53	58	73	61
4.....	72	102	111	95	4.....	63	66	74	68
1805.....	60	100	105	88	1845.....	24	21	30	25
6.....	60	88	88	79	6.....	22	25	27	25
7.....	76	122	138	112	7.....	0	0	0	0
8.....	91	159	160	137	8.....	70	66	82	73
9.....	100	158	152	137	9.....	60	66	73	66
1810.....	91	123	109	108	1850.....	84	121	98	101
1.....	96	127	128	117	1.....	55	98	62	72
2.....	115	119	154	129	2.....	100	157	86	114
3.....	19	25	42	29	3.....	78	119	62	86
4.....	65	68	94	76	4.....	112	156	91	120

Table 62-4.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1855.....	83	122	75	93	1880.....	0	0	0	0
6.....	51	77	48	59	1.....	30	35	24	30
7.....	06	14	16	12	2.....	73	70	71	71
8.....	57	86	65	69	3.....	109	83	54	82
9.....	28	41	37	35	4.....	115	98	74	96
1860.....	59	81	67	69	1885.....	129	107	80	105
1.....	52	72	49	58	6.....	122	98	65	95
2.....	84	94	62	80	7.....	94	77	51	74
3.....	24	27	19	23	8.....	111	101	82	98
4.....	50	49	40	46	9.....	103	99	77	93
1865.....	52	57	60	56	1890.....	111	122	69	101
6.....	98	141	89	109	1.....	98	113	70	94
7.....	79	118	59	85	2.....	115	125	78	106
8.....	116	175	107	133	3.....	40	55	36	44
9.....	110	136	78	108	4.....	109	117	80	102
1870.....	113	161	116	130	1895.....	73	72	41	62
1.....	39	41	41	40	6.....	39	33	04	35
2.....	79	97	98	91	7.....	66	60	60	62
3.....	36	51	38	42	8.....	84	75	63	74
4.....	84	111	90	95	9.....	38	37	23	33
1875.....	62	72	65	66	1900.....	33	34	19	29
6.....	43	66	59	56	1.....	39	34	26	33
7.....	25	23	14	21	2.....	28	22	10	20
8.....	41	25	22	29	3.....	77	67	57	67
9.....	23	20	14	19	4.....	11	0	0	04

TABLE 62-4.—*Continued*

Year	N.	SE.	SW.	Av.
1905.....	73	55	48	59
6.....	94	85	53	77
7.....	157	159	87	134
8.....	157	152	92	134
9.....	120	121	69	103
1910.....	115	119	86	107
1.....	129	142	107	126
2.....	98	119	81	99
3.....	42	43	34	40
4.....	87	100	74	87
1915.....	105	94	75	91
6.....	92	70	84	82
7.....	155	163	102	140
8.....	84	65	27	59
9.....	108	166	88	121
1920.....	84	119	74	92
1.....	103	171	96	123
2.....	134	175	123	144
3.....	129	169	134	144
4.....	122	154	106	127
1925.....	127	219	152	166
6.....	148	188	164	167

Year	N.	SE.	SW.	Av.
7.....	78	86	95	86
8.....	159	197	199	185
9.....	140	219	211	190
1930.....	114	143	141	133
1.....	119	166	154	146
2.....	151	179	197	176
3.....	148	223	216	196
4.....	95	87	108	97
1935.....	131	139	145	138
6.....	77	104	100	94
7.....	130	130	157	139
8.....	112	108	133	118
9.....	84	98	111	98
1940.....	68	78	90	79
1.....	170	176	203	183
2.....	111	96	130	112
3.....	91	111	130	111
4.....	116	123	157	132
1945.....	86	83	136	102
6.....	135	121	211	156
7.....	85	101	89	92

TABLE 62-5.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, trunk section 5, 19.3 feet above ground*

Year	N.	ENE.	SE.	SW.	WNW.	Av.	Year	N.	ENE.	SE.	SW.	WNW.	Av.
1740....	123	95	96	85	109	102	1780....	47	51	83	50	73	61
1....	215	215	214	192	182	204	1....	104	94	135	116	113	112
2....	157	133	121	150	163	145	2....	100	99	129	103	104	107
3....	281	275	260	268	312	279	3....	140	106	147	139	123	131
4....	258	225	266	228	267	249	4....	203	171	204	190	178	189
1745....	296	279	273	252	290	278	1785....	57	36	57	45	46	48
6....	312	328	362	316	285	321	6....	90	56	117	112	49	85
7....	221	239	239	194	186	216	7....	152	110	162	163	90	135
8....	68	89	79	75	92	81	8....	161	105	126	161	110	133
9....	248	263	220	228	230	238	9....	137	110	128	151	104	126
1750....	219	262	244	211	205	228	1790....	156	105	135	161	135	138
1....	186	206	206	157	135	178	1....	172	157	149	222	166	173
2....	39	42	51	14	30	35	2....	165	226	236	260	244	226
3....	135	147	115	79	85	112	3....	165	223	274	226	203	218
4....	108	105	112	73	103	100	4....	119	138	164	178	198	159
1755....	50	55	50	26	47	46	1795....	156	173	182	222	254	197
6....	134	119	130	87	130	120	6....	146	182	192	211	233	193
7....	136	113	166	100	135	130	7....	117	135	153	170	170	149
8....	116	126	205	92	140	136	8....	71	89	100	106	116	96
9....	108	105	151	93	105	112	9....	130	161	162	168	186	161
1760....	138	155	158	77	137	133	1800....	75	102	85	110	90	92
1....	69	92	103	51	68	77	1....	85	90	94	108	130	101
2....	63	67	98	55	50	67	2....	83	65	82	104	127	92
3....	11	28	40	18	15	22	3....	47	47	66	76	67	61
4....	69	77	73	63	40	64	4....	85	94	101	110	106	99
1765....	31	50	54	41	25	40	1805....	81	92	94	106	100	95
6....	46	81	82	44	54	61	6....	69	85	78	108	74	83
7....	45	79	87	59	52	64	7....	126	114	127	153	116	127
8....	52	63	102	67	53	67	8....	139	151	132	196	139	151
9....	21	21	67	44	39	38	9....	153	171	134	171	166	159
1770....	50	48	80	60	54	58	1810....	124	156	102	124	135	128
1....	58	41	80	68	55	60	1....	98	125	117	140	115	119
2....	44	35	56	51	43	46	2....	108	162	168	155	140	147
3....	0	07	21	20	27	15	3....	18	33	35	27	29	28
4....	29	32	40	37	33	34	4....	69	70	96	76	65	75
1775....	46	52	59	77	52	57	1815....	109	104	122	99	133	113
6....	77	95	100	101	71	89	6....	150	163	183	166	178	168
7....	68	99	93	101	80	88	7....	90	94	89	121	95	98
8....	48	46	69	65	66	59	8....	39	36	51	57	57	48
9....	62	68	86	90	68	75	9....	74	75	74	90	118	86

TABLE 62-5.—*Continued*

Year	N.	ENE.	SE.	SW.	WNW.	Av.
1820....	57	65	55	63	72	62
1....	130	130	131	142	125	132
2....	53	57	59	69	58	59
3....	102	88	82	132	88	98
4....	122	104	123	135	91	115
1825....	115	125	126	151	104	124
6....	137	139	149	159	124	142
7....	111	105	109	110	92	105
8....	108	93	116	102	84	101
9....	56	47	62	59	52	55
1830....	102	85	102	80	65	87
1....	122	110	161	140	76	122
2....	102	90	127	124	79	104
3....	104	112	103	131	97	109
4....	58	51	78	86	46	64
1835....	96	97	120	127	107	109
6....	78	57	77	90	61	73
7....	85	69	90	85	68	79
8....	124	93	120	109	101	109
9....	130	119	145	144	122	132
1840....	100	89	92	134	115	106
1....	86	58	88	84	76	78
2....	30	20	33	36	43	32
3....	61	59	99	74	76	74
4....	95	73	102	89	80	88
1845....	30	24	38	29	20	28
6....	34	27	46	36	18	32
7....	0	0	12	0	0	02
8....	97	69	94	82	61	81
9....	76	78	93	90	70	81
1850....	122	108	139	129	119	123
1....	85	84	76	118	83	89
2....	134	116	116	170	134	134

Year	N.	ENE.	SE.	SW.	WNW.	Av.
3....	115	104	118	147	100	117
4....	141	121	157	192	156	153
1855....	114	86	128	117	124	113
6....	68	56	72	79	80	71
7....	0	11	29	28	20	18
8....	69	79	88	94	96	85
9....	41	50	54	60	38	49
1860....	82	79	102	83	88	87
1....	72	61	91	107	110	88
2....	101	93	121	127	123	113
3....	22	29	37	43	30	32
4....	53	53	57	62	77	60
1865....	51	62	68	72	73	65
6....	129	125	142	165	203	153
7....	91	122	125	154	162	131
8....	150	181	186	215	227	192
9....	135	132	127	186	183	153
1870....	135	146	126	203	176	157
1....	46	33	44	78	55	51
2....	117	108	119	146	132	124
3....	60	58	73	73	82	69
4....	105	102	132	135	130	121
1875....	84	82	104	88	97	91
6....	75	85	87	107	75	86
7....	21	43	38	55	35	38
8....	31	45	32	50	22	36
9....	21	29	26	38	23	27
1880....	0	10	06	18	0	07
1....	41	47	32	55	33	42
2....	71	84	67	96	82	80
3....	108	91	77	120	108	101
4....	113	117	87	136	107	112

Table 62-5.—*Continued*

Year	N.	ENE.	SE.	SW.	WNW.	Av.
1885....	135	113	87	164	128	125
6....	120	114	94	141	140	122
7....	112	107	72	123	107	104
8....	103	102	95	154	130	117
9....	111	121	113	150	133	126
1890....	117	127	121	126	130	124
1....	122	77	85	134	120	108
2....	114	127	93	128	137	120
3....	63	68	50	86	70	67
4....	123	132	93	155	140	129
1895....	73	68	56	88	73	72
6....	46	38	30	54	42	42
7....	58	83	62	81	63	69
8....	65	65	82	83	82	75
9....	43	61	45	45	50	49
1900....	32	42	42	45	33	39
1....	38	50	45	50	41	45
2....	25	36	30	28	36	31
3....	86	72	80	81	84	81
4....	13	0	10	11	09	09
1905....	73	70	68	83	71	73
6....	99	82	73	103	83	88
7....	160	154	126	164	164	154
8....	152	145	130	175	170	154
9....	128	113	102	145	140	126
1910....	111	122	113	146	144	127
1....	126	147	135	187	166	152
2....	100	109	109	140	116	115
3....	62	45	34	64	60	53
4....	107	110	100	120	98	107
1915....	99	107	100	125	103	107
6....	82	103	87	109	100	96
7....	154	36	134	284	168	155
8....	92	59	74	131	102	92
9....	158	123	163	237	193	175
1920....	116	105	179	207	176	157
1....	137	115	222	188	214	175
2....	129	124	218	231	233	187
3....	144	117	245	186	214	181
4....	139	120	176	162	167	153
1925....	167	120	221	205	179	178
6....	172	158	225	206	176	187
7....	71	88	148	123	84	103
8....	147	151	208	241	171	184
9....	164	154	239	235	188	196
1930....	116	135	179	158	166	151
1....	127	123	150	170	154	145
2....	145	155	195	184	201	176
3....	161	164	203	214	195	187
4....	88	116	110	83	116	103
1935....	132	129	137	126	155	136
6....	72	69	105	85	91	84
7....	134	112	140	139	143	134
8....	84	107	120	109	108	106
9....	84	85	105	109	106	98
1940....	65	63	80	75	91	75
1....	148	185	150	183	209	175
2....	97	120	85	97	142	108
3....	100	128	115	103	159	121
4....	135	105	117	103	142	120
1945....	81	95	86	66	127	91
6....	126	159	142	129	203	152
7....	88	100	75	75	97	87

Table 62-6.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, trunk section 6, 25.0 feet above ground*

Year	N.	SE.	SW.	Av.
1758.....	130	104	94	109
9.....	185	252	208	215
1760.....	139	172	128	146
1.....	132	125	86	114
2.....	68	82	53	68
3.....	32	32	42	35
4.....	55	28	34	39
1765.....	25	06	22	18
6.....	05	09	10	08
7.....	20	15	26	20
8.....	33	25	30	29
9.....	22	41	20	28
1770.....	15	19	20	18
1.....	46	37	35	39
2.....	55	38	28	40
3.....	16	13	23	17
4.....	38	30	28	32
1775.....	80	59	47	62
6.....	132	81	75	96
7.....	166	83	59	103
8.....	120	62	42	75
9.....	122	72	55	83
1780.....	101	54	35	63
1.....	197	103	121	140
2.....	186	94	122	134
3.....	216	114	108	146
4.....	355	147	137	213
1785.....	100	18	46	55
6.....	216	102	80	133
7.....	272	116	136	175
8.....	290	91	130	170
9.....	233	84	129	149
1790.....	288	106	151	182
1.....	316	138	146	200
2.....	321	169	137	209
3.....	308	158	138	201
4.....	177	108	72	119
1795.....	247	136	119	167
6.....	248	125	122	165
7.....	181	120	98	133
8.....	139	89	66	98
9.....	240	125	106	157
1800.....	147	63	70	93
1.....	146	80	66	97
2.....	131	81	75	96
3.....	97	44	48	63
4.....	145	83	96	108
1805.....	143	93	86	107
6.....	100	72	72	81
7.....	188	99	93	127
8.....	197	141	117	152
9.....	174	116	120	137
1810.....	132	96	80	103
1.....	141	89	94	108
2.....	176	106	137	140
3.....	37	17	24	26
4.....	98	61	80	80
1815.....	134	69	100	101
6.....	169	152	140	154
7.....	107	77	78	87
8.....	86	42	46	58
9.....	121	62	66	83
1820.....	90	50	52	64
1.....	177	114	139	143
2.....	95	48	64	69
3.....	121	97	100	106
4.....	138	114	94	115
1825.....	138	123	133	131
6.....	168	141	146	152
7.....	145	115	119	126
8.....	122	113	125	120
9.....	78	65	65	69
1830.....	118	94	105	106
1.....	162	148	161	157
2.....	143	112	121	125
3.....	137	104	97	113
4.....	85	73	64	74

TABLE 62-6.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1835.....	135	109	104	116	1875.....	113	82	89	95
6.....	102	60	79	80	6.....	94	77	68	80
7.....	100	75	68	81	7.....	42	41	20	34
8.....	158	98	95	117	8.....	41	44	35	40
9.....	171	111	124	135	9.....	32	38	37	36
1840.....	135	109	105	116	1880.....	04	15	06	08
1.....	127	85	90	101	1.....	40	44	44	43
2.....	54	37	42	44	2.....	89	78	70	79
3.....	88	61	77	75	3.....	129	105	97	110
4.....	115	74	84	91	4.....	125	99	103	109
1845.....	35	25	37	32	1885.....	154	113	98	122
6.....	49	28	26	34	6.....	135	109	108	117
7.....	15	0	16	10	7.....	140	98	89	109
8.....	97	78	92	89	8.....	151	127	104	127
9.....	98	78	94	90	9.....	147	140	130	139
1850.....	142	132	155	143	1890.....	125	140	115	127
1.....	121	113	92	109	1.....	137	109	86	111
2.....	185	156	148	163	2.....	132	115	105	117
3.....	151	127	152	143	3.....	56	64	67	62
4.....	166	160	162	163	4.....	150	125	117	131
1855.....	152	120	114	129	1895.....	80	73	54	69
6.....	77	78	68	74	6.....	70	34	40	48
7.....	35	16	27	26	7.....	83	64	73	73
8.....	67	77	91	78	8.....	74	79	67	73
9.....	54	44	48	49	9.....	54	37	56	49
1860.....	106	85	91	94	1900.....	47	33	36	39
1.....	98	185	89	124	1.....	58	41	48	49
2.....	132	10	103	82	2.....	43	29	30	34
3.....	43	43	27	38	3.....	108	75	74	86
4.....	76	60	60	65	4.....	28	0	0	09
1865.....	81	64	75	73	1905.....	100	67	52	73
6.....	180	151	155	162	6.....	110	87	80	92
7.....	143	135	133	137	7.....	179	168	124	157
8.....	181	190	187	186	8.....	158	166	135	153
9.....	159	174	137	157	9.....	130	118	95	114
1870.....	154	165	134	151	1910.....	128	128	115	124
1.....	70	46	39	52	1.....	150	145	110	135
2.....	140	104	104	116	2.....	108	113	109	110
3.....	90	60	67	72	3.....	62	53	56	57
4.....	147	106	102	118	4.....	112	104	105	107

TABLE 62-6.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1915.....	126	111	103	113	2.....	120	131	153	135
6.....	109	84	107	100	3.....	153	139	154	149
7.....	168	196	143	169	4.....	95	67	76	79
8.....	93	76	85	85					
9.....	185	144	151	160	1935.....	125	91	109	108
1920.....	156	134	128	139	6.....	78	62	78	73
1.....	183	121	157	154	7.....	115	110	139	121
2.....	203	154	158	172	8.....	94	91	113	99
3.....	187	153	173	171	9.....	76	80	91	82
4.....	171	115	145	144	1940.....	61	72	89	74
1925.....	186	148	155	163	1.....	153	128	147	143
6.....	173	157	162	164	2.....	104	94	110	103
7.....	86	90	117	98	3.....	99	110	118	109
8.....	150	181	171	167	4.....	107	115	123	115
9.....	182	188	183	184	1945.....	108	81	93	94
1930.....	116	121	142	126	6.....	139	130	149	139
1.....	139	130	145	138	7.....	83	84	88	85

TABLE 62-7.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, trunk section 7, 30.1 feet above ground*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1787.....	125	27	100	84	3.....	70	76	67	71
8.....	157	176	174	169	4.....	113	95	113	107
9.....	149	140	154	148	1805.....	138	101	106	115
1790.....	218	171	237	209	6.....	100	96	107	101
1.....	228	177	251	219	7.....	138	148	175	154
2.....	209	182	202	198	8.....	151	174	227	184
3.....	227	186	222	212	9.....	128	153	180	154
4.....	127	92	109	109	1810.....	100	138	133	124
1795.....	244	212	262	239	1.....	90	141	131	121
6.....	214	205	217	212	2.....	113	151	165	143
7.....	164	158	152	158	3.....	15	35	22	24
8.....	134	122	101	119	4.....	61	82	60	68
9.....	187	176	141	168	1815.....	102	113	125	113
1800.....	109	122	100	110	6.....	163	170	229	187
1.....	106	92	85	94	7.....	102	110	111	108
2.....	93	97	97	96	8.....	61	60	57	59
					9.....	83	78	60	74

TABLE 62-7.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1820.....	74	62	63	66	1860.....	89	87	97	91
1.....	139	118	122	126	1.....	105	77	95	92
2.....	80	66	55	67	2.....	119	89	108	105
3.....	118	118	132	123	3.....	38	30	40	36
4.....	124	120	155	133	4.....	56	59	67	61
1825.....	113	128	138	126	1865.....	67	68	72	69
6.....	148	171	180	166	6.....	151	143	161	152
7.....	120	134	110	121	7.....	154	122	150	142
8.....	118	138	109	122	8.....	172	163	198	178
9.....	58	83	50	64	9.....	134	118	164	139
1830.....	95	100	89	95	1870.....	133	108	160	134
1.....	162	185	166	171	1.....	48	41	50	46
2.....	124	121	109	118	2.....	112	122	125	120
3.....	128	118	123	123	3.....	64	70	75	70
4.....	82	68	73	74	4.....	108	125	108	114
1835.....	122	110	108	113	1875.....	87	90	80	86
6.....	76	83	63	74	6.....	75	91	92	86
7.....	85	75	92	84	7.....	33	34	49	39
8.....	125	106	106	112	8.....	32	67	55	51
9.....	147	133	120	133	9.....	30	40	55	42
1840.....	109	107	93	103	1880.....	03	45	25	24
1.....	107	106	87	98	1.....	40	39	41	40
2.....	33	48	34	38	2.....	90	100	95	95
3.....	79	87	61	76	3.....	130	137	131	133
4.....	100	95	73	89	4.....	125	145	125	132
1845.....	33	30	27	30	1885.....	157	120	139	139
6.....	38	28	27	31	6.....	129	138	146	138
7.....	10	0	02	04	7.....	114	107	123	115
8.....	97	71	81	83	8.....	128	116	145	130
9.....	119	83	92	98	9.....	115	176	141	144
1850.....	160	117	147	141	1890.....	124	164	150	146
1.....	102	68	116	95	1.....	126	115	104	115
2.....	173	130	165	156	2.....	130	136	126	131
3.....	158	122	142	141	3.....	50	73	65	63
4.....	155	120	154	143	4.....	149	132	121	134
1855.....	129	105	126	120	1895.....	74	68	87	76
6.....	74	75	65	71	6.....	40	48	31	40
7.....	14	24	23	20	7.....	61	80	66	69
8.....	79	72	66	72	8.....	81	87	74	81
9.....	45	55	54	51	9.....	38	57	49	48

TABLE 62-7.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1900.....	31	41	30	34	4.....	148	107	108	121
1.....	42	52	38	44					
2.....	25	30	26	27	1925.....	177	133	144	151
3.....	81	83	73	79	6.....	167	122	147	145
4.....	14	14	0	09	7.....	78	68	92	79
					8.....	160	122	190	157
1905.....	78	79	60	72	9.....	173	142	178	164
6.....	90	118	87	98					
7.....	170	168	155	164	1930.....	125	123	127	125
8.....	175	186	166	176	1.....	134	107	120	120
9.....	135	133	133	134	2.....	145	147	152	148
					3.....	155	129	170	151
1910.....	132	127	134	131	4.....	97	93	60	83
1.....	125	162	143	143					
2.....	102	130	122	118	1935.....	120	114	78	104
3.....	54	60	57	57	6.....	74	78	54	69
4.....	98	123	100	107	7.....	127	137	104	123
					8.....	92	113	79	95
1915.....	86	114	84	95	9.....	98	95	88	94
6.....	102	121	92	105					
7.....	156	174	163	164	1940.....	68	77	68	71
8.....	69	73	76	73	1.....	153	136	132	140
9.....	173	154	135	154	2.....	103	101	77	94
					3.....	137	137	98	124
1920.....	127	94	115	112	4.....	139	101	104	115
1.....	148	112	115	125					
2.....	190	92	135	139	1945.....	131	89	60	93
3.....	147	123	127	132	6.....	204	154	124	161
					7.....	93	95	80	89

TABLE 62-8.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, trunk section 8, 33.4 feet above ground*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1795.....	173	160	186	173	1805.....	117	122	143	127
6.....	249	226	220	232	6.....	98	95	118	104
7.....	112	94	120	109	7.....	211	167	200	193
8.....	79	82	70	77	8.....	204	176	189	190
9.....	237	237	241	238	9.....	175	134	178	162
1800.....	150	117	197	155	1810.....	120	134	120	125
1.....	112	115	140	122	1.....	167	116	131	138
2.....	109	122	154	128	2.....	180	118	150	149
3.....	65	66	90	74	3.....	11	12	15	13
4.....	126	126	144	132	4.....	74	56	60	63

TABLE 62-8.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1815.....	138	112	118	123	1850.....	183	159	145	162
6.....	215	206	179	200	1.....	146	129	88	121
7.....	110	102	82	98	2.....	207	185	142	178
8.....	55	61	68	61	3.....	178	151	152	160
9.....	60	80	82	74	4.....	191	145	143	160
1820.....	55	64	65	61	1855.....	167	120	104	130
1.....	156	142	129	142	6.....	94	73	68	78
2.....	90	96	76	87	7.....	34	20	27	27
3.....	142	137	101	127	8.....	98	96	70	88
4.....	137	146	117	133	9.....	54	52	65	57
1825.....	132	139	129	133	1860.....	123	104	90	106
6.....	200	162	163	175	1.....	121	93	83	99
7.....	159	107	130	132	2.....	129	117	94	113
8.....	150	106	130	129	3.....	52	47	36	45
9.....	67	67	68	67	4.....	75	64	62	67
1830.....	128	100	110	113	1865.....	95	80	65	80
1.....	239	161	193	198	6.....	186	169	136	164
2.....	130	112	117	120	7.....	170	154	110	145
3.....	156	130	138	141	8.....	195	188	144	176
4.....	105	84	95	95	9.....	156	155	112	141
1835.....	132	109	124	122	1870.....	143	139	108	130
6.....	89	72	79	80	1.....	65	55	46	55
7.....	98	93	90	94	2.....	146	135	121	134
8.....	150	104	98	117	3.....	100	91	72	88
9.....	181	145	117	148	4.....	122	113	110	115
1840.....	160	122	104	129	1875.....	100	89	76	88
1.....	145	99	95	113	6.....	88	100	76	88
2.....	62	29	43	45	7.....	47	46	40	44
3.....	103	69	86	86	8.....	53	64	70	62
4.....	132	84	114	110	9.....	54	50	48	51
1845.....	45	20	28	31	1880.....	17	39	35	30
6.....	57	38	47	47	1.....	44	44	39	42
7.....	25	11	23	20	2.....	119	114	91	108
8.....	132	86	104	107	3.....	183	153	124	153
9.....	171	108	103	127	4.....	168	138	109	138

TABLE 62-8.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1885.....	167	143	122	144	7.....	164	212	151	176
6.....	142	119	118	126	8.....	98	89	76	88
7.....	126	112	105	114	9.....	176	164	161	167
8.....	137	143	119	133					
9.....	142	137	149	143	1920.....	144	114	87	115
					1.....	158	131	130	140
1890.....	170	148	126	148	2.....	189	134	141	155
1.....	143	123	105	124	3.....	165	130	164	153
2.....	139	136	110	128	4.....	152	122	138	137
3.....	65	72	61	66					
4.....	156	125	109	130	1925.....	169	134	145	149
					6.....	171	147	154	157
1895.....	87	76	71	78	7.....	98	89	93	93
6.....	53	56	50	53	8.....	171	149	158	159
7.....	83	81	80	81	9.....	184	184	171	180
8.....	82	87	77	82					
9.....	63	52	49	55	1930.....	126	116	140	127
					1.....	140	112	132	128
1900.....	55	39	38	44	2.....	173	154	190	172
1.....	50	53	50	51	3.....	162	146	133	147
2.....	35	28	29	31	4.....	92	67	95	85
3.....	97	93	88	93					
4.....	20	08	15	14	1935.....	117	100	106	108
					6.....	79	65	98	81
1905.....	95	72	77	81	7.....	117	120	149	129
6.....	115	107	100	107	8.....	95	101	133	110
7.....	203	175	134	171	9.....	98	97	98	98
8.....	210	193	148	184					
9.....	166	161	120	149	1940.....	63	80	73	72
					1.....	161	146	155	154
1910.....	154	146	115	138	2.....	110	97	98	102
1.....	172	157	145	158	3.....	110	115	131	119
2.....	115	131	119	122	4.....	127	114	108	116
3.....	70	62	68	67					
4.....	126	120	113	120	1945.....	113	88	92	98
					6.....	159	132	144	145
1915.....	116	126	106	116	7.....	91	83	87	87
6.....	101	113	109	108					

TABLE 62-9.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, trunk section 9, 37.7 feet above ground*

Year	N.	ENE.	SE.	SW.	WNW.	Av.
1814....	181	192	178	165	195	182
1815....	176	176	150	204	175	176
6....	233	172	158	202	292	211
7....	202	142	126	109	185	152
8....	114	103	76	106	108	101
9....	70	76	60	23	59	58
1820....	74	84	77	41	55	66
1....	166	225	235	120	131	175
2....	89	144	143	71	63	102
3....	89	142	153	110	91	117
4....	104	155	195	144	109	141
1825....	90	140	154	120	97	120
6....	127	178	218	170	142	167
7....	87	156	204	122	132	140
8....	61	125	140	96	87	102
9....	42	74	67	64	93	68
1830....	121	142	152	124	133	134
1....	157	194	251	156	171	186
2....	74	86	120	93	87	92
3....	88	153	147	91	108	117
4....	63	113	124	52	72	85
1835....	70	116	138	60	98	96
6....	50	94	107	56	69	75
7....	67	107	132	63	73	88
8....	74	143	170	82	86	111
9....	117	176	219	133	104	150
1840....	89	150	176	101	85	120
1....	95	133	146	87	78	108
2....	22	63	64	21	25	39
3....	78	100	113	58	52	80
4....	86	125	151	94	75	106
1845....	20	25	47	17	15	25
6....	25	39	66	26	25	36
7....	07	18	26	17	10	16
8....	80	102	125	108	70	97
9....	99	134	169	142	75	124
1850....	131	179	138	158	97	141
1....	87	134	100	87	55	93
2....	131	178	154	142	105	142
3....	129	155	135	141	100	132
4....	130	150	154	107	90	126
1855....	116	112	107	117	88	108
6....	68	68	100	95	54	77
7....	15	17	40	15	06	19
8....	73	71	85	101	70	80
9....	50	50	85	62	41	58
1860....	86	99	123	114	71	99
1....	77	91	114	101	75	92
2....	108	117	151	121	109	121
3....	40	40	63	42	36	44
4....	61	70	95	74	55	71
1865....	74	72	84	82	58	74
6....	145	175	170	161	120	154
7....	152	150	164	158	138	152
8....	165	174	182	177	173	174
9....	125	139	149	158	119	138
1870....	110	127	152	118	96	121
1....	52	42	60	46	34	47
2....	110	159	145	145	114	135
3....	56	94	84	97	69	80
4....	82	110	132	110	92	105
1875....	82	92	92	86	68	84
6....	68	92	92	67	59	76
7....	46	45	23	28	33	35
8....	59	77	68	53	60	63
9....	42	58	39	53	44	47
1880....	18	29	35	32	31	29
1....	56	61	56	66	47	57
2....	84	149	124	126	101	117
3....	105	153	157	183	119	143
4....	106	138	165	177	99	137

TABLE 62-9.—*Continued*

Year	N.	ENE.	SE.	SW.	WNW.	Av.	Year	N.	ENE.	SE.	SW.	WNW.	Av.
1885....	103	115	150	143	100	122	7....	160	223	198	124	102	161
6....	130	117	146	120	125	128	8....	95	110	125	73	71	95
7....	110	105	152	115	93	115	9....	183	231	238	150	132	187
8....	111	158	167	144	108	138							
9....	118	144	164	174	118	144	1920....	115	147	162	120	86	126
1890....	126	151	160	172	132	148	1....	122	154	175	137	96	137
1....	104	129	157	136	100	125	2....	135	168	185	131	90	142
2....	114	138	142	145	101	128	3....	116	141	172	113	104	129
3....	67	67	83	72	65	71	4....	100	117	163	106	94	116
4....	94	143	148	146	100	126	1925....	119	157	178	116	94	133
1895....	78	78	85	88	72	80	6....	124	172	197	135	108	147
6....	52	32	69	49	34	47	7....	76	105	100	60	60	80
7....	87	83	97	74	82	85	8....	128	204	200	112	105	150
8....	86	80	99	88	26	76	9....	135	209	200	133	104	156
9....	52	69	75	57	117	74	1930....	120	131	169	88	84	118
1900....	34	55	48	44	35	43	1....	100	120	163	93	83	112
1....	59	52	75	50	53	58	2....	130	161	212	119	116	148
2....	32	34	33	29	31	32	3....	133	185	192	134	113	151
3....	80	92	104	79	73	86	4....	77	81	132	80	64	87
4....	18	20	26	08	08	16	1935....	92	102	139	83	73	98
1905....	88	97	92	85	78	88	6....	78	75	102	58	55	74
6....	107	136	113	124	95	115	7....	108	135	163	95	102	121
7....	150	228	178	182	145	177	8....	101	122	137	88	81	106
8....	167	241	207	187	143	189	9....	80	109	129	65	74	91
9....	133	155	163	152	104	141	1940....	67	84	115	53	58	75
1910....	132	149	181	130	108	140	1....	148	164	180	124	122	148
1....	147	162	209	147	125	158	2....	103	113	128	92	80	103
2....	101	140	165	103	85	119	3....	142	126	163	102	98	126
3....	53	61	77	55	51	59	4....	106	124	175	108	83	119
4....	106	114	146	100	101	113	1945....	88	88	142	90	86	99
1915....	108	116	121	104	92	108	6....	116	146	194	110	131	139
6....	107	110	106	91	85	100	7....	76	87	130	70	110	95

TABLE 62-10.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, trunk section 10, 42.9 feet above ground*

Year	N.	SE.	SW.	Av.
1838	152	162	138	151
9	174	182	168	175
1840	150	163	127	147
1	120	132	96	116
2	70	74	50	65
3	86	92	58	79
4	100	139	84	108
1845	10	28	11	16
6	43	61	37	47
7	19	20	14	18
8	75	84	54	71
9	101	140	65	102
1850	135	166	58	120
1	99	119	68	95
2	153	152	102	136
3	128	143	94	122
4	121	134	88	114
1855	155	154	97	135
6	96	101	55	84
7	10	13	10	11
8	85	70	66	74
9	71	51	54	59
1860	78	76	79	78
1	58	69	67	65
2	122	115	92	110
3	34	33	20	29
4	68	59	76	68
1865	71	63	73	69
6	151	158	133	147
7	132	151	122	135
8	178	173	160	170
9	122	133	99	118
1870	115	108	94	106
1	50	37	42	43
2	147	139	117	134
3	108	70	52	77
4	107	102	54	88

Year	N.	SE.	SW.	Av.
1875	85	74	65	75
6	88	67	48	68
7	50	38	27	38
8	74	62	47	61
9	53	40	33	42
1880	23	13	17	18
1	50	39	48	46
2	139	116	89	115
3	180	128	116	141
4	157	129	129	138
1885	123	100	92	105
6	143	110	106	120
7	147	90	92	110
8	163	117	93	124
9	160	118	135	138
1890	160	120	140	140
1	140	104	99	114
2	131	86	87	101
3	90	64	55	70
4	147	105	93	115
1895	110	77	63	83
6	60	36	24	40
7	96	70	79	82
8	123	77	81	94
9	16	43	32	30
1900	103	32	25	53
1	61	39	51	50
2	26	16	19	20
3	90	75	76	80
4	18	12	0	10
1905	117	94	84	98
6	147	123	103	124
7	211	192	172	192
8	185	187	162	178
9	151	127	117	132
1910	143	103	118	121
1	151	113	116	127
2	143	102	99	115
3	72	50	45	56
4	132	96	98	109

TABLE 62-10.—*Continued*

Year	N.	SE.	SW.	Av.
1915.....	113	93	101	102
6.....	109	94	95	99
7.....	153	169	131	151
8.....	86	68	83	79
9.....	206	154	136	165
1920.....	139	98	79	105
1.....	140	113	92	115
2.....	159	149	106	138
3.....	130	123	93	115
4.....	132	133	88	118
1925.....	148	155	105	136
6.....	172	164	131	156
7.....	78	92	71	80
8.....	145	182	110	146
9.....	168	189	121	159
1930.....	142	128	96	119
1.....	167	131	92	130
2.....	157	160	94	137
3.....	161	177	119	152
4.....	88	69	61	73
1935.....	90	94	78	87
6.....	78	74	51	68
7.....	166	115	107	129
8.....	141	114	105	120
9.....	115	101	76	97
1940.....	70	68	55	64
1.....	158	140	140	146
2.....	130	86	101	106
3.....	114	154	133	134
4.....	124	130	109	121
1945.....	105	95	98	99
6.....	153	135	142	143
7.....	98	80	88	89

TABLE 62-11.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, trunk section 11, 47.7 feet above ground*

Year	N.	SE.	SW.	Av.
1865.....	140	142	150	144
6.....	143	154	164	154
7.....	172	158	156	162
8.....	135	122	106	121
9.....	110	72	80	87
1870.....	115	103	98	105
1.....	50	36	32	39
2.....	149	112	116	129
3.....	67	49	54	57
4.....	99	65	77	80
1875.....	62	38	44	48
6.....	45	19	34	33
7.....	31	17	21	23
8.....	54	44	49	49
9.....	32	30	35	33
1880.....	20	14	19	18
1.....	24	20	38	27
2.....	79	79	99	86
3.....	131	101	111	114
4.....	112	96	93	100
1885.....	100	80	61	80
6.....	93	77	87	86
7.....	96	91	80	89
8.....	122	102	129	118
9.....	169	133	130	144
1890.....	129	114	96	113
1.....	128	103	74	102
2.....	123	99	116	113
3.....	53	46	40	46
4.....	133	148	130	137
1895.....	80	74	81	78
6.....	40	26	27	31
7.....	75	64	56	65
8.....	100	64	82	82
9.....	40	29	21	30
1900.....	34	31	23	29
1.....	41	32	27	33
2.....	16	14	13	15
3.....	78	66	57	67
4.....	14	16	15	15

TABLE 62-11.—*Continued*

Year	N.	SE.	SW.	Av.
1905	92	78	83	84
6	141	125	122	129
7	171	168	149	163
8	170	183	138	164
9	146	144	114	135
1910	115	118	104	112
1	119	111	87	106
2	106	96	71	91
3	60	41	60	54
4	109	111	69	96
1915	105	89	86	93
6	94	85	70	83
7	140	114	107	120
8	63	57	44	55
9	121	130	119	123
1920	77	84	93	85
1	87	92	92	90
2	126	110	124	120
3	109	110	117	112
4	92	86	104	94
1925	112	107	113	111
6	159	129	129	139
7	85	81	55	74
8	130	104	96	110
9	114	103	96	104
1930	98	100	86	95
1	113	110	98	107
2	124	100	125	116
3	130	118	119	122
4	45	63	47	52
1935	71	87	60	73
6	73	77	63	71
7	117	110	113	113
8	117	117	114	116
9	91	79	87	86
1940	63	56	55	58
1	163	140	146	150
2	113	120	118	117
3	127	127	125	126
4	100	90	94	95
1945	103	86	73	87
6	137	130	106	124
7	78	75	65	73

TABLE 62-12.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, trunk section 12, 50.8 feet above ground*

Year	N.	SE.	SW.	Av.
1882	175	198	208	194
3	247	244	273	255
4	139	75	110	108
1885	105	78	68	84
6	121	84	73	93
7	131	105	86	107
8	122	128	82	111
9	152	155	135	147
1890	69	67	61	66
1	113	85	77	92
2	101	88	75	88
3	65	54	46	55
4	166	140	106	137
1895	95	68	70	78
6	37	27	34	33
7	47	37	40	41
8	64	68	73	68
9	41	28	30	33
1900	31	28	25	28
1	35	35	43	38
2	11	08	09	09
3	65	54	61	60
4	17	06	15	13

TABLE 62-12.—*Continued*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1905.....	81	59	77	72	7.....	64	66	56	62
6.....	129	82	129	113	8.....	96	126	95	106
7.....	137	97	110	115	9.....	91	103	90	95
8.....	130	113	119	121					
9.....	140	120	112	124	1930.....	74	89	79	81
					1.....	88	96	108	97
1910.....	110	77	92	93	2.....	101	106	130	112
1.....	72	67	56	65	3.....	108	76	121	102
2.....	73	56	52	60	4.....	40	36	34	37
3.....	26	26	30	27					
4.....	66	82	60	69	1935.....	53	53	46	51
					6.....	76	70	48	65
1915.....	62	74	60	65	7.....	118	139	95	117
6.....	68	54	58	60	8.....	102	106	108	105
7.....	90	74	73	79	9.....	74	64	77	72
8.....	41	65	44	50					
9.....	110	110	86	102	1940.....	50	48	59	52
					1.....	143	151	127	140
1920.....	86	70	80	79	2.....	113	111	88	104
1.....	96	95	74	88	3.....	111	113	105	110
2.....	114	136	104	118	4.....	91	68	70	76
3.....	102	103	90	98					
4.....	93	88	96	92	1945.....	89	52	65	69
1925.....	111	91	98	100	6.....	94	90	80	88
6.....	143	110	112	122	7.....	73	62	52	62

TABLE 62-13.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, trunk section 13, 54.0 feet above ground*

Year	N.	SE.	SW.	Av.	Year	N.	SE.	SW.	Av.
1898.....	109	112	88	103	9.....	123	179	118	140
9.....	71	70	88	76					
					1910.....	57	90	54	67
1900.....	21	30	35	29	1.....	0	48	22	23
1.....	55	53	46	51	2.....	46	49	49	48
2.....	23	40	23	29	3.....	26	30	19	25
3.....	68	102	57	76	4.....	47	26	32	35
4.....	22	23	21	22					
					1915.....	36	13	30	26
1905.....	63	100	59	74	6.....	45	32	39	39
6.....	91	130	90	104	7.....	50	53	34	46
7.....	73	100	60	78	8.....	32	41	30	34
8.....	94	191	121	135	9.....	60	89	56	68

TABLE 62-13.—*Continued*

Year	N.	SE.	SW.	Av.
1920.....	56	93	50	66
1.....	59	93	51	68
2.....	59	110	59	76
3.....	62	95	50	69
4.....	56	65	48	56
1925.....	63	88	52	68
6.....	62	120	80	87
7.....	31	59	32	41
8.....	41	56	42	46
9.....	38	38	42	39
1930.....	43	66	37	49
1.....	66	105	57	76
2.....	60	89	72	74
3.....	66	89	81	79

Year	N.	SE.	SW.	Av.
4.....	27	30	25	27
1935.....	39	39	48	42
6.....	42	59	58	53
7.....	80	124	66	90
8.....	74	109	78	87
9.....	45	54	54	51
1940.....	30	39	31	33
1.....	119	207	134	153
2.....	88	161	95	115
3.....	53	58	93	68
4.....	39	66	84	63
1945.....	40	73	57	57
6.....	61	99	68	76
7.....	33	48	29	37

TABLE 62-14.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, trunk section 14, 56.3 feet above ground*

Year	N.	SE.	SW.	Av.
1923.....	240	250	241	244
4.....	49	75	58	61
1925.....	51	68	59	59
6.....	73	74	100	82
7.....	11	50	61	41
8.....	16	21	0	12
9.....	23	13	0	12
1930.....	40	14	10	21
1.....	47	34	23	35
2.....	50	47	39	45
3.....	56	63	47	55
4.....	26	20	20	22

Year	N.	SE.	SW.	Av.
1935.....	34	34	46	38
6.....	56	50	48	51
7.....	106	71	97	91
8.....	94	66	130	97
9.....	67	49	73	63
1940.....	20	26	38	28
1.....	116	90	120	109
2.....	81	59	73	71
3.....	40	22	30	31
4.....	35	32	14	27
1945.....	49	56	20	42
6.....	47	33	34	38
7.....	33	24	10	22

TABLE 62-15.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, trunk section 15, 57.8 feet above ground*

Year	N.	SE.	SW.	Av.
1939.....	91	85	83	86
1940.....	96	94	103	98
1.....	154	143	135	144
2.....	98	113	89	100

Year	N.	SE.	SW.	Av.
3.....	21	40	47	36
4.....	51	75	60	62
1945.....	75	115	96	96
6.....	38	0	35	24
7.....	22	14	22	19

TABLE 62-1-A.—*Growth layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, branch section 1-A, 0.6 foot out from the trunk. 0 degrees is vertically up; 120-240 degrees taken clockwise*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1780	100	91	99	97	1820	12	19	26	19
1	79	70	65	71	1	28	79	52	53
2	79	55	65	66	2	0	26	17	14
3	54	40	45	46	3	30	61	48	46
4	87	72	77	79	4	25	72	55	51
1785	24	18	16	19	1825	23	72	50	48
6	57	47	66	57	6	23	81	45	50
7	64	56	64	61	7	27	41	45	38
8	21	29	37	29	8	30	59	62	50
9	36	41	42	36	9	07	11	10	09
1790	53	67	72	64	1930	23	39	48	37
1	78	97	92	89	1	41	67	75	61
2	80	83	85	83	2	16	45	49	37
3	89	93	75	86	3	28	60	43	47
4	26	23	20	23	4	12	35	29	25
1795	54	70	80	68	1835	27	82	52	57
6	52	54	58	55	6	09	34	19	21
7	33	44	50	42	7	19	33	35	29
8	39	36	47	41	8	23	55	40	39
9	49	57	56	54	9	21	67	44	44
1800	22	23	31	25	1840	10	36	31	26
1	36	40	44	40	1	20	38	36	31
2	36	50	57	48	2	0	0	09	03
3	23	33	43	33	3	28	29	29	29
4	46	54	74	58	4	33	36	32	34
1805	47	43	59	50	1845	0	05	07	04
6	36	53	46	45	6	12	05	0	06
7	64	60	68	64	7	0	0	0	0
8	68	66	59	64	8	20	30	27	26
9	39	53	52	48	9	18	37	32	29
1810	34	35	33	34	1850	18	71	34	41
1	42	50	60	51	1	13	35	20	23
2	40	72	43	52	2	25	62	44	44
3	0	11	10	07	3	16	47	35	33
4	37	37	44	39	4	18	45	24	29
1815	31	88	50	56	1855	19	41	40	33
6	44	83	77	68	6	17	29	24	23
7	23	49	55	42	7	0	0	0	0
8	12	16	17	15	8	15	30	24	23
9	30	20	22	24	9	0	0	03	01

TABLE 62-1-A.—*Continued*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1860.....	16	26	20	21	1895.....	08	16	21	15
1.....	17	16	19	17	6.....	0	0	0	0
2.....	28	54	33	38	7.....	20	20	29	23
3.....	0	0	0	0	8.....	13	20	24	19
4.....	16	09	08	11	9.....	0	0	0	0
1865.....	21	29	22	24	1900.....	05	10	13	09
6.....	45	53	43	47	1.....	10	07	10	09
7.....	28	51	35	38	2.....	0	0	0	0
8.....	32	78	38	49	3.....	13	18	17	16
9.....	20	41	32	31	4.....	0	0	0	0
1870.....	13	41	32	29	1905.....	17	16	22	18
1.....	0	06	11	06	6.....	12	08	16	12
2.....	12	27	24	21	7.....	20	13	33	22
3.....	13	34	31	26	8.....	18	10	29	19
4.....	10	47	29	29	9.....	15	08	20	14
1875.....	12	34	20	22	1910.....	18	12	24	18
6.....	06	22	19	16	1.....	17	06	21	15
7.....	0	0	0	0	2.....	18	14	30	21
8.....	07	12	12	10	3.....	0	0	0	0
9.....	07	12	0	06	4.....	07	02	12	07
1880.....	0	0	0	0	1915.....	22	18	18	19
1.....	11	13	12	12	6.....	11	11	18	13
2.....	22	21	17	20	7.....	47	14	39	33
3.....	19	39	33	30	8.....	15	0	0	05
4.....	26	46	38	37	9.....	59	30	56	48
1885.....	18	32	22	24	1920.....	52	45	67	55
6.....	24	28	14	22	1.....	49	60	67	59
7.....	17	12	21	17	2.....	73	72	67	71
8.....	36	38	29	34	3.....	65	57	62	61
9.....	31	17	28	25	4.....	87	56	81	75
1890.....	32	22	29	28	1925.....	92	48	84	75
1.....	20	17	21	19	6.....	122	61	100	94
2.....	22	22	23	22	7.....	51	32	55	46
3.....	10	09	15	11	8.....	93	54	92	76
4.....	14	14	24	17	9.....	100	74	107	94

TABLE 62-1-A.—*Continued*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1930.....	61	31	74	55	9.....	35	28	46	36
1.....	46	30	59	45					
2.....	47	38	72	52	1940.....	23	15	24	21
3.....	60	67	79	69	1.....	78	91	86	85
4.....	28	14	42	28	2.....	50	57	52	53
					3.....	32	24	43	33
					4.....	35	42	39	39
1935.....	43	26	61	43					
6.....	20	13	31	21	1945.....	12	23	26	20
7.....	47	48	82	59	6.....	23	34	52	36
8.....	30	32	44	35	7.....	17	21	30	23

TABLE 62-1-B.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, branch section 1-B, 2.0 feet out from the trunk. 0 degrees is vertically up; 120-240 degrees taken clockwise*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1787.....	82	88	77	82	8.....	48	87	77	71
8.....	80	81	63	75	9.....	46	63	49	53
9.....	55	63	50	56					
					1810.....	30	40	34	35
1790.....	71	93	77	80	1.....	52	57	40	50
1.....	68	77	66	70	2.....	58	50	69	59
2.....	90	89	95	91	3.....	10	08	04	07
3.....	88	73	82	81	4.....	48	49	27	41
4.....	27	29	34	30					
					1815.....	46	79	35	53
1795.....	58	62	70	63	6.....	51	88	63	67
6.....	39	37	53	43	7.....	37	49	45	44
7.....	30	38	37	35	8.....	16	20	16	17
8.....	24	25	23	24	9.....	35	28	27	30
9.....	30	32	44	35					
					1820.....	16	31	14	20
					1.....	56	47	43	49
1800.....	27	23	27	26	2.....	20	30	19	23
1.....	37	30	43	37	3.....	44	51	41	45
2.....	30	36	32	33	4.....	36	51	60	49
3.....	25	34	26	28					
4.....	40	53	49	47	1825.....	39	54	50	48
					6.....	28	91	56	58
1805.....	36	57	38	44	7.....	20	66	37	41
6.....	31	47	40	39	8.....	40	64	72	59
7.....	55	83	60	66	9.....	04	13	13	10

TABLE 62-1-B.—*Continued*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1830.....	26	43	40	36	1870.....	36	31	41	36
1.....	58	77	64	66	1.....	0	04	06	03
2.....	32	45	39	39	2.....	31	30	29	30
3.....	33	44	45	41	3.....	30	26	40	32
4.....	23	39	27	30	4.....	25	32	35	31
1835.....	28	81	51	53	1875.....	18	28	38	28
6.....	11	30	18	20	6.....	11	21	30	21
7.....	22	32	29	28	7.....	0	0	0	0
8.....	27	43	50	40	8.....	18	18	17	18
9.....	31	45	57	44	9.....	05	17	15	12
1840.....	16	32	33	27	1880.....	0	06	0	02
1.....	10	48	36	31	1.....	17	12	18	16
2.....	0	11	07	06	2.....	21	25	34	27
3.....	22	33	23	26	3.....	17	25	63	35
4.....	28	34	32	31	4.....	26	41	60	42
1845.....	0	13	03	05	1885.....	17	28	45	30
6.....	14	11	13	13	6.....	23	21	36	27
7.....	0	0	0	0	7.....	15	13	27	18
8.....	39	30	38	36	8.....	33	36	42	37
9.....	29	31	39	33	9.....	23	21	26	23
1850.....	20	77	57	51	1890.....	35	38	40	38
1.....	19	33	32	28	1.....	22	21	29	24
2.....	39	60	54	51	2.....	22	25	43	30
3.....	40	46	44	43	3.....	05	06	19	10
4.....	28	47	30	35	4.....	05	10	19	11
1855.....	30	37	40	36	1895.....	09	12	25	15
6.....	12	28	25	22	6.....	0	0	0	0
7.....	0	0	0	0	7.....	16	21	31	23
8.....	12	31	31	25	8.....	10	20	34	21
9.....	0	0	04	01	9.....	0	0	06	02
1860.....	14	18	32	21	1900.....	07	07	09	08
1.....	20	27	23	23	1.....	09	07	04	07
2.....	29	53	57	46	2.....	0	0	0	0
3.....	0	08	0	03	3.....	24	20	23	22
4.....	05	0	0	02	4.....	0	0	0	0
1865.....	25	28	35	29	1905.....	15	26	22	21
6.....	42	46	56	48	6.....	14	13	19	15
7.....	42	32	60	45	7.....	23	25	49	32
8.....	43	30	58	44	8.....	23	16	30	23
9.....	25	21	37	28	9.....	18	10	23	17

TABLE 62-1-B.—*Continued*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1910.....	19	27	30	25	9.....	50	71	80	67
1.....	22	09	13	15					
2.....	20	21	24	22	1930.....	23	27	42	31
3.....	0	0	0	0	1.....	19	34	59	37
4.....	03	04	14	07	2.....	35	60	62	52
					3.....	51	67	70	63
1915.....	28	29	24	27	4.....	16	17	12	15
6.....	15	18	24	19					
7.....	19	25	30	25	1935.....	31	23	37	30
8.....	0	0	0	0	6.....	15	19	16	17
9.....	35	42	61	46	7.....	45	52	59	52
					8.....	27	31	44	34
1920.....	45	48	70	54	9.....	29	35	34	33
1.....	46	53	89	63					
2.....	55	62	94	70	1940.....	10	13	23	15
3.....	41	50	73	55	1.....	65	75	83	74
4.....	51	59	80	63	2.....	37	53	62	51
					3.....	20	29	46	32
1925.....	47	51	75	58	4.....	32	50	42	41
6.....	65	62	89	72	1945.....	09	20	32	20
7.....	25	30	35	30	6.....	28	42	44	38
8.....	53	69	75	66	7.....	23	21	38	27

TABLE 62-1-C.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, branch section 1-C, 3.1 feet out from the trunk. 0 degrees is vertically up; 120-240 degrees taken clockwise*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1793.....	78	96	85	86	9.....	50	52	62	55
4.....	67	72	69	69					
					1810.....	30	34	45	36
1795.....	75	70	72	73	1.....	44	51	76	57
6.....	61	61	44	55	2.....	66	60	105	77
7.....	49	38	32	40	3.....	0	0	05	02
8.....	32	36	36	35	4.....	35	35	77	49
9.....	28	37	42	36					
					1815.....	38	66	96	67
1800.....	25	44	37	35	6.....	42	70	81	64
1.....	25	41	38	35	7.....	29	56	60	48
2.....	25	37	35	32	8.....	17	28	29	25
3.....	23	27	28	26	9.....	20	22	35	26
4.....	32	55	56	48					
					1820.....	16	27	31	25
1805.....	38	52	49	46	1.....	37	66	70	58
6.....	33	35	34	34	2.....	12	41	39	31
7.....	61	75	94	77	3.....	30	64	87	60
8.....	65	76	94	78	4.....	32	43	81	52

TABLE 62-1-C.—*Continued*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1825.....	33	44	84	54	1865.....	37	35	33	35
6.....	31	53	75	53	6.....	39	50	61	50
7.....	19	48	60	42	7.....	39	47	47	44
8.....	45	60	62	56	8.....	34	47	51	44
9.....	07	22	15	15	9.....	25	33	36	31
1830.....	41	44	74	53	1870.....	15	30	38	28
1.....	59	82	99	80	1.....	0	17	0	06
2.....	30	36	62	43	2.....	28	46	38	37
3.....	45	40	108	64	3.....	23	45	32	33
4.....	25	28	43	32	4.....	29	58	36	41
1835.....	29	48	75	51	1875.....	21	37	33	30
6.....	0	11	29	13	6.....	15	30	26	24
7.....	28	39	27	31	7.....	0	09	0	03
8.....	24	38	61	41	8.....	12	28	17	19
9.....	38	62	65	55	9.....	06	19	07	11
1840.....	25	41	40	35	1880.....	0	08	0	03
1.....	27	46	52	42	1.....	17	16	17	17
2.....	0	21	0	07	2.....	21	26	29	25
3.....	20	30	41	30	3.....	29	39	38	35
4.....	41	39	55	45	4.....	37	37	50	41
1845.....	05	09	07	07	1885.....	31	33	35	33
6.....	15	17	15	16	6.....	27	35	30	31
7.....	0	0	0	0	7.....	17	23	21	20
8.....	40	39	41	40	8.....	24	45	43	37
9.....	30	42	43	38	9.....	15	32	23	23
1850.....	25	65	66	52	1890.....	24	42	37	34
1.....	14	35	30	26	1.....	23	33	28	28
2.....	33	54	72	53	2.....	28	35	29	31
3.....	31	56	69	52	3.....	09	13	07	10
4.....	16	46	56	39	4.....	13	15	08	12
1855.....	30	44	55	43	1895.....	15	20	12	16
6.....	20	38	37	32	6.....	0	0	0	0
7.....	0	06	0	02	7.....	24	39	16	26
8.....	27	35	40	34	8.....	11	27	17	18
9.....	0	10	13	08	9.....	0	0	0	0
1860.....	17	29	29	25	1900.....	04	11	12	09
1.....	20	35	24	26	1.....	12	12	0	08
2.....	56	47	51	51	2.....	0	0	0	0
3.....	0	04	0	01	3.....	10	25	20	18
4.....	07	07	07	07	4.....	0	0	0	0

TABLE 62-1-C.—*Continued*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1905.....	17	33	23	24	7.....	23	19	25	22
6.....	15	22	14	17	8.....	47	39	62	49
7.....	16	28	25	23	9.....	60	41	77	59
8.....	10	26	20	19					
9.....	11	19	09	13	1930.....	25	27	39	30
					1.....	35	23	40	33
1910.....	18	24	15	19	2.....	58	38	59	52
1.....	11	14	08	11	3.....	66	49	67	61
2.....	29	38	24	30	4.....	0	08	24	11
3.....	0	0	0	0					
4.....	15	20	10	15	1935.....	32	17	49	33
					6.....	14	17	29	20
1915.....	19	12	10	14	7.....	46	51	76	58
6.....	34	18	125	59	8.....	29	34	35	33
7.....	0	0	0	0	9.....	33	35	29	32
8.....	39	34	38	37					
9.....	41	47	55	48	1940.....	26	16	18	20
					1.....	86	72	80	79
1920.....	40	54	56	50	2.....	79	51	45	58
1.....	38	40	40	39	3.....	29	24	27	27
2.....	54	64	42	53	4.....	32	45	31	36
3.....	51	41	11	34					
4.....	53	52	58	54	1945.....	26	22	08	19
1925.....	43	57	48	49	6.....	35	33	23	30
6.....	74	54	56	61	7.....	27	20	22	23

TABLE 62-1-D.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, branch section 1-D, 5.1 feet out from the trunk. 0 degrees is vertically up; 120-240 degrees taken clockwise*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1808.....	107	110	121	113	1.....	51	47	52	50
9.....	85	77	90	84	2.....	53	33	29	38
					3.....	57	50	49	52
1810.....	54	46	51	50	4.....	47	39	46	44
1.....	64	53	58	58					
2.....	51	40	65	52	1825.....	26	45	24	32
3.....	09	0	0	03	6.....	38	52	52	47
4.....	46	38	30	38	7.....	42	40	33	38
					8.....	46	55	55	52
1815.....	48	37	43	43	9.....	11	25	13	16
6.....	66	52	64	61					
7.....	56	44	45	48	1830.....	57	54	64	58
8.....	36	42	38	39	1.....	92	98	95	95
9.....	30	20	09	20	2.....	36	49	27	37
					3.....	51	61	40	51
1820.....	20	21	12	18	4.....	25	30	30	28

Table 62-1-D.—*Continued*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1835.....	30	29	48	36	1870.....	20	43	60	41
6.....	07	18	14	13	1.....	12	06	30	16
7.....	22	30	31	28	2.....	20	45	68	44
8.....	28	48	54	43	3.....	19	44	44	36
9.....	36	68	87	64	4.....	19	54	69	47
1840.....	27	40	30	32	1875.....	28	30	40	33
1.....	34	42	48	41	6.....	25	22	35	27
2.....	04	0	26	10	7.....	0	11	09	07
3.....	26	31	37	31	8.....	19	29	20	23
4.....	28	42	40	37	9.....	14	19	15	16
1845.....	05	08	07	07	1880.....	0	14	09	08
6.....	19	32	15	22	1.....	17	18	16	17
7.....	0	0	08	03	2.....	27	31	20	26
8.....	30	50	34	38	3.....	21	38	39	33
9.....	30	46	36	37	4.....	38	48	61	49
1850.....	29	54	62	48	1885.....	25	38	30	31
1.....	23	26	28	26	6.....	28	37	28	31
2.....	41	57	63	54	7.....	20	27	34	27
3.....	34	58	55	49	8.....	30	36	52	39
4.....	17	32	59	36	9.....	20	26	39	28
1855.....	26	43	66	45	1890.....	28	32	33	31
6.....	24	34	48	35	1.....	19	32	32	28
7.....	0	0	14	05	2.....	17	37	30	28
8.....	21	32	31	28	3.....	11	16	20	16
9.....	11	15	24	17	4.....	14	24	21	20
1860.....	18	31	56	35	1895.....	18	23	22	21
1.....	22	31	43	32	6.....	0	0	0	0
2.....	24	48	64	45	7.....	25	30	24	26
3.....	0	0	11	04	8.....	22	35	20	26
4.....	11	20	20	17	9.....	0	0	06	02
1865.....	21	40	33	31	1900.....	07	17	10	11
6.....	26	64	57	49	1.....	09	18	13	13
7.....	25	61	47	44	2.....	0	0	0	0
8.....	18	65	70	51	3.....	18	24	21	21
9.....	23	35	48	35	4.....	0	0	0	0

TABLE 62-1-D.—*Continued*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1905.....	22	32	24	26	7.....	39	39	26	35
6.....	19	22	13	18	8.....	44	53	64	54
7.....	30	33	24	29	9.....	48	67	82	66
8.....	21	19	33	24					
9.....	22	21	18	20	1930.....	25	26	37	29
					1.....	41	45	49	45
1910.....	22	22	26	23	2.....	68	56	58	61
1.....	12	08	12	11	3.....	59	53	78	63
2.....	22	25	19	22	4.....	12	0	17	10
3.....	0	0	0	0					
4.....	10	06	12	09	1935.....	43	31	35	36
					6.....	14	18	29	20
1915.....	22	30	20	24	7.....	53	41	75	56
6.....	15	20	16	17	8.....	38	29	42	36
7.....	32	37	14	28	9.....	43	31	41	38
8.....	16	16	0	11					
9.....	53	50	32	45	1940.....	27	15	12	18
					1.....	80	77	90	82
1920.....	76	55	41	57	2.....	45	53	66	55
1.....	96	36	43	58	3.....	20	26	36	27
2.....	89	63	53	68	4.....	31	52	51	45
3.....	62	50	53	55					
4.....	75	47	47	56	1945.....	0	22	20	14
1925.....	62	44	38	48	6.....	33	33	35	34
6.....	62	67	57	62	7.....	11	16	15	14

TABLE 62-1-E.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, branch section 1-E, 7.1 feet out from the trunk. 0 degrees is vertically up; 120-240 degrees taken clockwise*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1831.....	104	96	06	69	3.....	15	21	54	30
2.....	68	66	69	68	4.....	11	16	09	12
3.....	67	74	171	104					
4.....	15	22	07	15	1845.....	14	27	10	17
					6.....	18	33	17	23
1835.....	18	29	43	30	7.....	12	13	23	16
6.....	23	38	35	32	8.....	17	17	21	18
7.....	08	22	10	13	9.....	23	20	35	26
8.....	11	15	14	13					
9.....	14	14	21	16	1850.....	40	50	56	49
					1.....	23	23	21	22
1840.....	17	33	25	25	2.....	51	70	59	60
1.....	15	11	40	22	3.....	28	43	41	37
2.....	0	06	0	02	4.....	19	30	24	24

TABLE 62-1-E.—*Continued*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1855.....	31	39	40	37	1895.....	20	21	30	24
6.....	30	40	36	35	6.....	0	0	07	02
7.....	0	0	0	0	7.....	36	29	27	31
8.....	28	41	41	37	8.....	31	34	40	35
9.....	26	26	45	32	9.....	0	17	16	11
1860.....	40	40	45	42	1900.....	18	18	13	16
1.....	31	47	39	39	1.....	17	15	13	15
2.....	38	71	59	56	2.....	0	05	0	02
3.....	12	21	11	15	3.....	29	32	42	34
4.....	21	25	24	23	4.....	0	08	0	03
1865.....	57	32	42	44	1905.....	27	46	29	34
6.....	45	60	68	58	6.....	20	35	22	26
7.....	37	81	72	63	7.....	31	66	56	51
8.....	45	91	61	66	8.....	28	51	45	41
9.....	53	77	42	57	9.....	21	42	32	32
1870.....	38	71	61	57	1910.....	26	48	29	34
1.....	14	34	24	24	1.....	11	39	23	24
2.....	34	91	42	56	2.....	26	37	32	32
3.....	22	63	35	40	3.....	0	0	0	0
4.....	37	72	58	56	4.....	05	15	09	10
1875.....	35	46	48	43	1915.....	25	32	34	30
6.....	25	38	36	33	6.....	21	25	35	27
7.....	10	16	20	12	7.....	41	38	88	56
8.....	24	23	32	26	8.....	24	24	31	26
9.....	14	20	20	18	9.....	44	49	88	60
1880.....	04	12	08	08	1920.....	43	57	82	61
1.....	26	12	16	18	1.....	24	74	83	60
2.....	30	26	33	30	2.....	57	79	88	75
3.....	35	56	70	54	3.....	41	50	66	52
4.....	37	59	89	62	4.....	50	52	93	65
1885.....	15	40	46	34	1925.....	44	29	80	51
6.....	20	37	33	30	6.....	66	49	87	67
7.....	20	32	24	25	7.....	28	24	55	36
8.....	30	54	48	44	8.....	44	36	71	50
9.....	17	32	31	27	9.....	38	40	111	63
1890.....	32	45	47	41	1930.....	23	32	49	35
1.....	22	37	54	38	1.....	25	36	62	41
2.....	27	37	50	38	2.....	52	40	97	63
3.....	14	16	21	17	3.....	36	49	107	64
4.....	17	15	19	17	4.....	0	13	25	13

TABLE 62-1-E.—*Continued*

Year	0°	120°	240°	Av.
1935.....	33	28	58	40
6.....	14	16	28	19
7.....	49	54	85	63
8.....	27	34	48	36
9.....	24	31	39	31
1940.....	10	17	26	18
1.....	60	75	87	74
2.....	30	34	62	42
3.....	16	19	34	23
4.....	29	36	52	39
1945.....	07	18	24	16
6.....	22	34	44	33
7.....	20	15	36	24

TABLE 62-1-F.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, branch section 1-F, 8.6 feet out from the trunk. 0 degrees is vertically up; 120-240 degrees taken clockwise*

Year	0°	120°	240°	Av.
1854.....	88	87	94	90
1855.....	89	81	82	84
6.....	39	35	34	36
7.....	10	22	14	15
8.....	31	26	22	26
9.....	47	39	42	43
1860.....	20	21	25	22
1.....	20	18	17	18
2.....	46	24	34	35
3.....	08	09	07	08
4.....	08	10	05	08
1865.....	25	23	32	27
6.....	51	42	32	42
7.....	66	64	57	62
8.....	63	56	53	57
9.....	35	23	36	31
1870.....	31	37	37	35
1.....	16	21	18	18
2.....	58	64	61	61
3.....	41	35	41	39
4.....	58	54	37	50
1875.....	41	37	45	41
6.....	23	30	26	26
7.....	17	24	25	22
8.....	29	36	49	38
9.....	22	36	24	27
1880.....	10	14	12	12
1.....	15	06	12	11
2.....	24	17	37	26
3.....	77	41	44	54
4.....	73	53	65	64
1885.....	41	41	47	43
6.....	29	26	28	28
7.....	20	33	31	28
8.....	41	52	51	48
9.....	38	28	28	31
1890.....	41	41	36	39
1.....	42	39	41	41
2.....	38	37	38	38
3.....	16	23	20	20
4.....	18	26	24	23
1895.....	45	26	31	34
6.....	13	12	14	13
7.....	26	36	31	31
8.....	40	60	49	50
9.....	08	25	16	16
1900.....	17	20	20	19
1.....	15	38	19	24
2.....	06	08	05	06
3.....	21	36	28	28
4.....	0	0	0	0
1905.....	21	41	48	37
6.....	17	61	52	43
7.....	37	77	57	57
8.....	29	62	45	45
9.....	29	57	60	49

Table 62-1-F.—*Continued*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1910.....	28	50	35	38	9.....	51	81	65	66
1.....	32	27	20	26					
2.....	34	38	22	31	1930.....	31	51	31	38
3.....	0	0	0	0	1.....	37	49	45	44
4.....	14	15	15	15	2.....	45	58	52	52
					3.....	38	73	61	57
1915.....	37	50	44	44	4.....	11	18	15	15
6.....	22	43	22	29					
7.....	40	64	35	46	1935.....	19	45	28	31
8.....	26	47	28	34	6.....	17	26	27	23
9.....	46	123	94	88	7.....	48	70	50	56
					8.....	36	49	40	42
1920.....	51	96	81	76	9.....	28	45	37	37
1.....	42	62	69	58					
2.....	46	74	88	69	1940.....	15	22	28	22
3.....	48	61	62	57	1.....	50	77	53	60
4.....	51	74	77	67	2.....	23	54	43	40
					3.....	20	27	36	28
1925.....	40	56	46	47	4.....	21	42	43	35
6.....	69	67	69	68	1945.....	18	34	28	27
7.....	33	40	34	36	6.....	22	42	58	41
8.....	51	66	55	57	7.....	20	29	32	27

Table 62-1-G.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, branch section 1-G, 10.0 feet out from the trunk. 0 degrees is vertically up; 120-240 degrees taken clockwise*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1868.....	154	194	186	178	4.....	35	43	76	51
9.....	108	69	92	90					
					1885.....	05	27	16	16
1870.....	44	59	80	61	6.....	19	20	13	17
1.....	15	18	31	21	7.....	31	21	12	21
2.....	34	48	60	47	8.....	27	24	19	23
3.....	10	17	15	14	9.....	32	26	20	26
4.....	22	27	54	34					
					1890.....	32	32	22	28
1875.....	28	21	39	29	1.....	38	30	32	33
6.....	21	11	50	27	2.....	34	30	25	30
7.....	20	19	27	22	3.....	19	10	24	18
8.....	26	29	56	37	4.....	41	17	35	31
9.....	08	16	16	13					
					1895.....	35	28	28	30
1880.....	07	06	08	07	6.....	14	09	22	15
1.....	09	12	08	10	7.....	43	28	28	33
2.....	28	21	27	25	8.....	54	52	42	49
3.....	44	43	71	53	9.....	09	06	19	11

TABLE 62-1-G.—*Continued*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1900.....	11	10	24	15	4.....	38	46	48	44
1.....	21	07	20	16	1925.....	28	28	32	29
2.....	11	0	0	04	6.....	48	45	64	52
3.....	24	23	20	22	7.....	15	29	21	22
4.....	0	0	0	0	8.....	27	40	49	39
1905.....	28	19	27	25	9.....	30	37	53	40
6.....	44	18	21	28	1930.....	19	25	40	28
7.....	14	33	30	26	1.....	23	27	36	29
8.....	15	22	27	21	2.....	25	32	49	35
9.....	18	18	17	18	3.....	25	32	41	33
1910.....	12	22	25	20	4.....	0	09	07	05
1.....	10	24	48	27	1935.....	16	26	20	21
2.....	23	21	26	23	6.....	12	18	13	14
3.....	0	0	05	02	7.....	34	45	27	35
4.....	06	08	09	08	8.....	23	32	19	25
1915.....	20	25	30	25	9.....	22	26	15	21
6.....	21	19	22	21	1940.....	0	12	04	05
7.....	29	27	33	30	1.....	32	52	40	41
8.....	25	24	42	30	2.....	21	39	27	29
9.....	50	35	63	49	3.....	0	21	12	11
1920.....	33	35	37	35	4.....	15	21	20	19
1.....	26	27	35	29	1945.....	0	19	05	08
2.....	51	41	60	51	6.....	19	09	33	20
3.....	39	37	55	44	7.....	09	07	0	05

TABLE 62-1-H.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, branch section 1-H, 11.6 feet out from the trunk. 0 degrees is vertically up; 120-240 degrees taken clockwise*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1893.....	78	59	55	64	1.....	31	40	66	46
4.....	75	67	42	61	2.....	06	17	05	09
					3.....	18	25	32	25
1895.....	30	38	33	34	4.....	03	0	0	01
6.....	24	27	31	27					
7.....	23	38	40	34	1905.....	15	06	09	10
8.....	38	62	45	48	6.....	21	10	21	17
9.....	20	40	28	29	7.....	23	29	35	29
					8.....	15	35	17	22
1900.....	16	21	20	19	9.....	16	19	21	19

TABLE 62-1-H.—*Continued*

Year	0°	120°	240°	Av.
1910.....	24	31	29	28
1.....	28	38	23	30
2.....	23	34	23	27
3.....	0	07	07	05
4.....	14	16	11	14
1915.....	25	35	45	35
6.....	16	17	23	19
7.....	31	48	32	37
8.....	26	43	49	39
9.....	44	73	82	66
1920.....	40	56	55	50
1.....	34	56	53	48
2.....	32	70	67	56
3.....	31	59	56	49
4.....	33	69	54	52
1925.....	23	39	31	31
6.....	32	65	55	51
7.....	28	42	30	33
8.....	21	46	44	37
9.....	47	52	60	53
1930.....	24	62	42	43
1.....	28	38	51	39
2.....	40	40	45	42
3.....	30	42	48	40
4.....	12	23	18	18
1935.....	25	33	33	30
6.....	18	27	35	27
7.....	49	63	73	62
8.....	28	35	42	35
9.....	18	30	36	28
1940.....	10	20	17	16
1.....	09	59	66	45
2.....	41	38	43	41
3.....	30	32	19	27
4.....	13	21	29	21
1945.....	17	15	21	18
6.....	11	13	40	21
7.....	11	09	30	17

TABLE 62-2-A.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, branch section 2-A, 0.8 feet out from the trunk. 0 degrees is vertically up; 120-240 degrees taken clockwise*

Year	0°	120°	240°	Av.
1860.....	118	131	122	124
1.....	100	111	133	115
2.....	84	115	90	96
3.....	24	40	24	29
4.....	30	25	25	27
1865.....	38	38	36	37
6.....	52	54	49	52
7.....	64	75	62	67
8.....	68	105	75	83
9.....	27	20	26	24
1870.....	47	43	38	43
1.....	18	15	17	17
2.....	47	54	60	54
3.....	17	24	22	21
4.....	29	44	31	35
1875.....	27	23	25	25
6.....	25	33	30	29
7.....	18	19	18	18
8.....	25	24	24	24
9.....	17	23	23	21
1880.....	14	24	09	16
1.....	27	37	23	29
2.....	57	100	78	78
3.....	52	115	78	82
4.....	43	80	86	70
1885.....	31	62	45	46
6.....	43	75	73	64
7.....	34	66	79	60
8.....	39	100	79	73
9.....	38	83	77	66
1890.....	49	41	45	45
1.....	34	83	69	62
2.....	37	68	67	57
3.....	11	28	17	19
4.....	31	67	53	50

TABLE 62-2-A.—*Continued*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1895.....	22	48	39	36	2.....	22	42	66	43
6.....	12	16	09	12	3.....	25	42	51	39
7.....	26	47	46	40	4.....	24	50	71	48
8.....	37	79	78	65					
9.....	0	17	0	06	1925.....	30	49	64	48
					6.....	43	65	98	69
1900.....	14	18	17	16	7.....	12	26	37	25
1.....	14	27	19	20	8.....	19	46	64	43
2.....	0	08	11	06	9.....	26	71	96	64
3.....	25	55	52	44					
4.....	0	15	10	08	1930.....	19	46	61	42
					1.....	20	45	46	37
1905.....	35	70	91	65	2.....	34	65	76	58
6.....	38	75	92	68	3.....	33	50	81	55
7.....	37	91	104	77	4.....	13	24	27	21
8.....	39	99	105	81					
9.....	29	57	58	48	1935.....	19	48	45	37
					6.....	13	25	22	20
1910.....	42	62	52	52	7.....	36	55	74	55
1.....	40	76	56	57	8.....	25	40	48	38
2.....	33	64	79	59	9.....	27	33	42	34
3.....	07	33	32	24					
4.....	24	61	47	44	1940.....	09	16	18	14
					1.....	35	75	104	71
1915.....	21	63	68	51	2.....	26	42	71	46
6.....	20	36	35	30	3.....	10	32	39	27
7.....	39	66	76	60	4.....	30	27	48	35
8.....	23	33	29	28					
9.....	46	49	55	50	1945.....	10	21	05	12
					6.....	20	29	38	29
1920.....	35	45	49	43	7.....	18	23	20	20
1.....	29	30	47	35					

TABLE 62-2-B.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, branch section 2-B, 3.0 feet out from the trunk. 0 degrees is vertically up; 120-240 degrees taken clockwise*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1873.....	94	12	122	76	1.....	21	36	37	31
4.....	82	42	63	62	2.....	57	55	67	60
					3.....	54	46	72	57
1875.....	44	33	42	40	4.....	63	76	91	77
6.....	45	42	52	46					
7.....	31	36	43	37	1885.....	41	49	58	49
8.....	54	43	45	47	6.....	56	69	76	67
9.....	14	21	28	21	7.....	42	77	65	61
					8.....	56	74	65	65
1880.....	17	17	19	18	9.....	55	83	94	77

Table 62-2-B.—*Continued*

Year	0°	120°	240°	Av.
1890.....	46	42	22	37
1.....	40	54	59	51
2.....	32	49	64	48
3.....	11	09	18	13
4.....	35	61	65	54
1895.....	29	43	67	46
6.....	13	19	25	19
7.....	36	49	39	41
8.....	44	70	70	61
9.....	06	10	28	15
1900.....	11	18	19	16
1.....	14	34	36	28
2.....	07	04	11	07
3.....	28	54	70	51
4.....	05	10	17	11
1905.....	41	59	65	55
6.....	42	64	77	61
7.....	40	75	94	70
8.....	42	54	94	63
9.....	35	54	46	45
1910.....	48	45	59	51
1.....	40	55	102	66
2.....	30	94	67	64
3.....	09	41	30	27
4.....	30	51	48	43
1915.....	08	78	75	54
6.....	25.	44	50	40
7.....	28	50	90	56
8.....	20	29	57	35
9.....	35	42	70	49
1920.....	32	76	49	52
1.....	27	54	32	38
2.....	38	67	47	51
3.....	27	66	34	42
4.....	32	66	40	46
1925.....	24	67	43	45
6.....	42	97	54	64
7.....	14	33	21	23
8.....	22	52	40	38
9.....	14	61	55	43
1930.....	25	60	39	41
1.....	26	49	50	42
2.....	43	90	49	61
3.....	43	70	37	50
4.....	09	27	11	16
1935.....	33	45	62	47
6.....	14	25	05	15
7.....	31	61	61	51
8.....	32	86	43	54
9.....	21	59	27	36
1940.....	0	17	19	12
1.....	45	92	73	70
2.....	24	67	57	49
3.....	08	52	24	28
4.....	21	43	45	36
1945.....	12	16	15	14
6.....	15	33	26	25
7.....	11	12	08	10

TABLE 62-2-C.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, branch section 2-C, 5.0 feet out from the trunk. 0 degrees is vertically up; 120-240 degrees taken clockwise*

Year	0°	120°	240°	Av.	Year	0°	120°	240°	Av.
1889.....	135	148	151	145	8.....	37	51	37	42
					9.....	40	73	70	61
1890.....	88	75	100	88	1920.....	31	56	62	50
1.....	100	115	138	118	1.....	16	33	85	45
2.....	71	83	88	81	2.....	28	42	64	45
3.....	09	24	28	20	3.....	14	42	44	33
4.....	48	77	73	66	4.....	20	42	59	40
1895.....	37	67	79	61	1925.....	34	37	48	40
6.....	06	19	17	14	6.....	36	57	54	49
7.....	22	40	41	34	7.....	06	20	19	15
8.....	27	60	56	48	8.....	15	26	25	22
9.....	10	35	33	26	9.....	16	46	43	35
1900.....	10	17	11	13	1930.....	16	27	32	25
1.....	10	18	12	13	1.....	17	34	35	29
2.....	06	12	09	09	2.....	22	51	45	39
3.....	26	52	63	47	3.....	22	60	51	44
4.....	08	13	09	10	4.....	12	27	21	20
1905.....	21	43	45	36	1935.....	18	72	48	46
6.....	26	42	56	41	6.....	10	33	40	28
7.....	33	68	55	52	7.....	27	75	95	66
8.....	39	63	77	60	8.....	19	66	81	55
9.....	29	41	43	38	9.....	08	35	53	32
1910.....	15	29	18	21	1940.....	0	17	18	12
1.....	30	33	38	34	1.....	36	80	94	70
2.....	23	41	45	36	2.....	27	47	96	57
3.....	04	10	13	09	3.....	0	19	51	23
4.....	24	30	33	29	4.....	21	28	54	34
1915.....	38	55	39	44	1945.....	0	09	32	14
6.....	41	46	27	38	6.....	10	23	39	24
7.....	38	53	51	47	7.....	06	13	14	11

TABLE 62-2-D.—*Growth-layer thicknesses, in hundredths of a millimeter, along designated radii of the ponderosa pine, OL-S-62, branch section 2-D, 6.3 feet out from the trunk. 0 degrees is vertically up; 120-240 degrees taken clockwise*

Year	0°	120°	240°	Av.
1897.....	114	120	87	107
8.....	98	85	89	91
9.....	30	69	59	53
1900.....	29	19	23	24
1.....	19	16	20	18
2.....	12	15	15	14
3.....	33	27	37	32
4.....	08	09	09	09
1905.....	21	17	15	18
6.....	22	18	12	17
7.....	43	24	25	31
8.....	60	48	37	48
9.....	40	32	31	34
1910.....	13	11	06	10
1.....	35	04	24	21
2.....	37	27	26	30
3.....	15	16	16	16
4.....	43	46	35	41
1915.....	16	24	19	20
6.....	22	24	25	24
7.....	37	36	42	38
8.....	42	48	41	44
9.....	45	31	48	41
1920.....	37	44	30	37
1.....	25	53	21	33
2.....	39	31	28	33
3.....	32	32	26	30
4.....	32	25	31	29
1925.....	18	19	22	20
6.....	47	27	27	34
7.....	20	15	12	16
8.....	40	22	20	27
9.....	30	23	23	25
1930.....	30	26	14	23
1.....	33	33	17	28
2.....	38	28	32	33
3.....	34	32	22	29
4.....	28	15	19	21
1935.....	53	24	18	32
6.....	37	21	23	27
7.....	54	53	33	47
8.....	58	50	35	48
9.....	41	19	17	26
1940.....	22	21	20	21
1.....	88	56	45	63
2.....	65	27	39	44
3.....	27	15	0	14
4.....	31	24	26	27
1945.....	23	10	18	17
6.....	32	19	13	21
7.....	09	14	11	11

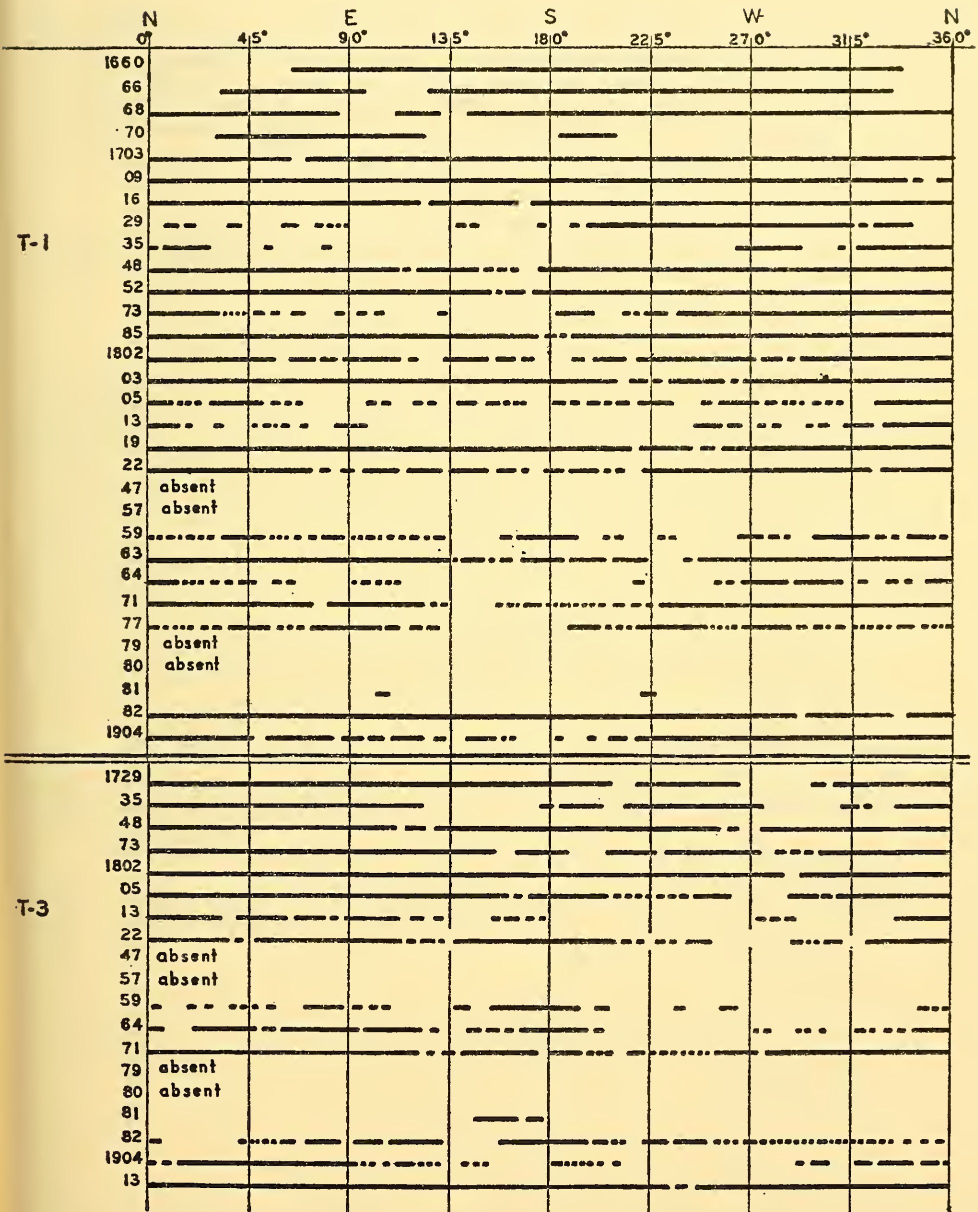

FIG. 94 A.—Circuit uniformity among partial growth layers, or lenses, in sections T-1 and T-3, tree OL-B-42. (See also text fig. 84.)

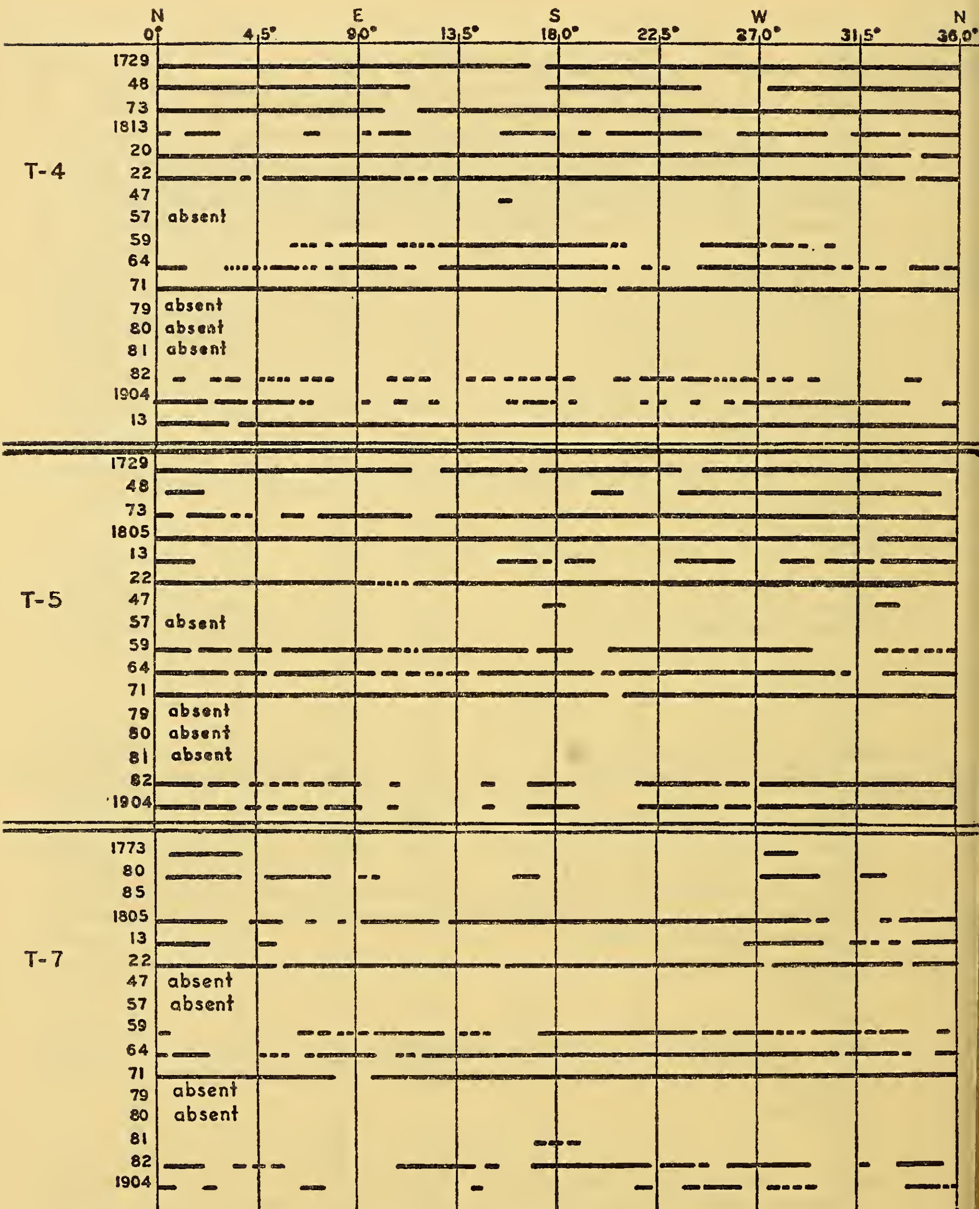

FIG. 94 B.—Circuit uniformity among partial growth layers, or lenses, in sections T-4, T-5, and T-7, tree OL-B-42.

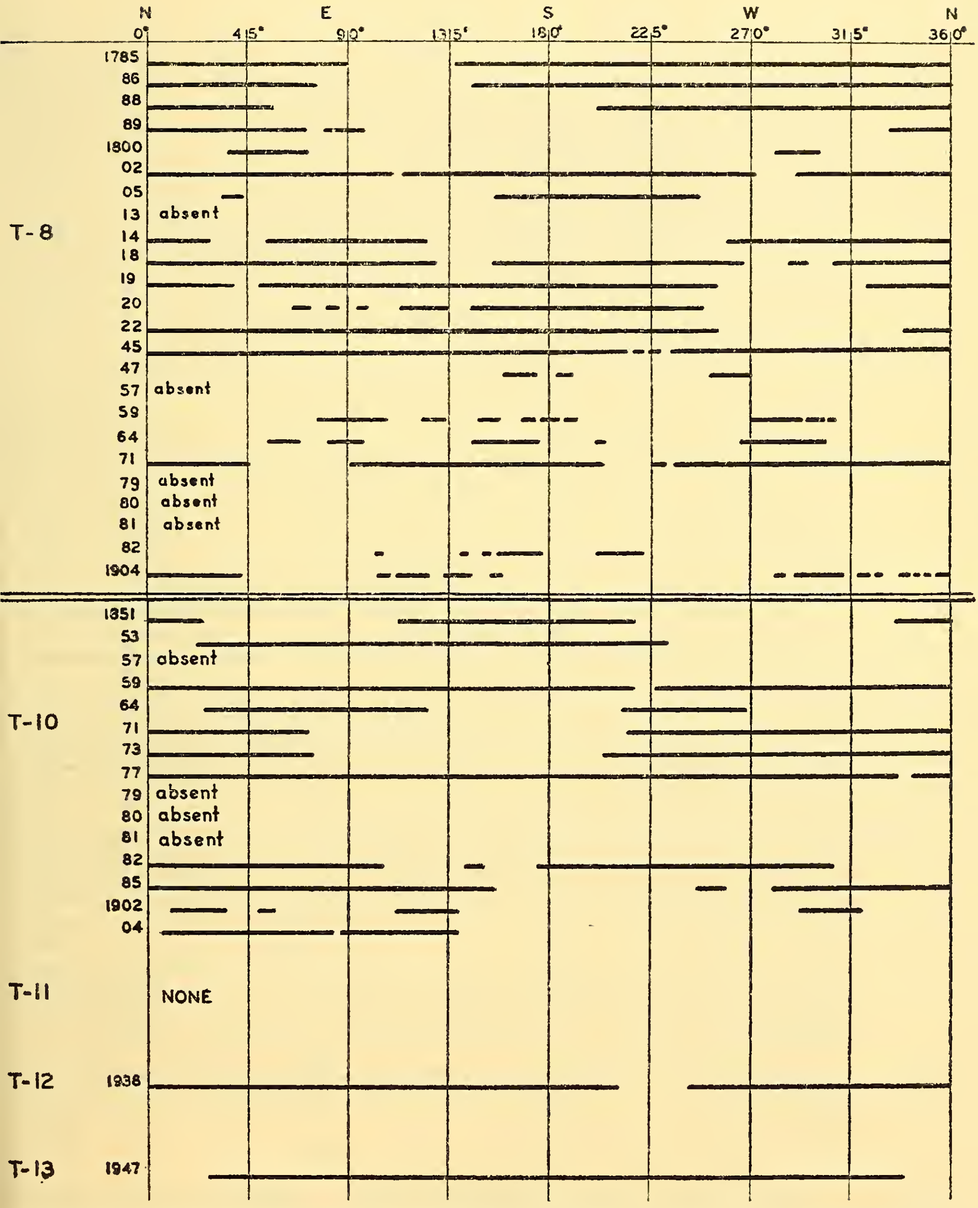

FIG. 94 C.—Circuit uniformity among partial growth layers, or lenses, in sections T-8 and T-10 to T-13, tree OL-B-42.

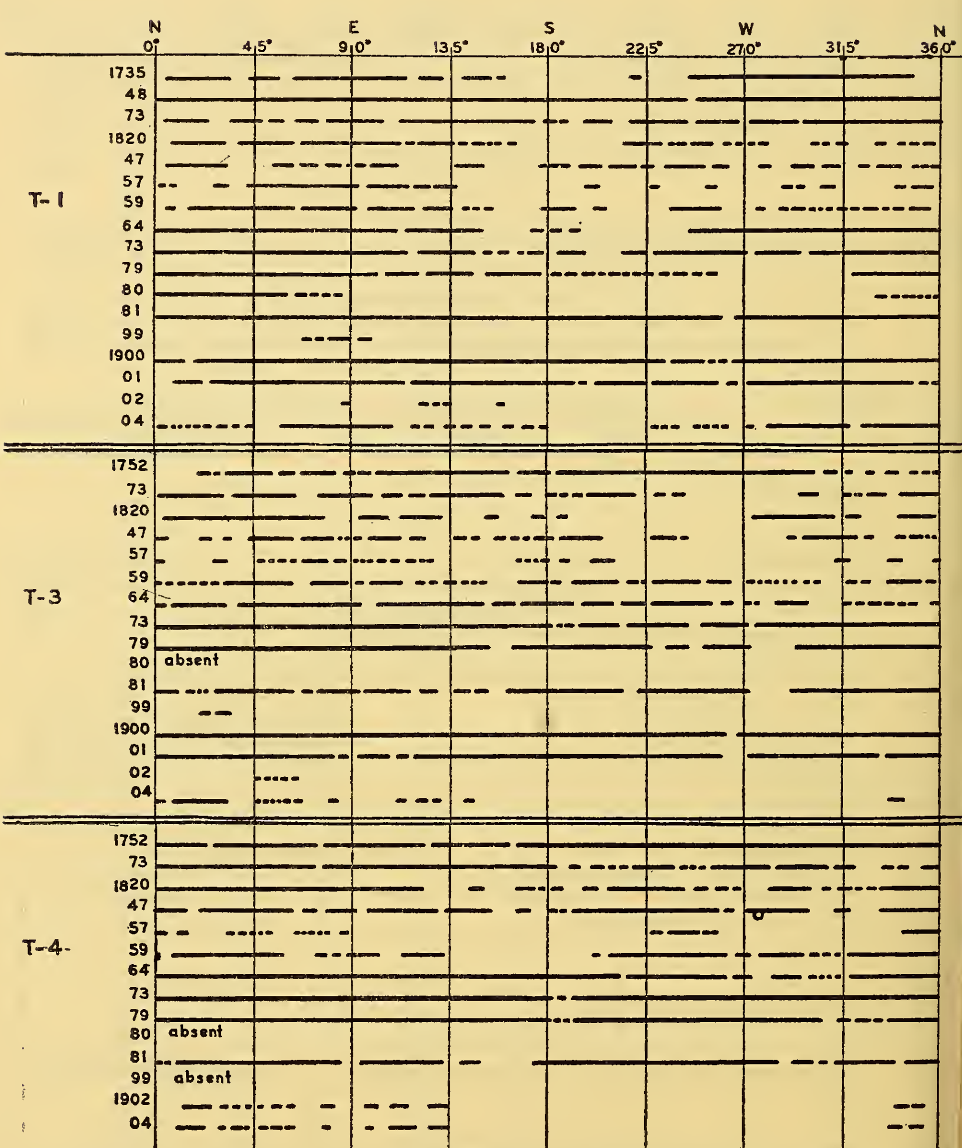

FIG. 95 A.—Circuit uniformity among partial growth layers, or lenses, in sections T-1, T-3, and T-4, tree OL-SO-57. (See also text fig. 85.)

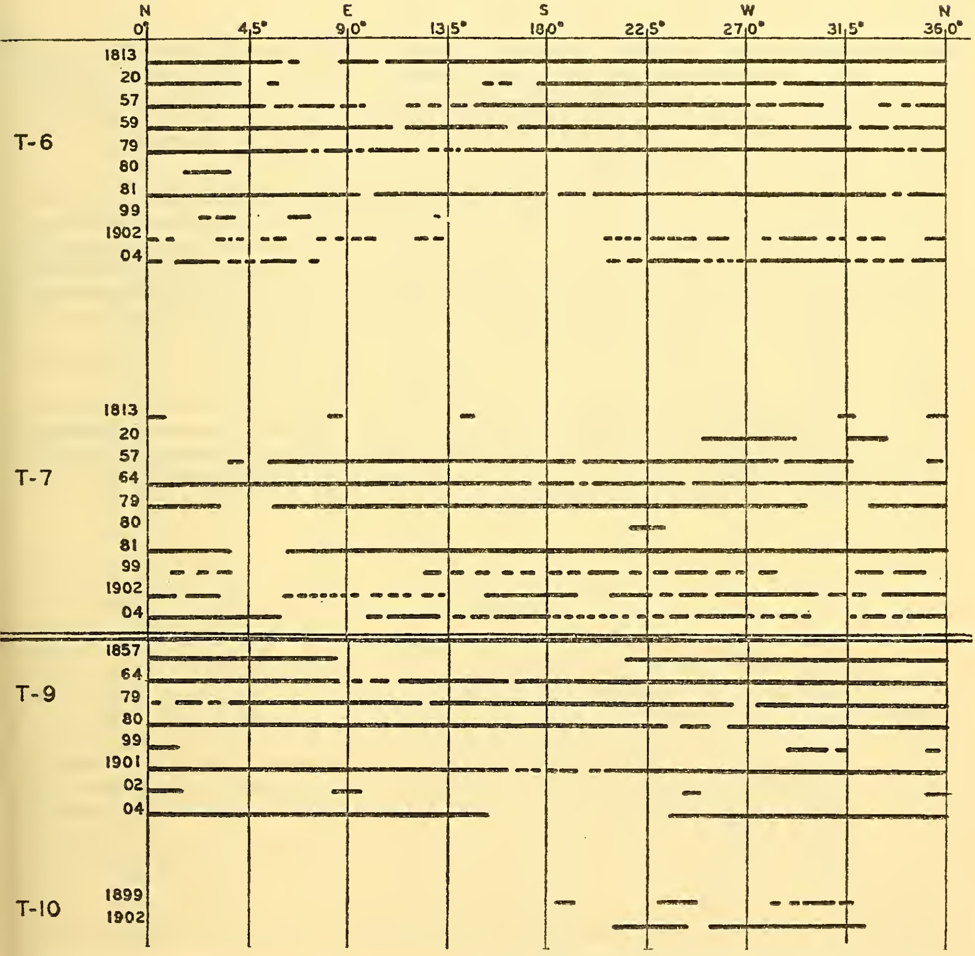

FIG. 95 B.—Circuit uniformity among partial growth layers, or lenses, in sections T-6, T-7, T-9, and T-10, tree OL-SO-57.

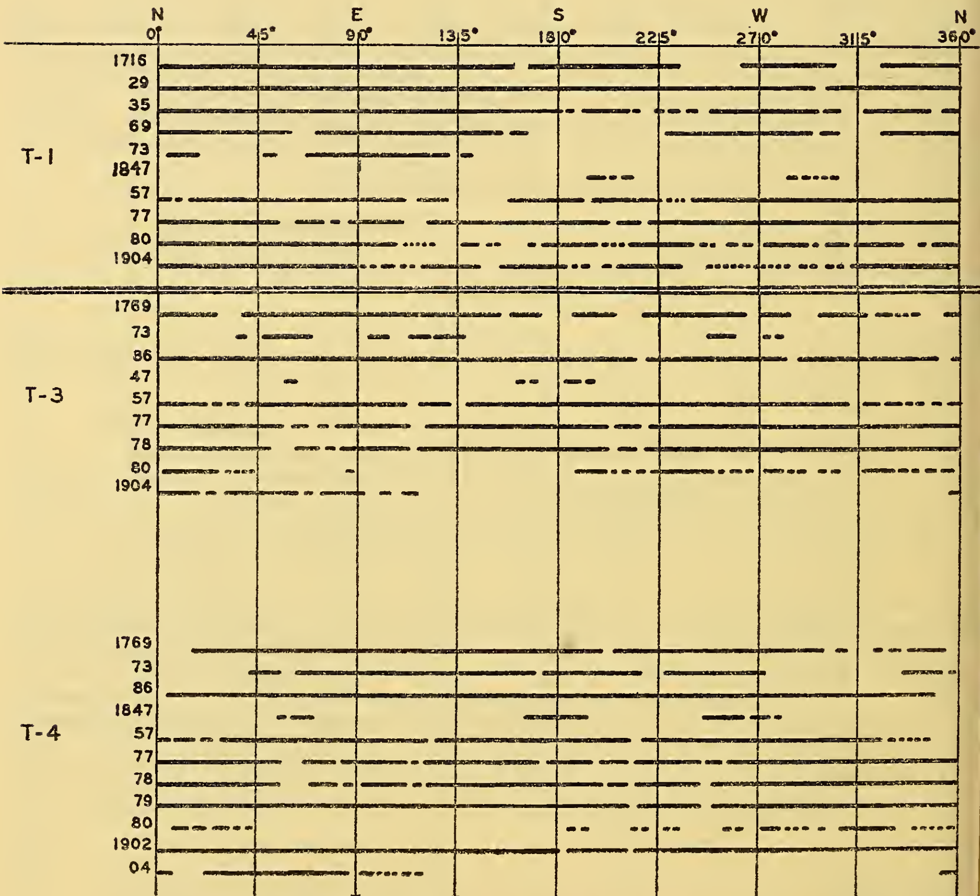

FIG. 96 A.—Circuit uniformity among partial growth layers, or lenses, in sections T-1, T-3, and T-4, tree OL-S-62. (See also text fig. 86.)

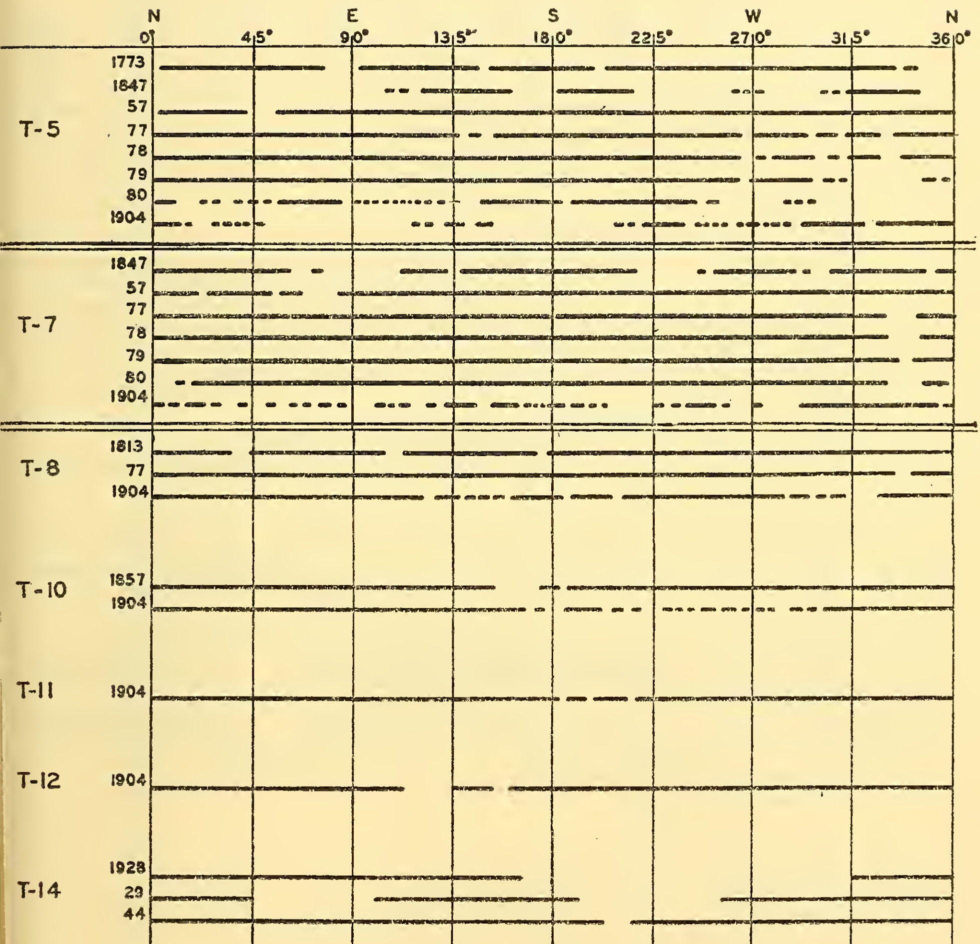

FIG. 96 B.—Circuit uniformity among partial growth layers, or lenses, in sections T-5, T-7, T-8, T-10 to T-12, and T-14, tree OL-S-62.

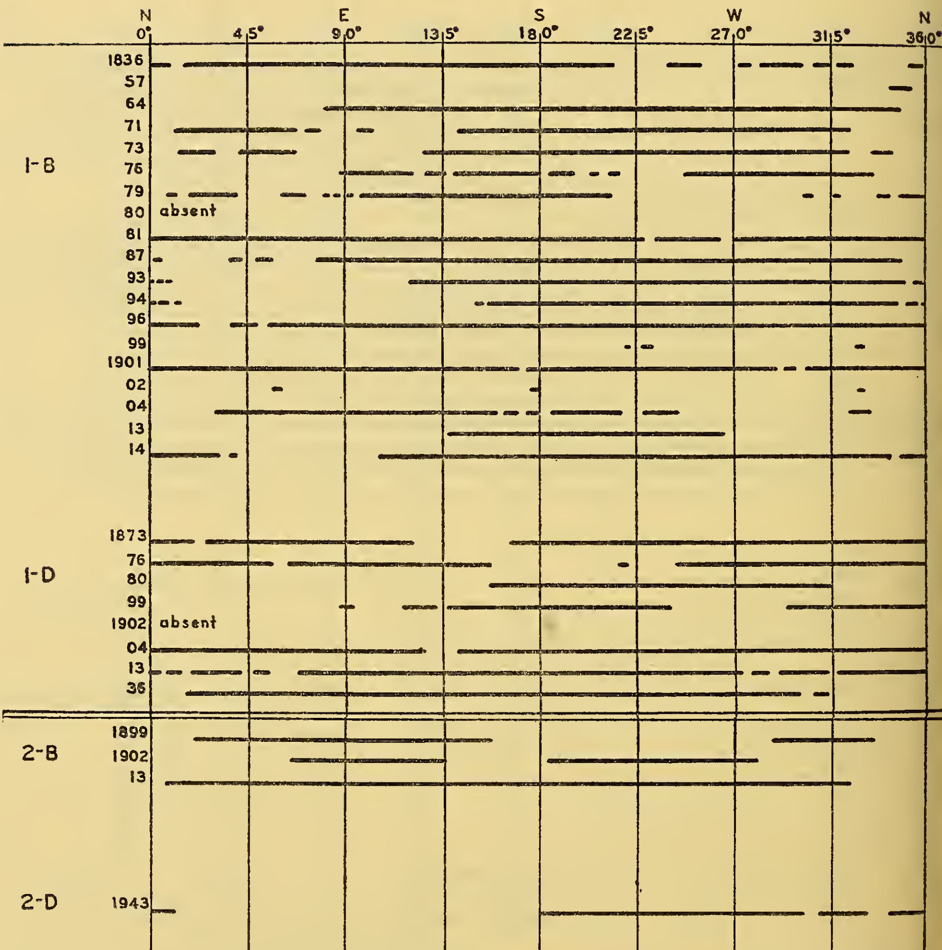

FIG. 97.—Circuit uniformity among partial growth layers, or lenses, of tree OL-SO-57, in Branch 1, sections B and D, and in Branch 2, sections B and D. (See also text fig. 87.)

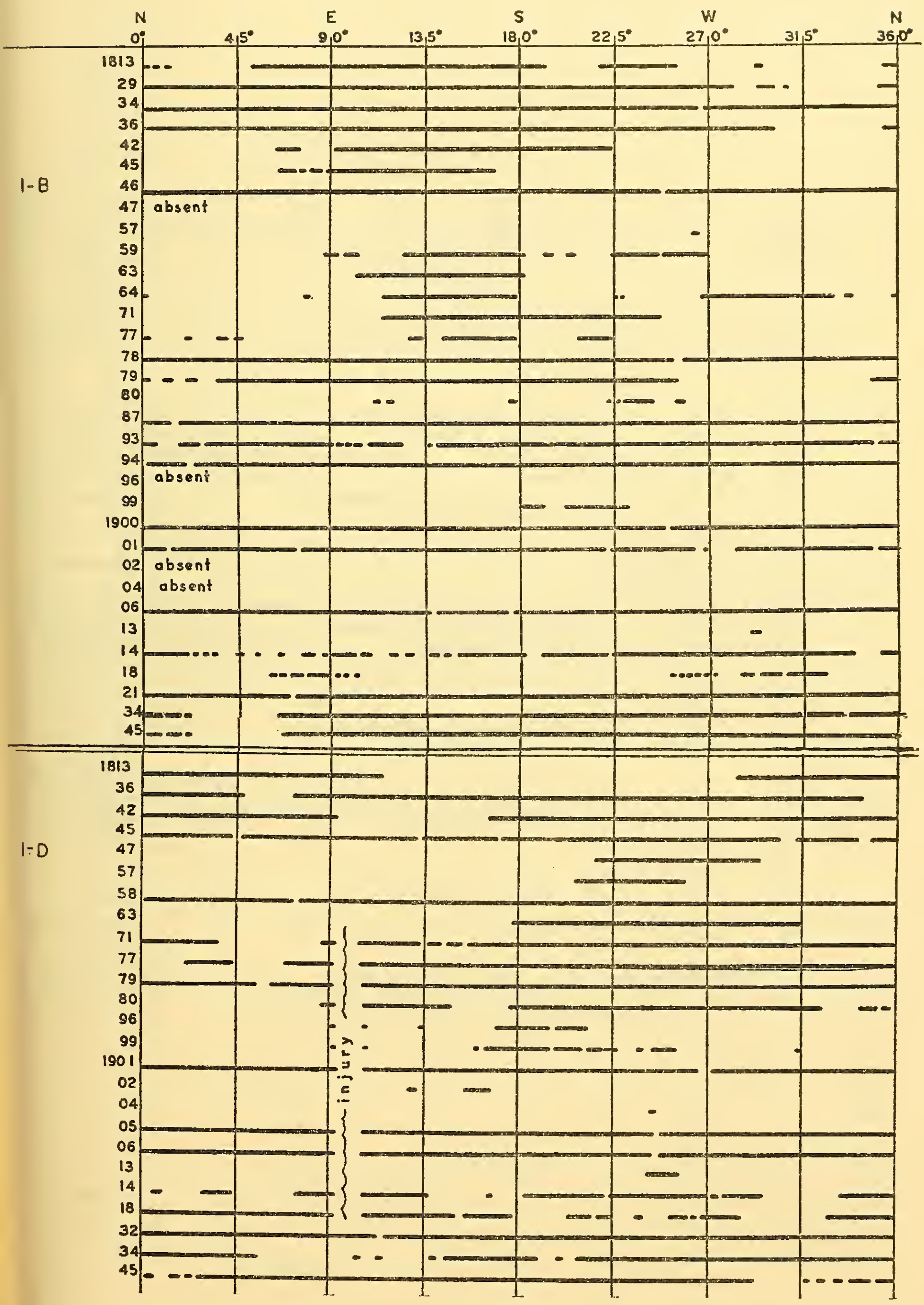

FIG. 98 A.—Circuit uniformity among partial growth layers, or lenses, of tree OL-S-62, in Branch 1, sections B and D. (See also text fig. 88.)

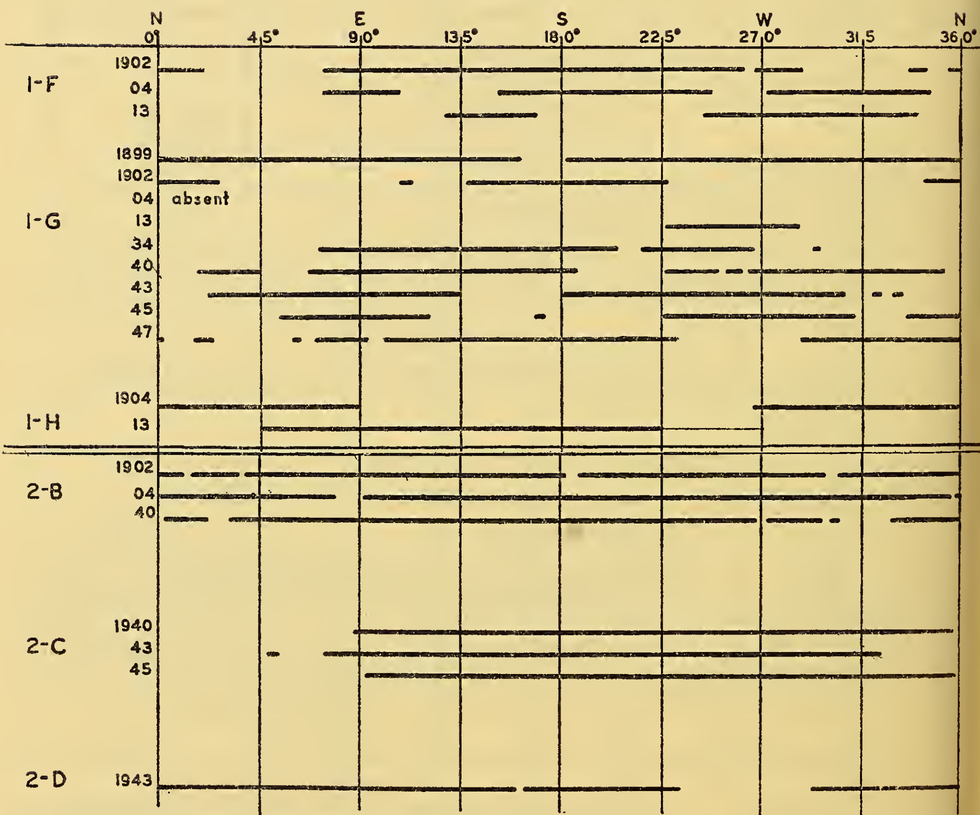

FIG. 98 B.—Circuit uniformity among partial growth layers, or lenses, of tree OL-S-62, in Branch 1, sections F, G, and H, and in Branch 2, sections B, C, and D.

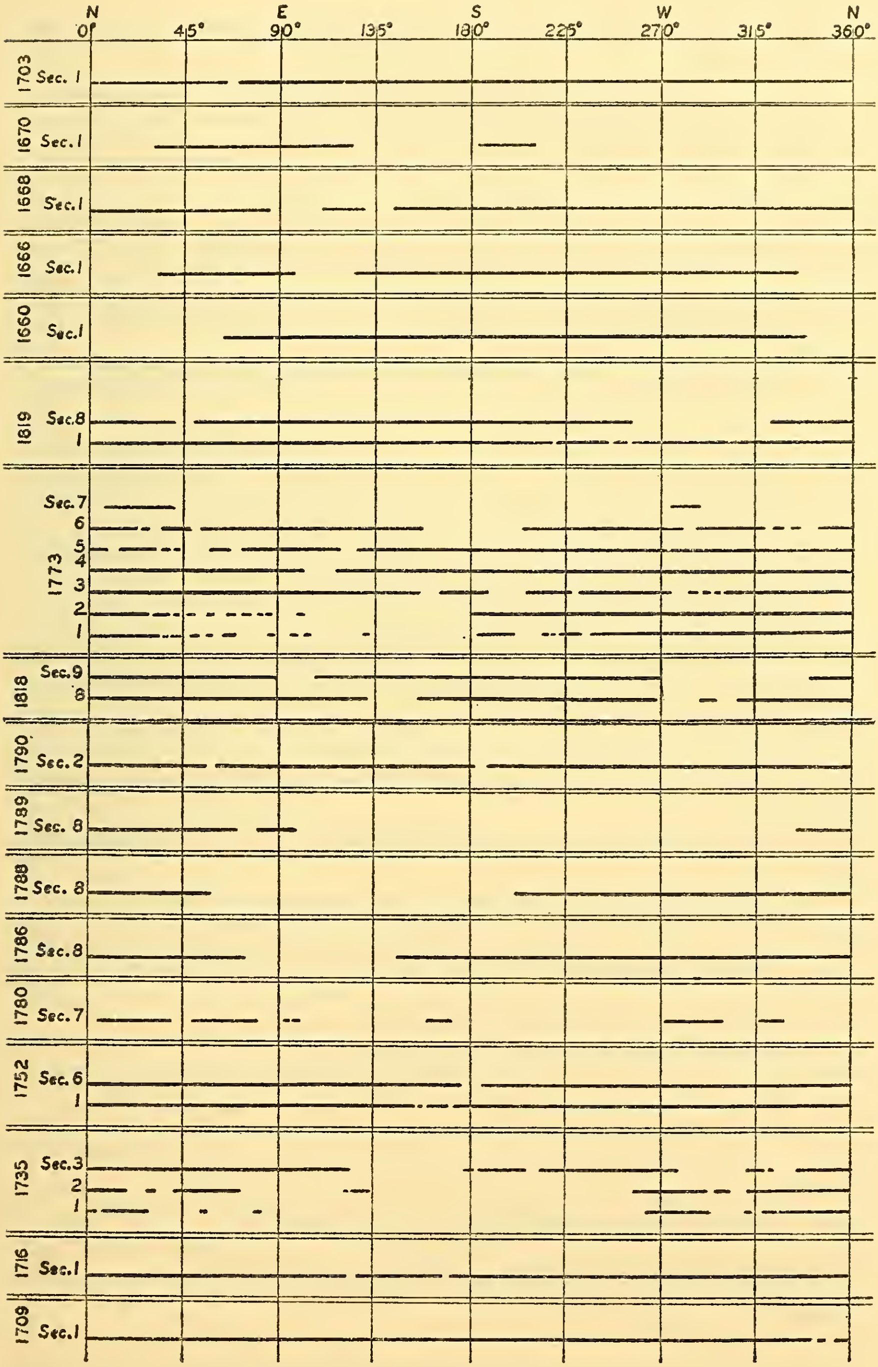

Fig. 99 A.—Longitudinal uniformity among partial growth layers, or lenses, from designated trunk sections of tree OL-B-42. (See also text figs. 89 and 90.)

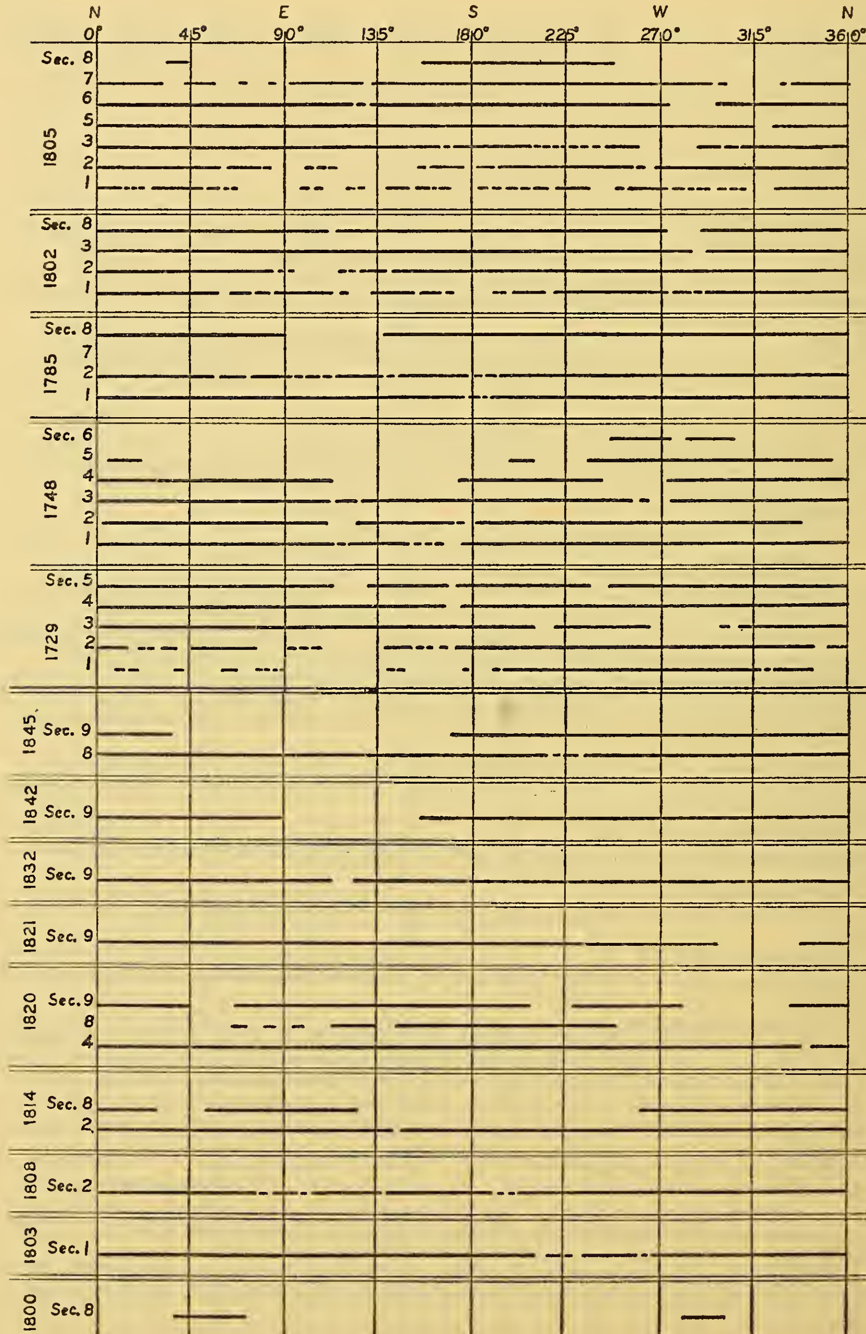

FIG. 99 B.—Longitudinal uniformity among partial growth layers, or lenses, from designated trunk sections of tree OL-B-42.

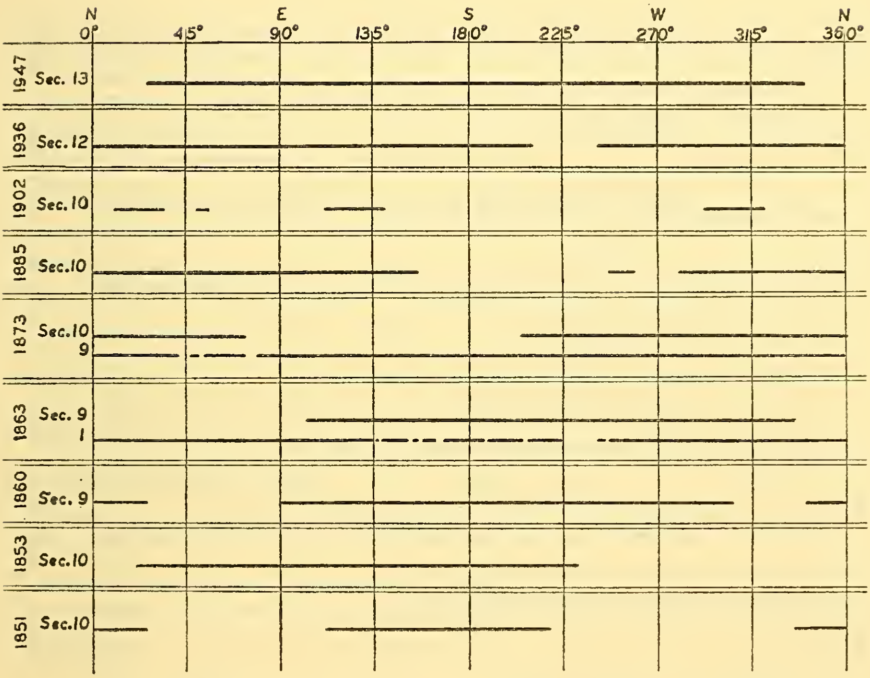

FIG. 99 C.—Longitudinal uniformity among partial growth layers, or lenses, from designated trunk sections of tree OL-B-42.

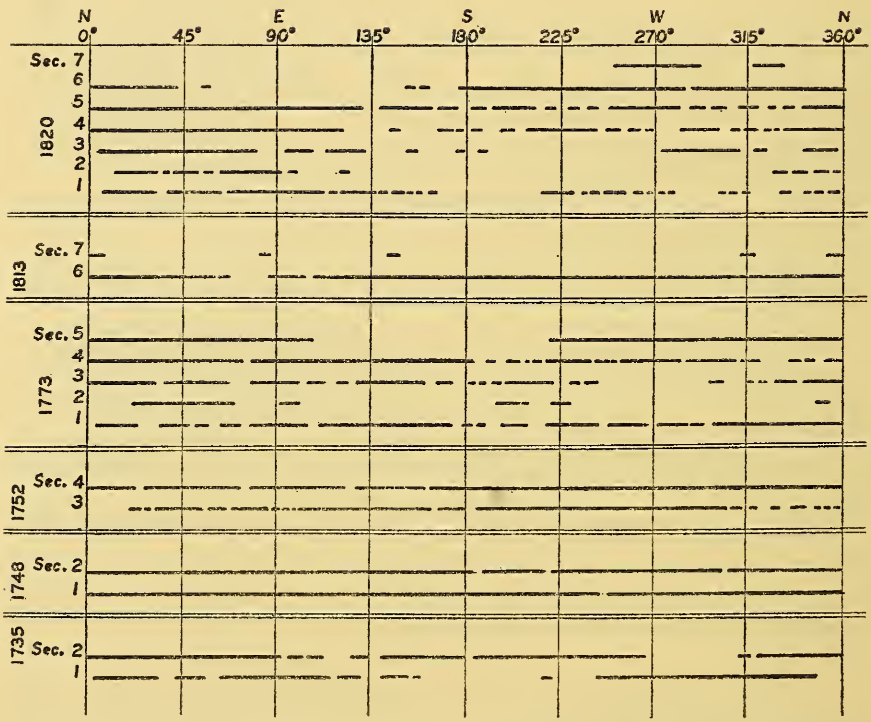

FIG. 100.—Longitudinal uniformity among partial growth layers, or lenses, from designated trunk sections of tree OL-SO-57. (See also text figs. 91 and 92.)

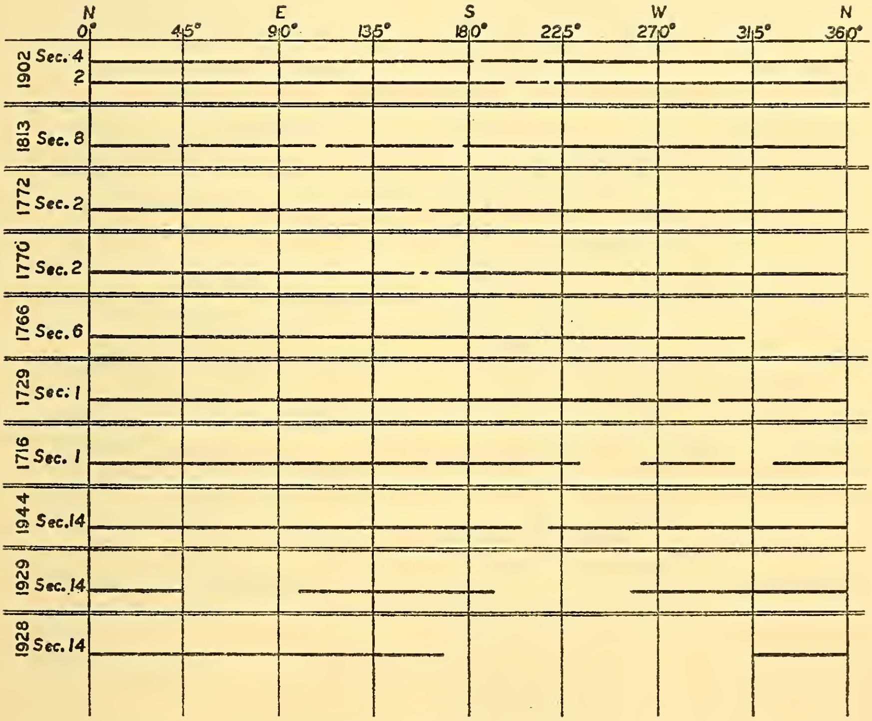

FIG. 101.—Longitudinal uniformity among partial growth layers, or lenses, from designated trunk sections of tree OL-S-62. (See also text fig. 93.)

INDEX

SMITHSONIAN MISCELLANEOUS COLLECTIONS
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Charles D. and Mary Vaux Walcott
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TERTIARY ECHINOIDS FROM THE CALOOSAHATCHEE AND TAMIAMI FORMATIONS OF FLORIDA

(With 18 Plates)

By
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Associate Curator, Division of Invertebrate Paleontology and Paleobotany
United States National Museum
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(With 18 Plates)

Echinoids in the Caloosahatchee and Tamiami formations are abundant and well preserved. There are seven species in the Caloosahatchee and nine in the Tamiami, with two of the subspecies occurring in both formations. Five species and two subspecies are new. These echinoids are of particular interest because many of the species are very similar to species now living in the Caribbean. This similarity makes it possible to suggest several phylogenetic lineages. Furthermore, most of the species are represented by many specimens, thus permitting a biometric study of their variation and ontogeny.

The living *Clypeaster prostratus* (Ravenel) is redescribed to facilitate easy comparison with its fossil relative *Clypeaster crassus* Kier, new species, in the Tamiami formation. An extraordinary hexamerous variant of this species is figured and described.

ACKNOWLEDGMENTS

I thank Druid Wilson, of the U.S. Geological Survey, who not only collected many of the specimens described herein but also took me to the localities where most of them were collected. His knowledge of the stratigraphy and molluscan faunas of the Caloosahatchee and Tamiami formations made it possible to determine the relationships of the echinoid faunas. John Ayres presented me with many specimens and guided Mr. Wilson and me to a Caloosahatchee locality near Denaud where we collected many well preserved echinoids. Thomas Phelan, John Reynolds, and Wesley Stark kindly sent me many echinoids. Drs. Norman F. Sohl and Richard S. Boardman critically read the manuscript and made valuable suggestions. I thank F. Stearns MacNeil for his opinions on the stratigraphy of the Late Tertiary of Florida and Dr. J. Wyatt Durham and Mrs. Carol Wagner for their opinions on several of the clypeasteroids. The graphs, map, and the text-figure of the tubercles of *Lytechinus variegatus plurituberculatus* Kier, new subspecies, were drawn by Lawrence B. Isham, scientific illustrator, Department of Geology, U. S. National Museum.

The cost of the publication of the plates was covered by part of a grant from the National Science Foundation.

PREVIOUS WORK

Very little work has been done on the echinoid faunas of the Caloosahatchee and Tamiami formations. Twitchell (in Clark and Twitchell, 1915, p. 218) described one species from the Caloosahatchee, *Diplothecanthus dalli,* and referred another specimen to *Diplothecanthus rosaceus* (Linnaeus). These specimens were referred by Cooke (1942, p. 11; 1959, p. 34) and DuBar (1958, p. 209) to *Clypeaster rosaceus* (Linnaeus) and are herein considered as a subspecies, *C. rosaceus dalli.* Clark and Twitchell (1915, p. 209) referred some specimens from what is now considered the Tamiami formation to *Encope macrophora* (Ravenel). Mansfield (1932, p. 48) erected a new subspecies *Encope macrophora tamiamiensis,* which Cooke (1942, p. 20) considered as a separate species referring Clark and Twitchell's specimens to it. Mansfield, in the same paper, described a new cassiduloid, *Cassidulus* (*Rhynchopygus* ?) *evergladensis,* a species herein referred to *Rhyncholampas.* Finally, DuBar (1958, p. 61) stated that a large echinoid fauna, including several regular forms and cassiduloids, occurred in his Bee Branch member of the Caloosahatchee formation.

ECHINOIDS FROM THE CALOOSAHATCHEE FORMATION

The echinoid fauna of the Caloosahatchee formation comprises seven species, including one new species and two new subspecies:

Lytechinus variegatus plurituberculatus Kier, new subspecies
Echinometra lucunter (Linnaeus)
Encope michelini imperforata Kier, new subspecies
Clypeaster subdepressus (Gray)
Clypeaster rosaceus dalli (Twitchell)
Rhyncholampas ayresi Kier, new species
Agassizia porifera (Ravenel)

The Caloosahatchee formation is described in detail by DuBar (1958, 1962). It consists of tan, sandy or silty, extremely fossiliferous marl that uncomformably overlies the Tamiami formation.

Many workers have considered the Caloosahatchee to be Pliocene (Heilprin, 1887; Dall and Harris, 1892; Mansfield, 1939; Olsson and Harbison, 1953; Bergendahl, 1956). However, DuBar (1958, 1962) and MacNeil (1962, personal communication) place it in the Pleistocene. Unfortunately, the echinoids are of little assistance in determining its age. There are no well-dated Pleistocene or Pliocene echinoid faunas known in the Western Hemisphere to compare with the Caloosahatchee echinoids, and the fauna is distinct from any of the European faunas. Furthermore, the relationship of the fauna to the Recent Caribbean fauna likewise gives no significant clues as to the age of the formation. Five of the species are still living, but three of them are subspecifically differentiated from Recent forms. The two extinct species, *Agassizia porifera* (Ravenel) and *Rhyncholampas ayresi* Kier, new species, are distinct from any echinoids now living in the Caribbean. These similarities and differences are of little use in determining the age of the fauna until more is known of the rate of speciation in Late Tertiary echinoids.

ECHINOIDS FROM THE TAMIAMI FORMATION

The Tamiami echinoid fauna consists of nine species, including four new species and two new subspecies:

Arbacia crenulata Kier, new species
Lytechinus variegatus plurituberculatus Kier, new subspecies
Clypeaster crassus Kier, new species
Clypeaster sunnilandensis Kier, new species
Encope tamiamiensis Mansfield
Encope michelini imperforata Kier, new subspecies
Mellita aclinensis Kier, new species
Rhyncholampas evergladensis (Mansfield)
Echinocardium gothicum (Ravenel) ?

As redefined by Parker (1951) and DuBar (1958), the Tamiami formation is represented by several facies. At Sunniland (fig. 2, p. 8) it is a soft gray limestone with abundant echinoids and mollusks. At Buckingham it is a phosphatic, argillaceous, fossiliferous marl, and in the subsurface along the Caloosahatchee River it consists of beds of clay and sand, most of which are almost devoid of megafossils. It has been described in detail by DuBar (1958, 1962).

Most workers consider the Tamiami formation as Late Miocene. The echinoids are of little use in determining the age of the Tamiami because so many of the species are confined to the Tamiami or found elsewhere in poorly dated beds. Five of the species are confined to the Tamiami; two of the subspecies to the Tamiami and Caloosahatchee. *Clypeaster crassus* Kier, new species, has been found in South Carolina in deposits considered by Cooke (1959, p. 36) to be Pleistocene, but Wilson (1962 personal communication) suggests that these deposits may be Late Miocene.

EVOLUTION

Many of the taxa in the two formations and those living today in the Caribbean are so similar that it is reasonable to suggest several phylogenetic lineages (fig. 1). *Clypeaster subdepressus,* a species known from the Caloosahatchee and the Recent, appears to be descended from the Tamiami *Clypeaster sunnilandensis.* The two species are alike in all characters except petal III, which is open in *C. sunnilandensis* and closed in *C. subdepressus. Clypeaster rosaceus dalli* is distinguished from *Clypeaster rosaceus rosaceus* only by its broader test. *Clypeaster prostratus,* a living species, can be distinguished from the Tamiami *Clypeaster crassus* only by its thinner margin; it is probably descended from it.

Encope michelini imperforata from the Tamiami and Caloosahatchee is probably the ancestor of *Encope michelini michelini,* known only from the Pleistocene-Recent. The two subspecies are very similar, differing only in the development of the posterior lunule. *Lytechinus variegatus plurituberculatus,* also from the Tamiami and Caloosahatchee, is similar in all respects to *Lytechinus variegatus variegatus* except for the number of tubercles in the ambulacra. *Rhyncholampas ayresi* from the Caloosahatchee is similar to *Rhyncholampas evergladensis* from the Tamiami and probably is descended from it.

ECOLOGY

Echinoids of both the Tamiami and Caloosahatchee formations evidently lived in shallow water. Five out of the seven species found in the Caloosahatchee formation are still living: *Lytechinus variegatus, Echinometra lucunter, Clypeaster rosaceus, Clypeaster subdepressus,* and *Encope michelini.* These species occur today in shallow water. H. L. Clark (1933) included all of them in his report on the littoral echinoderms of Puerto Rico. According to Clark (op. cit., p. 74), "the littoral sea urchins are so well known and the line between them and the deep water forms is so easy to draw that there

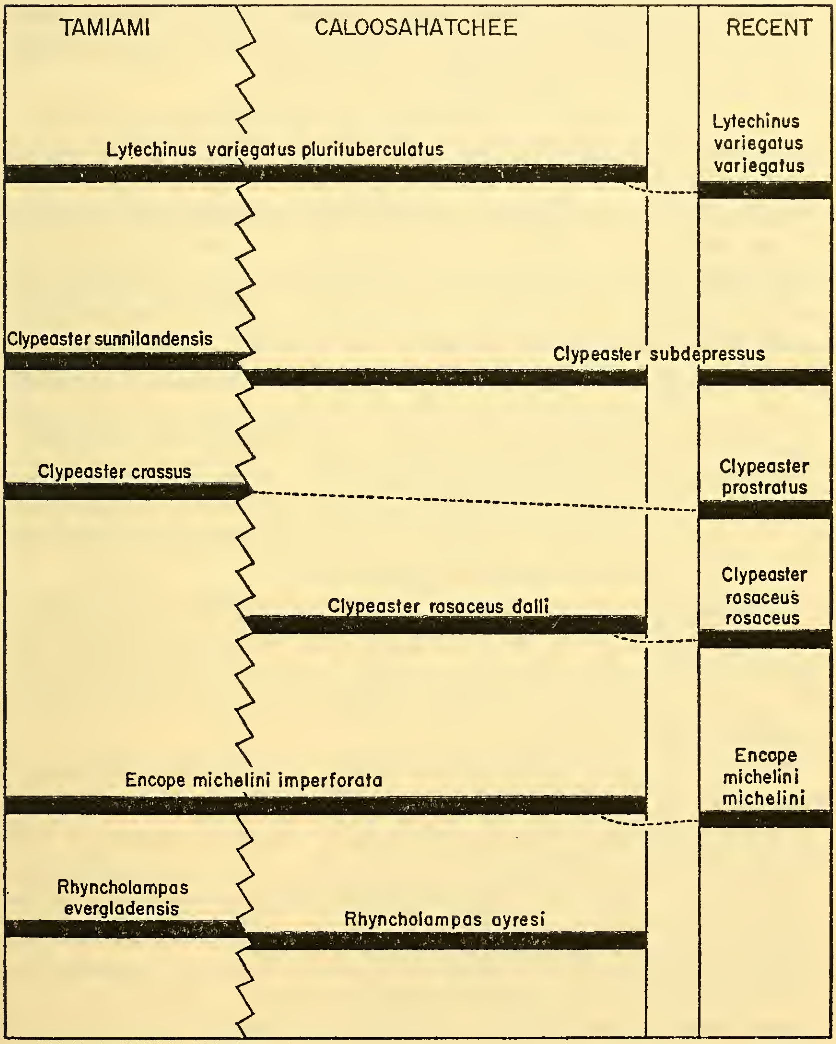


FIG. 1.—Suggested lineages of some of the species.

is little room for difference of opinion as to what species should be included in this report." In his description of the echinoids of the Barbados-Antigua expedition, Clark (1921, p. 103-104) considered *Lytechinus variegatus, Echinometra lucunter,* and *Clypeaster rosaceus* as "strictly littoral" and as "those species which occur along shore, or on reefs easily accessible at low tide."

According to Sharp and Gray (1962, p. 313), *Lytechinus variegatus* off North Carolina is most common in shallow water on sandy bottoms where there is material for protective covering and where wave action is at a minimum. They found the small adhesive discs of the tube-feet of this species inadequate for withstanding even moderately heavy wave action. Clark (1933, p. 81) reported that off Puerto Rico *L. variegatus* is most often found on a rather firm sandy bottom that is covered with short eelgrass or turtle grass.

I have observed *Clypeaster rosaceus* and *L. variegatus* in great numbers off the northeast tip of Key Biscayne, Fla. Here the water is sheltered and less than 3 feet deep. The echinoids live on a sandy grassy floor, and individuals of both species cover themselves with fragments of shells and echinoid tests. Sharp and Gray (op. cit., p. 313) have shown that in *L. variegatus* this covering of the test serves as a protection against intense light.

The other two clypeasteroids, *Clypeaster subdepressus* and *Encope michelini,* are found in sandy bottoms, but *Echinometra lucunter* is usually found on rock or coral, suggesting that, although the sea floor was probably predominately sandy, there may have been some areas of hard sea floor.

The two extinct Caloosahatchee species, the cassiduloid *Rhyncholampas ayresi* and the spatangoid *Agassiza porifera,* are little help in making paleoecological interpretations. Little is known of the ecology of the cassiduloids (Kier, 1962, p. 21). *Rhyncholampas pacificus* (A. Agassiz), which resembles *R. ayresi,* is known from depths of 5 to 60 feet, but nothing is known of its living habits. Of the two living species of *Agassizia,* one of them, *A. scrobiculata* Valenciennes, is, according to Mortensen (1951, p. 345), "an eminently littoral form," but the other, *A. excentrica* A. Agassiz, occurs in depths from 45 to 900 meters.

Two of the living littoral species, *L. variegatus* and *Encope michelini,* also occur in the Tamiami formation. Four of the extinct Tamiami species, *Clypeaster crassus, Clypeaster sunnilandensis, Encope tamiamiensis,* and *Mellita aclinensis,* are clypeasteroids. Species of this order generally occur in the littoral zone (Hyman, 1955,

p. 579) or littoral-sublittoral zone (Mortensen, 1948, p. 17). Two of the three extinct nonclypeasteroids, *Rhyncholampas evergladensis* and *Echinocardium gothicum* ?, belong to genera which occur today in both shallow and deep water. The third species, *Arbacia crenulata,* is a member of a genus that almost always is littoral.

FLORIDA LOCALITIES (FIG. 2)

UNNAMED POST-CALOOSAHATCHEE PRE-FORT THOMPSON UNIT

According to Druid Wilson (1962, personal communication), this unnamed unit contains the beds referred by Mansfield (1939, p. 34) to the upper Pliocene; DuBar's unit 6 (1958, p. 80) at Ortona Lock, and DuBar's unit F (1962), p. 14) at Shell Creek, which, he observed, contained a molluscan fauna considerably different from the underlying Caloosahatchee bed. Both units are included by DuBar in the Caloosahatchee formation.

Locality No.	*U.S.G.S. No.*	*Description*
1	22704	Float from road metal pit on south side of Florida route 80 southwest of town of Belle Glade, Palm Beach County.
CALOOSAHATCHEE FORMATION (BEE BRANCH MEMBER OF DUBAR IN CALOOSAHATCHEE RIVER AREA).		
2	23082	Float from north bank of Caloosahatchee River and from road metal ("La Belle") pits on north bank in SE ¼ sec. 12, T. 43 S., R. 28 E., Sears quad., Hendry County.
3	23083	Outcrops along north bank of Caloosahatchee River and in road metal ("La Belle") pits on north bank in SE ¼ sec. 12, T. 43 S., R. 28 E., Sears quad., Hendry County.
4	23085	Float from north bank of Caloosahatchee River west of Three Way Rock Co. pits, in SW ¼ sec. 6, T. 43 S., R. 29 E., La Belle quad., Hendry County.
5	23084	Float from Three Way Rock Co. pits on north bank of Caloosahatchee River in SW ¼ sec. 6, T. 43 S., R. 29 E., La Belle quad., Hendry County.
6	22373	Float in Denaud pits, in NW ¼ sec. 14, T. 43 S., R. 28 E., Sears quad., Hendry County.
7	22387	Caloosahatchee Canal (south bank), 1 mile east of bridge at La Belle, Hendry County.
8	22914	2-3 feet of outcrop above 5 feet (approx.) greenish-gray clay in west bank of canal in SE ¼ sec. 18 and NE ¼ sec. 19 (over distance of approx. 0.3 mi.), T. 40 S., R. 22 E., El Jobean quad., float and in place.

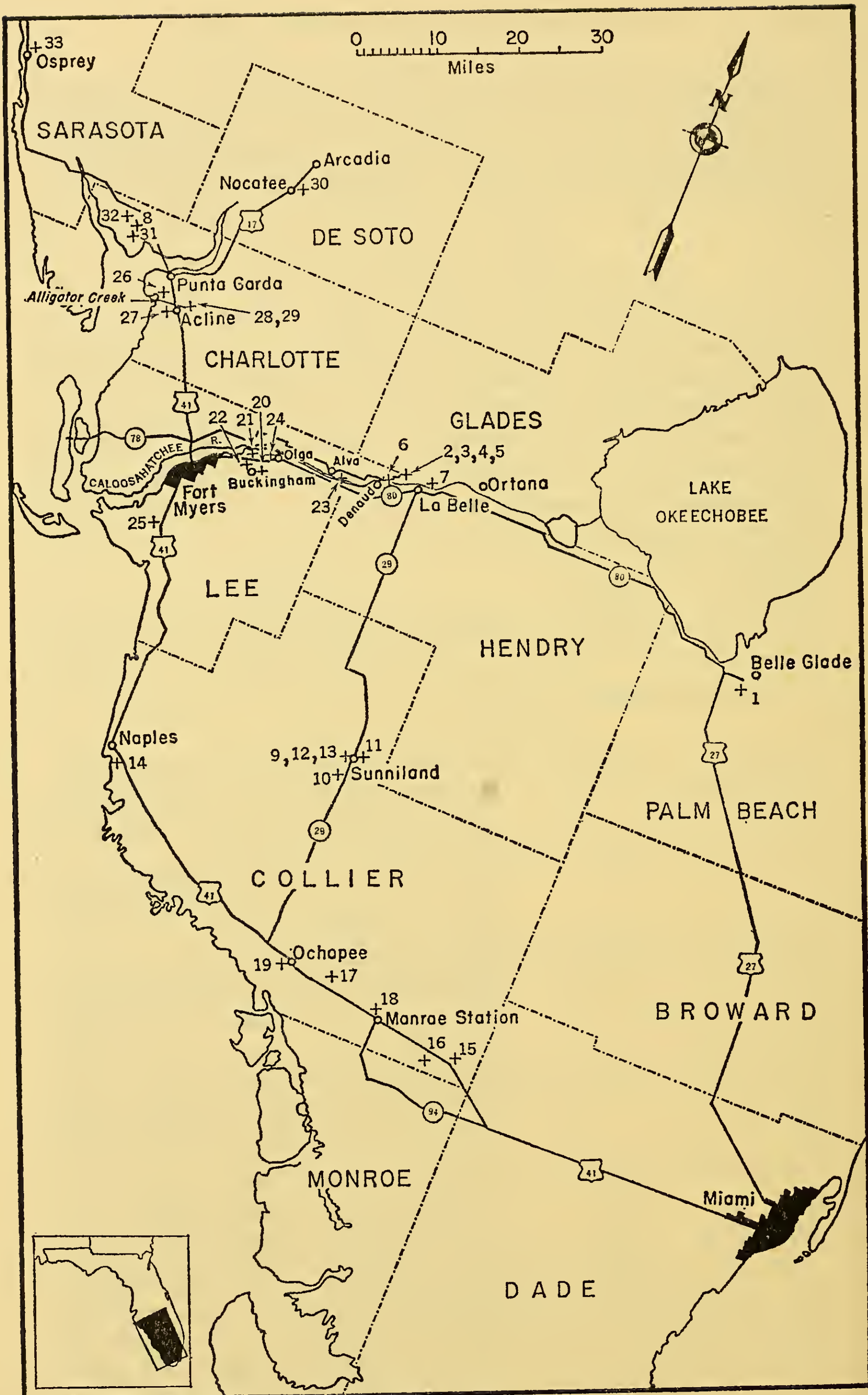


FIG. 2.—Sketch map of echinoid localities.

Locality No.	*U.S.G.S. No.*	*Description*
		TAMIAMI FORMATION (TYPICAL)
9	22587 21067	Sunniland Rock Co. pits west side of Florida route 29, Sunniland, Collier County, in NW ¼ sec. 29, T. 48 S., R. 30 E.
10	22879	Float from pits west side of Florida route 29 about 1.3 miles south of Sunniland.
11	22880	Float from pits 0.3 mile east of Florida route 29 at Sunniland, Collier County, in SE ¼ sec. 29, T. 48 S., R. 30 E.
12	22881	Float from pits about 0.5 mile west of Florida route 29 near Sunniland, Collier County, in SW¼ sec. 29, T. 48 S., R. 30 E.
13	22882	Float from pit in Sunniland Rock Co. property about 0.1 mile south of pits 0.5 mile west of Florida route 29 near Sunniland, Collier County, in SW ¼ sec. 29, T. 48 S., R. 30 E.
14	21263	Golden Shores, Naples, just south of U.S. route 41 and east of Naples Bay, NW ¼ sec. 10, T. 50 S., R. 25 E.
15	21262	North of Tamiami Trail (U.S. route 41) at point 11.7 miles east of Monroe Station.
16	21260	South side of Tamiami Trail (U.S. route 41) at a point 7.1 miles east of western intersection of U.S. route 41 and Florida route 94.
17	21091	1 mile north of Tamiami Trail (U.S. route 41) at a point 4.7 miles east of Ochopee post office.
18	21044	From pits of Sunniland Rock Co. at Monroe Station just north of Tamiami Trail (U.S. route 41).
19	22792	Float from canal in subdivision on south side of Tamiami Trail (U.S. route 41) about 0.8 mile west of Ochopee post office.
		TAMIAMI FORMATION ("BUCKINGHAM" FACIES)
20	22604 22597	Type locality of "Buckingham limestone," Buckingham, Lee County, in SW ¼ sec. 5, T. 44 S., R. 26 E.
21	21169	Spoil banks of canals at end and between Tropic Avenue and Ponciana Boulevard 10 miles east of Fort Myers at Fort Myers Shores, in NW ¼ sec. 29, T. 43 S., R. 26 E., Lee County.
22	21128	Spoil bank of pit in Baucom Ranch, south of Florida route 80 and Fort Myers Shores, in SE ¼ sec. 31, T. 43 S., R. 26 E., Lee County.
23	21066	Float from pits on east side of "County marl pits" (east side of Spanish Creek) about 1.3 miles east of Alva, just south of Florida route 78 in NW ¼ NW ¼ sec. 23, T. 43 S., R. 27 E., Lee County.

Locality No.	*U.S.G.S. No.*	*Description*
24	23086	Float from north spoil bank of canal about 0.2 mile southwest of bridge over Caloosahatchee River at Olga, Lee County, NE ¼ NE ¼ sec. 21, T. 43 S., R. 26 E., Olga quad.
25	21015	West Coast Rock Co. pits 0.3 mile west of U.S. route 41 about 8.0 miles south of Fort Myers in SW ¼ sec. 26, T. 45 S., R. 24 E., Fort Myers SW quad.
	TAMIAMI FORMATION (BARNACLE–ECHINOID–OYSTER FACIES)	
26	22454	Float from spoil banks of canals and north bank of North Fork (of Alligator Creek) west of U.S. route 41, in NE ¼ NW ¼ sec. 20, R. 23 E., T. 41 S., Punta Gorda, Sea Lanes subdivision, Punta Gorda quad.
27	21257 22315 22318	Spoil banks from group of pits in sec. 29, T. 41 S., R. 23 E., about 1 miles southwest of Acline, Charlotte County.
28	22592	Outcrop in west bank of Alligator Creek (South Prong), about 2.5 miles east of U.S. route 41 and just south of bridge on paved road in NE ¼ sec. 26, T. 41 S., R. 23 E., Cleveland quad., Charlotte County.
29	22742	From bed and banks of Alligator Creek (South Prong) northwest of bridge in NE ¼ sec. 26, T. 40 S., R. 23 E., Cleveland quad., Charlotte County.
30	21258	Spoil from borrow pit along Florida route 760, 1.6 miles east of junction of U.S. route 17 and Florida route 760 at Nocatee, in NW ¼ SE ¼ sec. 24, T. 38 S., R. 24 E. (Bergendahl, 1956, p. 74).
31	22911	Float from spoil on west side of canal in Port Charlotte area, Charlotte County, in SW ¼ sec. 20, T. 40 S., R. 22 E., El Jobean quad.; locality directly opposite eastward turn in canal.
32	22916	Float from east side of "Sam Knight" canal crossing with U.S. route 41 about 2.4 miles west of "Murdock" Station (Port Charlotte), Murdock quad., in SW ¼ sec. 2, T. 40 S., R. 21 E., Charlottee County.
	UNNAMED LATE MIOCENE FORMATION	
33	22584	Osprey, Sarasota County, float from road metal pit some distance east of U.S. route 41 just north of North Creek.

SYSTEMATICS

ARBACIA CRENULATA Kier, new species

Plate 1, figures 1-5; text figures 3-7

Diagnosis.—Species characterized by crenulated ornamentation on plates.

Material.—Thirty-one specimens most of which are extremely well preserved with all the ornamentation visible.

Shape.—Medium size, varying from a horizontal diameter of 11.8 to 42.0 mm; moderately high, with height 40 to 50 percent of diameter, height-diameter ratio constant throughout growth (text fig. 3).

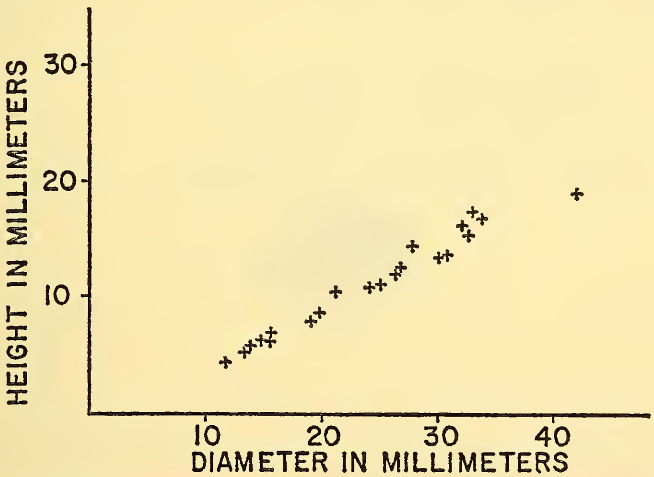


Fig. 3.—*Arbacia crenulata* Kier, new species. Height of the test relative to the diameter.

Apical system.—Preserved in 21 specimens; all oculars exsert in all specimens (text fig. 4); oculars generally pentagonal, small usually without tubercles; genital plates large with genital pore in center of each plate; periproct elongate diagonally from interambulacra 3 to 1, at greatest width between 13 to 17 percent of horizontal diameter of test.

Ambulacra.—At ambitus one-half width of interambulacra; poriferous zones straight from apical system to near margin, arcuate around large tubercles at margin, greatly widened adorally; adorally tubercles so large that pore pairs perforate bosses; ambulacral plates compound, trigeminate; in each poriferous zone 35 pore-pairs in specimen 13.8 mm in diameter, 42 in specimen 19.7 mm in diameter, 56 in specimen 30 mm in diameter; the number of primary tubercles in each ambulacrum varies from 7 in a specimen 11.8 mm in diameter to 20 in a specimen 33 mm in diameter; one large pit in each ambulacrum near peristome (pl. 1, fig. 4); primary tubercles very large adorally, but greatly reduced in size and number to ambitus.

Interambulacra.—Plates low, 22 in interambulacrum of specimen 13.8 mm in diameter, 24 in specimen 19.7 mm in diameter, 28 in specimen 30 mm in diameter; primary tubercles very small in area extending from apical system to slightly above ambitus, no tubercles in median region, one tubercle on each plate near adradial suture, in some specimens tubercles smaller on every other plate in some series; tubercles very large in area from slightly above ambitus to peristome; usually two tubercles on each plate.

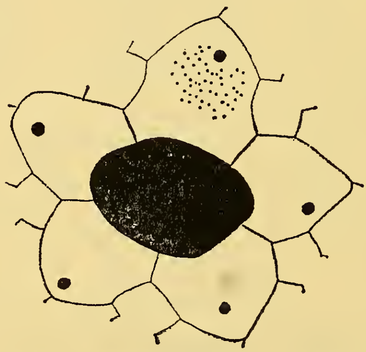


FIG. 4.—*Arbacia crenulata* Kier, new species: Apical system of holotype, U.S.N.M. 648133, from the "Buckingham facies" of the Tamiami formation, from loc. 20, × 4.

Peristome.—Very large, one-half as wide as horizontal diameter of test, pentagonal, relative size of peristome constant throughout adult growth (text fig. 5); gill slits wide, continuing considerable distance on surface of test (pl. 1, fig. 4); auricles high, slender, not joined.

Periproct.—Opening elongated along line passing through interambulacra 1 and 3; size constant throughout growth (text fig. 6).

Tuberculation.—All primary tubercles imperforate, smooth, on highly inflated bosses; surface of all plates, where tubercles do not occur, crenulated with series of narrow grooves and ridges running from apical system to peristome (pl. 1, fig. 5). Number of tubercles relative to size constant throughout growth (text fig. 7).

Comparison with other species.—This species is very similar to

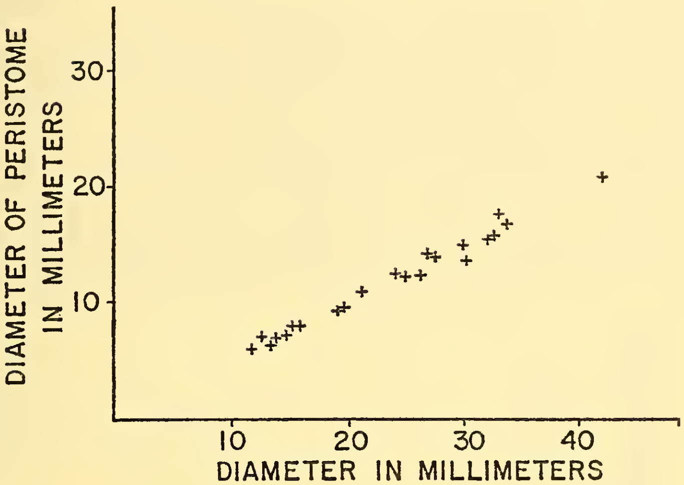


FIG. 5.—*Arbacia crenulata* Kier, new species. Diameter of the peristome relative to the diameter of the test.

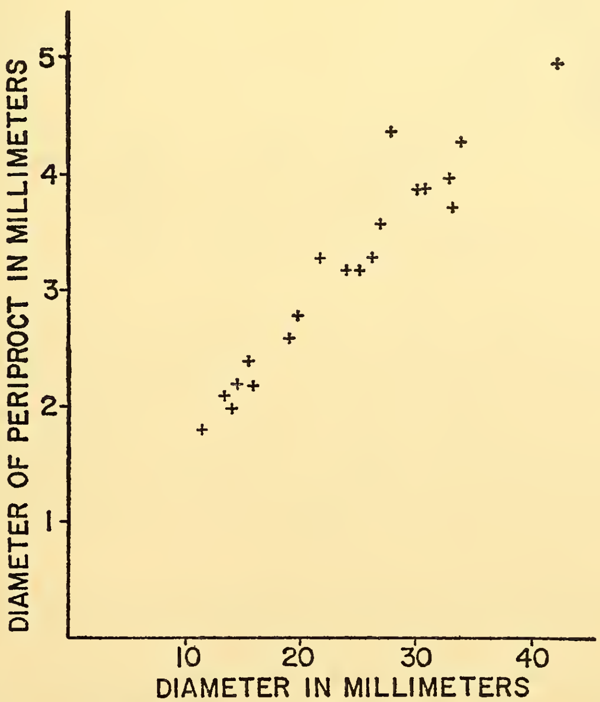


FIG. 6.—*Arbacia crenulata* Kier, new species. Diameter of the periproct relative to the diameter of the test.

Arbacia improcera (Conrad) from the upper part of the Yorktown formation (Late Miocene). Both species have the same shape, same number of tubercles in the ambulacra and interambulacra, and same number of ambulacral and interambulacral plates. *A. crenulata* differs in the surface ornamentation of the plates. In *A. crenulata* the ornamentation consists of fine crenulations (pl. 1, fig. 5) that extend adorally, whereas in *A. improcera* there are granules (pl. 1, fig. 6). Furthermore, in *A. crenulata* the naked areas in the ambulacra and interambulacra extend farther adorally than in *A. impro-*

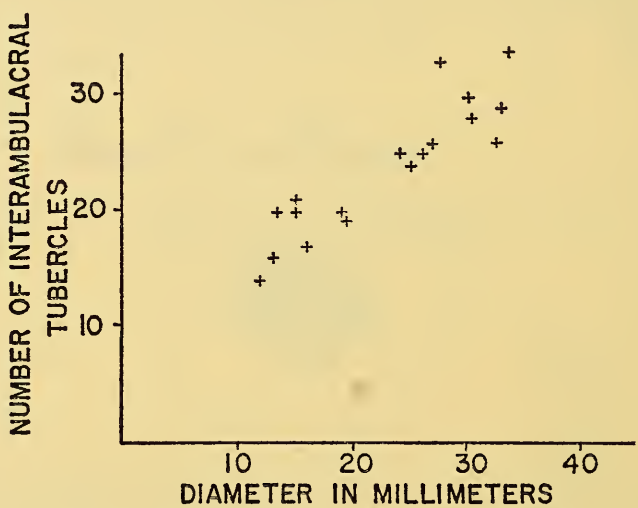


FIG. 7.—*Arbacia crenulata* Kier, new species. Number of interambulacral tubercles relative to the diameter of the test.

cera. *A. crenulata* is easily distinguished from *Arbacia waccamaw* Cooke by its much more ventral ambitus, lower interambulacral plates, and smaller adapical tubercles. It is distinguished from *Arbacia rivuli* Cooke in having fewer tubercles in the adapical interambulacra. *A. crenulata* is similar to *Arbacia sloani* (Clark) from the Late Miocene (Duplin marl) but unfortunately no well preserved specimens are known of *A. sloani,* and it is not possible to make a detailed comparison of the two species.

Occurrence.—This species is most common in the "Buckingham" facies and the barnacle–echinoid–oyster facies of the Tamiami formation. Very few specimens were collected from the typical Tamiami.

Tamiami formation: Typical Tamiami: Loc. 12, 14.

Tamiami formation, "Buckingham" facies: Loc. 20, 21, 22, 23, 24, 25.

Tamiami formation, barnacle-echinoid-oyster facies: Loc. 26, 29, 30.

Unnamed late Miocene formation: Loc. 33.

Type.—Holotype, U.S.N.M. 648133, loc. 20.

LYTECHINUS VARIEGATUS VARIEGATUS (Leske)

Plate 2, figure 3

Cidaris variegata (part) Leske, 1778, Klein's Naturalis dispositio Echinodermatum, p. 149, pl. 10, figs. B, C.

Lytechinus variegatus (Lamarck). Mortensen, 1943, Monograph of the Echinoidea, vol. 3, pt. 2, p. 437, pl. 24, figs. 1-9; pl. 25, figs. 1-12, pl. 53, figs. 1, 6, 7, 11, 13.

Lytechinus variegatus (Leske). Cooke, 1959, U. S. Geol. Surv. Prof. Paper 321, p. 15, pl. 2, figs. 12, 13.

Lytechinus variegatus (Leske). Cooke, 1961, Smithsonian Misc. Coll., vol. 142, No. 4, p. 10, pl. 5, figs. 1-2.

A detailed description and synonymy are given by Mortensen (1943, pp. 437-446). This species occurs today in the West Indies, extending as far north as North Carolina and as far south as Brazil. It was previously known as a fossil from the Pliocene San Gregorio formation in Venezuela (Cooke, 1961, p. 10). The San Gregorio specimens appear to be slightly different and may not belong to this subspecies. Cooke reports this subspecies from deposits in South Carolina which he considers to be Pleistocene.

Type.—Figured specimen, U.S.N.M. 648151.

LYTECHINUS VARIEGATUS PLURITUBERCULATUS Kier, new subspecies

Plate 2, figures 1, 2; Plate 3, figure 1; Plate 4, figure 4; text figures 8-11

Diagnosis.—Distinguished from nominate subspecies by more numerous tubercles in ambulacra.

Material.—Two specimens from the Tamiami formation; 13 from the Caloosahatchee.

Shape.—Size moderate, varying from 48 to 56 mm in horizontal diameter, height varying from 55 to 60 percent (average 57) of the diameter; marginal outline circular to subpentagonal; peristome depressed.

Apical system.—Partially preserved on only one specimen (text fig. 8), genital plates of different size, genital 5 smaller than others; ocular plates I and V broadly insert, other oculars exsert.

Ambulacra.—Ambulacra moderately broad, approximately 60 percent width of interambulacra, in specimen 54 mm in diameter 36

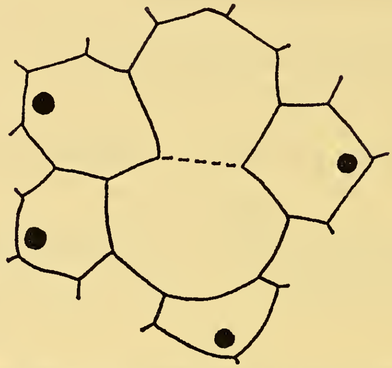


FIG. 8.—*Lytechinus variegatus plurituberculatus* Kier, new subspecies: Apical system of U.S.N.M. 648150, from the Caloosahatchee formation, loc. 6, × 4. Genital 2 absent on specimen.

plates in each series; two regular series of secondary tubercles parallel to primary series in each ambulacrum; this series extending from midway between apical system and margin to near peristome, in specimen 54 mm long from 25 to 31 secondary tubercles in each area.

Interambulacra.—Secondary tubercles well developed (text fig. 9), of approximately same size as primary; at margin in specimen 48 mm in diameter one secondary tubercle adradial to primary, two admedial; in specimen 56 mm in diameter two tubercles adradial, three admedial, number of secondary tubercles variable in different interambulacra

FIG. 9.—*Lytechinus variegatus plurituberculatus* Kier, new subspecies: Side view at ambitus showing tuberculation in U.S.N.M. 648149, from the Caloosahatchee formation, loc. 6, × 4.

in same specimen; in larger specimens doubling of adradial secondary tubercles usually in alternate plates.

Peristome.—Larger, varying from 31 to 34 percent (average 32) of diameter of test; gill slits well developed, curving toward medial line of interambulacra.

Comparison with the nominate subspecies.—This subspecies is identical in all its characters with the nominate subspecies except in the number and arrangement of the secondary tubercles in the ambulacra and the lateral distance between the primary ambulacral

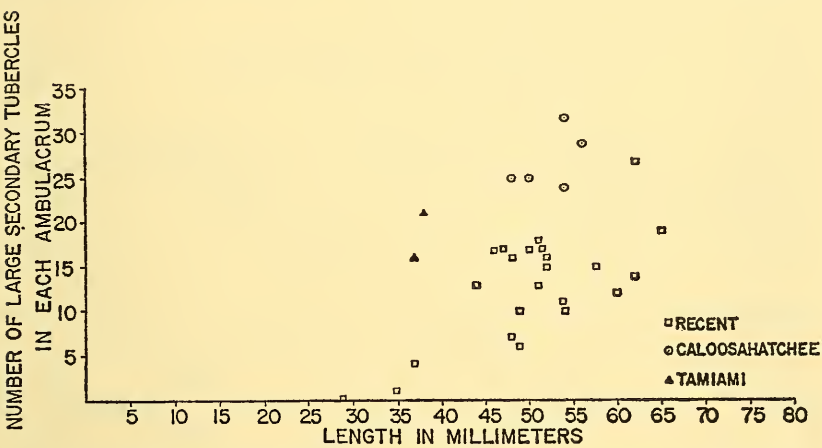


FIG. 10—*Lytechinus variegatus* (Leske). Number of large secondary tubercles in each ambulacrum relative to the length of the specimens in the Recent *L. variegatus variegatus* (Leske) and in the Caloosahatchee and Tamiami *L. variegatus plurituberculatus* Kier, new subspecies.

tubercles. In the nominate subspecies the secondary tubercles are usually irregularly arranged, alternating from either side of the median suture (pl. 2, fig. 3). In *L. variegatus plurituberculatus,* however, the secondary tubercles are in two regular series (text fig. 8; pl. 2, fig. 2). Furthermore, they are much more numerous (see scatter diagram, text fig. 10) than in the nominate subspecies. I have found only one specimen out of 59 studied of the nominate subspecies that had a double series of tubercles. Mortensen (1943, p. 440) reports that specimens with a double series of secondary tubercles are rare.

The lateral distance between the primary tubercles of the same ambulacrum is usually greater in *L. variegatus plurituberculatus* than in the nominate subspecies. In the five Caloosahatchee specimens in which this area can be seen this distance averaged 13.1 percent of the length, with a standard deviation of 0.29. In the nominate subspecies (using 59 specimens) this distance averages 11.2 percent of the length, with a standard deviation of 0.69. Even though there are so few fossil specimens the difference between this distance between the primary ambulacral tubercles is highly significant as shown in a scatter diagram (text fig. 11) and by biometric analysis. Using the

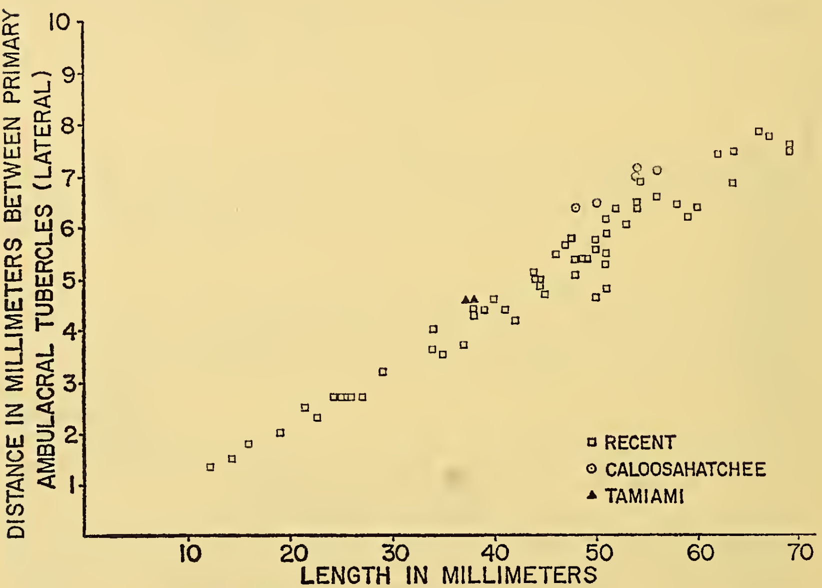


FIG. 11.—*Lytechinus variegatus* (Leske). Distance between primary ambulacral tubercles relative to length of test in specimens of *L. variegatus variegatus* (Leske) from the Recent and specimens of *L. variegatus plurituberculatus* Kier, new species, from the Caloosahatchee and Tamiami formations.

procedure recommended by Burma (1948, p. 731) and followed by Kier (1957, p. 86) a value of 12.6 was found for the difference in the means of the distance between the primary ambulacral tubercles in the two populations. Since a result of 3 or more is almost certainly significant, with the degree of probability increasing greatly with the increase of this number, it is evident that these populations are significantly different in this character. In the two Tamiami specimens the distance between the primary tubercles is less than that in the Caloosahatchee specimens but more than in the nominate subspecies, with an average of 12.15 percent of the length and a standard deviation of 0.07.

Although these differences in the number and arrangement of the tubercles are significant, there is some overlap, and some of the specimens are intermediate between the two taxa. It is for this reason, together with the great similarity between the taxa in all their other features, that these taxa are herein subspecifically rather than specifically distinguished from each other.

Occurrence.—Caloosahatchee formation, loc. 2, 6. Tamiami formation ("Buckingham" facies), loc. 20.

Types.—Holotype, U.S.N.M. 648149, loc. 6; figured specimen U.S.N.M. 648150, loc. 6.

ECHINOMETRA LUCUNTER (Linnaeus)

Plate 3, figure 2; Plate 4, figures 1-3

Echinus lucunter Linnaeus, 1758, Systema naturae, ed. 10, p. 665.

Echinometra lucunter (Linnaeus). Mortensen, 1943, Monograph of the Echinoidea, vol. 3, pt. 3, p. 357. (See this work for the pre-1943 references to this species.)

Echinometra lucunter (Linnaeus). Caso, 1948, Inst. Biol. México, vol. 19, p. 199, figs. 10-11.

Echinometra lucunter (Linnaeus). Dartevelle, 1953, Ann. Mus. Congo Belge, vol. 13, p. 38, figs. 7-8, pl. A, fig. 5, pl. i, figs. 4-6.

Echinometra lucunter (Linnaeus). Clark, 1954, Bull. U.S. Fish Comm., vol. 55, p. 374.

Echinometra lucunter (Linnaeus). Clark, 1955, Journ. West Afr. Sci. Assoc., vol. 1, p. 52.

Echinometra lucunter (Linnaeus). Bernasconi, 1955, Biol. Inst. Oceanogr. São Paulo, vol. 6, p. 62, pl. 2, figs. 1, 5.

Echinometra lucunter (Linnaeus). Tommasi, 1957, Pap. Dep. Zool. Sec. Agric. São Paulo, vol. 13, p. 29, figs. 16, 20, pl. 1, figs. 4, 6.

Remarks.—There are seven specimens which can be referred to this species. Although the fossil specimens are only slightly elongated, whereas in most of the Recent specimens the test is greatly elongated, this difference is not considered significant. According to Clark (1954, p. 374, footnote), Recent specimens are commonly circular in outline in the western part of the Gulf of Mexico.

Ecology.—This species is usually found living on rocks in the littoral zone.

Distribution.—This species is found living today in the West Indies from Florida to Brazil and off the west coast of Africa. Arnold and Clark (1934, p. 140) report it as a fossil from Jamaica, and Dartevelle (1953, p. 38) found it in the Pleistocene of Angola.

Fossil occurrence in Florida.—Caloosahatchee formation, loc. 6.

Types.—Figured specimens, U.S.N.M. 648152-3, loc. 6.

CLYPEASTER PROSTRATUS (Ravenel)

Plate 5, figures 2, 3; Plate 6, figures 1, 2; Plate 7, figures 1-4; text figures 12-17

Scutella gibbosa Ravenel, 1845, Proc. Acad. Nat. Sci. Philadelphia, vol. 2, p. 253 (not *Scutella gibbosa* Risso, 1825).

Clypeaster prostratus Ravenel. Mortensen, 1948, Monograph of the Echinoidea, vol. 4, pt. 2, p. 118, pl. 16, fig. 1; pl. 24, fig. 1; pl. 25, figs. 1, 2; pl. 26, fig. 5. (See this work for the pre-1948 references to this species.)

Clypeaster prostratus Ravenel. Cooke, 1959. U.S. Geol. Surv. Prof. Paper 321, p. 36.

Before Mortensen (1948, p. 118) this species had never been adequately described. Although Mortensen's description is thorough, it is based on only two specimens. Since 38 specimens are now available, a redescription is warranted.

Diagnosis.—Species characterized by thin pentagonal test with thick margin, flat area between end of petals and margin, and closed paired petals.

Material.—Thirty-eight specimens, all dried.

Shape.—Smallest specimen 37 mm long, largest 91, average 70 mm; wide, average width 91 percent of length; length-width ratio with little variation (text fig. 12); test pentagonal with truncated posterior margin, pointed anterior with greatest width anterior to center, in some specimens slight indentation at margin in interambulacra 4 and 1; margin thick, 6.5 mm thick in specimens 91 mm long, area between margin and ends of petals very slightly sloping, horizontal, or slightly depressed; petaloid area inflated; test low, average height 17 percent of length (text fig. 13); adoral surface flat.

Apical system.—Central (pl. 7 fig. 4), small, madreporite large, button shaped, five genital pores; ocular plates small.

Ambulacra.—Petals broad, short, extending three-fifths distance from apical system to margin; anterior petal (III) slightly longer than others, in specimen 91 mm long anterior paired petals (II, IV) shortest, approximately 9 percent shorter (25 mm long in holotype) than petal III; posterior paired petals intermediate (27.2 mm in specimen 91 mm long), 6-8 percent shorter than petal III; paired petals closed, anterior petal (III) open; interporiferous zone approximately twice width poriferous zone; number of pore-pairs varying with size, in smallest specimen (37 mm long) 37 pore-pairs in petal III, in largest (91 mm long) 61; as evident from text fig. 14, rate of addition of new pore-pairs decreasing in larger specimens; in specimen 91 mm long 59 pore-pairs in petals II or IV, 65 in petals I or V.

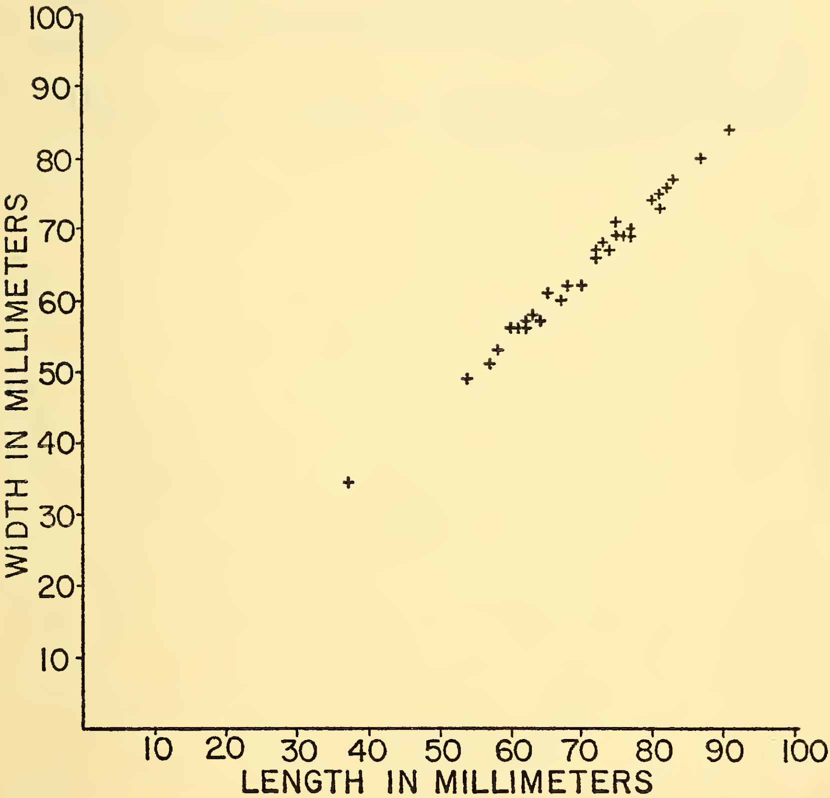


FIG. 12.—*Clypeaster prostratus* (Ravenel). Width relative to length of test.

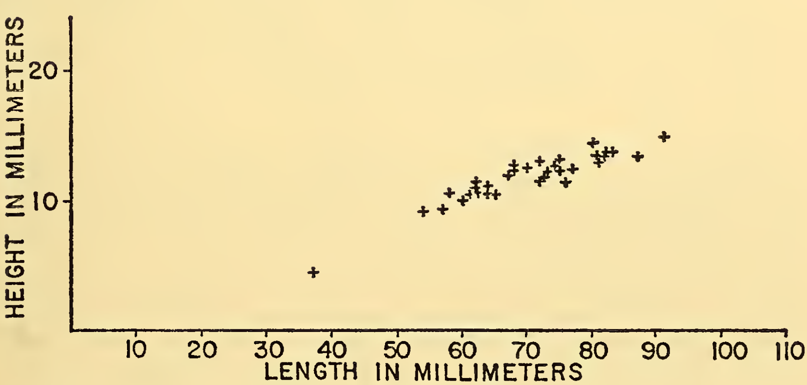


FIG. 13.—*Clypeaster prostratus* (Ravenel). Height relative to length of test.

Periproct.—Inframarginal, located near posterior margin; on holotype 3.5 mm from margin, opening irregular in shape, usually elongated transversely.

Peristome.—Central to slightly posterior, pentagonal, pointed anteriorly, truncated posteriorly.

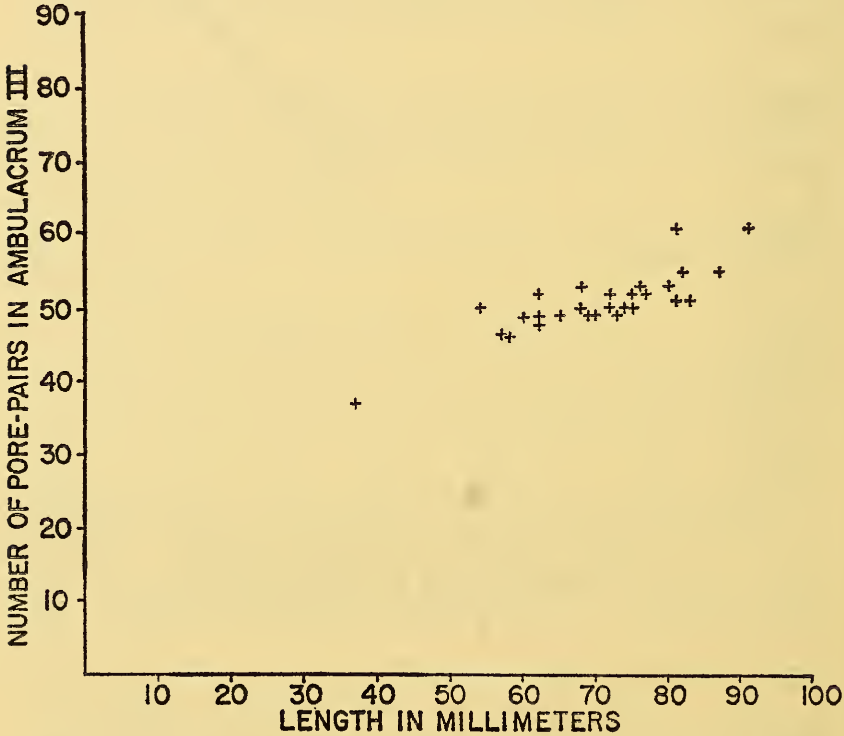
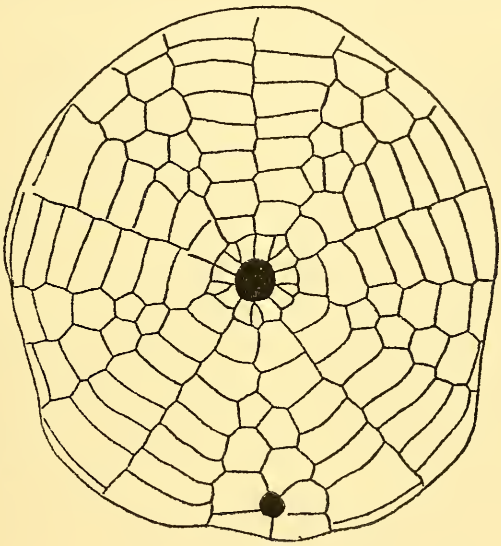


FIG. 14.—*Clypeaster prostratus* (Ravenel). Number of pore-pairs in ambulacrum III relative to length of test.

Adoral plate arrangement.—Primordial interambulacral plates much smaller than ambulacral plates, difficult to see because of extension of ambulacral plates over suture, on inside of test (text fig. 16) interambulacral plates only visible near outer edge of basicoronal plates, on outside of test (text fig. 16) plates more exposed, extending almost to peristome; basicoronal interambulacral plates separated from postbasicoronal plates by two pairs of ambulacral plates (text fig. 15); 6 to 7 ambulacral, 4 or 5 interambulacral postbasicoronal plates in each series on adoral surface.

Color.—Yellow-brown except for five brown specimens.

Comparison with other species.—This species is most similar to *Clypeaster subdepressus.* It differs in having a thicker margin, a less elongate and less inflated test, and a flatter area between the ends of the petals and the margin. Petal III in *C. prostratus* is more open and shorter relative to the other petals, and the paired petals are more constricted distally. The basicoronal interambulacral plates do not



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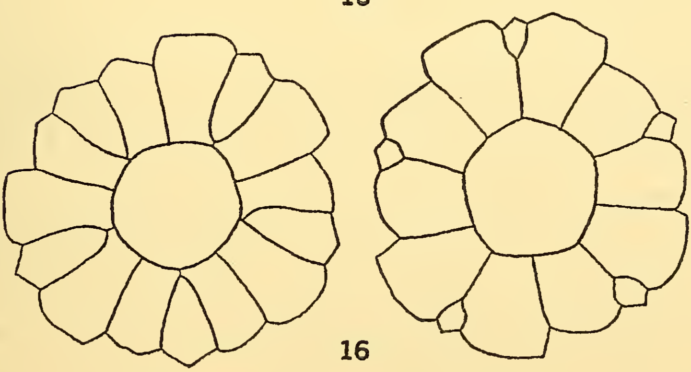

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FIGS. 15, 16.—*Clypeaster prostratus* (Ravenel) : 15, Adoral view of U.S.N.M. 648176, from the Recent, Gulf of Mexico, lat. 29° 10′ N., long. 85° 31′ W., *Albatross* station 2375, × 1; 16, exterior and interior views of basicoronal plates of U.S.N.M. 648173 from same locality as above, × 3.

extend to the peristome in *C. prostratus*. Apparently this species is smaller than *C. subdepressus*, although it is possible that no fully grown adults have been collected. *C. prostratus* resembles in its marginal outline and thick margin *Clypeaster ravenelii* (A. Agassiz). However, in *C. ravenelii* the petals are widely open.

Aberrant specimen.—One specimen is a perfect hexamerous variant belonging to Jackson's (1929, p. 541) group 18. There are six genital pores, six petals (pl. 6, fig. 1), six ambulacral grooves (pl. 6, fig. 2), and six pyramids and teeth (pl. 5, fig. 3). The plate arrangement is completely normal (text fig. 17) except that there are two extra ambulacral and two extra interambulacral series. The shape of the test is not regular and the test is not bilaterally or radially symmetrical. The anterior petal (III) can be identified because it is more open than the others. Because of the location of the periproct the petals between it and petal III on the left side of the test are normal. The extra petal is one of those lying between petals V and III on the right side of the test (as viewed adapically). There seems to have been no disruption in the production of plates, for the petals have the same number of pore pairs found in a normal specimen of this size. This aberrant form was evidently not produced by any pathological accident since all the test is hexamerous. It is probably the result of a mutation.

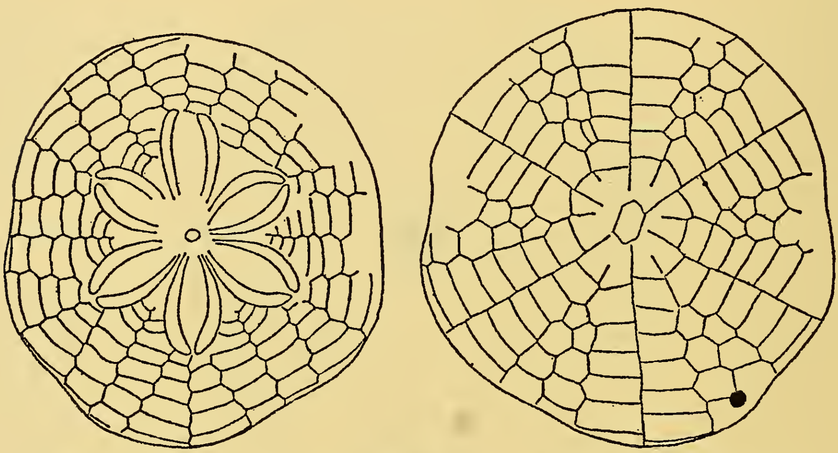


FIG. 17.—*Clypeaster prostratus* (Ravenel): Adapical and adoral views of hexamerous variant, U.S.N.M. 648174, from the Recent, Gulf of Mexico, lat. 29° 10′N., long. 35° 31′ W., *Albatross* station 2375, × 1.

Occurrence.—Living off South Carolina and Georgia and in the Gulf of Mexico with a bathymetrical distribution of 25-55 meters.

Types.—Figured specimens, U.S.N.M. 648173-5.

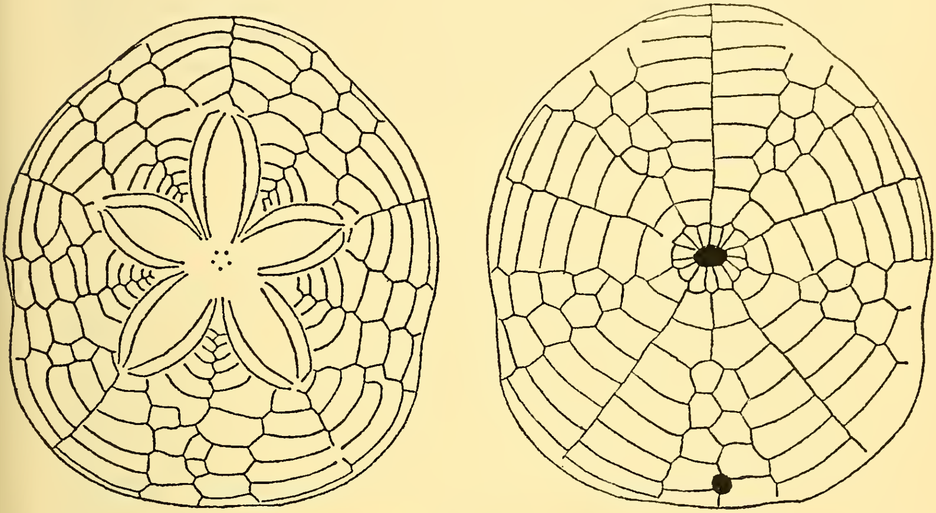


Fig. 18.—*Clypeaster subdepressus* (Gray): Adapical and adoral views of U.S.N.M. 648177, from the Recent, Gulf of Mexico, off Galveston, Tex., × ½.

CLYPEASTER SUBDEPRESSUS (Gray)

Plates 8, 9; text figure 18

Echinanthus subdepressa Gray, 1825, Ann. Philos., ser. 2, vol. 26, p. 427.

Clypeaster (*Stolonoclypus*) *subdepressus* (Gray). Mortensen, 1948, Monograph of the Echinoidea, vol. 4, pt. 2, p. 112, pl. 23, figs. 1-3; pl. 24, fig. 3; pl. 25, fig. 6; pl. 26, figs. 1-6, pl. 27, fig. 4; pl. 45, figs. 4, 11, 14, 15. (See this reference for the pre-1948 citations of this species.)

Clypeaster subdepressus (Gray). Sanchez Roig, 1949, Paleont. Cubana, vol. 1, p. 82.

Stolonoclypus subdepressus (Gray). Sanchez Roig, 1952, Revision de los Clypeasteridos Cubanos, p. 17.

Clypeaster subdepressus (Gray). Breder, 1955, Bull. Amer. Mus. Nat. Hist., vol. 106, no. 3, pl. 1, fig. 3.

Clypeaster subdepressus loculatus Bernasconi, 1956, Neotropica, vol. 2, p. 35, fig.

Clypeaster (*Stolonclypus*) *subdepressus* (Gray). Krau, 1956, Mem. Inst. Oswaldo Cruz, vol. 54, p. 415-416, figs. 5-10, 13, 15, 17, 19.

Clypeaster (*Stolonclypus*) *subdepressus* (Gray). Tommasi, 1957, Pap. Dept. Zool. Sec. Agr. São Paulo, vol. 13, p. 30-31, figs. 22-24, pl. 2, figs. 3, 4.

Clypeaster subdepressus lobulatus Bernasconi, 1958, Bol. Inst. Oceanogr. São Paulo, vol. 7, p. 122, pl. 1, figs. 4a-c.

Clypeaster subdepressus (Gray). Cooke, 1959, U.S. Geol. Surv. Prof. Paper 321, p. 36, pl. 11, figs. 2-4.

Material.—Seven specimens.

Remarks.—There is little doubt that these specimens belong to this living species. They are identical in all characters. The species is known all over the West Indies from Florida to Brazil. Sanchez Roig (1949, p. 82) reported it as fossil from the Pleistocene of Cuba. The specimens which Cooke (1959, p. 36) referred to this species are herein referred to *Clypeaster crassus* Kier, new species.

Fossil occurrence.—Caloosahatchee formation, loc. 3, 4, 6.

Types.—Figured specimen, U.S.N.M. 648162 (fossil), loc. 3; U.S.N.M. 648177 (Recent).

CLYPEASTER ROSACEUS (Linnaeus)

Echinus rosaceus Linnaeus, 1758, Systema naturae, ed. 10, p. 665.
Clypeaster rosaceus (Linnaeus). Mortensen, 1948, Monograph of the Echinoidea, vol. 4, pt. 2, p. 40, pl. 1, figs. 2-4; pl. 64, figs. 1-5. (See this work for a list of the pre-1948 references to this species.)
Clypeaster rosaceus (Linnaeus). Sanchez Roig, 1949, Paleont. Cubana, vol. 1, p. 78.
Clypeaster rosaceus (Linnaeus). Sanchez Roig, 1952, Revisión de los Clypeasteridos Cubanos, p. 9.
Clypeaster rosaceus (Linnaeus). Durham, 1955, Univ. California Publ. Geol. Sci., vol. 31, no. 4, text figs. 15a, 25a.
Clypeaster rosaceus (Linnaeus). Cooke, 1959, U.S. Geol. Surv. Prof. Paper 321, p. 34, pl. 10, figs. 1-3.
Clypeaster rosaceus (Linnaeus). Cooke, 1961, Smithsonian Misc. Coll., vol. 142, No. 4, p. 16, pl. 5, fig. 3.

CLYPEASTER ROSACEUS ROSACEUS (Linnaeus)

This subspecies has been recorded as fossil from the Miocene of Venezuela (Cooke, 1961, p. 16) and the Pleistocene of Cuba (Sanchez Roig, 1949, p. 78). It was not found in the Tamiami or Caloosahatchee formations.

Ecology.—I have observed this species off Key Biscayne, Fla., in 3 feet of water living on top of the sand sea floor. They had covered the top of their tests with sea shells and portions of the dead tests of other echinoids.

CLYPEASTER ROSACEUS DALLI (Twitchell)

Plate 10; text figures 19-23

Diplothecanthus rosaceus (Lamarck). Clark and Twitchell, 1915, U.S. Geol. Surv. Monogr. 54, p. 219, pl. 102, figs. 1a, b; pl. 103, figs. 1a, b.
Diplothecanthus dalli Twitchell, 1915, U.S. Geol. Surv. Monogr. 54, p. 218, pl. 99, figs. 2a, b; pl. 100, figs. 1a, b.

Clypeaster dalli (Twitchell). Jackson, 1922, Carnegie Inst. Washington Publ.. 306, p. 37, pl. 4, fig. 1.

Clypeaster rosaceus (Linnaeus). Cooke (part), 1942, Journ. Paleont., vol. 16, p. 11.

Clypeaster rosaceus (Linnaeus). DuBar, 1958, Florida Geol. Surv. Bull. 40, p. 209, pl. 12, fig. 17.

Clypeaster rosaceus (Linnaeus). Cooke (part), 1959, U.S. Geol. Surv. Prof. Paper 321, p. 34.

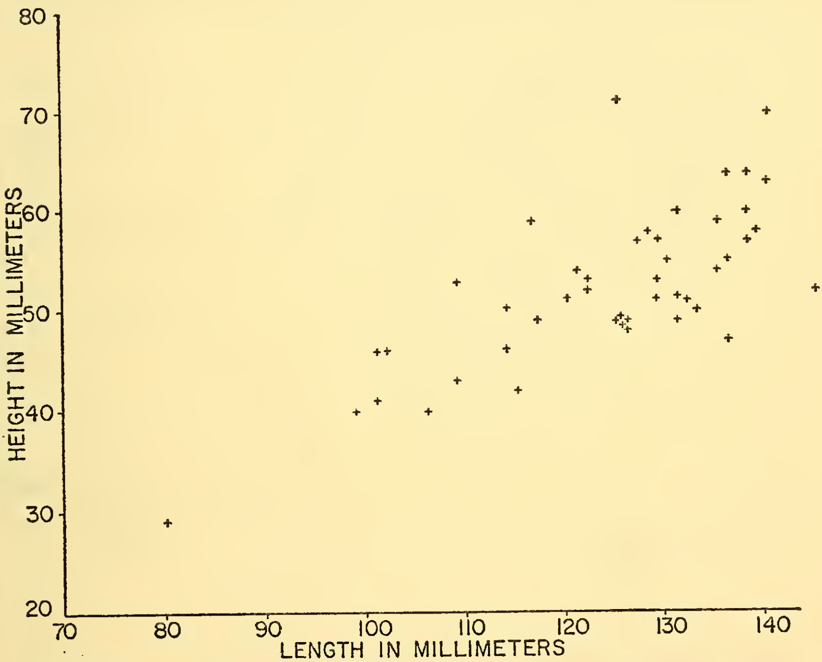


FIG. 19.—*Clypeaster rosaceus dalli* (Twitchell). Height relative to length of test.

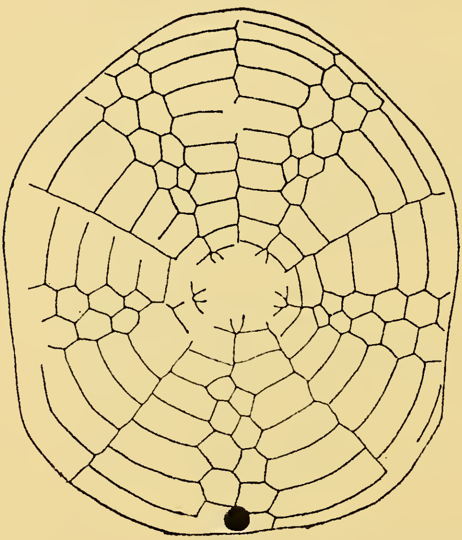
Diagnosis.—Subspecies characterized by broad test.

Material.—Sixty-nine specimens.

Shape.—Large, largest specimen 145 mm long, smallest 70 mm; elongate with width varying from 79 to 90 percent of the length; height very variable (text figs. 19, 21, 22), varying from 36 to 57 percent of the length; marginal outline variable, angularly pentagonal in some specimens, smoothly pentagonal in others; anterior margin pointed, posterior truncated, sides indented slightly in all but three specimens; petals strongly inflated in some specimens, slightly inflated in other, adorally test greatly depressed in area immediately around peristome.

Apical system.—Central, monobasal, madreporite pentagonal, genital pores small, five, varying in position from adjacent to madreporite, or far distant, occurring in interambulacra.

Ambulacra.—Petals all similar, broad, closed, long petals II, III, IV extending almost to margin, petals V, I over two-thirds distance to margin; number of pore-pairs in each poriferous zone variable; pore-pairs near apical system extremely small, difficult to see; poriferous zones only slightly depressed relative to interambulacra.



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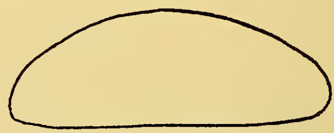

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Figs. 20-22.—*Clypeaster rosaceus dalli* (Twitchell): 20, Adoral view of U.S.N.M. 648164; 21, right side of U.S.N.M. 648165; 22, right side of U.S.N.M. 648166. All from the Caloosahatchee formation, loc. 6. All × ½.

Periproct.—Small, inframarginal, situated within 1 or 2 mm of posterior margin, at junction between fourth and fifth postbasicoronal interambulacral plates.

Adoral interambulacra.—Primiordinal interambulacral plates much smaller than ambulacral plates (text fig. 20), separated from postbasicoronal plates by two pairs of ambulacral plates; 9 or 10 postbasicornal plates in each interambulacrum adorally; 16-20 plates in each ambulacrum.

Peristome.—Central to slightly posterior, deeply depressed, circular to slightly pentagonal, opening 10 mm wide on specimen 100 mm long.

Variation.—This subspecies, as is also true of the nominate subspecies, is very variable in many of its features. The test varies in shape, from low to highly inflated, with angular to rounded marginal outline. The petals may be highly inflated or only slightly inflated. In the apical system, all the genital pores may be widely separated from the madreporite, or any number of them may be in contact with the madreporite. The characters which do not vary are the outline of the petals, the position and size of the periproct, and the extent of the depressed area around the peristome.

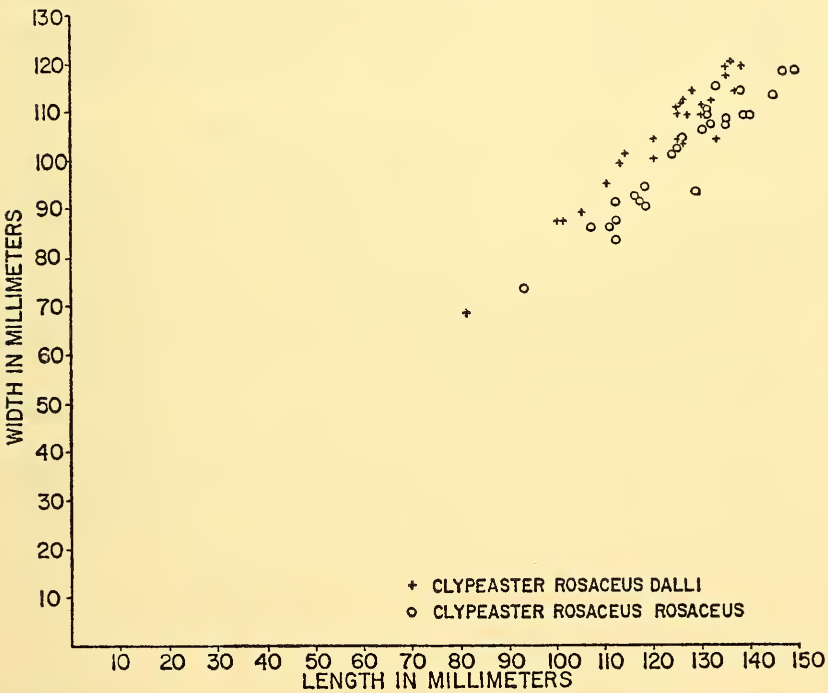


FIG. 23.—*Clypeaster rosaceus* (Linnaeus). Width of the test relative to length.

Comparison with other species.—This subspecies is distinguished from the nominate subspecies by its wider test. In all other features these specimens are indistinguishable from the nominate subspecies. Although there are some specimens of *C. rosaceus rosaceus* that are as wide as specimens of *C. rosaceus dalli,* most of them are narrower (see graph in text fig. 23). I have examined the specimen that Jackson referred to *Clypeaster dalli* and it can not be distinguished from the Caloosahatchee specimens. Jackson states that his specimen came from the Miocene or Pliocene of the Dominican Republic, but evidently this age determination is based only on the fact that the same species occurs in the Caloosahatchee.

Occurrence.—Post-Caloosahatchee, pre-Fort Thompson loc. 1. Caloosahatchee formation loc. 2, 3, 6.

Cooke (1959, p. 34) suggested that all the Florida specimens of this species came from the Pleistocene Fort Thompson formation. However, neither DuBar nor Wilson and I have ever collected any specimens of *C. rosaceus dalli* from the Fort Thompson. Wilson and I have collected several specimens of this subspecies in place in the Caloosahatchee formation (DuBar's Bee Branch member).

Types.—Holotype, U.S.N.M. 164670; figured specimens, U.S.N.M. 648163-6.

CLYPEASTER CRASSUS Kier, new species

Plate 11, figs. 1-3; text figure 24; table 1

Clypeaster subdepressus Cooke, 1942 (not Gray), Journ. Paleont., vol. 16, p. 11; pl. 4, fig. 5.

Clypeaster subdepressus Cooke (not Gray), 1959, U.S. Geol. Surv. Prof. Paper 321, p. 36, pl. 11, figs. 2-4.

Diagnosis.—Species characterized by thick margin and marginally indented interambulacra.

Material.—Three specimens from Florida; 10 from South Carolina, three well preserved.

Shape.—Smallest specimen 91 mm long, largest 126; average width 90 percent of length, average height 19 percent; test pentagonal with truncated posterior margin, pointed anterior with greatest width anterior to center; strong indentations in interambulacra 4, 5, 1; margin thick, 10 percent of length, area between margin and ends of petals flat or slightly depressed; petaloid area inflated; adoral surface flat.

Apical system.—Slightly posterior to center, five genital pores, small ocular plates, madreporite star-shaped.

Ambulacra.—Petals broad, short, extending three-fifths distance from apical system to margin; anterior petal (III) slightly longer than others (see table 1), anterior paired petals (II, IV) shortest, posterior paired petals (V, I) intermediate; interporiferous zone approximately twice width poriferous zone; approximately 60 pore-pairs in each poriferous zone (see table 1).

Periproct.—Inframarginal, located near posterior margin; on holotype (91 mm long) opening 5.5 mm from margin, opening irregular in outline, elongated transversely.

TABLE 1.—*Dimensions of 6 specimens of* Clypeaster crassus *Kier, new species*

	Length	Width	Height	Thickness of margin	Number of pore-pairs Petal III	II	I	Length of petal III	II	I
Florida	91	85	15	8.3	60	58	55	26.3	24.9	24.8
	121	108	20	9.8	..	..	..	38.5	32.5	33.3
	141	121	..	12.0	71	64	69	45.0	35.7	38.5
South Carolina	101	89	18	8.2	67	63	62	32.5	29.0	29.0
	110	101	21	10.1	67	57	60	34.5	29.6	30.3
	126	115	27	11.5	64	61	65	41.0	37.7	39.0

Peristome.—Central to slightly posterior, pentagonal, pointed anteriorly, truncated posteriorly.

Adoral plate arrangement.—Plate sutures of basicoronal plates not visible on all plates; basicoronal interambulacral plates separated from postbasicoronal plates by two pairs of ambulacral plates (text fig. 24); 7 to 8 ambulacral, 3 to 5 interambulacral postbasicoronal plates in each series on adoral surface.

Comparison with other species.—*C. crassus* is very similar to the living species *Clypeaster prostratus* and is probably an ancestor of it. It is similar in shape, size, petal arrangement, plate arrangement, and position of apical system, periproct, and peristome. It differs mainly in having a thicker margin. In *C. crassus* the margin is 10 percent of the length, whereas in the average specimen of *C. prostratus* it is 7.2 percent of the length. In *C. crassus* the interambulacra are much more strongly indented at the margin in areas 4, 5, 1, and the poriferous zones are slightly wider.

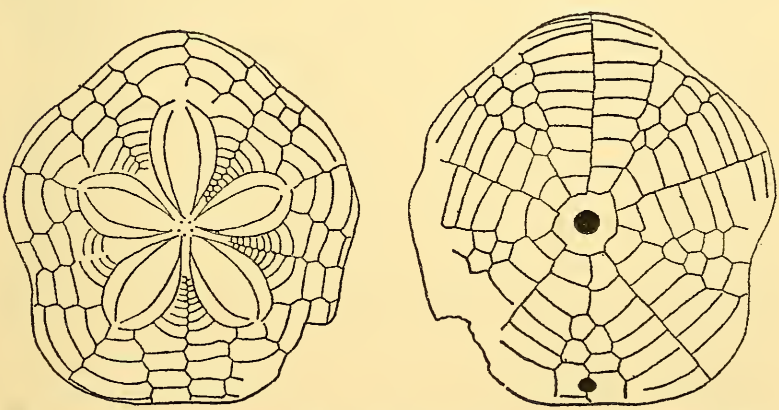


FIG. 24.—*Clypeaster crassus* Kier, new species: Adapical and adoral views of U.S.N.M. 648176, from Intracoastal Waterway Canal about 5 miles southwest of Little River, Horry County, S. C., × ½. Basicoronal plate sutures not visible.

Cooke (1959, p. 36) referred his specimens of this species from South Carolina to *Clypeaster subdepressus* Gray. However, *C. crassus* has a much thicker margin and the area between its margin and the ends of its petals is flat or depressed whereas it slopes marginally in *C. subdepressus.* In *C. crassus* petal III is more widely open and not as long relative to the other petals, and the test is less elongate and smaller.

Occurrence.—Florida, Tamiami formation, loc. 9, 10. South Carolina, U.S.G.S. 18759, Intracoastal Waterway canal 1.5 miles southwest of highway bridge near Nixons Crossroads, about 15 miles northeast of Myrtle Beach.

Types.—Holotype U.S.N.M. 648142, loc. 9; figured specimens, U.S.N.M. 648143, loc. 9, 648176, U.S.G.S. 18759.

CLYPEASTER SUNNILANDENSIS Kier, new species

Plate 3, figure 3; plates 12, 13

Diagnosis.—Species characterized by large, low, elongate test with petal III open distally.

Material.—Fourteen specimens.

Shape.—Large, largest specimen 157 mm long, smallest 119 mm, average 140 mm; test elongate, average width 85 percent of length; marginal outline pentagonal, anterior pointed, posterior truncated, interambulacra 4, 1 slightly indented at margin; area between margin and ends of petals sloping marginally; test low, average height 20 percent of length; margin thin, thickness approximately 7 percent of length; petaloid area inflated, adoral surface slightly depressed.

Apical system.—Central to slightly anterior, five genital pores, small ocular plates, madreporite star-shaped.

Ambulacra.—Petals broad, of unequal length, anterior petal (III) longest, 20 percent longer than anterior paired petals (II, IV); posterior paired petals intermediate in length; anterior petal open, gap at distal end of petal averaging 6.2 mm in width or 4.4 percent of length, posterior petals open in some specimens; interporiferous zone approximately twice width of poriferous zone; in specimen 139 mm long 75 pore-pairs in poriferous zone of petal III, 64 in petal II, 69 in petal I, in specimen 119 mm long, 68 pore-pairs in zone of petal II, 57 in petal IV.

Periproct.—Inframarginal, located near posterior margin, on specimen 130 mm long, 4.1 mm from posterior margin, opening irregular in outline, elongated transversely.

Peristome.—Central, shape not preserved on any specimen.

Adoral plate arrangement.—Plate sutures not visible on any specimen.

Comparison with other species.—*C. sunnilandensis* is identical in all characters to *C. subdepressus* except that its anterior petal (III) is open whereas in *C. subdepressus* it is closed. I examined 35 specimens of *C. subdepressus,* and in all these specimens the anterior petal was closed, whereas in all the 12 specimens of *C. sunnilandensis* in which this area was exposed the petal was open.

Occurrence.—Tamiami limestone, loc. 9, 10.

Types.—Holotype, U.S.N.M. 648135, loc. 9; figured specimen, U.S.N.M. 648134, loc. 9.

ENCOPE MICHELINI L. Agassiz

Encope michelini L. Agassiz, 1841, Monographies d'échinodermes . . . , Mon. 2, p. 58, pl. 6a, figs. 9, 10.

Encope michelini L. Agassiz. Mortensen, 1948, Monograph of the Echinoidea, vol. 4, pt. 2, p. 441, pl. 70, fig. 23. (See this reference for the pre-1948 references to this species.)

Encope michelini L. Agassiz. Cooke, 1959, U.S. Geol. Surv. Prof. Paper 321, p. 49, pl. 18, figs. 2, 3.

Encope michelini L. Agassiz. Cooke, 1961, Smithsonian Misc. Coll., vol. 142, No. 4, p. 17, pl. 6, figs. 5-6; pl. 7, fig. 5.

ENCOPE MICHELINI IMPERFORATA Kier, new subspecies

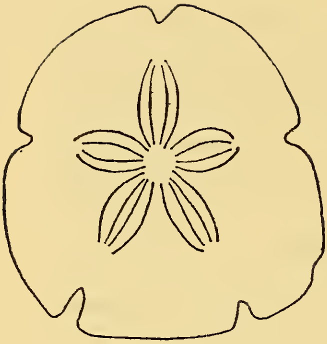
Plate 5, figure 1; Plate 6, figures 3, 4; text figures 25-30; table 2

Diagnosis.—Subspecies distinguished from nominate subspecies by absence of posterior interambulacral lunule in many specimens.

Material.—Sixteen specimens.

Shape.—From 82 to 140 mm long. Broad with width varying from 94 to 101 percent (average 96) of length; test very low varying from 7 to 12 percent (average 9) of length; greatest width posterior to center, anterior margin rounded, posterior sharply truncated; greatest height posterior to center; ambulacral notches well developed on some specimens (text figs. 25, 30), absent on others; posterior closed interambulacral lunule present in six of twelve specimens preserving area where it would occur, irregularly developed, in some specimens opening very small (text fig. 26), in others quite large (text fig. 28), usually irregular in shape, unsymmetrical; in one specimen opening in adapical surface but none in adoral; in six specimens no lunule (text figs. 25, 29, 30); adoral surface flat to slightly depressed except for slight elevation between peristome and periproct; margin sharp.

Apical system.—Slightly anterior, madreporite large, star shaped,



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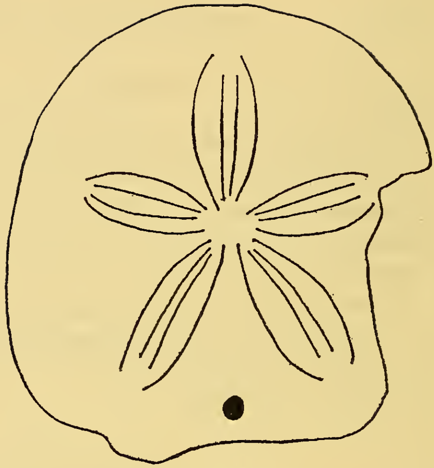

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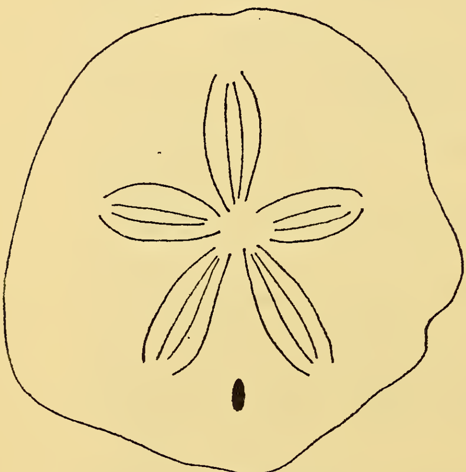

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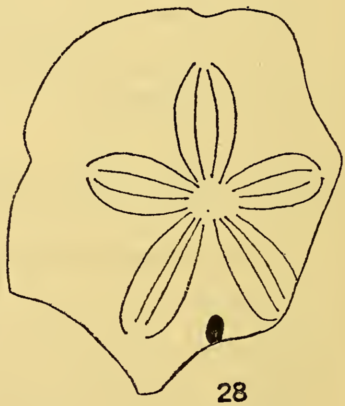

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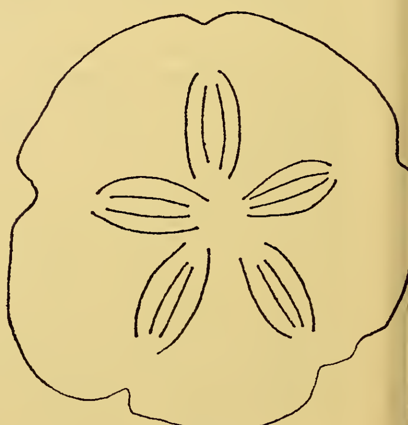

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FIGS. 25-30.—(See opposite page for legend.)

five genital pores, genital pore 5 eccentric to right on most specimens.

Ambulacra.—Petals broad, closing distally, interporiferous zone wider in petal III than in other petals; anterior petal III, posterior paired petals (V and I) of approximately same length (see table 2); anterior paired petals shorter than others, in most specimens petal II shorter than petal IV; in smallest specimen 76 pore pairs in petal III, 59 in II, 61 in IV, 82 in V or I; in larger specimen 100 mm long 92 pore pairs in petal III, 70 in II, 81 in IV, 118 in V or I.

TABLE 2.—*Encope michelini imperforata* Kier, new subspecies

	Length of petal				
Length of test	III	II	IV	V	I
109	39	..	31	41	41
100	32.5	27.3	29.2	36	..
106	33	25.1	25.1	..	..
115	36	27.2	29.4	36	36.5
122	38	32.3	32.5	39.5	39
82	23	17.1	18.4	22.3	22.4
90	32.5	16.8	17.8	22.8	..

Adoral plate arrangement.—Sutures not visible on specimens.

Periproct.—Opening longitudinal, located one-third distance from peristome to posterior margin.

Peristome.—Central, circular.

Comparison with nominate subspecies.—This subspecies is similar in all respects to the nominate subspecies except that its posterior closed lunule is quite small or entirely absent. In one-half of the specimens of *Encope michelini imperforata* the lunule is absent whereas in the nominate subspecies it is apparently always present. I examined 186 specimens of the nominate subspecies, and in all of them this lunule was present.

Remarks.—This subspecies, as with the nominate subspecies, is very variable in the shape of the test. The ambulacral notches are very well developed in many of the specimens but completely absent in others.

Occurrence.—Post-Caloosahatchee, pre-Fort Thompson, loc. 1. Caloosahatchee formation, loc. 4, 6, 7. Tamiami ("Buckingham" facies) formation, loc. 23.

Types—Holotype, U.S.N.M. 648167, loc. 2; figured specimens,

FIGS. 25-30.—*Encope michelini imperforata* Kier, new species: 25, U.S.N.M. 648169, loc. 7; 26, U.S.N.M. 648167, loc. 2; 27, U.S.N.M. 648170, loc. 4; 28, U.S.N.M. 648168, loc. 6; 29, U.S.N.M. 648171, loc. 4; 30, U.S.N.M. 648172, loc. 4. All approximately × ½.

U.S.N.M. 648169, loc. 7; U.S.N.M. 648170, 648171, 648172, loc. 4; U.S.N.M. 648168, loc. 6.

ENCOPE TAMIAMIENSIS Mansfield

Plate 14, figures 1-6; text figures 31-35

Encope macrophora (Ravenel) (part), Clark and Twitchell, 1915, U. S. Geol. Surv. Mon. 54, p. 206, pl. 94, figs. 1a-f.

Encope macrophora tamiamiensis Mansfield, 1932, U. S. Geol. Surv. Prof. Paper 170-D, p. 48, pl. 17, fig. 8.

Encope michelini Agassiz. Barry, 1941, Proc. U.S. Nat. Mus., vol. 90, pl. 65, fig. 4.

Encope tamiamiensis Mansfield. Cooke, 1942, Journ. Paleont., vol. 16, no. 1, p. 20

Encope tamiamiensis Mansfield. Cooke, 1959, U. S. Geol. Surv. Prof. Paper 321, p. 48, pl. 17, figs. 3, 4.

Diagnosis.—Species characterized by thin margin, smaller lunule, and more posterior apical system.

Material.—More than 1,000 specimens.

Shape.—Length varying from 7.6 to 122 mm; width varying from slightly wider than high to 80 percent of length, with average specimen slightly narrower than long (text fig. 31); marginal outline subcircular, truncated posteriorly; five ambulacral notches; anterior notch slight, posterior notches deep; on smallest specimens no notches; posterior notch well developed, present on all specimens, elongate, irregular in shape and size; test low, height varying from 10 to 20 percent with an average of 14 percent of the length (text fig. 32), greatest height posterior of center at anterior edge of lunule; margin very sharp with test thin at margin; adoral surface evenly concave.

Apical system.—Anterior (text fig. 33) distance from anterior margin to apical system approximately 40 percent of length of test; large central star-shaped madreporite with five genital pores, genital pore 5 usually eccentric to right (pl. 14, fig. 5).

Ambulacra.—Anterior petals II, III, IV lanceolate, straight, of approximately equal length, with interporiferous zones wider, equal to or narrower than poriferous zones; posterior petals V and I longer, curving posteriorly, interporiferous zones narower than poriferous. In specimen 75 mm long 70 pore-pairs in each poriferous zone in petal III; 62 in petals II or IV; 80 in petals V or I; rate of introduction of new pore-pairs decreases with growth (text fig. 34.).

Periproct.—Opening small, elongate, located at anterior edge of lunule at inner margin of first pair of postbasicoronal plates in most specimens, in several not in lunule but anterior to it.

Peristome.—Anterior, small opening, subcircular; food grooves bifurcating near peristome, one or two lateral branches to each groove.

Adoral plate arrangement.—Basicoronal plates small (text fig. 35), interambulacral plates larger than ambulacral, posterior interambulacral plate considerably larger than others; paired interambulacra

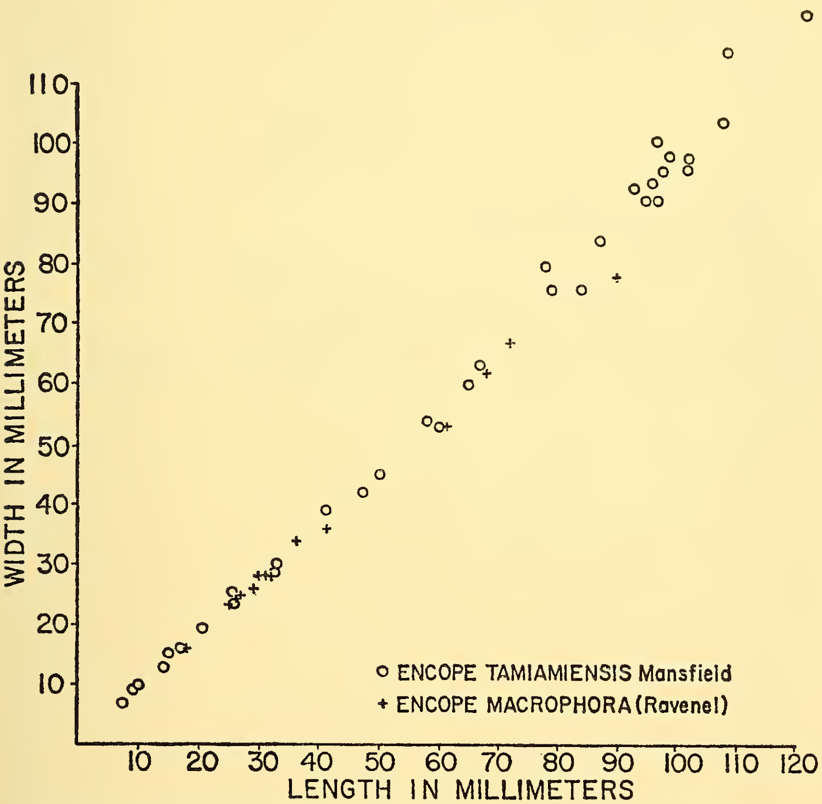

FIG. 31.—*Encope tamiamiensis* Mansfield, *Encope macrophora* (Ravenel). Width of test relative to length of test.

separated from basicoronal plates by first pair of postbasicoronal ambulacral plates; posterior interambulacrum in contact with basicoronal plate; interambulacra with 3 or 4 postbasicoronal plates in each column; ambulacra with 6 or 7 postbasicoronal plates to each column.

Growth.—On the smallest specimen, 7.6 mm long, the posterior notches are very slightly developed and there are no anterior notches. The posterior lunule is very small. The first anterior notches occur in a specimen 14.2 mm long, where they are only slightly developed.

The posterior petals are straight in all the smaller specimens (pl. 14, fig. 1), but curve posteriorly in all the specimens over 17 mm long. There are no genital pores in any of the specimens less than 20 mm long.

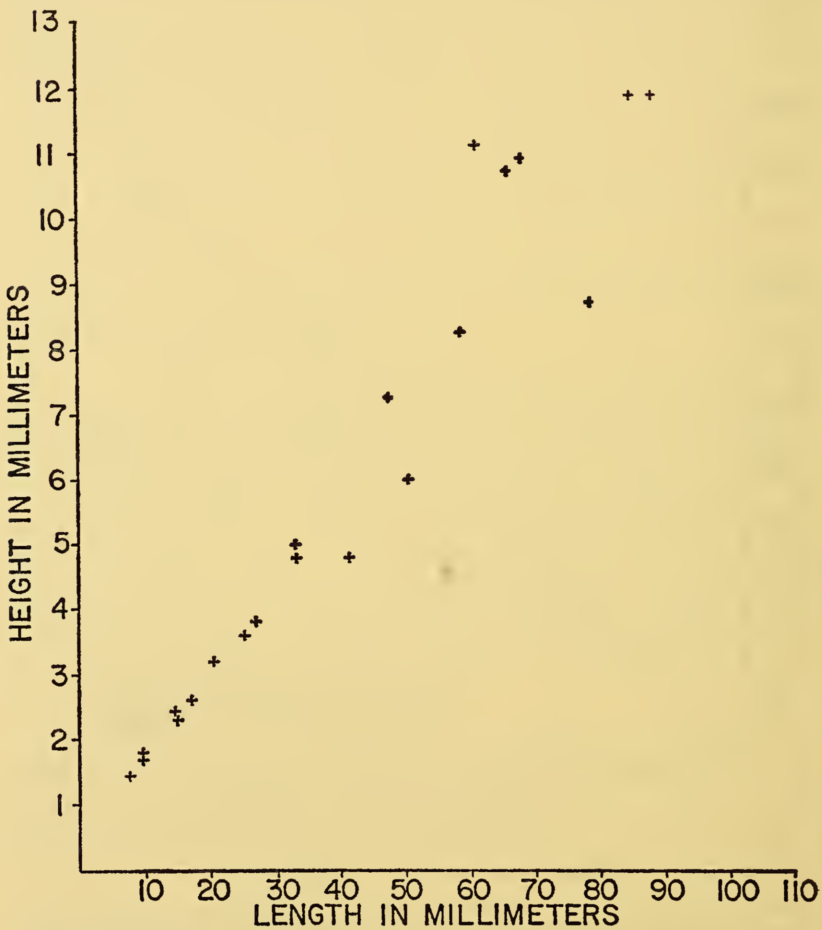

FIG. 32.—*Encope tamiamiensis* Mansfield. Height of test relative to length of test.

Variation.—The posterior lunule is very variable in its outline and size. In many of the specimens it is not symmetrical. Genital pore 5 is eccentric to the right in most of the specimens. In a population of 25, 23 of the specimens had an eccentric pore and in only two was the pore not eccentric.

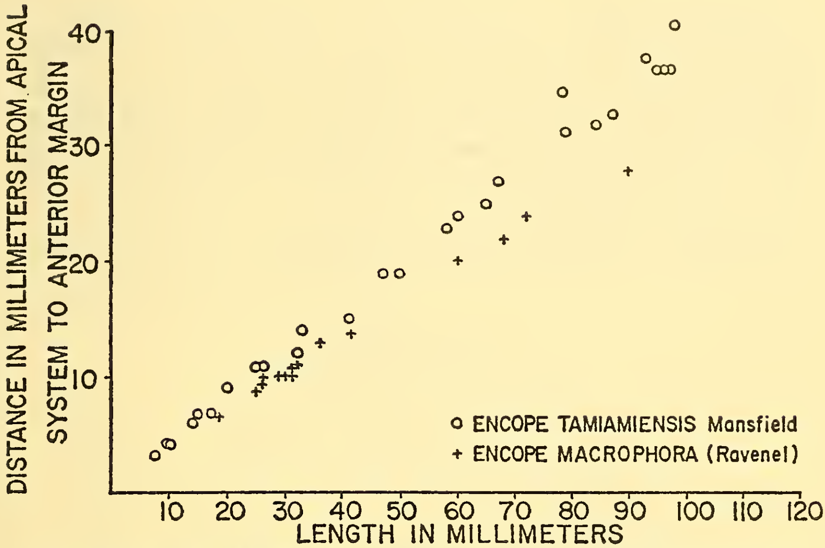

FIG. 33.—*Encope tamiamiensis* Mansfield, *Encope macrophora* (Ravenel). Distance of apical system from anterior margin relative to the length of the test.

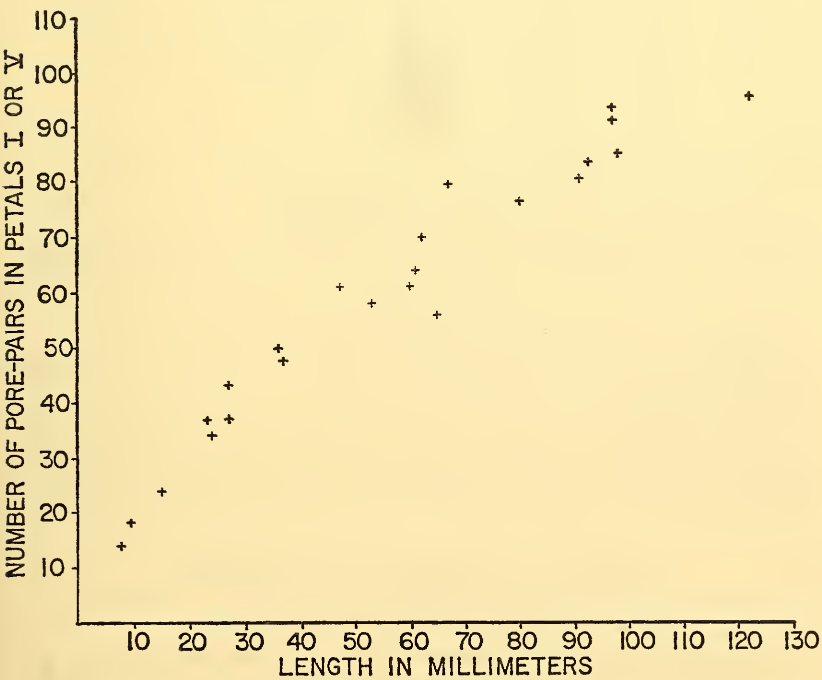

FIG. 34.—*Encope tamiamiensis* Mansfield. Number of pore-pairs in petals I or V relative to length of test.

Comparison with other species.—*E. tamiamiensis* is similar to *Encope macrophora* (Ravenel) from the Late Miocene of South Carolina. However, in *E. tamiamiensis* the margin is thinner, the lunule is smaller, and the apical system is less anterior (text fig. 33). Furthermore, in *E. tamiamiensis* the anterior paired petals (II and IV) are less curved posteriorly. Both species have the same length-width ratio (text fig. 31).

Occurrence.—Tamiami formation (typical), loc. 9, 10, 11, 14, 15, 17, 18, 19.

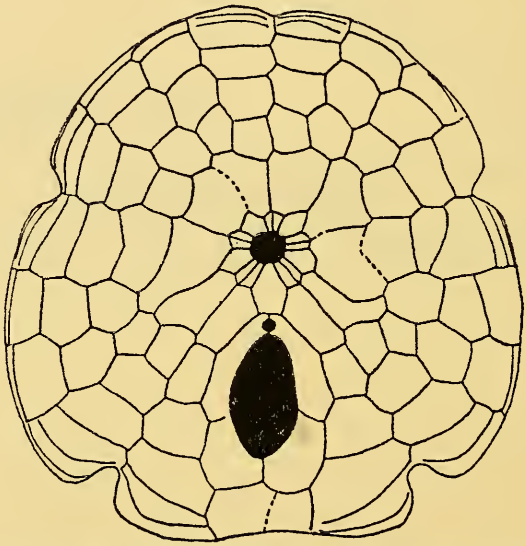

FIG. 35.—*Encope tamiamiensis* Mansfield: Adoral view of U.S.N.M. 648141, from the Tamiami formation, loc. 31, × 1.

Tamiami formation ("Buckingham" facies), loc. 20.

Tamiami formation (barnacle-echinoid-oyster facies), loc. 26, 27, 28, 29, 31, 32.

Types.—Figured specimens, U.S.N.M. 648137, loc. 27; U.S.N.M. 648138, loc. 26; U.S.N.M. 648139; loc. 11; U.S.N.M. 648140-1, loc. 31.

MELLITA ACLINENSIS Kier, new species

Plate 15, figures 1-3; text figures 36-41; tables 3, 4

Diagnosis.—Species characterized by five ambulacral lunules.

Material.—Eleven nearly complete specimens and many fragments.

Shape.—Smallest specimen 16.5 mm long, largest 73 mm (see table 3 for dimensions); margin subcircular except for truncated posterior margin on some specimens; width approximately equal to length; test very low with thin sharp margin; adoral surface flat to slightly concave; 5 elongate ambulacral lunules in large specimens, lunule in ambulacrum III smaller than others; lunule in posterior interambulacrum very elongate, extending far between petals.

Apical system.—Slightly anterior, distance from anterior margin to apical system approximately 45 percent of length of test; large madreporite; four genital pores.

TABLE 3.—*Dimensions of 11 specimens of* Mellita aclinensis *Kier, new species*

Length mm	Width mm	Height mm	Length of petal III mm	II mm	I mm
16.5	16.3	2.4	4.0	3.8	4.3
21.8	22.5	2.7	...	4.4	6.1
22.7	23.0	3.1	5.7	5.0	6.3
24.0	23.6	3.2	5.9	5.4	6.4
25.7	25.5	3.3	6.0	5.5	...
30.0	32.7	4.0	7.9	7.4	9.1
31.7	31.4	4.1	8.5	8.3	8.9
35.0	37.0	5.0	9.2	7.7	9.8
44.0	...	...	10.5	10.0	12.1
...	56.0	5.6	11.2	11.3	15.3
73.0	...	...	...	...	...

Ambulacra.—Anterior petals II, III, IV lanceolate, straight, petal III longer, extending almost two-thirds distance from apical system to anterior margin, petals II and IV only halfway to margin; posterior petals V and I longer than anterior petals, not straight but curving posteriorly; in all petals poriferous zone equal in width to interporiferous; petals almost closed; in specimen 35 mm long, 34 pore pairs in single poriferous zone of petals II, III, IV, 47 in petals V or I. Adorally, five pairs of food grooves extending from peristome to near margin (pl. 15, fig. 3); area circumscribed by pair of grooves expanding distally with greatest width near lunule, constricted distal to lunule; area broad between adjacent pairs of grooves. Secondary pores difficult to see in most specimens, apparently confined to area circumscribed by food grooves.

Periproct.—Opening small, elongate, located at anterior edge of lunule.

Peristome.—Anterior, small, subcircular to pentagonal, food grooves bifurcating near peristome.

Adoral plate arrangement.—Basicoronal plates small (text fig. 36); adoral-most plate of interambulacrum 5 considerably larger than other basicoronal plates; paired interambulacra separated from basicoronal plates by one pair of ambulacral plates, three postbasicoronal plates in each column on adoral surface; first pair of postbasicoronal interambulacral plates elongate; posterior interambulacrum in contact with basicoronal plates; half of periproct within basicoronal interambulacral plate; first postbasicoronal plate of posterior interambulacrum extending length of lunule.

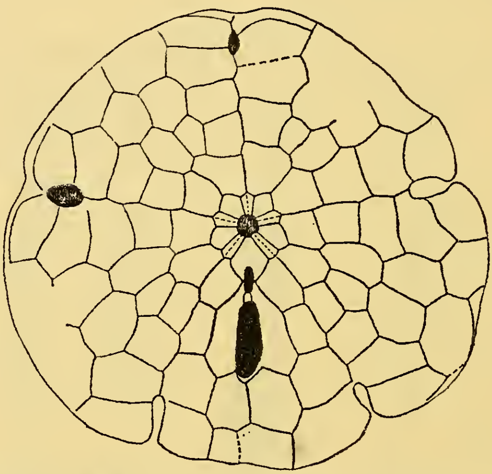

FIG. 36.—*Mellita aclinensis* Kier, new species: adoral view of U.S.N.M. 648192, from the Tamiami formation, loc. 27. × 2.

Aberrant specimen.—In one of the specimens the anterior ambulacrum (III) is not fully developed (text fig. 37). The plate arrangement is normal adoral to the tip of the petal, but there are no ambulacral plates between the apical system and the tip of this petal. Evidently production of ambulacral plates ceased after the first few petaloid plates had been formed and the resulting gap was filled by the prolongation of the interambulacral plates which would normally be adjacent to this ambulacrum.

Ontogeny.—The ambulacral lunules are not present in the smallest specimen, 16.5 mm long (text fig. 38), but there are slight marginal notches in ambulacra II and IV and more developed notches in V and I. In a specimen 21.8 mm. long (text fig. 39) there are deep notches in the paired ambulacra, with the notches in ambulacra II and IV almost closed, and in a specimen 24.0 mm long (text fig. 40) there are lunules in all the paired ambulacra. A lunule in ambulacrum III is present in a specimen 35.0 mm long (text fig. 41).

Comparison with other species.—This species is distinguished from all the other species of the genus in having in adult specimens five instead of four ambulacral lunules.

Remarks.—Previously all species of the Mellitidae having four genital pores and five ambulacral lunules have been referred to *Leodia*. Although this species has five ambulacral lunules, it has all

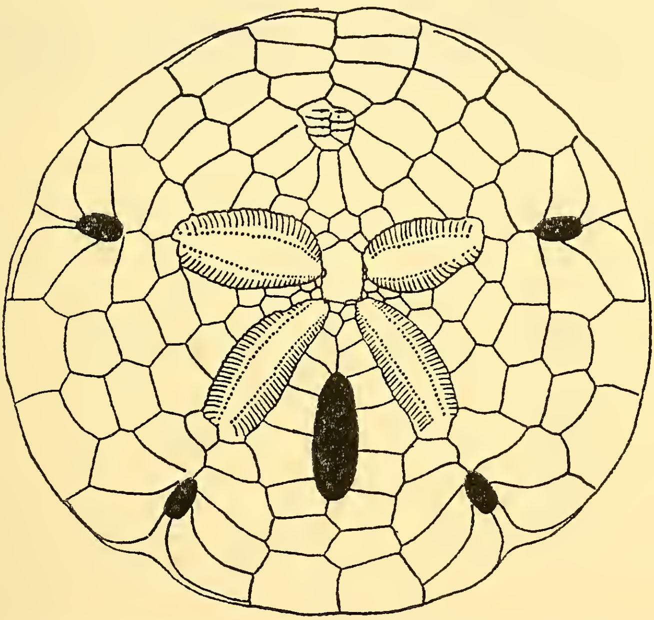

FIG. 37.—*Mellita aclinensis* Kier, new species: Adapical view of abnormal specimen U.S.N.M. 648193, from the Tamiami formation, loc. 27, × 3.

the other characters of *Mellita* that distinguish this genus from *Leodia* (see table 4). Therefore it seems reasonable to consider this a species of *Mellita*, and to broaden the generic concept of the genus to include species having five ambulacral lunules.

Durham (1961, p. 3) predicted that *Mellita* would be found in the Miocene and Pliocene of the Neotropical region: "In view of its occurrence only in the tropical and warm temperate areas of the western Atlantic and eastern Pacific, it is evident that *Mellita* must have a fossil record extending back to at least the upper Miocene when the Central American seaways were open (Durham and Alli-

TABLE 4.—*Characters distinguishing* Mellita *from* Leodia

Mellita	Leodia
Four ambulacral lunules	*Five ambulacral lunules
*Posterior lunule extending far anteriorly between posterior petals	Posterior lunule not extending far anteriorly between posterior petals
*Paired interambulacra separated from basicoronal row by one pair of ambulacral plates	Paired interambulacra separated from basicoronal row by two pairs of ambulacral plates
*Periproct partly within basicoronal interambulacral plate	Periproct outside basicoronal plate
*First pair of post-basicoronal plates in paired interambulacra elongate	First pair of postbasicoronal plates in paired interambulacra short
*Lunules formed by closing of marginal notches	Lunules formed by resorption of test

The characters marked with an asterisk occur in *Mellita aclinensis.*


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FIGS. 38-41.—*Mellita aclinensis* Kier, new species: Growth series showing development of lunules: 38, U.S.N.M. 648189; 39, U.S.N.M. 648190; 40, U.S.N.M. 648191; 41, U.S.N.M. 648136. From the Tamiami formation, loc. 27, all × 1½.

son, 1960 pp. 66–67), permitting migration from the Panamic to the Caribbean area or vice versa."

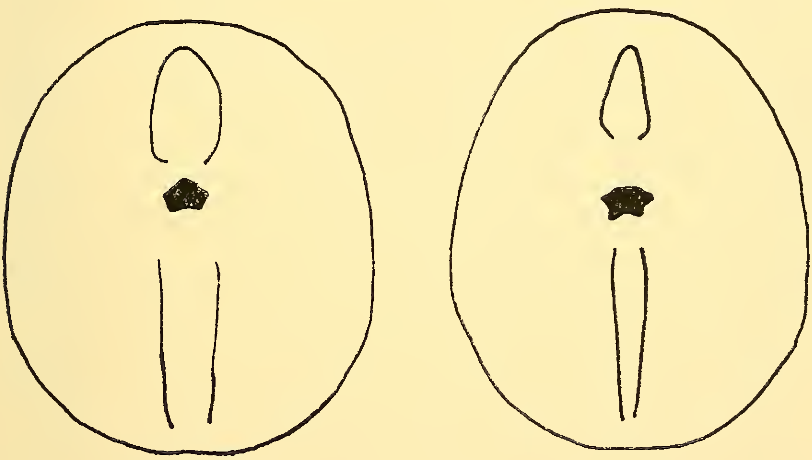
Occurrence.—Tamiami formation (barnacle-echinoid-oyster facies), loc. 27.

Types.—Holotype, U.S.N.M. 648136; figured specimens, U.S.N.M. 648189-648193.

RHYNCHOLAMPAS AYRESI Kier, new species

Plate 16, figures 3-6; text figures 43-46

Diagnosis.—Species characterized by highly inflated adapical surface, steep sides, smooth marginal outline, narrow naked zone in interambulacrum 5, narrow phyllode III.



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FIGS. 42, 43.—*Rhyncholampas evergladensis* (Mansfield): 42, Adoral view of U.S.N.M. 648148, from the Tamiami formation, loc. 9; 43, *Rhyncholampas ayresi* Kier, new species: Adoral view of U.S.N.M. 648160, from the Caloosahatchee formation, loc. 6. These two drawings show the difference in the width of the naked zones in ambulacrum III and interambulacrum 5.

Material.—Twenty-seven specimens.

Shape.—Varying in length from 54 to 65 mm, average 63 mm, in smaller specimens width approximately 85 percent of length, in larger 90 percent of length (text fig. 44) with greatest width posterior to center (text fig. 43); adapical surface highly inflated with steeply sloping sides, height averaging 55 percent of length (text fig. 45); adoral surface flat or in few specimens slightly depressed around peristome.

Apical system.—Anterior, four genital pores, compact.

Ambulacra.—Petals well developed, broad, lanceolate, with greatest width one-third distance from apical system to end of petal, all petals of approximately equal length, petals II, IV wider than others, petal III narrower, 43 to 45 pore-pairs in posterior zones of petal II or IV in specimens 54 to 60 mm long; poriferous zones of unequal

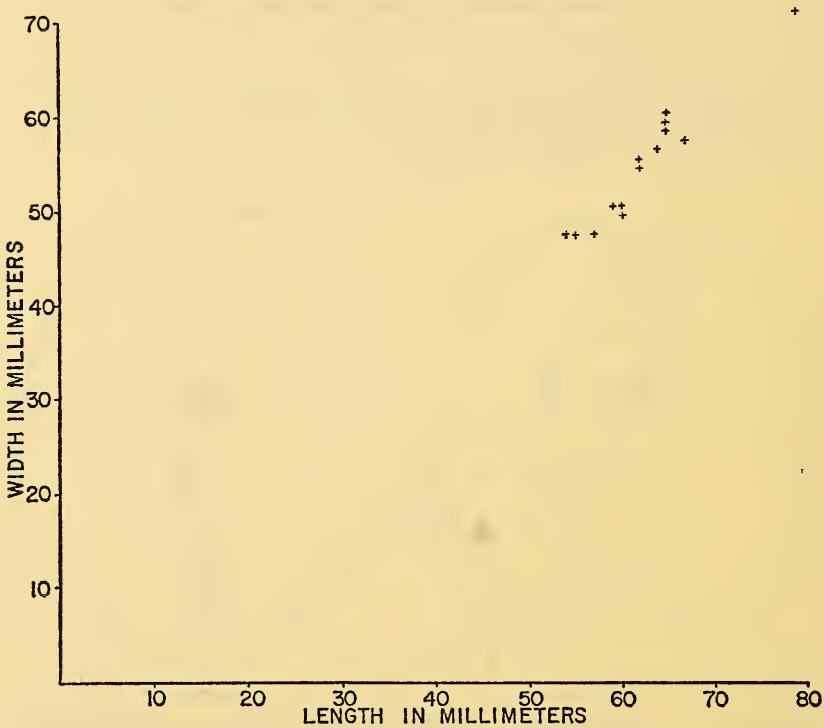


FIG. 44.—*Rhyncholampas ayresi* Kier, new species. Width relative to length of test.

length with one to three more pore-pairs in right poriferous zone of petal II, posterior zones of petals II, IV, and anterior poriferous zones of petals V, I; single pores in ambulacral plates beyond petals.

Periproct.—Supramarginal, wider than high, with slight groove extending from opening to posterior margin.

Peristome.—Anterior, pentagonal, depressed, wider than high.

Floscelle.—Phyllodes well developed, broad (text fig. 46), approximately 30 pores in each phyllode, with 10 in each outer series, 4-6 irregularly arranged in each inner. Buccal pores present. Bourrelets very prominent (pl. 16, fig. 6), pointed.

Tuberculation.—Tubercles adorally much larger than adapically, narrow naked granular zone (text fig. 43) in median area of interambulacrum 5 and ambulacrum III adorally.

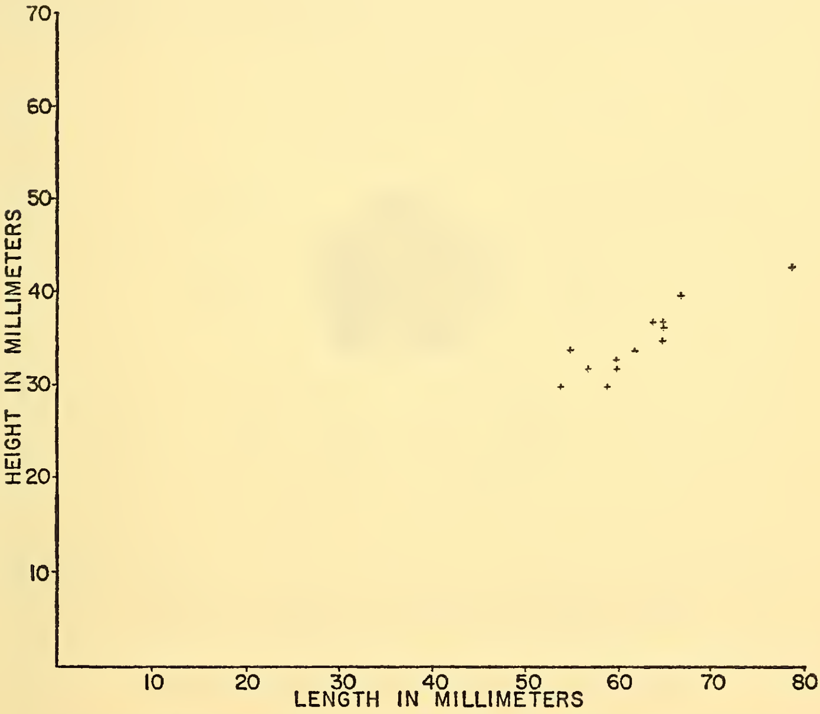


Fig. 45.—*Rhyncholampas ayresi* Kier, new species. Height relative to length of test.

Comparison.—This species is distinguished from *Rhyncholampas evergladensis* by having more of its adapical surface inflated, by its steeper sloping sides, less pointed adapical surface, and less angular marginal outline. The adoral surface in *R. ayresi* is less depressed, the naked zone in interambulacrum 5 is narrower (text fig. 43), and phyllode III is narrower.

Remarks.—The specimens from South Carolina that Cooke (1959, pl. 23, figs. 8-14) referred to *Cassidulus sabistonensis* Kellum seem to be intermediate between *R. ayresi* and *R. evergladensis.* Further study is necessary before these specimens can be definitely assigned.

Occurrence.—Caloosahatchee formation, loc. 2, 3, 4, 6.

Types.—Holotype, U.S.N.M. 648160, loc. 6; figured specimen, U.S.N.M. 648161, loc. 6.

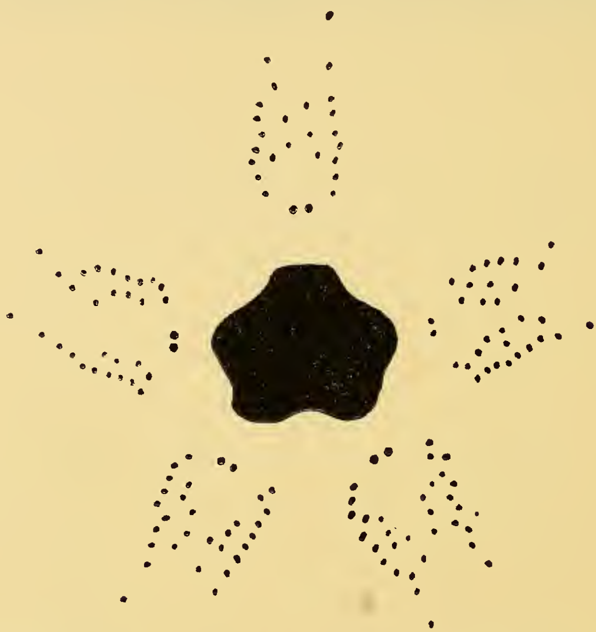


FIG. 46.—*Rhyncholampas ayresi* Kier, new species: Floscelle of U.S.N.M. 648161, from the Caloosahatchee formation, loc. 6, × 5.

RHYNCHOLAMPAS EVERGLADENSIS (Mansfield)

Plate 17, figures 1-5; text figures 42, 47-50

Cassidulus (*Rhynchopygus ?*) evergladensis Mansfield, 1932, U. S. Geol. Surv. Prof. Paper 170, p. 48, pl. 18, figs. 1-10.
Cassidulus (*Cassidulus*) *evergladensis* Mansfield. Cooke, 1942, Journ. Paleont. vol. 16, no. 1, p. 30, pl. 8, figs. 5, 6.
Cassidulus sabistonensis Cooke, 1959, U. S. Geol. Surv. Prof. Paper 321, p. 57 (in part); not *Cassidulus sabistonensis* Kellum.

Diagnosis.—Species characterized by angular marginal outline, gently sloping sides, depressed adoral surface, wide naked zone in interambulacrum 5, and wide phyllode III.

Material.—One hundred and one specimens.

Shape.—Large, varying from 35 to 97 mm in length; width fairly constant, usually approximately 83 per cent of length (text fig. 47);

greatest width at midlength or posterior to midlength; margin usually slightly angular but in some specimens smooth, anterior, posterior slightly truncated; heights variable, some specimens considerably higher than others with height varying from 44 to 58 percent of the height, larger specimens usually slightly lower than smaller (text fig. 48); greatest height central to slightly anterior, usually at apical system; sides gently curving, in some specimens curving sharply at margin; adoral surface concave.

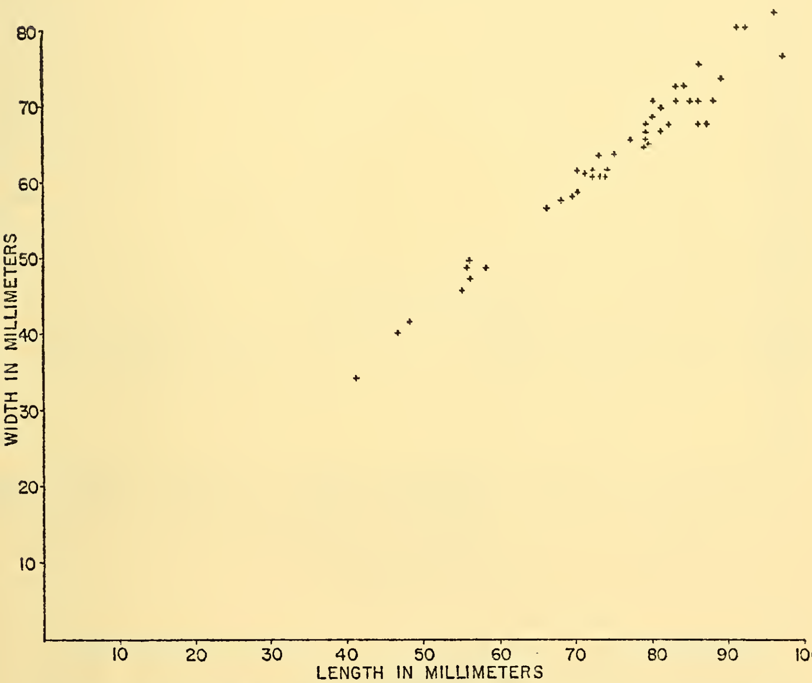


FIG. 47.—*Rhyncholampas evergladensis* (Mansfield). Width of the test relative to the length.

Apical system.—Anterior, four genital pores, compact (pl. 17, fig. 3).

Ambulacra.—Petals well developed, broad, with greatest width one-third distance from apical system to end of petal, petals of approximately equal length, petals II, IV wider than other petals, petal III narrower; poriferous zones of unequal length, one to three more pore-pairs in right poriferous zones of petal III, posterior poriferous zones of petals II, IV, anterior poriferous zones of petals V, I; number of pores variable, specimens 80 mm long having from 44 to 53 pore-pairs in posterior poriferous zone of petal II or IV; fewer pores in smaller specimens with 37 pore-pairs in posterior poriferous zone of petal II of specimen 35 mm long, very few pore-pairs added in specimens over 70 mm long (text fig. 49); single pores in ambulacral plates beyond petals.

Periproct.—Supermarginal, wider than high, shallow grove extending from opening to posterior margin.

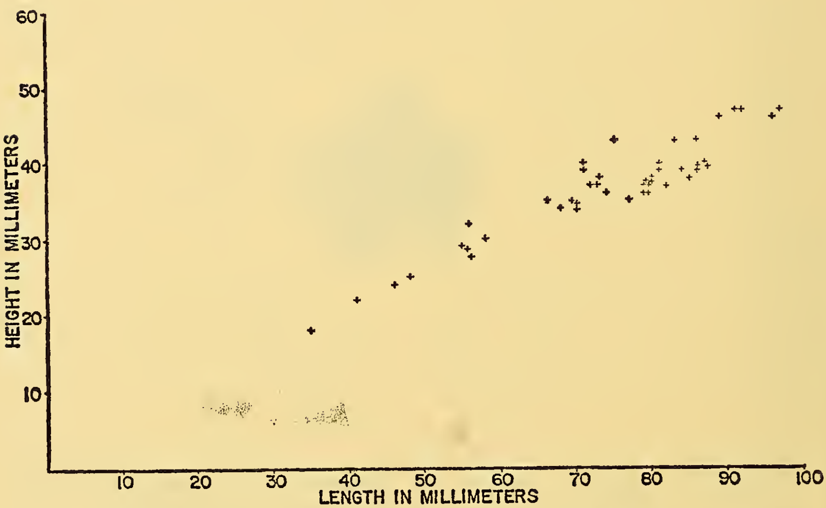


FIG. 48.—*Rhyncholampas evergladensis* (Mansfield). Height of the test relative to the length.

Peristome.—Anterior, pentagonal, depressed, wider than high.

Floscelle.—Phyllodes well developed, broad (text fig. 50), approximately 34-37 pores in each phyllode, 11 or 12 in each outer series, 5-7 irregularly arranged in each inner series; approximately same number in smallest specimen preserving phyllode (40 mm long) as in largest (90 mm long). Buccal pores present. Bourrelets very prominent, pointed.

Tuberculation.—Tubercles adorally much larger than adapically, naked granular zone in median area of interambulacrum V and ambulacrum III adorally.

Comparison with other species.—This species is distinguished from *R. ayresi* Kier by its more pointed adapical surface, more gently sloping sides, and more angular marginal outline. Its adoral surface

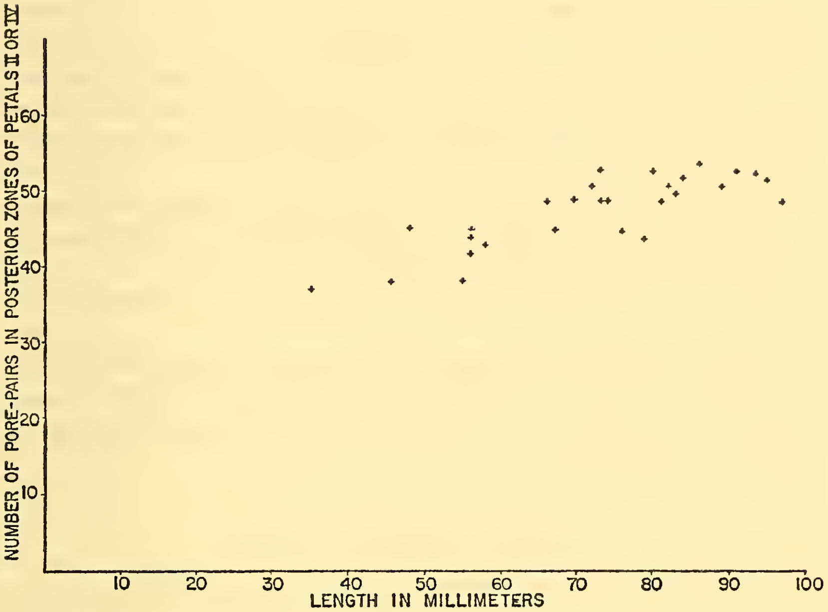


Fig. 49.—*Rhyncholampas evergladensis* (Mansfield). Number of pore-pairs in posterior zones of petals II or IV relative to length of test.

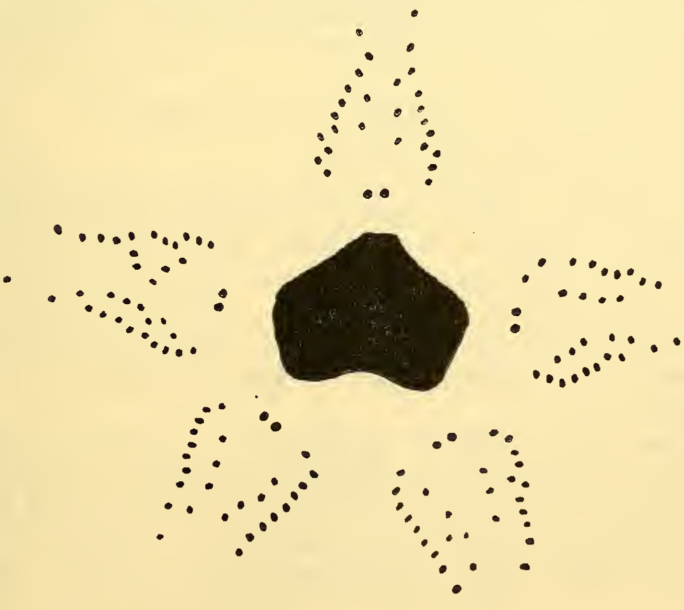


Fig. 50.—*Rhyncholampas evergladensis* (Mansfield): Floscelle of U.S.N.M. 648148, from the Tamiami formation, loc. 9, × 5.

is more depressed, the naked zone in interambulacrum 5 is wider (text fig. 42), and phyllode III is wider.

R. evergladensis is similar in many of its characters to *R. pacificus* (A. Agassiz), a species living off the west coast of the United States, but is distinguished by its wider petals and more steeply sloping posterior margin.

R. evergladensis is distinguished from *Rhyncholampas sabistonensis* (Kellum) by its higher and narrower test. Cooke (1959, p. 57) considered the two species synonyms.

Occurrence.—Tamiami formation (typical), loc. 9, 11, 13, 15, 16, 18, 19.

Tamiami formation (barnacle-echinoid-oyster facies), loc. 26, 27.

Types.—Lectotype, herein designated, U.S.N.M. 37329 (Mansfield, 1932, pl. 18, figs. 1-3), U.S.G.S. 11177; figured specimens, U.S.N.M. 648145-9, loc. 9.

AGASSIZIA PORIFERA (Ravenel)

Plate 16, figures 1-2; Plate 18, figures 1-5; text figures 51-58

Brissopsis poriferus Ravenel, 1848, Echinidae, Recent and fossil, of South Carolina, p. 4, figs. 5, 6.

Agassizia porifera (Ravenel). McCrady, in Tuomey and Holmes, 1857, Pleiocene fossils of South Carolina, p. 5, pl. 1, figs. 5-5b; pl. 2, figs. 4, 4a.

Agassizia porifera (Ravenel). Cooke, 1942, Journ. Paleont., v. 16, no. 1, p. 45.

Agassizia porifera (Ravenel). Cooke, 1959, U. S. Geol. Surv. Prof. Paper 321, pp. 74-75, pl. 31, figs. 1-8.

Diagnosis.—Species characterized by large inflated test.

Material.—Thirty-seven specimens.

Shape.—Large, largest specimen 79 mm long, 76 mm wide, 64 mm high; broad (text fig. 57), with greatest width at center or slightly posterior; moderately to highly inflated, height varying from 69 to 90 percent of length (text fig. 58), with highest point anterior of center slightly posterior of apical system; marginal outline angular with slight anterior, posterior truncation; adoral surface moderately inflated, in some specimens keel developed in midline of interambulacrum 5.

Apical system.—Anterior, ethmolytic (text fig. 56), madreporite extending posteriorly, sutures between genital plates not visible.

Ambulacra.—Ambulacrum III not petaloid, in very slight groove not extending to margin; anterior paired petals, II, IV, narrow, depressed in groove, long, when viewed from above extending almost to margin, when viewed from side extending midway from top to bottom of specimen; anterior poriferous zones slightly developed, (pl. 18, fig. 5; text fig. 54) pore-pairs minute, 34 in posterior poriferous zone of specimen 79 mm long, 31 in specimen 49 mm long; petal straight, or curved anteriorly or posteriorly distally; posterior petals V, I depressed in groove, short, extending slightly more than half distance to margin, interporiferous zones very narrow, pores strongly conjugate, 23 pore-pairs in poriferous zone of specimen 49 mm long, 30 in specimen 79 mm long.

Periproct.—Transverse, situated high on posterior truncation.

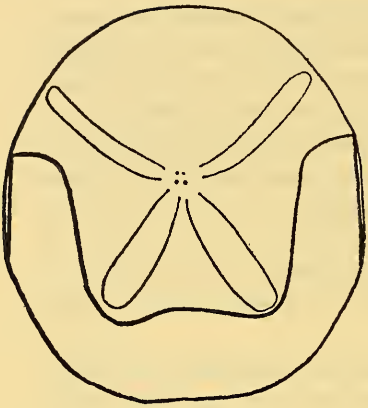
Peristome.—Very eccentric anteriorly, transverse, with well-developed lip.

Fascioles.—Peripetalous fasciole at anterior very low, below margin, not visible adapically, passing around petals II, IV below ends of petals, curving adapically very abruptly posterior to these petals, extending toward apical system, then abruptly turning posteriorly (text figs. 51-53), passing around end of petals V, I, then curving anteriorly forming pronounced lobe, convex toward apical system, in some specimens. Lateroanal fasciole originates from peripetalous fasciole just posterior to petals II, IV, extending posteriorly slightly adapical to margin in interambulacra 4, 1, passing adorally near periproct, then forming distinct deep sulcus immediately adoral to periproct; this sulcus a consistent character in species, occurring in all 23 specimens in which this area visible.

Phyllodes.—Phyllodes well developed, broad (text fig. 55), 4 or 5 pores in phyllode III, 7 or 8 in phyllodes II or IV, 5 or 6 in phyllodes V or I; numbers and position of pores quite consistent in all specimens.

Remarks.—The Florida specimens are clearly conspecific with those described and illustrated by Cooke (1959, p. 74, pl. 31, figs. 1-8) from South Carolina. On first impression they do not appear to be conspectific with Ravenel's holotype as figured by McCrady (in Tuomey and Holmes, 1857, pl. 1, figs. 5-5b). Most of the Florida specimens are larger and more inflated, but one specimen (pl. 18, figs. 3, 4) is approximately the same size as the holotype and can not be distinguished specifically. As shown in a height to length graph (text fig. 58), there is a disproportionate increase in height relative to length in the larger specimens.

The specimen figured by Clark and Twitchell (1915, pl. 97, figs. la-d) does not appear to belong to this species. I have studied this specimen from the American Museum of Natural History. As it is slightly crushed, its original shape is not certain, but it appears to have been considerably higher than *A. porifera.*



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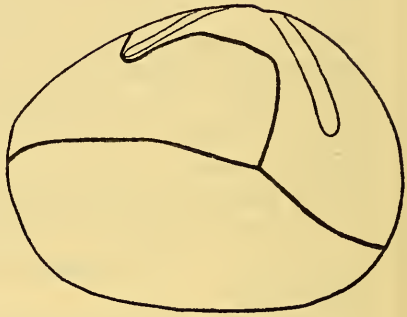

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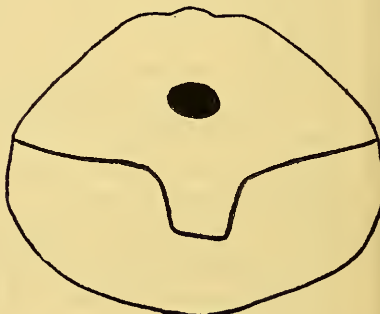

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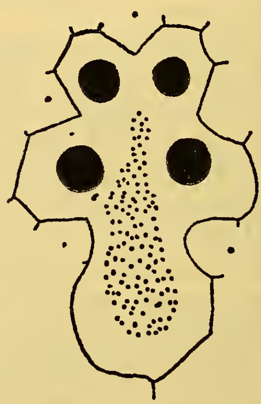

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FIGS. 51-56.—(See opposite page for legend.)

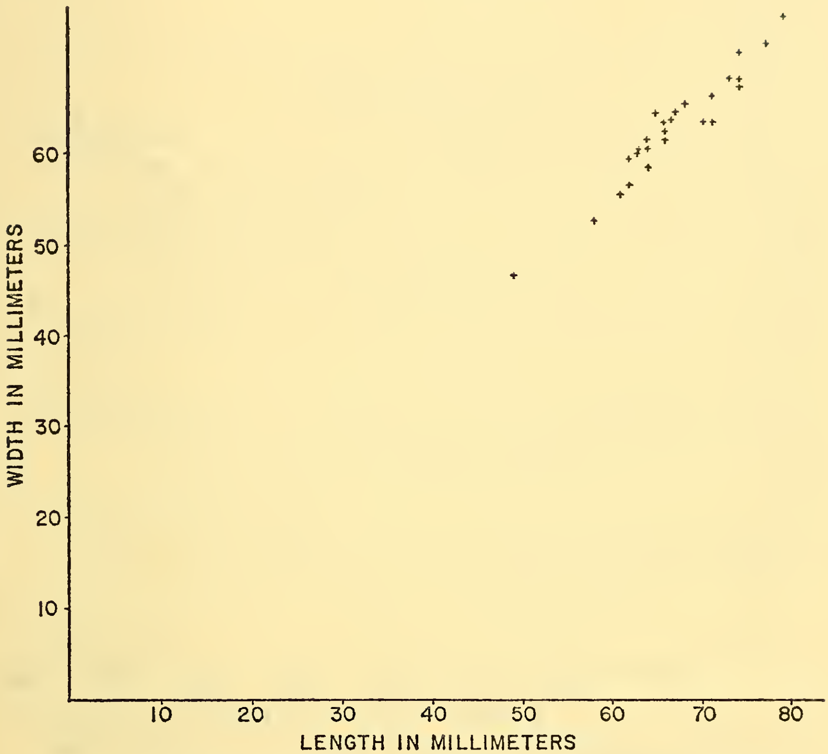

FIG. 57.—*Agassizia porifera* (Ravenel). Width of test relative to length.

Occurrence.—Florida, Caloosahatchee formation, loc. 2, 6. South Carolina, The Grove, Cooper River; U.S.G.S. 18759, Intracoastal Waterway canal in Horry County 1 to 1½ miles southwest of the bridge on U.S. Highway 17 near Nixons Crossroads, about 5 miles southwest of Little River.

Types.—Location of holotype not known; figured specimens, U.S.N.M. 562462, U.S.G.S. 18759, 648154-9, loc. 6.

FIGS. 51-56.—*Agassizia porifera* (Ravenel): 51-53, Adapical, right side, posterior of U.S.N.M. 648157, from the Caloosahatchee formation, loc. 6, showing position of fascioles, × 0.6; 54, portion of ambulacrum IV of U.S.N.M. 648154, from the Caloosahatchee formation, loc. 6, showing the slightly developed anterior poriferous zone, × 13; 55, peristomal region of U.S.N.M. 648158, from the Caloosahatchee formation, loc. 6, × 2; 56, apical system of U.S.N.M. 648159, from the Caloosahatchee formation, loc. 6, × 11.

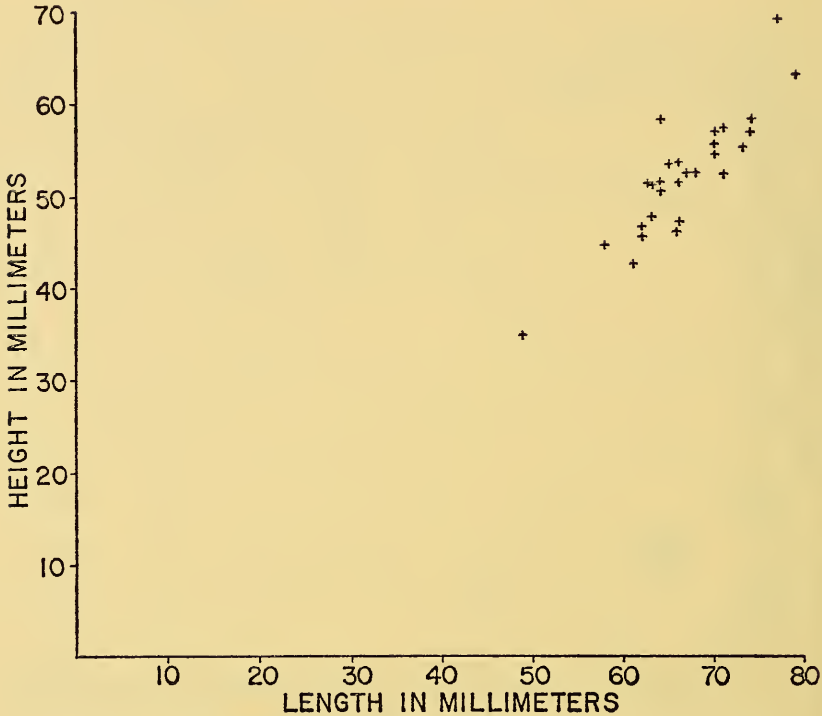

Fig. 58.—*Agassizia porifera* (Ravenel). Height of test relative to length.

ECHINOCARDIUM GOTHICUM (Ravenel) ?

Plate 11, figure 4

Remarks.—There are 29 fragments that appear to belong to this species of Ravenel (1848, p. 4). The petal arrangement and fascioles are identical to Cooke's (1959, pl. 33, figs. 7-10) figured specimens. Without having any complete specimens it is not possible to know the shape of the test, and these fragments can be referred only provisionally to this species.

Occurrence.—Tamiami formation (barnacle-echinoid-oyster facies), loc. 26, 32.

Figured specimen.—U.S.N.M. 648144, loc. 32.

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EXPLANATION OF PLATES

Plate 1

Plate 2

Plate 3

Plate 4

PLATE 5

PLATE 6

PLATE 7

PLATE 8

PLATE 9

PLATE 10

PLATE 11

Page

Echinocardium gothicum (Ravenel) ? 56
4, Fragment of test, U.S.N.M. 648144, from the Tamiami formation, loc. 32, × 1.

PLATE 12

Clypeaster sunnilandensis Kier, new species 32
Adapical view of holotype, U.S.N.M. 648135, from the Tamiami formation, loc. 9, × 1.

PLATE 13

Clypeaster sunnilandensis Kier, new species 32
Adoral view of U.S.N.M. 648134 from the Tamiami formation, loc. 9, × 1. Side view of same specimen pl. 9, fig. 3.

PLATE 14

Encope tamiamiensis Mansfield 36
1, Adapical view of U.S.N.M. 648137 from the Tamiami formation, loc. 27, × 2.
2, Adapical view of U.S.N.M. 648138 from the Tamiami formation, loc. 26, × 2.
3, 4, Adapical, adoral view of U.S.N.M. 648139 from the Tamiami formation, loc. 11, × 1.
5, Apical system of same specimen in fig. 3, × 3.
6, Peristomal region in U.S.N.M. 648140 from the Tamiami formation, loc. 31, × 4 (approx.).

PLATE 15

Mellita aclinensis Kier, new species 40
1, 2, 3, Adapical, right side, adoral view of holotype U.S.N.M. 648136 from the Tamiami formation, loc. 27, × 2.

PLATE 16

Agassizia porifera (Ravenel) 52
1, Side view of U.S.N.M. 648156 from the Caloosahatchee formation, loc. 6, × 1.
2, Posterior view of same specimen figured on pl. 11, figs. 3, 4, × 1.

Rhyncholampas ayresi Kier, new species 45
3, Adapical view of holotype, U.S.N.M. 648160, from the Caloosahatchee formation, loc. 6, × 1.
4, Adoral view of U.S.N.M. 648161 from the Caloosahatchee formation, loc. 6, × 1.
5, Right side of holotype, × 1.
6, View of peristome of specimen in fig. 4, × 1.

PLATE 17

1, Adapical view of U.S.N.M. 648145 from the Tamiami formation, loc. 9, × 1.

2, Right side view of U.S.N.M. 648146 from the Tamiami formation, loc. 9, × 1.

3, Apical system of U.S.N.M. 648147 from the Tamiami formation, loc. 9, × 7.

4, Floscelle of U.S.N.M. 648148 from the Tamiami formation, loc. 9, × 4.

5, Adoral view of same specimen in fig. 4, × 1.

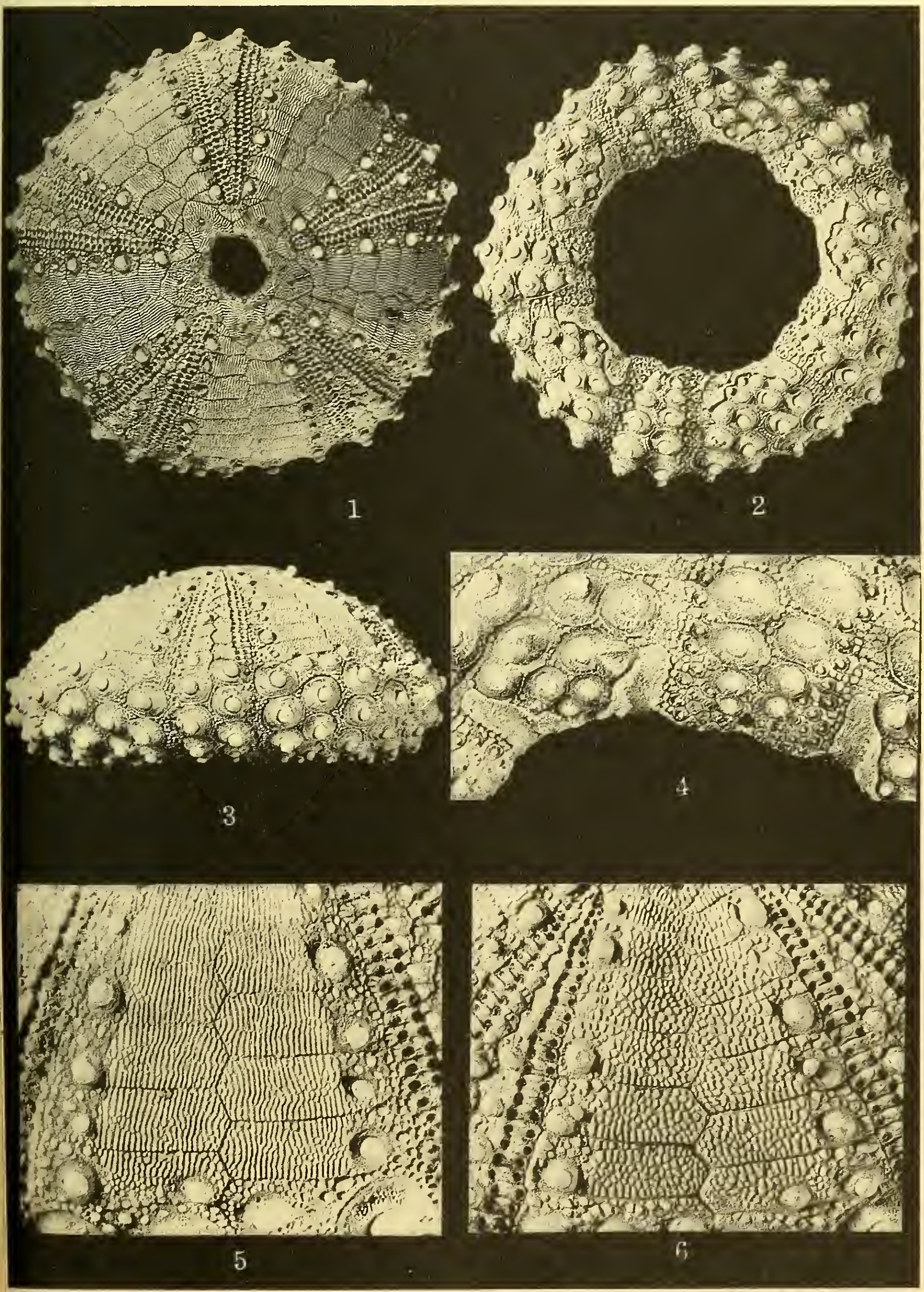
PLATE 18

1, 2, Adapical, adoral view of U.S.N.M. 648154 from the Caloosahatchee formation, loc. 6, × 1.

3, 4, Adapical, left side of U.S.N.M. 648155 from the Caloosahatchee formation, loc. 6, × 1. Posterior view of same specimen on pl. 12, fig. 2.

5, View of petal IV of same specimen in fig. 1, × 5.

PLATES



1-5, ARBACIA CRENULATA KIER, NEW SPECIES; 6, ARBACIA IMPROCERA (CONRAD)

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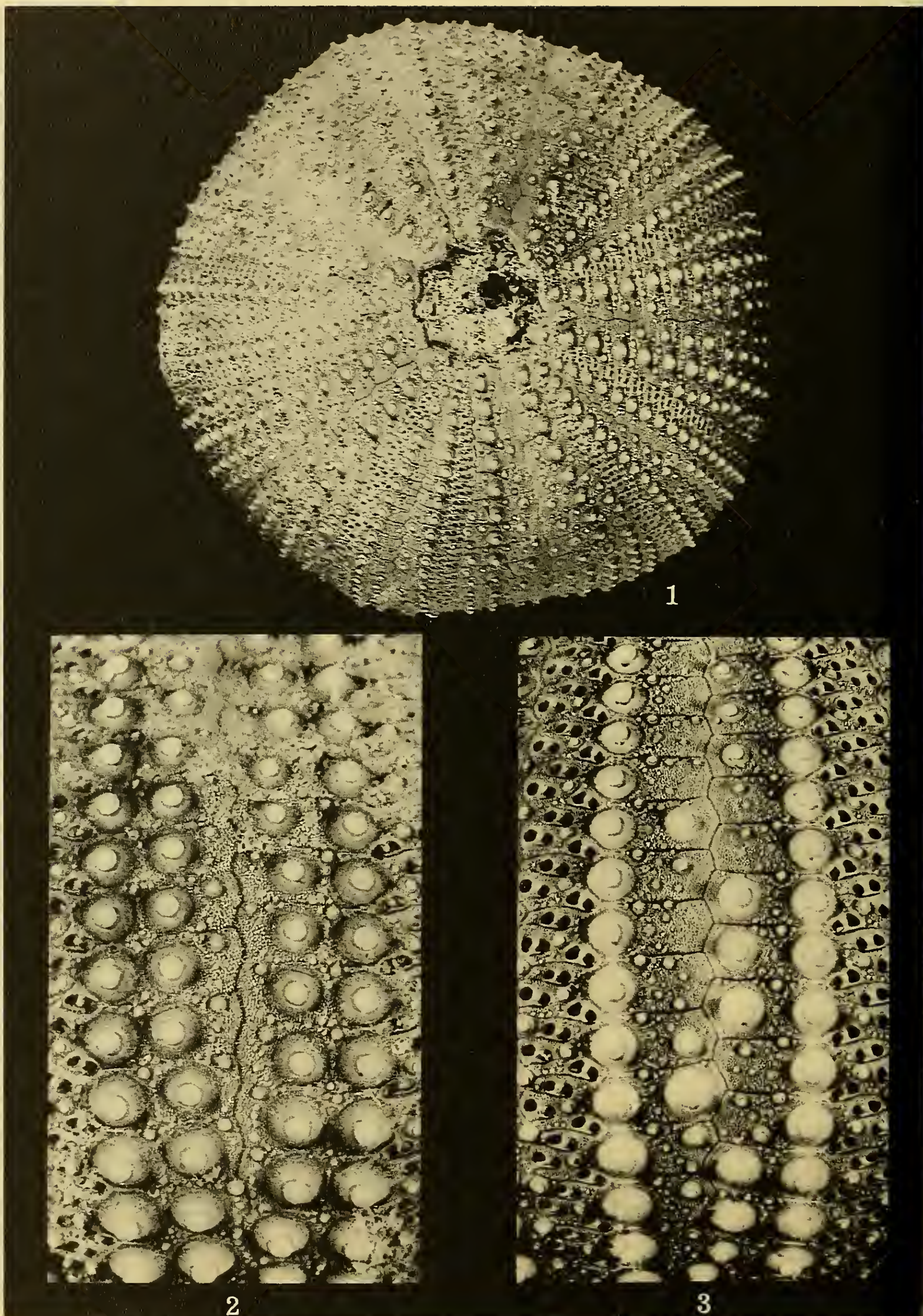

1-2, LYTECHINUS VARIEGATUS PLURITUBERCULATUS KIER, NEW SUBSPECIES;
3, LYTECHINUS VARIEGATUS VARIEGATUS (LESKE)

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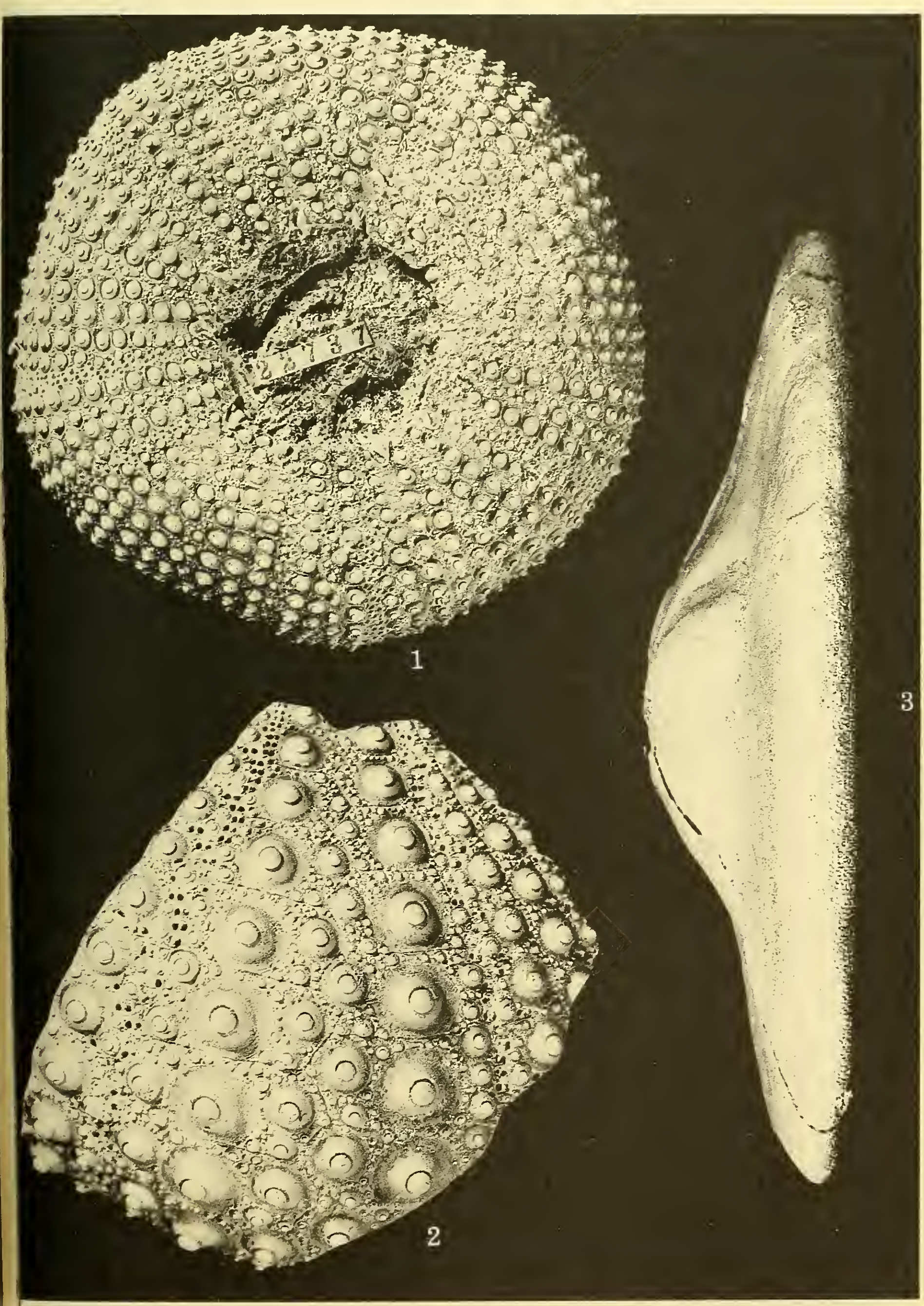

1, LYTECHINUS VARIEGATUS PLURITUBERCULATUS KIER, NEW SPECIES; 2, ECHINOMETRA LUCUNTER (LINNAEUS); 3, CLYPEASTER SUNNILANDENSIS KIER, NEW SPECIES

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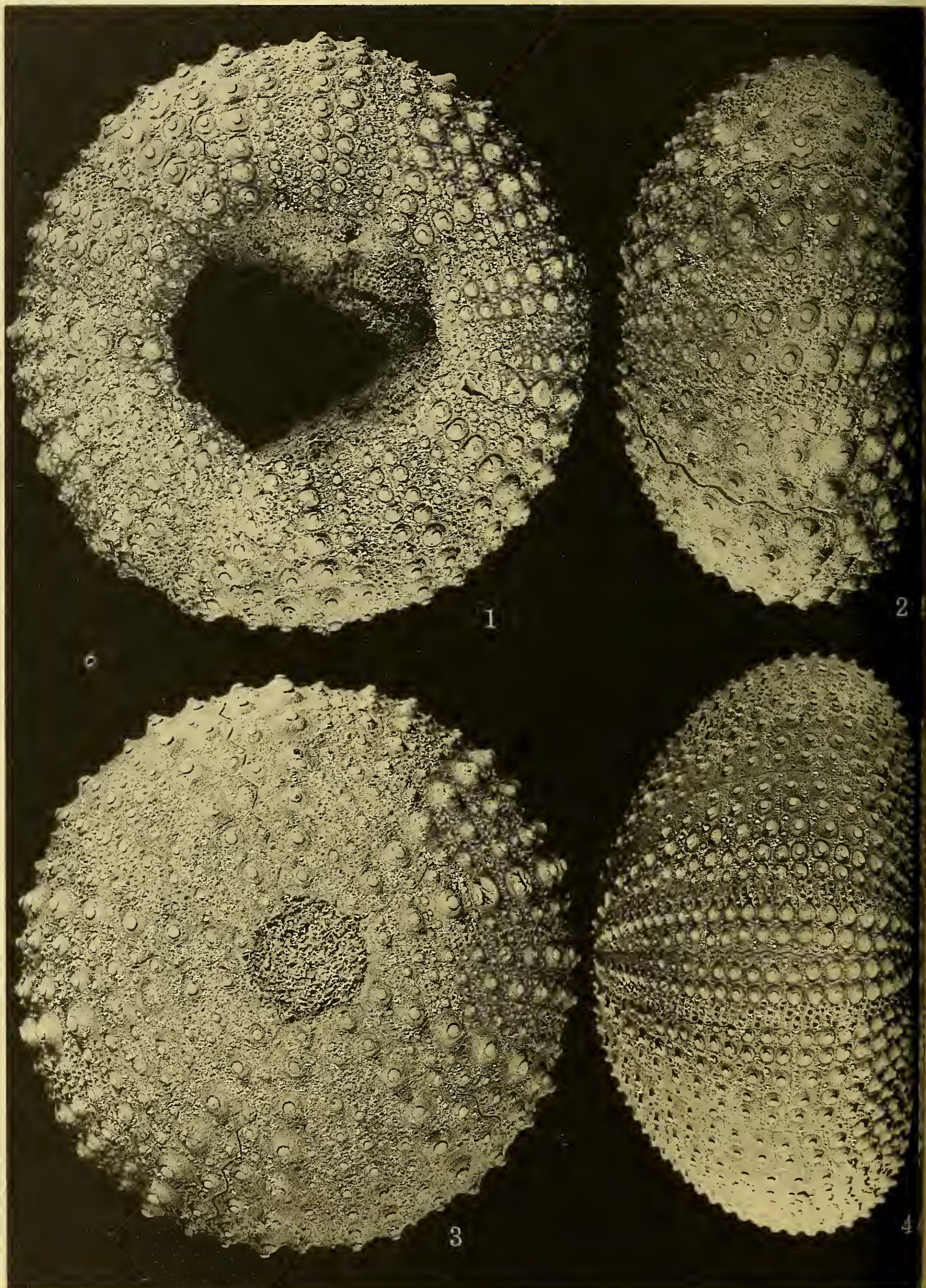
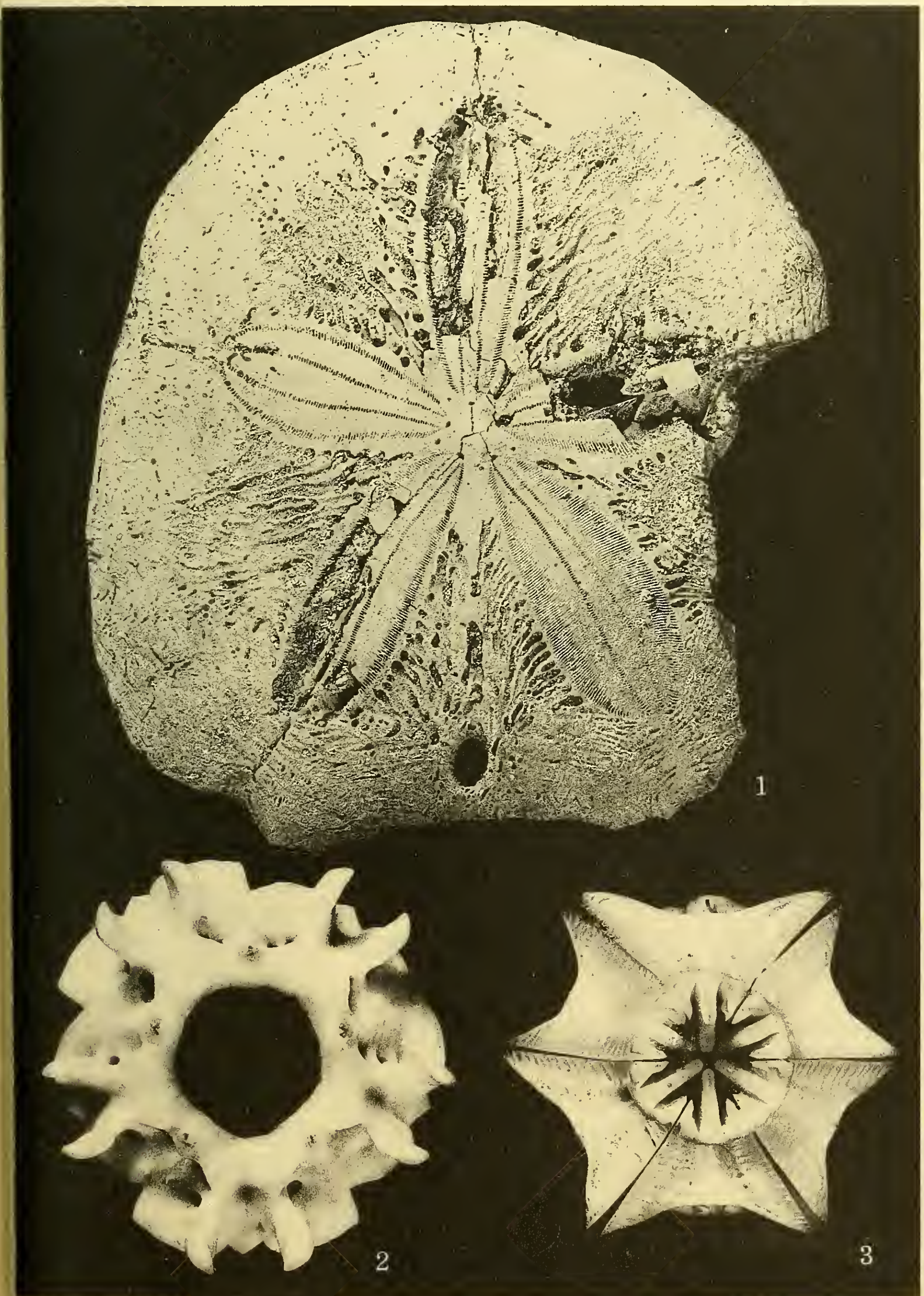


1-3, Echinometra lucunter (Linnaeus); 4, Lytechinus variegatus pluritouberculatus Kier, New Subspecies

(See explanation of plates at end of text.)

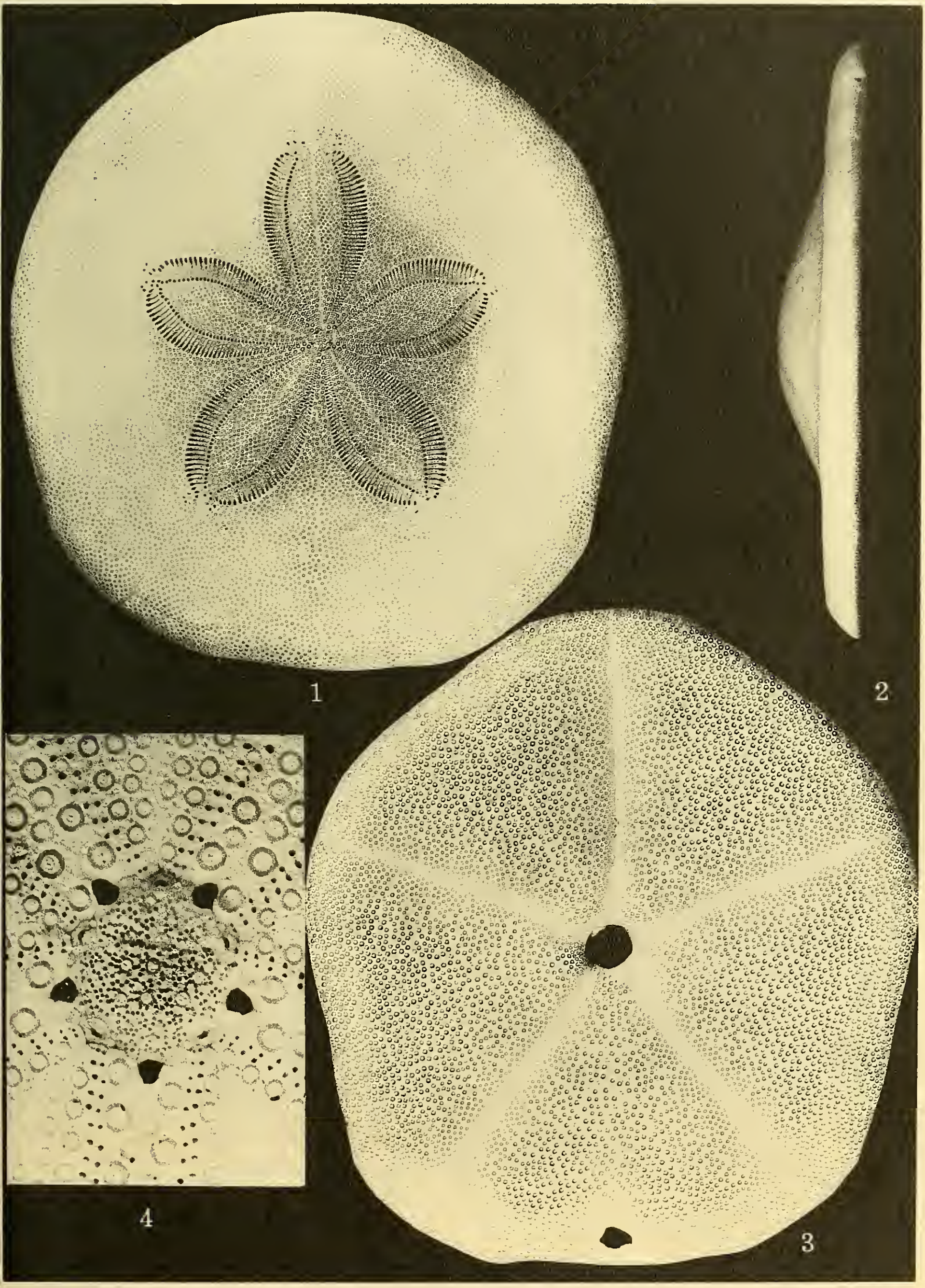


1, ENCOPE MICHELINI IMPERFORATA KIER, NEW SUBSPECIES; 2-3, CLYPEASTER PROSTRATUS (RAVENEL)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)

1-2, Clypeaster prostratus (Ravenel); 3-4, Encope michelini imperforata Kier, New Subspecies

(See explanation of plates at end of text.)



CLYPEASTER PROSTRATUS (RAVENEL)

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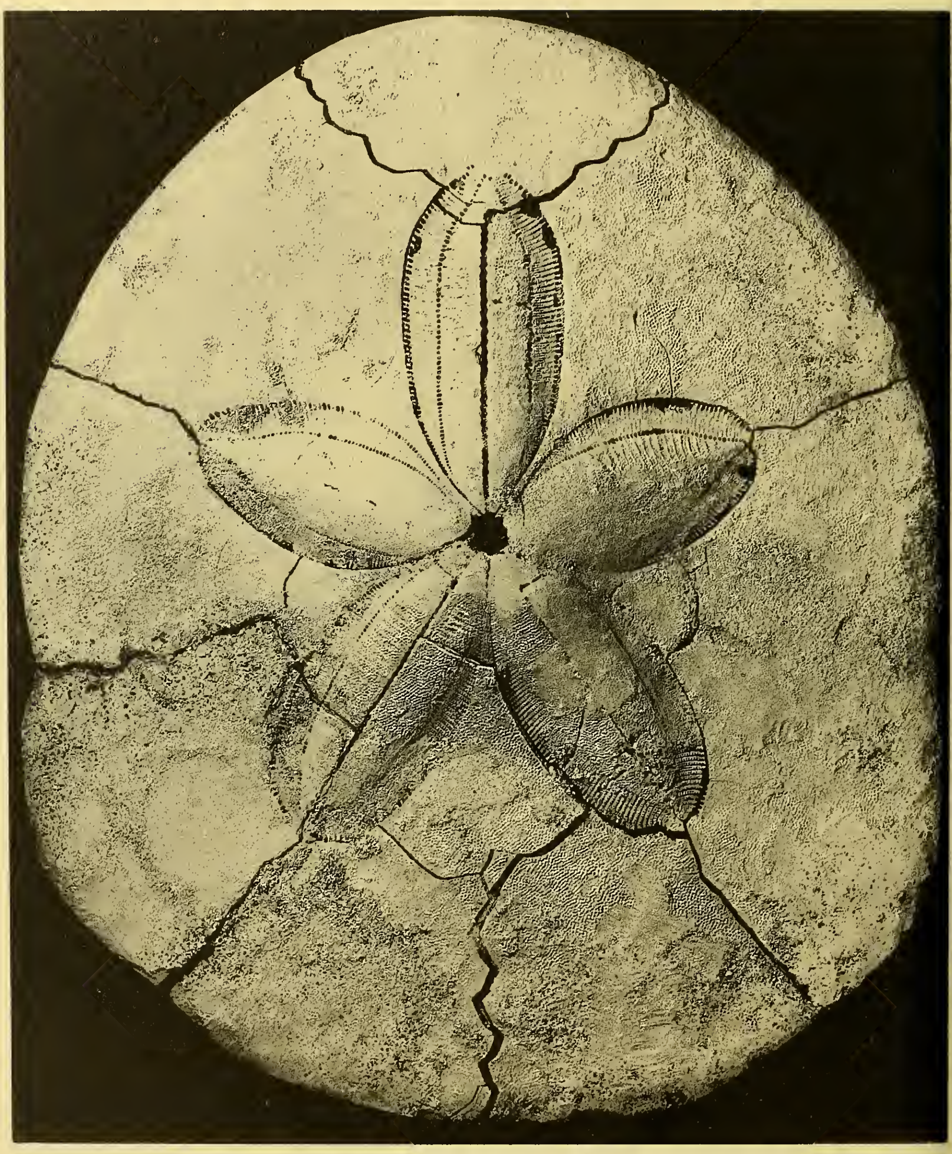

CLYPEASTER SUBDEPRESSUS (GRAY)

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CLYPEASTER SUBDEPRESSUS (GRAY)

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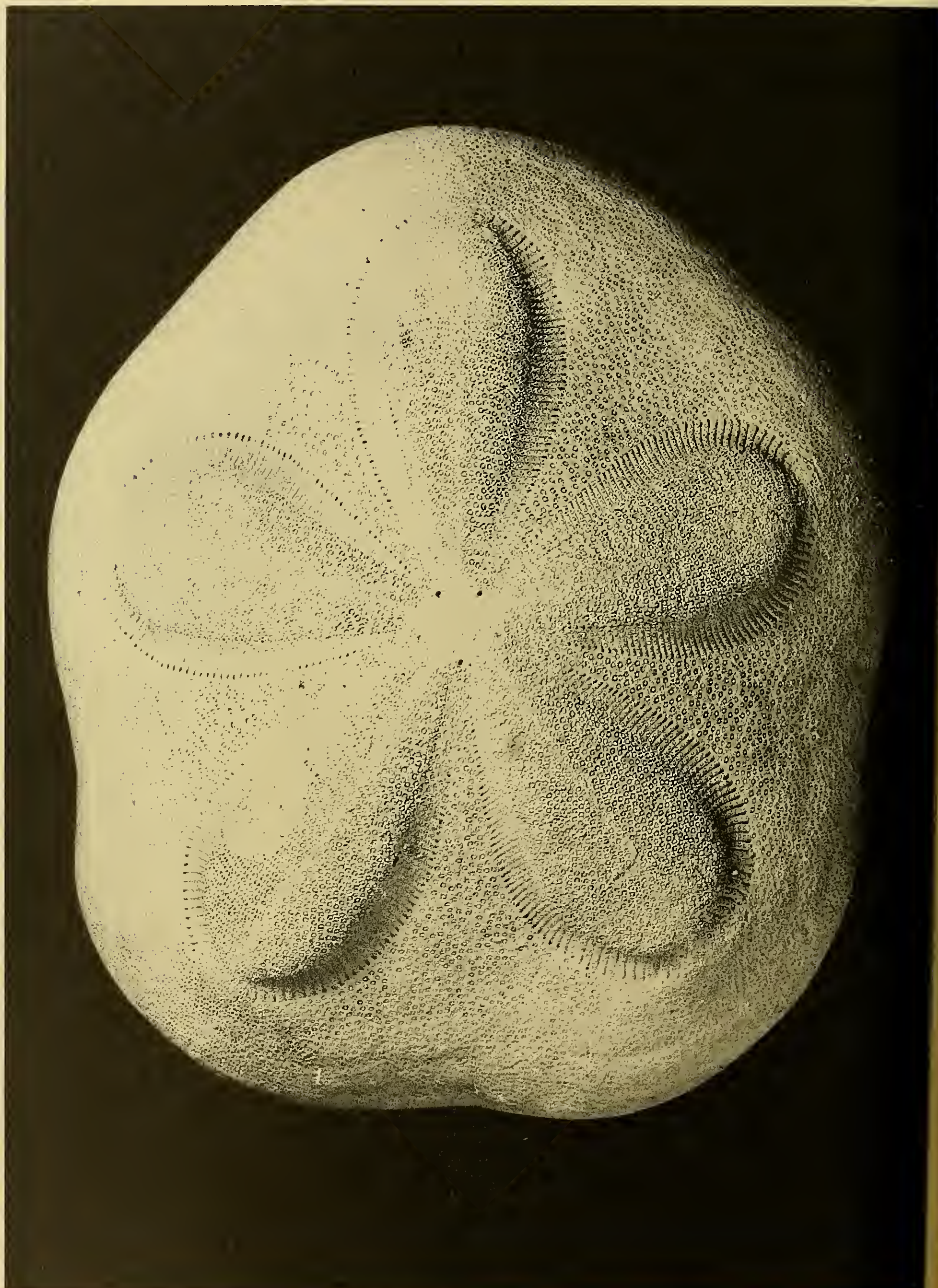

CLYPEASTER ROSACEUS DALLI (TWITCHELL)

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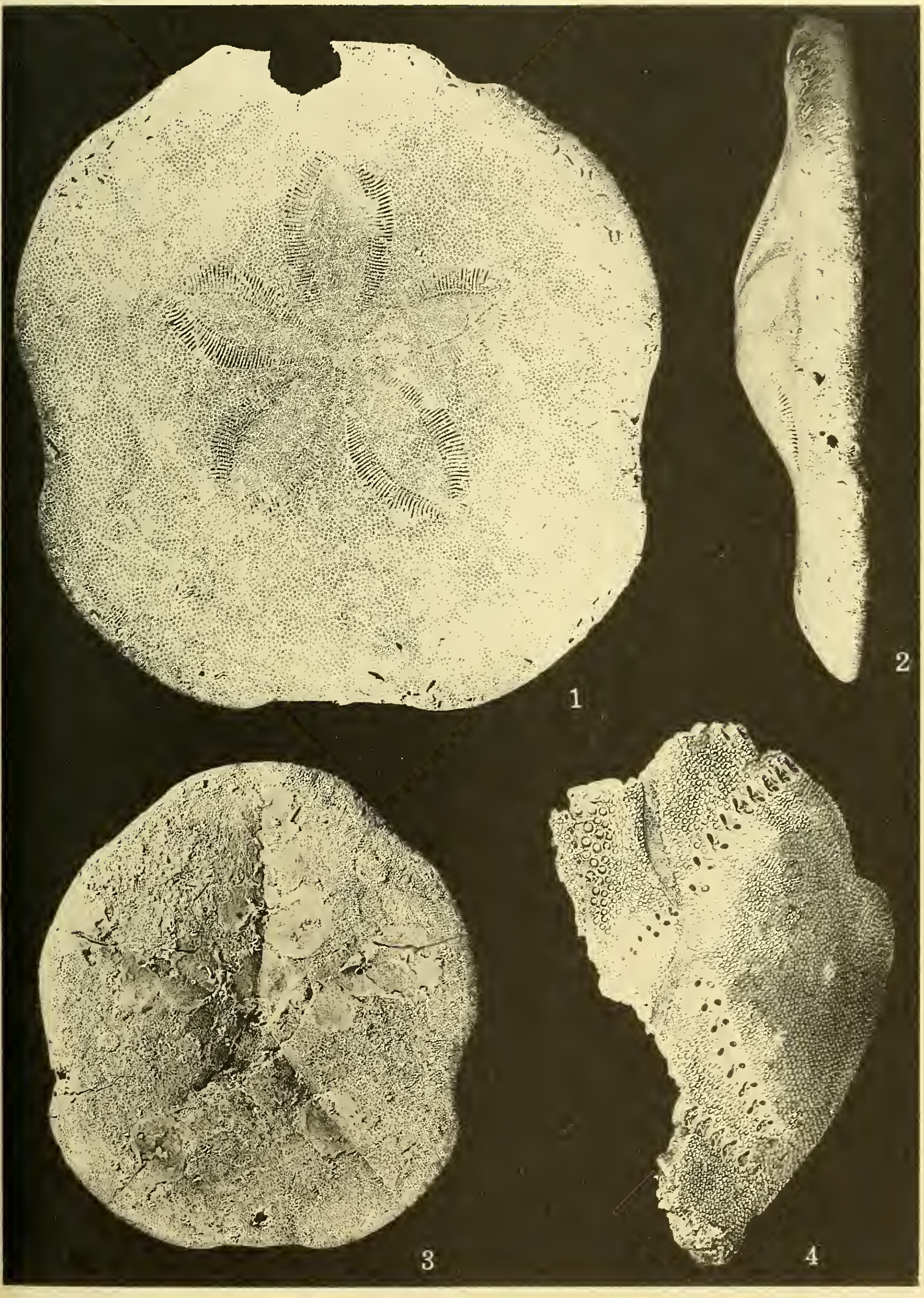

1-3, CLYPEASTER CRASSUS KIER, NEW SPECIES; 4, ECHINOCARDIUM GOTHICUM (RAVENEL)?

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CLYPEASTER SUNNILANDENSIS KIER, NEW SPECIES

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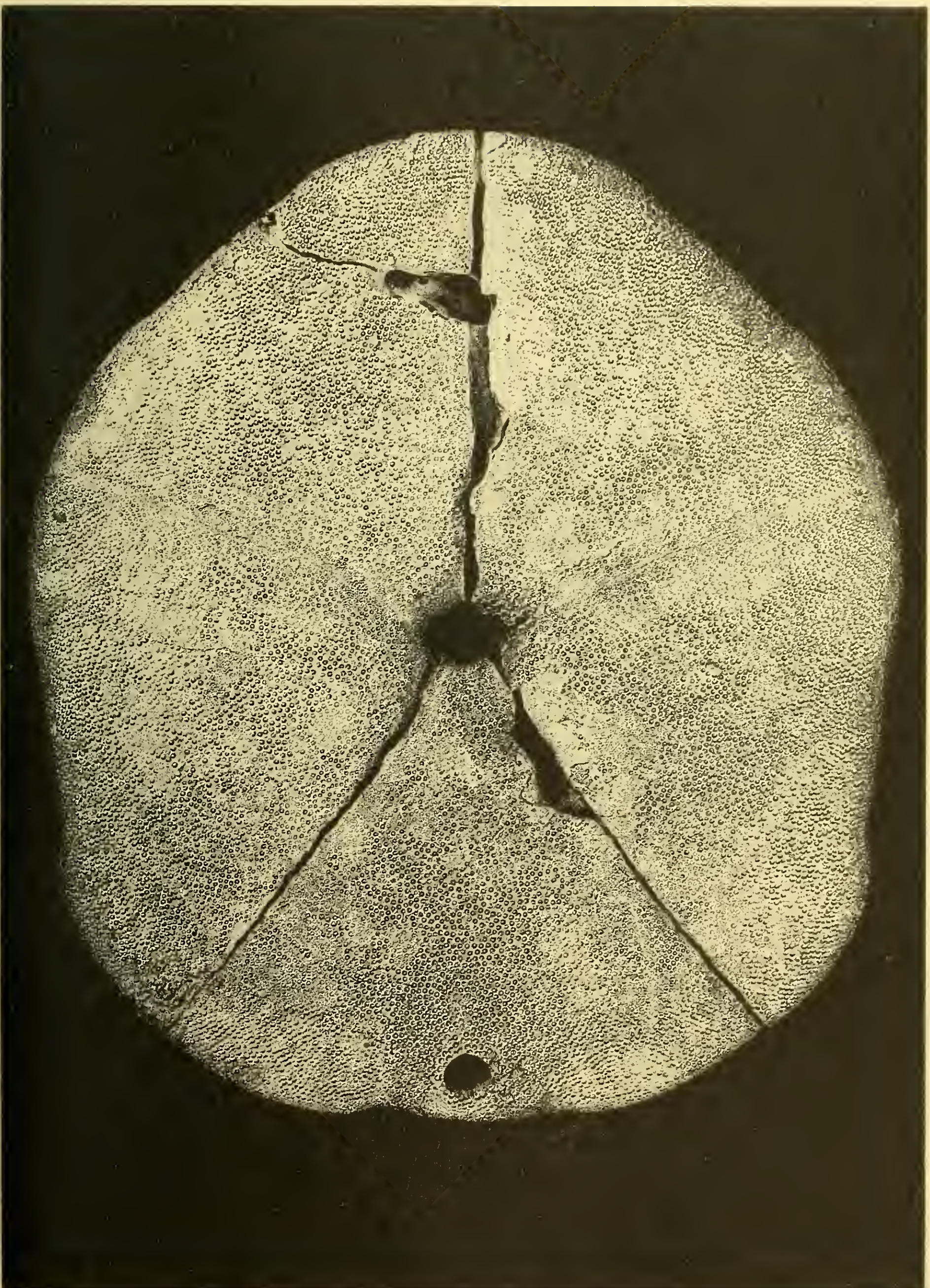

Clypeaster sunnilandensis Kier, New Species

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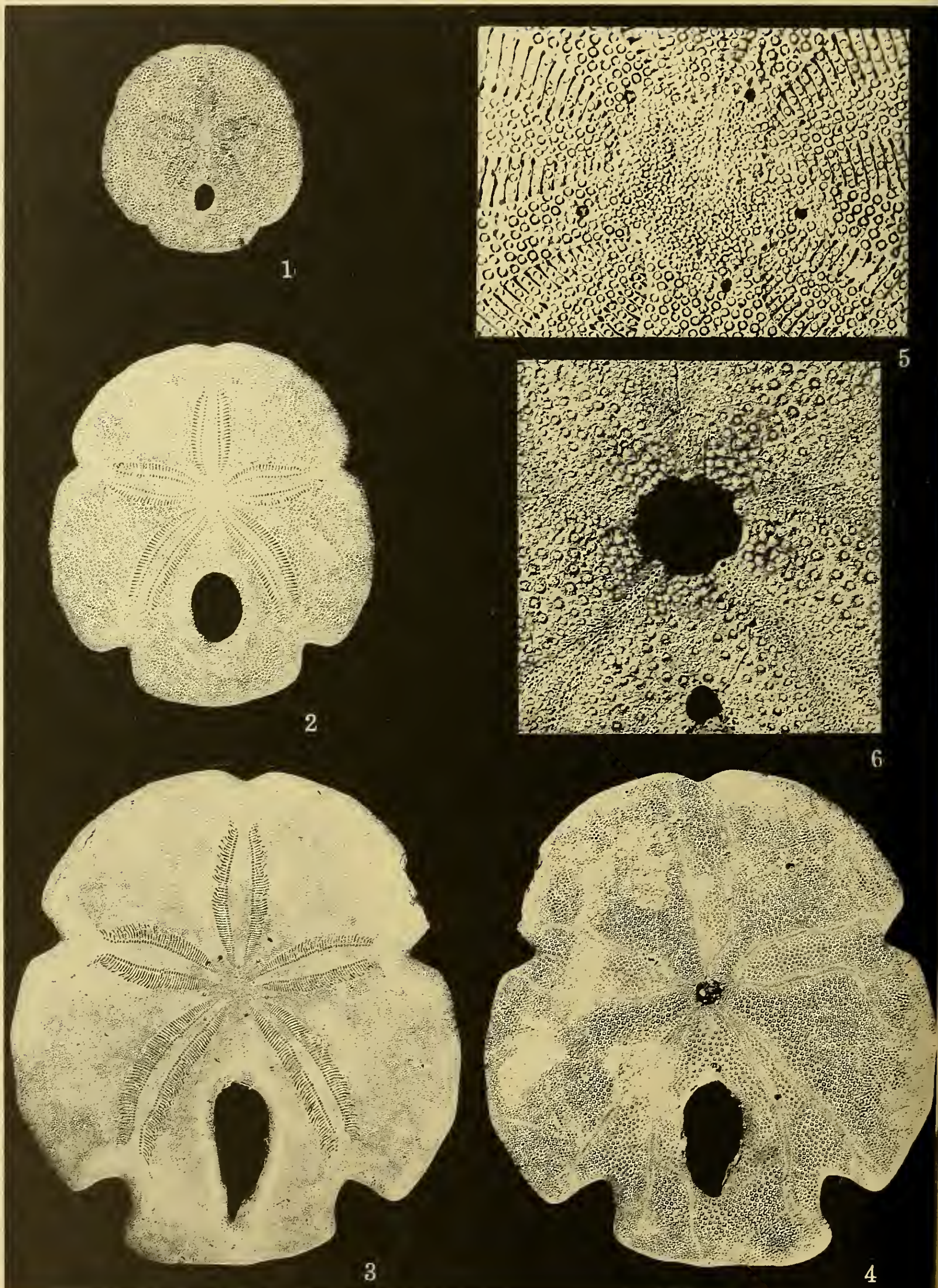

ENCOPE TAMIAMIENSIS MANSFIELD

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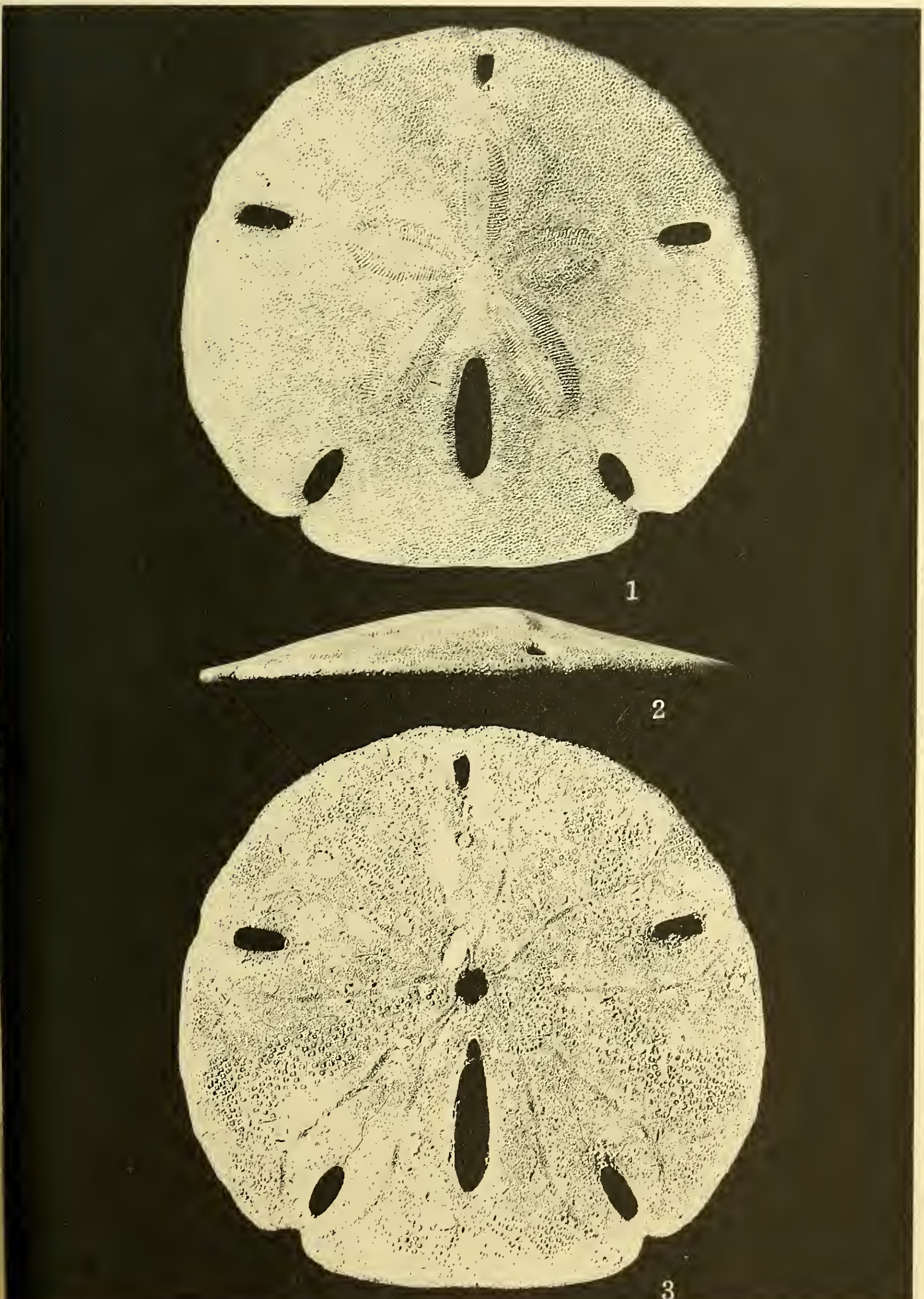
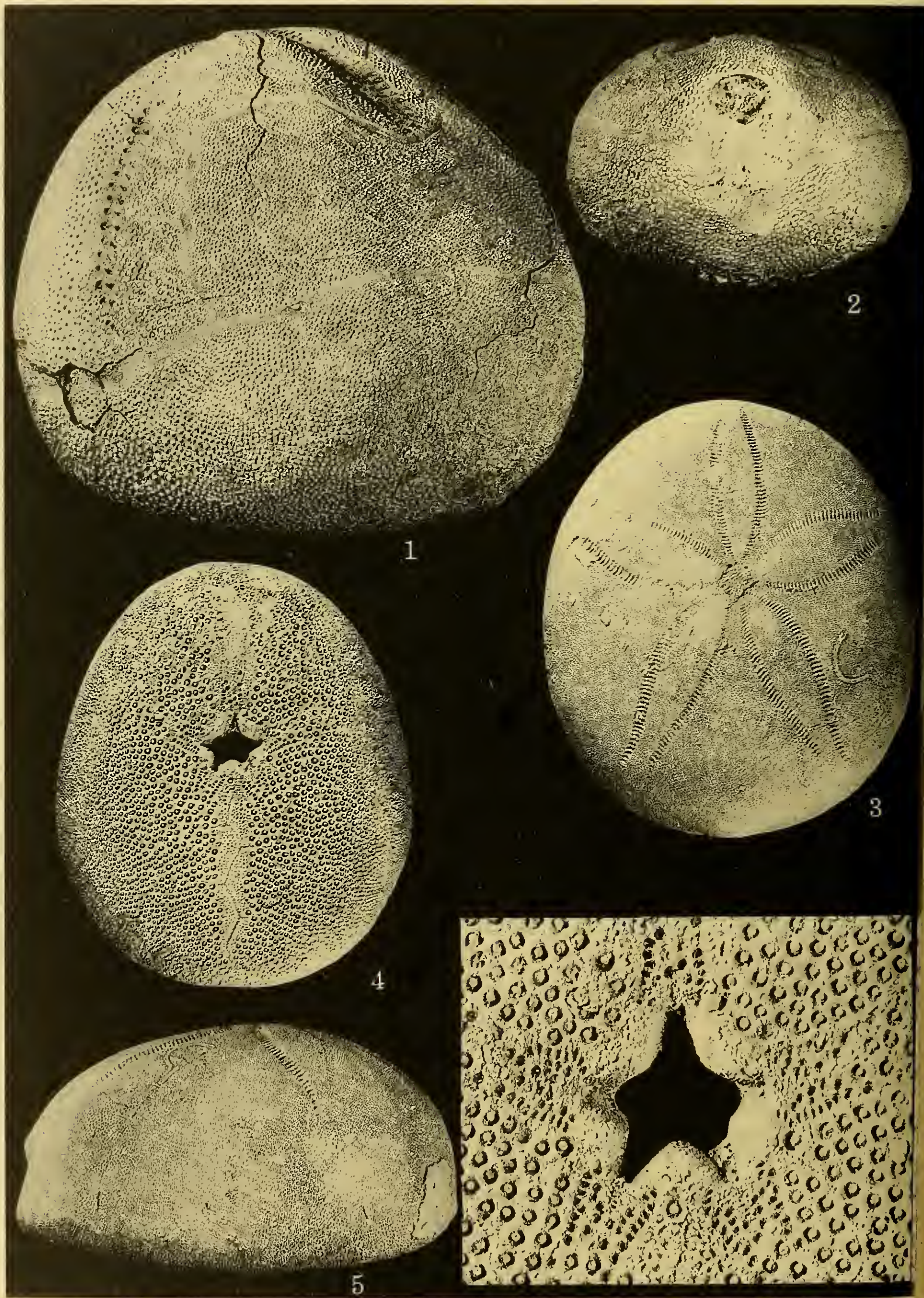


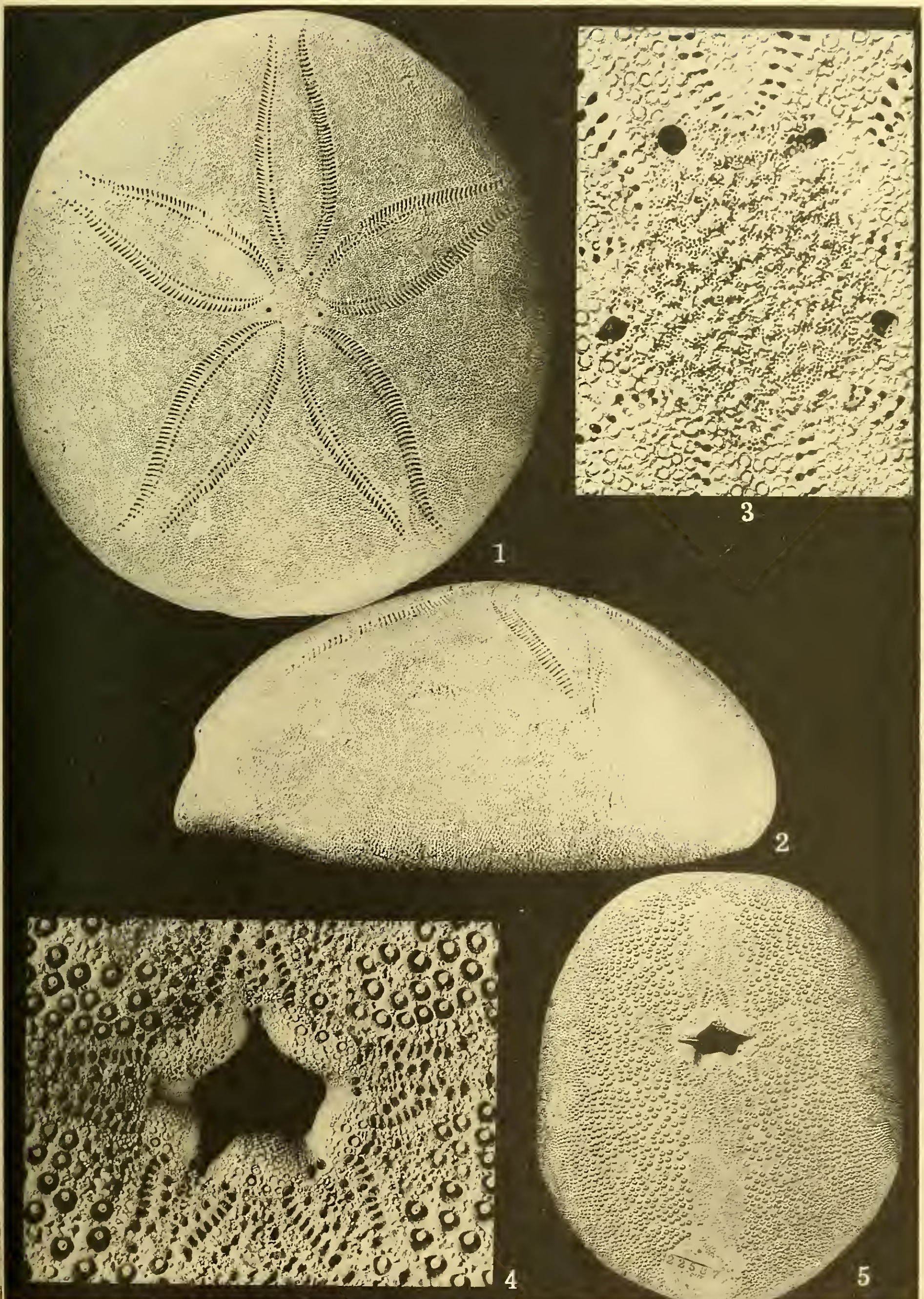
MELLITA ACLINENSIS KIER, NEW SPECIES

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



1-2, AGASSIZIA PORIFERA (RAVENEL); 3-6, RHYNCHOLAMPAS AYRESI KIER, NEW SPECIES

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



RHYNCHOLAMPAS EVERGLADENSIS (MANSFIELD)

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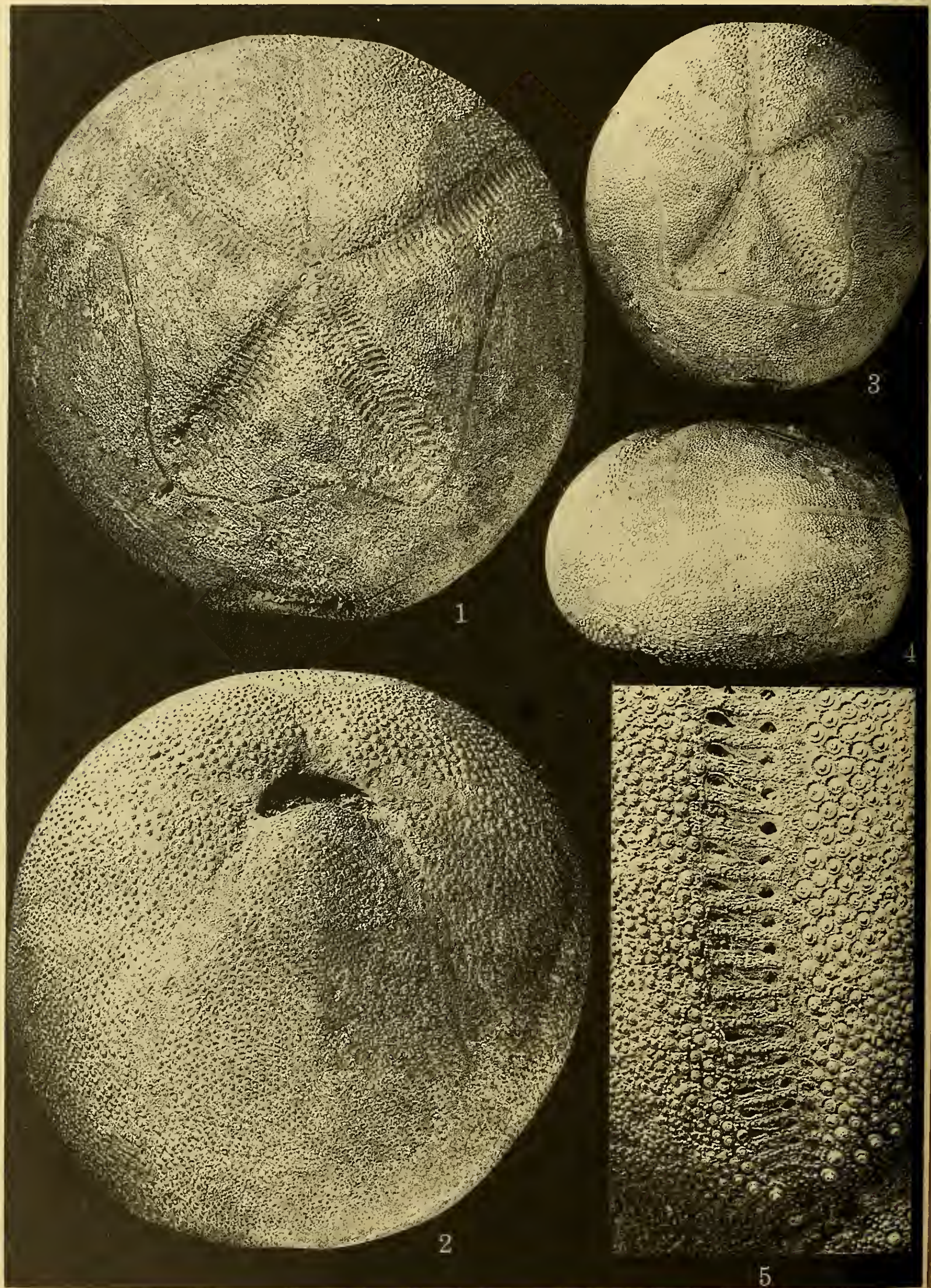

AGASSIZIA PORIFERA (RAVENEL)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)

SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 145, NUMBER 6

ADDITIONS TO RECORDS OF BIRDS KNOWN FROM THE REPUBLIC OF PANAMÁ

By
ALEXANDER WETMORE
Research Associate
Smithsonian Institution

(Publication 4523)

CITY OF WASHINGTON
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ADDITIONS TO RECORDS OF BIRDS KNOWN FROM THE REPUBLIC OF PANAMÁ

By Alexander Wetmore
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The notes that follow, pertaining to recent studies on avian collections made in Panamá, include descriptions of two species and two geographic races not known previously. The two named from Darién are based on specimens received from the Gorgas Memorial Laboratory in Panamá and derive from recent field work directed by Dr. Pedro Galindo. Included with these are further records of birds from the little-known island of Escudo de Veraguas, located 18 kilometers at sea off the base of the Valiente Peninsula, Bocas del Toro, and report of two North American migrants not found previously in the republic.

I. ADDITIONAL RECORDS FROM ISLA ESCUDO DE VERAGUAS, WITH DESCRIPTION OF A NEW SPECIES OF HUMMINGBIRD

In the course of a visit to Isla Escudo de Veraguas early in March 1958, I collected a thick-spined rat (genus *Hoplomys*), the first island record for this group, and a race that proved to be new to science (Handley, 1959, pp. 9-10). Following its description, Dr. C. O. Handley, Jr., of the U. S. National Museum, through cooperation of the U. S. Army, came to the island in 1962 and lived there in a shore camp from March 20 to 24. In addition to a series of the rat, and many bats, he preserved in formalin a number of birds caught in mist nets, and prepared a few others, shot for specimens, as study skins. The 41 birds collected have added considerably to earlier information on the avifauna, available from my own brief visit four years earlier (Wetmore, 1959, pp. 1-27).

Migrants recorded by Dr. Handley include several that had not been listed from the island previously. A belted kingfisher, taken March 21, is the eastern subspecies *Megaceryle alcyon alcyon*. Several eastern wood peewees (*Contopus virens*) were present and in song on March 23, when one was taken for a skin. Several small groups of barn swallows passed on this same day, moving toward the north. On March 21 single purple martins were reported at intervals during the day in northward flight off shore. One was recorded on March 19 on the airstrip at Fort Sherman, Canal Zone, and another was observed March 20 at sea about 15 kilometers off the mouth of Río Belén, on the boundary between the provinces of Colón and Veraguas. Swainson's thrushes (*Hylocichla ustulata*), taken March 21 and 24, and a red-eyed vireo (*Vireo olivaceus*), on March 23, are identified to species only, as they were placed in formalin. Other migrants, all in formalin, include the black-and-white warbler (*Mniotilta varia*), on March 22, and the prothonotary warbler (*Protonotaria citrea*), worm-eating warbler (*Helmitheros vermivorus*), ovenbird (*Seiurus aurocapillus*), and northern water-thrush (*Seiurus noveboracensis*), taken on March 21. A male summer tanager (*Piranga rubra rubra*) in full breeding plumage, prepared as a skin, was collected March 21, and another was recorded on the day following.

An immature yellow-crowned night heron, another addition to the island list, appears to be the resident race of Panamá, *Nyctanassa violacea caliginis,* while a single green heron (*Butorides virescens*), seen March 20 and 21, was believed to be a migrant. A pair of pygmy kingfishers (*Chloroceryle aenea aenea*) caught in mist nets set up near the lagoon March 24, form an interesting addition to the island residents. Men with me in 1958, and those with Handley, saw a small rail that was not collected, but from the description it may have been the white-throated rail (*Laterallus albigularis*) which is common on the mainland. George Barratt, with Handley, also reported a night bird with batlike flight that probably was a species of goatsucker.

Specimens in formalin of the endemic races of the manakin, *Manacus vitellinus amitinus,* bay wren, *Thryothorus nigricapillus odicus,* and blue-gray tanager, *Thraupis virens caesitia,* all show clearly the decidedly larger size of the first two, and the heavier bill found in the tanager when compared to birds of the adjacent mainland. The same character of larger dimension is present in the island form of the thick-spined rat, described by Dr. Handley, and is in much greater evidence in the hummingbird, whose description follows.

AMAZILIA HANDLEYI, new species

Characters.—In general appearance similar to *Amazilia tzacatl tzacatl*[1] but much larger, and darker in color; bill decidedly heavier; feet larger; brown of tail, upper and under tail coverts, and lores, darker; back and wing coverts decidedly darker and duller.

Description.—Type, ♂ ad., U. S. Nat. Mus. 477282, from Isla Escudo de Veraguas, collected March 22, 1962, by C. O. Handley, Jr., and F. M. Greenwell (orig. no. 1188). Crown, hindneck, back, and wing coverts (except the primary coverts) deep green, with a sheen of dull bronze that changes on lower back and rump to a darker shade with an iridescence of dull russet; upper tail coverts liver brown; tail chocolate, edged and tipped with dull black; primaries, secondaries, and primary coverts dull black with a faint sheen of violet; a narrow line of chocolate on the lores; foreneck, sides of neck, upper breast, and sides clear bright green, with some of the throat feathers edged narrowly with dull white; a small tuft of white feathers on the upper line of the sides near center; lower breast and upper abdomen hair brown; lower abdomen and tibial tufts white; under tail coverts walnut brown; edge of wing lined narrowly with chocolate. Tips and sides of maxilla and tip of mandible dull black; rest of bill dull reddish brown; bare lower end of tarsus, toes, and claws dull black. (From dried skin.)

Measurements.—Males (4 specimens), wing 67.5-68.7 (68.1), tail 40.0-41.5 (40.6), culmen from base 24.4-27.6 (24.5) mm.

Female (one specimen), wing 67.1, tail 41.1, culmen from base 25.8 mm.

Type, male, wing 67.5, tail 40.0, culmen from base 27.6 mm.

Range.—Confined to Isla Escudo de Veraguas, off the base of Peninsula Valiente, Bocas del Toro, Panamá.

Remarks.—During my visit to Escudo de Veraguas early in March 1958 I had brief glimpses of hummingbirds at flowers among low bushes back of the beach, but none came sufficiently near to allow me to shoot any for specimens. As they turned in flight I had brief glimpses of brown in the tail as in Rieffer's hummingbird (*Amazilia t. tzacatl*) common on the mainland, and these Escudo birds were so identified and recorded (Wetmore, 1959, p. 6). During the work of Dr. Handley five were captured in mist nets set for bats, and with these in hand it was obvious immediately that while they

[1] *Trochilus Tzacatl* De la Llave, Registro Trimestre, vol. 2, no. 5, Jan. 1833, p. 48. (México.)

resembled Rieffer's hummingbird in color pattern, they were so much larger, especially in bulk of body and total length, and also so much darker colored, that they were examples of an unknown form. From careful examination the differences are of such a nature that they must be considered as representative of a distinct species. This is named for Charles O. Handley, Jr., in recognition of his continuing interest in the avifauna during his field work concerned with the mammals of Panamá.

The five birds taken by Dr. Handley were preserved in formalin and were prepared as skins by Mrs. Roxie Laybourne on their arrival at the U. S. National Museum. Their much greater size was obvious, but to make certain that the color differences were not due to the preservative I placed a recently taken study skin of *Amazilia tzacatl tzacatl* in the same fluid in which the hummingbirds from Isla Escudo de Veraguas had been received. When dried after a month of such immersion this specimen showed no change of any kind. It is interesting to record that in this skin, and in the larger relative here described, the feathers along the side of the neck when wet were metallic reddish purple, a color that disappeared completely as the specimens dried.

Amazilia tzacatl as a species maintains uniform size, within the usual limits of individual variation, throughout a vast area from eastern México, Central America, and Colombia to western Ecuador and western Venezuela. The only variation apparent is in a buffy wash on the abdomen in that part of the population found in southwestern Colombia and Ecuador on which birds of that section are separated as a geographic race under the name *A. t. jucunda*. It has been noted above that the bird of Isla Escudo de Veraguas compared with *tzacatl* differs in decidedly darker coloration and in much larger size. It is clearly evident that the island group is of a stock similar to that of the mainland, so that on first consideration it would appear that they should be related as subspecies. The color differences, while considerable, would not militate against this. But the size difference in terms of bulk of body of the island bird is so much greater—over 50 percent more than that of the mainland group—with its complete isolation, make it reasonable to regard *handleyi* as a separate species.

As stated in my earlier paper (Wetmore, 1959, pp. 3-4) it is probable that the island had connection with the mainland during the fluctuations in sea level of Pleistocene time so that the present inhabitants among birds and mammals may have come to it during such periods. It is interesting that the hummingbird, the manakin, the wren, and the rat all differ from present-day mainland relatives in definitely greater size. In the tanager this distinction is also evident but is restricted to the bill. Perhaps this species has come to the island more recently than the others.

II. DESCRIPTIONS OF A WOOD-QUAIL AND A TYRANT FLYCATCHER FROM THE SERRANÍA DEL DARIÉN

During part of June and July 1963, the Gorgas Memorial Laboratory, under arrangements directed by Dr. Pedro Galindo, established three camps in the Serranía del Darién, in the vicinity of Cerro Tacarcuna, to serve as bases for the investigation of this little-known area. The birds collected included specimens of a beautiful wood-quail, related to Andean mountain forms to the south but unlike any of those known, and a flycatcher of a South American species not recorded before from Panamá. Descriptions of these follow.

Family PHASIANIDAE

ODONTOPHORUS DIALEUCOS, new species

Characters.—Generally similar to *Odontophorus strophium* (Gould)[2] but with crown black; back and scapulars without white shaft lines; entire upper surface olive, with rufous only as a band on the hindneck; foreneck similar in the two white bands above and below, with the space between mixed black and dull rufous; rest of lower surface olive rather than rufous and cinnamon, without shaft lines or a black collar below the lower white band; breast, sides, and flanks dull olive-buff, finely barred and mottled with slaty black.

Description.—Type, ♂, U.S. Nat. Mus. 483327, from 1,450 meters elevation, 6½ kilometers west of the summit of Cerro Malí, Darién, Panamá, taken June 7, 1963, by Pedro Galindo (orig. no., Gorgas Mem. Lab. 4-00384) : Crown black with slight, partly concealed mottling of dull rufous, and tiny spots of white; a prominent white superciliary streak that extends back of the eye; a band of hazel mottled and lined with sooty black on the hindneck that laterally becomes cinnamon-buff as it extends around to meet the posterior end of the white superciliary; back, rump, and upper tail coverts brownish olive, finely barred and mottled with sooty black, with scattered faint spots and indistinct bars of cinnamon; wing coverts, inner secondaries, and

[2] *Ortyx* (*Odontophorus*) *strophium* Gould, Proc. Zool. Soc. London, vol. 11, 1843 (March, 1944), p. 134. (Bogotá, Colombia.)

tertials snuff brown, barred and spotted finely with sooty black, and lined and spotted sparingly with small, irregular marks of buffy white; tertials with heavy, irregular markings of black, inner secondaries barred broadly with black; primaries fuscous, finely mottled with dull cinnamon-buff on outer webs; a band of white across the upper foreneck extending at either side over the malar region beneath the eye, and on the lower eyelid; a broad band of black mixed with Mars brown and russet extending between the two white bands from the lower cheeks across the middle foreneck and upper throat, changing to dull black over the ear coverts; a broad band of white across the lower foreneck; rest of lower surface dull buffy brown to tawny-olive, heavily mottled with sooty black, spotted sparingly and indistinctly with buffy white, becoming Saccardo's umber, with slightly heavier markings of black and cinnamon-buff on the flanks and under tail coverts; under wing coverts fuscous, sparingly and indistinctly spotted with dull Saccardo's umber. Bill, tarsi, and toes black (in dried skin).

Measurements.—Male (type), wing 129.5, tail 44.3, culmen from base 19.8, tarsus 45.2 mm.

Female, wing 131.0, tail 46.7, culmen from base 19.6, tarsus 47.5 mm.

Remarks.—The male and female from which this bird is described were taken together. The adult female is very slightly browner than the male. This specimen has the lores and the superciliary area black like the crown, with only a fine spotting of white. The chin also seems to have had the white band considerably reduced by black (though this can not be ascertained clearly as some of the feathers of this area are missing.) The line of the culmen and the tip of the maxilla in this bird are partly brown.

The discovery of this beautiful wood-quail, isolated in the higher levels of the Serranía del Darién, adds another form to populations of this genus with prominent markings of white on the head and neck. It is most like *Odontophorus strophium* of the Bogotá region of Colombia, which has the foreneck similar, with a black center bordered broadly with white above and below. This species differs, however, in the presence of a narrow black collar on the neck below the border of the lower white band. Also *strophium* is rufous and cinnamon on the breast and sides, with prominent white shaft lines and spots, has the crown fuscous-brown, and the whole upper surface rufescent rather than olive, with heavier, more prominent markings. *Odontophorus columbianus* (Gould) of the subtropical zone of the mountains of northern Venezuela in general resembles *strophium* but has the entire foreneck white above the narrow basal black collar. Also it is spotted along the sides with black, and heavily with white on the breast. *Odontophorus parambae* Rothschild, found in the tropical zone from west-central Colombia south to Ecuador, has a single white band across the lower area of the black foreneck. *Odontophorus leucolaemus,* more remote, in Costa Rica and western Panamá, has the entire upper foreneck white, with the lower area and upper breast jet black. And finally there may be noted *Odontophorus atrifrons* of the Andes of northern Colombia and *O. erythrops melanotis* found on Cerro Pirre and Cerro Azul in Panamá, in which the foreneck is solid black.

All these are similar in size, form, and, so far as known, in habits, so that it is reasonable to postulate common ancestry. Their present-day differences in pattern of markings, coupled with variations in color, may unite them in a super species, but these distinctions appear so fixed and so definite that to group them as subspecies under one specific name would conceal their interesting divergences.

The name for the species here described is from the Greek *dialeukos,* marked with white.

Family TYRANNIDAE

ELAENIA CANICEPS ABSITA, new subspecies

Characters.—Male, similar to that of *Elaenia caniceps parambae* (Hellmayr)[3] but lighter, clearer gray above and across the breast; whiter on throat and abdomen; partly concealed white area of center of crown larger; white edgings on lesser wing coverts more extensive. Female, with pileum darker gray (around the white center); breast, sides, and abdomen decidedly paler, less deeply yellow.

Description.—Type, ♂, U.S. Nat. Mus. 483342, from the old Tacarcuna Village site, headwaters of the Río Pucro, 950 meters elevation, on the base of Cerro Malí, Serranía del Darién, collected by Pedro Galindo, July 4, 1963 (orig. no., Gorgas Mem. Lab. 3-00329). Crown deep neutral gray, with an extensive, partly concealed central area in which the basal two-thirds of each feather is pure white; a narrow line of grayish white across forehead and upper edge of lores; back, rump, and upper tail coverts neutral gray; wings black, with the wing coverts tipped, and the inner primaries, secondaries, and tertials broadly edged with white; tail feathers mouse gray edged with neutral gray, mainly toward base, and tipped narrowly with grayish white;

[3] *Serpophaga parambae* Hellmayr, Bull. Brit. Orn. Club, vol. 14, Feb. 27, 1904, p. 54. (Paramba, elevation 3,500 feet, Provincia de Esmeraldas, Ecuador.)

a very narrow line of white on the edge of both eyelids; lores, side of head below eye, and anterior auricular feathers neutral gray at the tips and more or less white at the base; throat and upper foreneck very pale grayish white; lower foreneck, upper breast, and sides pallid neutral gray; flanks, abdomen, and under tail coverts pure white; edge of wing white with a slight spotting of neutral gray; inner wing coverts and edge of inner webs of primaries white; outermost wing coverts white mixed with neutral gray. Bill dull black, with the base of the gonys whitish; tarsus, toes, and claws black. (From dried skin.)

Measurements.—Male, type, wing 58.0, tail 49.4, culmen from base 10.5, tarsus 15.5 mm.

Female, wing 52.5, tail 42.8, culmen from base 10.2, tarsus 15.6 mm.

Range.—Known only from the upper Río Pucro, at 950 meters elevation on the base of Cerro Malí, Serranía del Darién, Panamá.

Remarks.—A female, U.S. Nat. Mus. 483341, was taken with the male at the same location, on July 4, 1963 (Gorgas Mem. Lab. no. 3-00328). This bird has the following colors: Crown slightly darker than in the male, with the same partly hidden white center; upper surface Krönberg's green; tail feathers blacker than in the male, edged lightly with dull green; light edgings on wing chartreuse yellow; side of head as in male; throat and upper foreneck duller white; lower foreneck, breast, and sides washed lightly with vetiver green; abdomen sea-foam green; under tail coverts chalcedony yellow; lighter part of under wing coverts, and inner webs of basal part of primaries like abdomen.

The male has been compared with the type of *Elaenia c. parambae* in the American Museum of Natural History. Through the kindness of James Bond I have examined a female and two males of that race in immature dress in the Academy of Natural Sciences of Philadelphia, taken on the Río Jurubidá, inland from Nuquí near the central coast of the Department of Chocó, northwestern Colombia. The two marked male in color are like the female. Compared with the female from Cerro Malí the three from Nuquí are very slightly clearer green on the back, with the base color of the crown faintly lighter gray. Below they differ decidedly as the throat and upper foreneck are duller, grayer, the lower foreneck, breast, and sides are much greener, and the rest of the under surface is decidedly deeper yellow.

The specimens from the Cerro Tacarcuna massif in Darién mark an interesting addition to the flycatchers known from Panamá. As a species, *Elaenia caniceps* ranges from Colombia and southern Venezuela to Bolivia, northern Argentina, and southern Brazil. With the present description four subspecies are recognized in this area.

The name of the present race, the most northern population known, is taken from the Latin *absitus,* in the sense of one living remote or distant from its relatives.

III. A WESTERN SUBSPECIES OF THE PLAIN-COLORED TANAGER

The plain-colored tanager, in its subspecies *Tangara inornata languens* Bangs and Barbour, is a common bird of the tropical zone in Panamá from the central lowlands eastward into Colombia. Through recent work of the Gorgas Memorial Laboratory at a field station in Bocas del Toro, I have received from Eustorgio Méndez three specimens from Almirante that mark a considerable extension of range. These prove to represent an undescribed race.

TANGARA INORNATA RAVA, new subspecies

Characters.—Similar to *Tangara inornata languens* Bangs and Barbour,[4] but with throat, lower breast, abdomen, and under tail coverts light buff to pinkish buff; a faint wash of the same color on lower rump and upper tail coverts; lesser wing coverts decidedly darker blue.

Description.—Type, ♂, U.S. Nat. Mus. 483344, from Almirante (Milla 2), Bocas del Toro, Panamá, collected August 23, 1963, by Eustorgio Méndez (orig. no., Gorgas Mem. Lab. 6936). Dorsal surface from crown to upper tail coverts neutral gray; wings and tail sooty black; lesser wing coverts methyl blue to Paris blue, with a metallic sheen; sides of head like crown, with the feathers of the ear coverts with faint grayish white shaft lines; chin sooty gray; foreneck pale olive-buff; chest and sides pale neutral gray; center of breast, abdomen, under tail coverts, and axillars pale pinkish buff to pinkish buff. Bill, tarsus, toes, and claws black. (From dried skin.)

Measurements.—Male (one, the type), wing 69.7, tail 45.4, culmen from base 10.9, tarsus 17.8 mm.

Female (two specimens), wing 65.4, 68.0, tail 43.6, 43.7, culmen from base 10.9, 11.0, tarsus 17.1, 17.2 mm.

Range.—Western area of the Province of Bocas del Toro in the Caribbean lowlands of Panamá; probably extending on the Caribbean slope in Costa Rica.

Remarks.—The well-known race *Tangara inornata languens* of this tanager has been recorded in Panamá on the Pacific slope west through

[4] *Tangara inornata languens* Bangs and Barbour, Bull. Mus. Comp. Zoöl., vol. 65, Sept. 1922, p. 227. (Lion Hill, Canal Zone, Panamá.)

the Canal Zone to Chorrera in the western sector of the Province of Panamá. On the Caribbean side I have taken it in the valley of the Río Indio west to El Uracillo, in northern Coclé, and Chilar in western Colón. In the American Museum of Natural History there is one from "Cascajal, Coclé" collected February 5, 1889. No collector is indicated, but the label and writing are those of Heyde and Lux, whose locality is believed to have been on the Caribbean slope on the Río Cascajal, a tributary of the Río Coclé del Norte.

The first specimen from Bocas del Toro, an immature female, taken in a mist net and prepared by Rudolfo Hinds, December 16, 1960, marked a considerable extension of range. The prominent buff of the under surface of this bird, which attracted immediate attention, was attributed at the time with some uncertainty to the age of the specimen, though this color did not agree with that found in other young birds of this species that I had seen. A second skin from Almirante, an adult female, taken September 25, 1962, was as deep buff as the first one, and with the receipt of an adult male secured August 23, 1963, it was apparent that a racial difference was indicated.

Approximately 75 skins of the race *languens* and 40 of *T. i. inornata* from central and eastern Colombia have been available for comparison. A faint wash of pale pinkish buff on the center of the abdomen and the under tail coverts is found in a number of these specimens, but in none is this color prominent as it is in the skins from Bocas del Toro. It is most evident in a few skins taken a hundred years ago by McLeannan in which this color seems due in part to discoloration from age as museum specimens. In all individuals in these long series the lesser wing coverts are light blue, with no approach to the darker color of this area in the birds from Bocas del Toro.

It is probable that the race described here ranges beyond the international boundary in the lowlands of the Caribbean slope of Costa Rica. While no specimens are available at this time, Dr. Paul Slud informs me that he has a few records of *Tangara inornata* (which he will publish in detail later) from that area.

The name is from the Latin adjective *ravus,* in the sense of tawny.

IV. ADDITIONS TO THE RECORDED LIST OF BIRDS FROM THE REPUBLIC OF PANAMÁ

Knot, *Calidris canutus rufa* (Wilson): Two immature males taken at Puerto Obaldía, San Blas, on September 12 and 22, 1934, by Hasso von Wedel are the only present report for this species. The specimens, originally in the Herbert Brandt collection at the Museum of the University of Cincinnati, are now in the U.S. National Museum. In the period of northern winter the knot, which nests in the far north, is found from eastern United States south to Tierra del Fuego. There are, however, few records of it in Central America.

Caspian tern, *Hydroprogne caspia* (Pallas): In the files of the U.S. Fish and Wildlife Service there is record of one banded by L. Tyler on South Limestone Island, in Georgian Bay, Lake Huron, Ontario, on June 11, 1955, that was found wounded at Aligandí, San Blas, on the evening of November 12 of that year. According to the report, forwarded by Dr. Alcibíades Iglésias, the bird died the following day. The occurrence on the San Blas coast is one to be expected, as this tern is reported as a migrant to the Caribbean coast of Colombia from Cartagena to the lower Río Magdalena.

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WETMORE, ALEXANDER.

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SMITHSONIAN MISCELLANEOUS COLLECTIONS
VOLUME 145, NUMBER 7

A PHYTOPHYSIOGNOMIC RECONNAISSANCE OF BARRO COLORADO ISLAND, CANAL ZONE

By
CHARLES F. BENNETT, JR.

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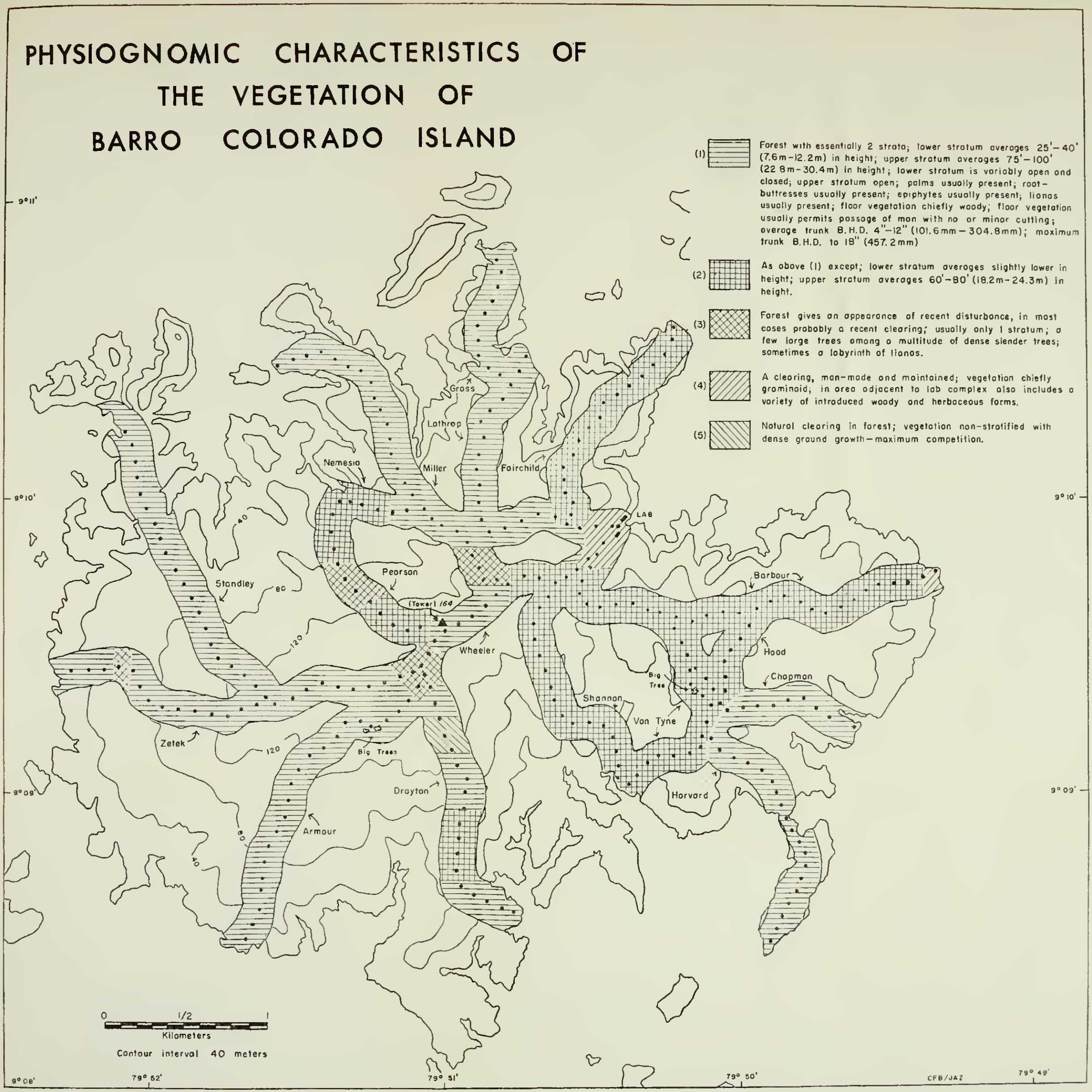
PHYSIOGNOMIC CHARACTERISTICS OF THE VEGETATION OF BARRO COLORADO ISLAND
(1) Forest with essentially 2 strata; lower stratum averages 25'–40' (7.6m–12.2m) in height; upper stratum averages 75'–100' (22.8m–30.4m) in height; lower stratum is variably open and closed; upper stratum open; palms usually present; root-buttresses usually present; epiphytes usually present; lianas usually present; floor vegetation chiefly woody; floor vegetation usually permits passage of man with no or minor cutting; average trunk B.H.D. 4"–12" (101.6mm–304.8mm); maximum trunk B.H.D. to 18" (457.2mm)
(2) As above (1) except; lower stratum averages slightly lower in height; upper stratum averages 60'–80' (18.2m–24.3m) in height.
(3) Forest gives an appearance of recent disturbance, in most cases probably a recent clearing; usually only 1 stratum; a few large trees among a multitude of dense slender trees; sometimes a labyrinth of lianas.
(4) A clearing, man-made and maintained; vegetation chiefly graminoid; in area adjacent to lab complex also includes a variety of introduced woody and herbaceous forms.
(5) Natural clearing in forest; vegetation non-stratified with dense ground growth—maximum competition.
9°11'
9°10'
9°09'
9°08'
79° 52'
79° 51'
79° 50'
79° 49'
Gross
Lothrop
Nemesio
Miller
Fairchild
LAB
Pearson
Standley
(Tower) 164
Wheeler
Barbour
Hood
Chapman
Big Tree
Shannon
Van Tyne
Zetek
Big Trees
Drayton
Armour
Harvard
40
80
120
0 1/2 1
Kilometers
Contour interval 40 meters
CFB/JAZ

A PHYTOPHYSIOGNOMIC RECONNAISSANCE OF BARRO COLORADO ISLAND, CANAL ZONE

By Charles F. Bennett, Jr.

Barro Colorado Island (hereafter BCI) has been and continues to be the site of intensive and varied research on problems of tropical biology. Increasingly, during the 40 years of the man-made island's existence, the studies have focused on problems that require detailed analysis of the basic ecological conditions occurring on the island. It is in an effort to make a contribution to the knowledge of one of these basic conditions—the phytophysiognomy—that this paper is written.

With the exception of a sketch map which attempted to show some physical aspects of the forest on BCI (Enders, 1935) no map of the phytophysiognomy of the island has heretofore been made available. This may, in part, account for the numerous allusions to "tropical rain-forest," "primeval tropical forest," and "climax forest" that one encounters in many published papers dealing with some aspects of the island's biology.

Possibly it is incorrect to allude to any parcel of arboreal vegetation in the American (or Old World) tropics as being primeval in the sense that it represents an entity quite uninfluenced by the hand of man. Millennia-long human occupance of these lands would seem to preclude such usage. Areas not now settled by man may suggest the primeval but may surprise one when soil samples are taken, as was recently the case in Dutch Guiana where charcoal was discovered (Shulz, 1960). BCI scarcely is sited in an isolated position in the American tropics. It was once a low hill among many similar to it on the isthmus, and it seems fatuous to suggest that shifting cultivators (Cuna-Cueva) who occupied the general area at the time of Spanish entry spared this particular hill from fire and crops. In the four centuries since the Conquest the hill was adjacent to the major routes of transisthmian crossing. The hill's transformation into an island was perhaps only among the most recent of a long series of ecological manipulations by man, for the manipulations did not cease at once—holdings of several small farmers had to be purchased before the island could be turned into a preserve (Anon., 1925).

Previous writers have mentioned the human ecological role on BCI (e.g., Kenoyer 1929; Zetek, n.d.; Standley, 1933; Chapman, 1938), but the import of their statements was sometimes lost through hopeful allusions to the supposed presence of primeval or climax forest on the island. In this writer's opinion, biologists would do well to consider such forest areas as extremely rare entities anywhere in the tropics and to dismiss the idea completely in reference to BCI.

Perhaps even more persistent are the published allusions to the existence of a tropical rainforest cover on BCI. There is some justification for this misconception because of the plethora of vague and inexact ways in which certain specialists have employed the term tropical rainforest. This inexactness has performed no service to biologists and particularly to those seeking to demonstrate similarities and/or differences between spatially separated tropical regions.

In climatology, tropical rainforest has been defined quantitatively and is referred to as tropical rainforest climate. The term refers to precipitation and temperature, *viz*, the average temperature of the coldest month is no lower than 18°C. (64.4°F.), and the average precipitation of the dryest month is not less than 60 mm. (2.2 inches). This is a part of the Köppen Climatic Classification, and the quantitative values given above are coded as follows: the temperature value receives *A* (signifying an always warm tropical climate); the precipitation value receives an *f* (indicating abundant precipitation distributed throughout the year). Together, *Af* signifies tropical rainforest climate, or, to put it another way, only under these climatic conditions can tropical rainforest be expected to occur. Although there are *Af* stations within the Republic of Panama, BCI is not such a station because *f* conditions of precipitation do not occur there. The months of January, February, and March have average precipitation of less than 60 mm. On the other hand, the remaining eight months are usually very wet and much of the annual average precipitation, which exceeds 2,500 mm. (100 inches), falls during this period. The designation for this precipitation pattern in the Köppen system is *m*. Thus BCI has an *Am* or Tropical Monsoon Climate.[1]

The Köppen system represents an attempt to correlate the known data on precipitation and temperature with the distribution of major vegetational regions (based principally on De Candole's system of dividing the world's plant cover into five groups supposedly correlated

[1] The author is in the process of completing for publication the first of a series of climatological studies of BCI. Therefore, more detailed analysis is not here presented.

with their temperature requirements, *viz*, macrotherms, mesotherms, microtherms, hekistotherms, xerophytes). This obviously results in broadly generalized climatic-vegetation regions. One must, therefore, turn to other sources when the plant physiognomy of smaller regions is to be examined. For this purpose the work of J. S. Beard has been considered as most important and applicable (Beard, 1944, 1955).

Although Beard employs the climax concept in his approach to tropical vegetation, which this writer holds to be of doubtful value, it is nonetheless true that the tropical forest formations recognized by Beard, climax or no, have the decided significance of being entities that in fact exist and can be recognized rather easily by investigators employing the classification in the field.

Because the reader is above referred to Beard's work, which is readily available in libraries, only the briefest remarks regarding it will be made here. He recognizes rainforest as constituting a major formation, and in addition to this optimal formation he recognizes six seasonal formations (as well as other special formations) ranked according to their divergence from the optimal rainforest situation. The first two in the ranking concern us here, *viz*, Evergreen Seasonal Forest and Semi-Evergreen Seasonal Forest. On BCI the oldest appearing forest seems to be more or less intermediate with the two just named formations. If one were required to assign a broader term to the older forest cover on the island the term Tropical Monsoon Forest would apply.

To return to my earlier comments, recent vegetation disturbances by man on BCI makes rigorous application of Beard's or any other system to the entire island quite impossible. There are in fact a number of rather distinct phytophysiognomic microregions on the island which are of obvious importance to the distribution and numbers of animal species present. Further, these conditions are not to be considered as static, and as they change so too will the structure of the island's fauna change. In order to contribute in a small measure to the understanding of the phytophysiognomy of the island, I conducted a mapping-reconnaissance during two weeks in August 1960. A discussion of the results of that reconnaissance follows.

As is known to those familiar with the area, BCI is crossed by a network of trails which more or less intercept most of the larger biotopes occurring on the island. It is probable that a large percentage of the field observations on the island are made on or within a few yards of the trails. Therefore, the reconnaissance was confined to the trails, as the accompanying map (fig. 1) will clearly indicate.[2] Time limitations prevented proper surveys between the trails, and it is believed that map reliability has been increased through refraining from extrapolating trail data to fill the large map interstices between the trails.

Special note should be taken of the fact that the mapping was accomplished during the wet season. This tends to bias the observations to some extent as the forest on BCI is facultatively deciduous, and while sometimes appearing extraordinarily lush and green in the rainy period it will also present a very xeric appearance during an exceedingly well-developed dry season as, e.g., 1958. Also, during those years in which the dry season is not very dry, as e.g., 1963, leaf fall will be found to be very much less than in normal years. This point is stressed because we are often misled by authors whose work in the tropics has almost always been in one season (coinciding no doubt with the academic year summer recess), and many of us have at times almost lost sight of the fact that while the lowland tropics may be the place where winter never comes, it is very definitely a place where ecologically significant seasonal changes of temperature and precipitation occur.

There is not yet a standardized system for mapping the physiognomic characteristics of tropical vegetation. Therefore, I devised my own list of phytophysiognomic characters which seemed to be of importance. The specific details mapped were as follows:

1. Number of tree strata present.
2. Average estimated height of each tree stratum.
3. Canopy characteristics of each tree stratum.
4. Presence of palms.
5. Average breast-height-diameter of trees.
6. Occurrence of the following special features:

   a. root buttresses.
   b. stilt roots.
   c. lianas.
   d. epiphytes.
   e. density of floor vegetation.
   f. nature of floor vegetation.
   g. leaf litter on forest floor.

It is obvious that this list is too detailed to permit all the items being conveniently shown on a map of the scale employed in this paper. Therefore, the details were generalized into five categories which are discussed below.

[2] The base map employed appeared in Woodring, 1958.

The trails on the island are marked at 100-meter intervals, and it was therefore possible to maintain good mapping control. The distribution of the various categories appearing on the map are correct as read *along* the trail. The width of the distribution of the vegetation type along any given trail has been standardized to approximately 100 meters as a cartographic convenience and does not represent actual field limits to the transects. On the other hand, the width is realistic in that the conditions as mapped usually extend at least 50 meters on each side of the trails.

The five map categories are as follows:

(1) Forest with essentially 2 tree strata; the lower stratum averages 25′ to 40′ (7.6 m. to 12.2 m.) in height; the upper stratum averages 75′ to 100′ (22.8 m. to 30.4 m.) in height: the lower stratum is variably open and closed; the upper stratum is open; palms are usually present; root buttresses usually present; epiphytes are usually present; lianas usually present; floor vegetation density is only moderate and usually permits the passage of a man with little or no cutting; floor vegetation is chiefly woody; average breast-height-diameter of trees is 4″ to 12″ (102 mm. to 305 mm.); maximum breast-height-diameters seldom exceed 18″ (457 mm.).

This unit (1) has a discontinuous distribution on the island. Although rather limited in area in the center of the island, it becomes rather extensive in the extreme west, extreme southeast, and in the north and northwest parts. On a trail-length basis this unit accounts for approximately 11 km. This appears to be the oldest of the various forest units present on the island. I would, however, refrain from calling it either mature or climax for reasons given above.

(2) More or less as (1) above except that the bottom stratum averages slightly lower in height and the upper stratum averages 60′ to 80′ (18.2 m. to 24.3 m.) in height.

As indicated, there is rather little other than height difference to distinguish the second category from the first. This is probably slightly younger forest than (1). It is concentrated in the east, northeast, and central parts of the island. Its linear extent along trails is approximately 7.5 km.

(3) A forest which presents an appearance of recent disturbance, in most cases probably a clearing in the past 40 years. There is usually a single-tree stratum with an occasional larger tree spaced at broad intervals among a multitude of closely spaced very slender trees; sometimes dense labyrinths of lianas occur.

Most, if not all, of the areas mapped as (3) represent sites that not very long ago were devoted to farming. One occasionally encounters rather forceful testimony to this in the form of an isolated mango (*Mangifera indica*) or coconut tree (*Cocos nucifera*), which probably mark old house sites. Those who frequently postulate the rapid recovery of tropical forest on a site after it has been deserted by man would find these situations (3) quite instructive. Total trail length slightly exceeds 0.5 km.

> (4) A clearing, man-made and man-maintained; vegetation is chiefly graminoid but in clearing adjacent to laboratory complex there is also a wide variety of exotic woody and herbaceous forms.

Although very limited on the map, areas of (4) occur elsewhere on the island away from trails and adjacent to canal marking devices. The latter are usually in grass or grass, herbaceous forms and young palms. Heavier growth is kept down through regular maintainence by Canal officials. Areas of (4) are among the most interesting from a faunal standpoint of all five units shown on the map. Total trail length is approximately 0.5 km.

> (5) Natural clearing in the forest; vegetation is not stratified and ground cover is dense in the earlier seral stages; an abundance of herbaceous species during early seral stages giving way later to an increasing density of woody forms.

This (5) is the most transient phytophysiognomic unit mapped on BCI. These clearings usually result from tree blowdowns during high winds. The map includes only the largest one encountered.

Some further discussion of the phytophysiognomic details recognized in the reconnaissance is desirable, not only to add further to the map detail but also to augment understanding of the physical character of the vegetation of BCI. Since a number of these details have been discussed above in connection with the major categories employed on the map, only the "special features" are discussed below.

a. *Root buttresses.* No areas of marked concentration of this interesting feature were noted. Root buttresses occur as a generally distributed feature with the lowest incidence occurring in areas designated as (3) on the map. Of course this feature does not as a rule occur in clearings.

b. *Stilt roots.* This feature appears to have a random distribution. Sometimes one finds small colonies of the palm *Iriartea* spp. which possess this character.

c. *Lianas.* Although lianas are generally distributed over the island, they are not abundant except at clearing edges, and in area (3).

d. *Epiphytes.* At no place on the island were epiphytes encountered in abundance, although this feature is definitely ubiquitous. Most trees have a complement which becomes abundantly apparent when limbs fall to the forest floor during high winds or as the result of insect tunneling and general decay. But one does not encounter the incredibly festooned limbs of, for instance, the cloud forest of other parts of the tropics.

e. *Density of floor vegetation.* Although the forest floors of BCI never suggest the "vaulted aisles" of some writers, the ground cover under the older forest tends to be moderate and usually allows passage with very little work with the machete. This is somewhat surprising because the sunlight reaches the ground quite abundantly in the normal dry season, and this would seem to facilitate growth. But this is also the period of drought, and the fact remains that for at least 8 months of the year the amount of light reaching the ground is so slight as to probably restrict growth. Other inhibiting factors are also undoubtedly present. In clearings, however, the dense tangles of vegetation prevent all but the most determined person from passing.

f. *Nature of floor vegetation.* Woody floor vegetation is the rule in the older forested areas. But even in these situations considerable quantities of herbaceous vegetation is sometimes encountered although this is usually most abundant in clearings. One special feature deserving mention is the occurrence of dense thickets of a terrestrial bromeliad with the local name piñuela (probably *Ananas* spp.). One of the most extensive of such areas occurs not far from the end of Zetek trail in the western end of the island. These thickets are almost impenetrable to man but provide shelter and food to a considerable array of animal species.

g. *Leaf litter.* I am not aware that this is usually included as a phytophysiognomic feature, but it is so included here because it is of considerable ecologic significance. This is an extremely variable feature varying from season to season, from year to year, and from place to place at any given time. Contrary to numerous published remarks which indicate that leaf litter is virtually nonexistent on the floor of tropical forests except for limited periods during the year, leaves persist in quantity on the forest floor of BCI throughout the year. Although fungal and bacterial action is rapid and more or less continuous, there is a more or less continuous increment of shed leaves to the floor during all periods of the year. The greatest deposition usually occurs during the height of the dry season. It is rare to encounter any sizable area of forest floor completely devoid of leaf litter at any time of the year. Seasonal conditions, as well as local conditions of slope, and wind exposure are important modifying factors.

ACKNOWLEDGMENTS

I wish to express gratitude to: Dr. Martin H. Moynihan, Director of the Canal Zone Biological Area, who unfailingly gave assistance to this project; to Mrs. Adela Gomez, administrative assistant to Dr. Moynihan, for her many kind acts of assistance; and to my wife, Carole, who assisted in the final preparation of the manuscript.

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(With Five Plates)

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INTRODUCTION

A blue, plastic, marine silty-clay of Late Pleistocene age is found in southeastern New Hampshire and in southwestern, central, and southeastern Maine. It has been referred to by various authors as "marine clay," "the clay," or "leda clay." No formal name had been assigned to this clay until Bloom (1960) proposed the name "Presumpscot formation" for this well-defined unit, and his designation has been adopted here.

Mollusks are relatively common in the Presumpscot formation. Clapp (1907) gave an extensive faunal list, and Little (1917) compiled a similar list for the Waterville, Maine, area. Bloom (1960) presented a chart showing the present latitudinal range of mollusks found in the Presumpscot formation. The microfossils have been largely overlooked, and the only published work is that of Morton (1897), who listed 45 species of Foraminifera from samples taken in southern Maine. The present study describes the Foraminifera contained in samples from a series of borings near Waterville, Maine. The depositional environment is inferred by comparing the distribution and abundance of the fauna in the clay with modern counterparts.

I wish to thank Dr. R. Cifelli, who suggested the study and devoted much of his time and energy to it. Dr. Leo LaPorte also offered many helpful suggestions throughout the investigation. Miss Ruth Todd made many helpful comments concerning the manuscript. F. Boyce, Jr., of the Soils Laboratory, Maine State Highway Commission, was kind enough to send samples from several borings and furnish pertinent data concerning the bore holes. Dr. A. Norvang generously sent specimens for comparison from the Museum in Copenhagen. Thanks are also due to Dr. Koons and Dr. Hickox of Colby College for pointing out field relations in the Waterville area. Dr. Bloom was kind enough to show me several interesting localities in southwestern Maine. The Foraminifera were illustrated by Lawrence B. Isham, scientific illustrator, U. S. National Museum. Figured specimens are deposited in the U. S. National Museum.

LOCATION AND METHODS

The samples used in the present study were taken from borings made across Messalonskee Stream in Kennebec County, approximately 1 mile northwest of Waterville, Maine. The samples were obtained from the Soils Laboratory, Maine State Highway Commission, who made the borings to determine soil stratification and consistency data of the Messalonskee Stream area. Figure 1 shows the location of the Waterville area and the locations of the borings.

Of the 39 samples of clay obtained from the Soils Laboratory, 38 were from four borings and 1 from a fifth boring. The samples were fairly uniform in size, each containing about 750 cc. of clay.

Each sample was disaggregated by boiling in water and then washed in a 200-mesh brass screen. Microscopic examination of the residues showed them to be composed mainly of quartz with some mica and lithic fragments. Some of the residues were treated with carbon tetrachloride in the manner described by Cushman (1948a, p. 27). Although many of the foraminiferal tests floated in this treatment, an appreciable percentage did not. A liquid with a specific gravity of 2.58 was then obtained by mixing acetylene tetrabromide and acetone. When a washed-samples residue was poured into a separatory funnel containing this liquid, the quartz sank while the tests of the Foraminifera floated. The fraction of the residue that initially sank was subjected to a second separation to insure maximum recovery of foraminiferal tests. This method yielded a concentration of sink to float of 20:1. A quantitative study made on three samples showed that the poorest recovery yielded 95 percent of the total population, the best, 100 percent.

BEDROCK GEOLOGY

The area of this study is underlain by the Waterville formation (named by Perkins and Smith, 1925), which has two predominant lithologies: bluish calcareous shale and gray arenaceous shale, and dark-bluish slate interbedded with quartzitic layers. These two

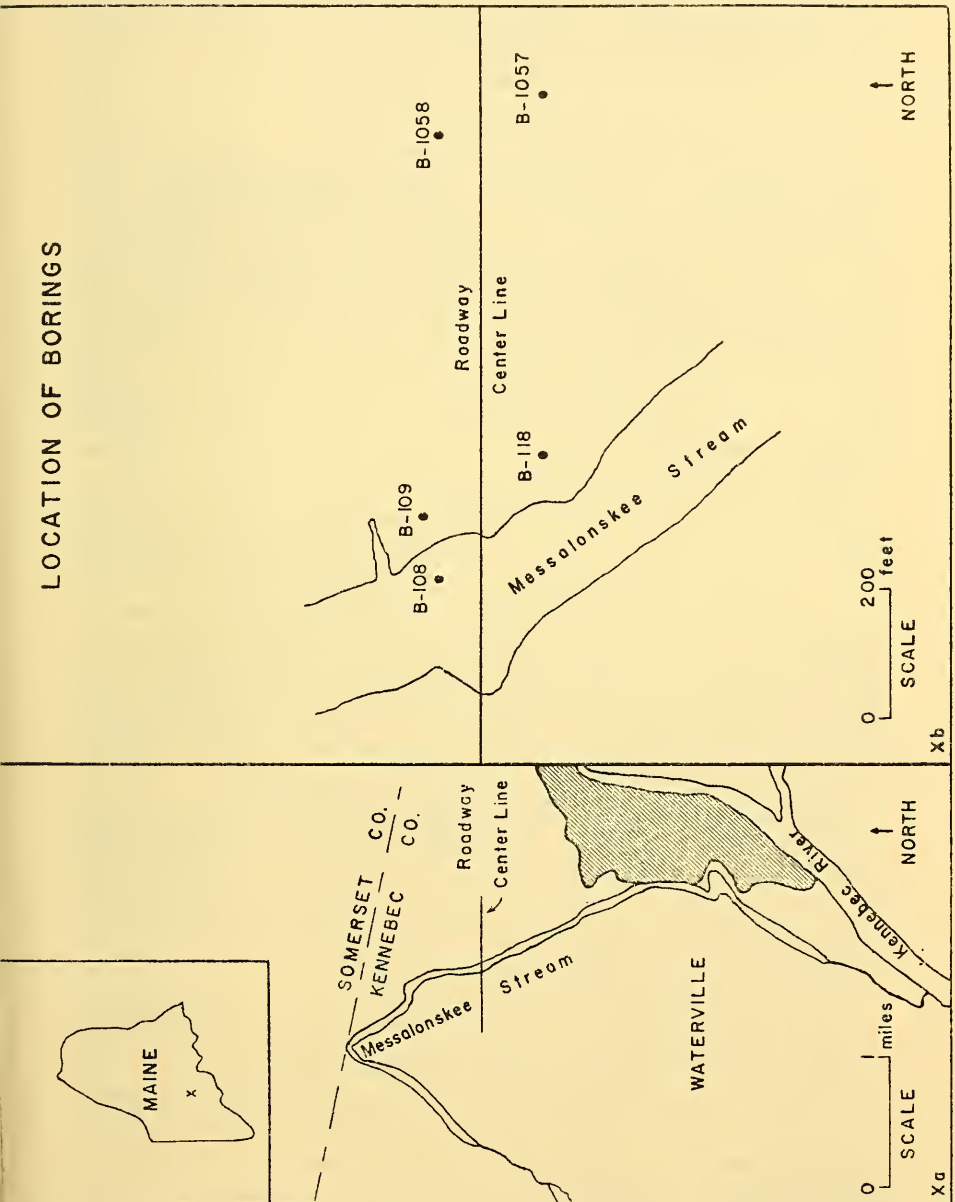

Fig. 1.—Location of borings.

lithologies are interbedded and folded into a series of small plunging folds. The average strike of the beds is in a northeasterly direction. Graptolite-bearing slates from an abandoned quarry northwest of Waterville indicate a Mid-Silurian age.

PRESUMPSCOT FORMATION

During Late Pleistocene time, when a sufficient quantity of water was returned to the sea from the melting continental glacier, the southern and central portions of Maine which had been depressed by the ice were partially submerged. Within the drowned valleys of this area a blanket of marine clay was deposited. The clay occurs at sea level along the coast and at higher elevations toward the north-northwest, reaching a height of 440 feet in west central Maine (Goldthwait, 1949). The marine clay overlies till, bedrock, or stratified sand and gravel. It is the youngest stratigraphic unit in the Waterville area and has been given the name "Presumpscot formation" by Bloom (1960).

In the Waterville area a time lapse between the retreat of the glacier and the advance of the sea was hypothesized by Little (1917), who presented several lines of evidence from examination of eroded esker deposits. Further evidence of subaerial erosion was cited by Goldthwait (1951), who has shown that in the Portland-Sebago area, valleys were cut into outwash plains prior to the deposition of the clay. However, 25 miles southeast of Portland in the Biddeford area, Bloom (1960) has indicated that a local glacial advance occurred after the marine submergence was already in progress.

Because there is a lack of well-defined shore features, Caldwell (1959, p. 16) believed that the inundation lasted for a relatively short period of time, and that the sea began its retreat soon after reaching its maximum northern extension. Leavitt and Perkins (1935, p. 202) for similar reasons concluded that the marine submergence was relatively short, "a few thousand years at the most."

I am aware of only one radiocarbon date that indicates the age of the clay. R. L. Dow of the Maine Department of Sea and Shore Fisheries collected some mollusk shells from marine clay in the Morrison Corner gravel pit 8 miles north of Waterville. A radiocarbon date made on this material in 1958 by the U. S. Geological Survey indicates an age of 11,800±200 years. The exact stratigraphic location of the shells was not indicated. However, owing to the proximity of the Morrison Corner gravel pit to the area under study, the clays of the two areas are probably of the same age.

The Presumpscot formation varies greatly in thickness because it was deposited on a very irregular surface. The maximum thicknesses (over 110 feet) are found in buried valleys. The "clay" is composed mainly of clear angular quartz, although some mica and feldspar are present. According to Goldthwait (1953), analyses of grain size of 43 samples by E. Cromier in 1949 showed an average of 39 percent clay, 37½ percent silt, and 23½ percent sand. There was, however, much variation between samples. No analyses were made of the samples used in the present study.

Boulders are scattered throughout the Presumpscot formation and were presumably ice-rafted to their present position.

Much of the marine clay is fossiliferous, and mollusk shells have been reported from various areas. Some of the workers who have compiled faunal lists are Clapp (1907), Little (1917), and Bloom (1960).

Although megafossils are found in many areas, their distribution is patchy, and mollusk shells are normally found only in isolated pockets of the marine clay. Foraminifera appear to be abundant where mollusk shells are present.

STRATIGRAPHY AT MESSALONSKEE STREAM

The profiles made across Messalonskee Stream by the Soils Laboratory indicate that the clay rests on till west of the stream and on bedrock east of the stream. Sand layers are occasionally found in the clay. In this area the clay is directly overlain by soil. The clay attains a maximum thickness of 90 feet in the lower parts of the stream valley and extends in constantly diminishing thicknesses on either side of the stream. It has an average thickness of 54 feet in these borings.

A brown clay overlies a blue-gray clay in the Messalonskee area. The detailed boring sheets of the Soils Laboratory do not indicate the nature of the contact. Goldthwait (1951) has observed these color variations in the clay elsewhere and has suggested that the brown color is due to oxidation of the blue clay. Caldwell (1959, p. 30) has made a chemical analyses of two pairs of brown and blue clay samples from the Farmington area. He found, as one would expect if the brown clay represents weathering of blue clay, that the ratio of ferric to ferrous iron is greater in the brown clay. I have observed that in some gravel pits the brown clay is directly overlain by soil, which indicates that brown clay is actually the C-horizon of a soil profile and is, as Goldthwait (1951) suggested, a weathering phenomenon.

In correlating the borings of the Messalonskee area (figs. 2 and 4) the following assumptions were made:

1. The base of the clay represents the original depositional surface and is time-equivalent throughout the area.

2. The rate of sedimentation was constant within the area studied.

These assumptions appear to be reasonable because the borings studied are confined to an area that measures only 0.1 by 0.2 miles.

Figure 2 shows the stratigraphic relations of the borings. In boring No. 1058 clay rests directly on bedrock, while in borings Nos. 118, 108, and 109 till underlies the clay. The dashed line indicates the original depositional surface.

FORAMINIFERAL DISTRIBUTION

Of the samples obtained from the Messalonskee Stream area, 26 yielded Foraminifera, whereas 13 were barren. Of the 13 barren samples 11 were within the top 13 feet of the borings. Two of these were samples of soil and the rest of brown silty clay. Because the top samples of some of the borings are actually soil and because the zone of weathering extends to at least the depth of the first two samples of each boring, I conclude that the absence of fossils in these uppermost samples is due to their destruction by leaching. However, it is doubtful that leaching is responsible for the absence or scarcity of Foraminifera in the upper 30 feet or so of the section shown in figure 4.

Foraminiferal abundance is generally low in all samples. Only 14 of the 26 samples that contained Foraminifera yielded more than 160 individuals. If one disregards the effect of compaction, then these samples contain only about 3 individuals per 10 ml. A 10-ml. sample from an area such as Long Island Sound usually contains several hundred individuals.

Altogether 19 species representing 13 genera are present. Only five species are abundant or common; the remainder are rare and either occur in only one sample or else are distributed at random throughout. All the Foraminifera are benthonic, and only one species, represented by two specimens, is arenaceous. *Elphidium clavatum* is by far the most abundant species in the samples.

The percentage distribution of the Foraminifera found in the samples from the Messalonskee area is shown in figure 3. In figure 4 the percentage distribution of the common Foraminifera is shown

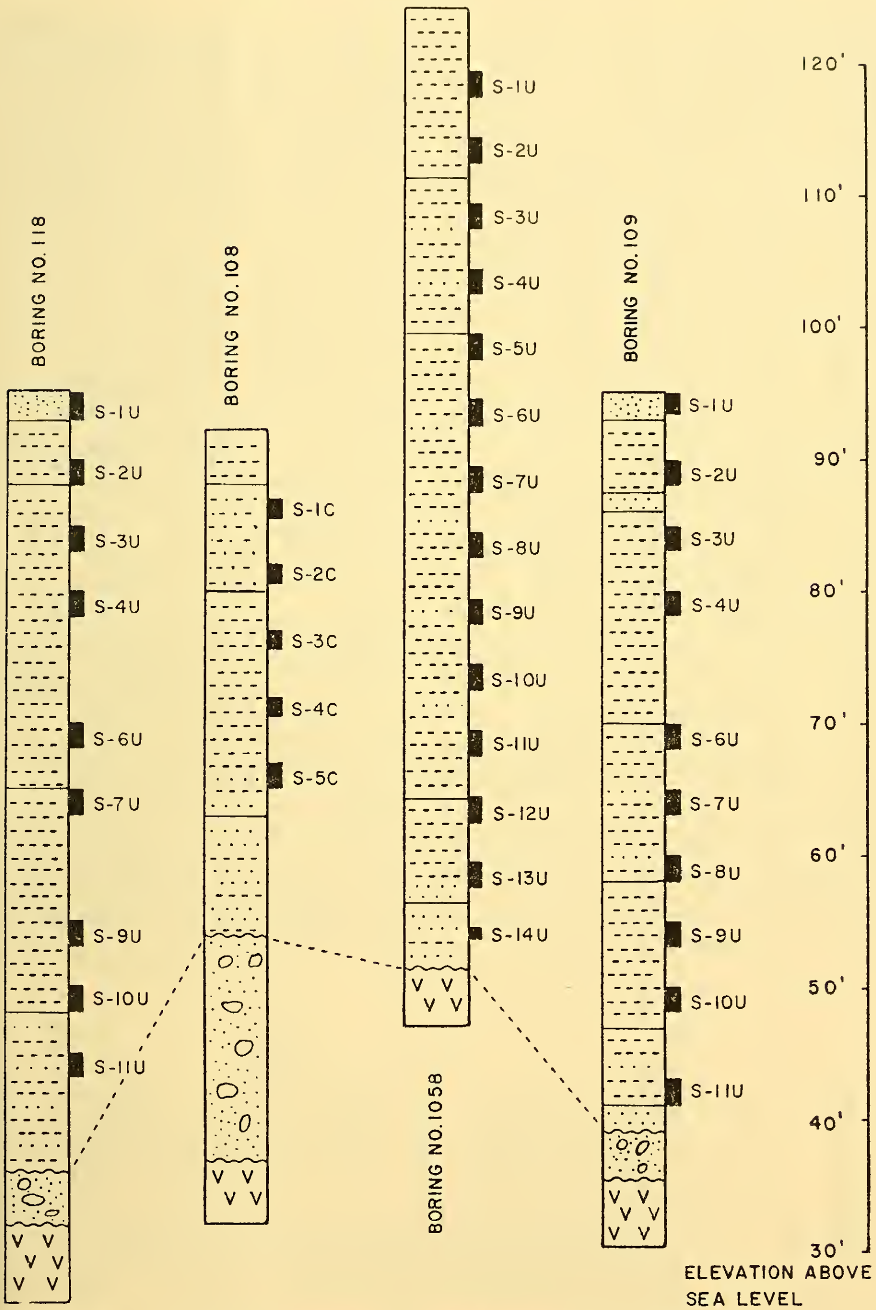

FIG. 2.—Stratigraphic location of samples in borings.

BORING NO.	SAMPLE NO.	ELEVATION	TOTAL POPULATION	SPECIES IN %	BUCCELLA FRIGIDA	CASSIDULINA BARBARA	CASSIDULINA TERETIS	CIBICDES cf. LOBATULUS	CORNUSPIRA sp.	EGGERELLA ADVENA	ELPHIDIUM sp.	ELPHIDIUM CLAVATUM	ELPHIDIUM ORBICULARE	ELPHIDIUM VARIUM	FISSURINA cf. CUCURBITASEMA	GLOBULINA GLACIALIS	LAGENA CLAVATA	NONIONELLA AURICULA	PATEORIS HAUERINOIDES	PYRGO WILLIAMSONI	QUINQUELOCULINA SEMINULUM	TRILOCULINA sp.	TRILOCULINA TRIHEDRA
B-1058	S-5U	97.5'-99.5'	2									100											
	S-7U	87.5'-89.5'	6									83				17							
	S-8U	82.5'-84.5'	36									100											
	S-9U	77.5'-79.5'	20		5							55	35			5							
	S-10U	72.5'-74.5'	213		2							75	20	1		1							
	S-11U	67.5'-69.5'	538		4	.2						55	15	19		2	1		1		2		
	S-12U	62.5'-64.5'	22			14						64	9						14				
	S-13U	57.5'-59.5'	628		13	.3		.3			3	34	16	29		1	.2	1		1			
	S-14U	53.5'-54.5'	204									99	1										
B-108	S-3C	75.5'-77'	195		2							40	40	20		2	1						
	S-4C	70.5'-72'	365		3	1						57	21	18				1		.3			
	S-5C	65'-67'	5									80								20			
B-109	S-4U	78'-80'	9									78				22							
	S-6U	68'-70'	297									81	16	2		.3			1		.3		
	S-7U	63'-65'	1022		1	1						75	11	8	1	1	.1			2			
	S-8U	58'-60'	1041		4	2				.2		50	22	21		1				1	1		
	S-9U	53'-55'	165			88						12							1				
	S-10U	48'-50'	9									89							11				
	S-11U	42'-44'	5									100											
B-118	S-4U	78'-80'	13									100											
	S-6U	68'-70'	46									85	6	4		4							
	S-7U	63'-65'	574		8	2						73	10	5	.2	2			1				
	S-9U	53'-55'	880			69	.3		.1			28	2	.1	.1	.1				.3			
	S-10U	48'-50'	6									100											
	S-11U	43'-45'	259			1						95							2			1	2
B-1057																							
	S-7U	76'-78'	765		15	1						41	26	16		1					1		

FIG. 3.—Percent distribution of Foraminifera.

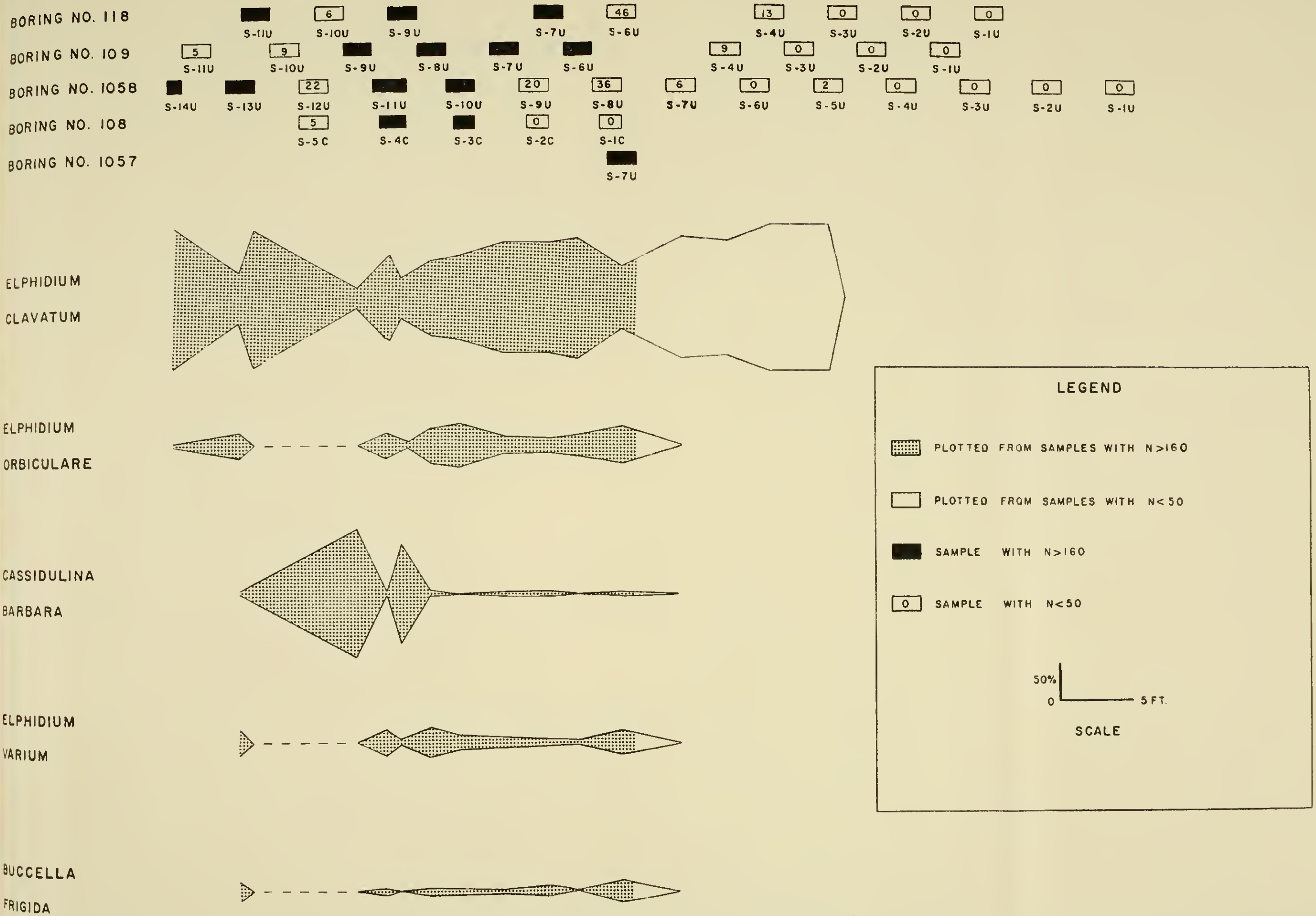

Fig. 4.—Percent distribution of common species in correlated borings.

[illegible]

diagrammatically, using the depositional surface of figure 2 as the base. Fourteen samples have more than 160 individuals and 11 have less than 50. Curiously, no sample has a total number of individuals that falls between these two figures. Samples with more than 160 individuals are marked black on the diagram, while samples with less than 50 individuals have the actual number of specimens present indicated within the rectangle representing the sample. The lower part of the section shown in figure 4 contains all the samples that have more than 160 individuals. In order to minimize the possibility of fluctuation in the distribution curve that might be due to inadequate populations, only samples with more than 160 individuals were used in plotting the data from the lower part of the section. In the upper part of the section where there are no samples with more than 160 individuals, samples with less than 50 individuals were used in plotting the data.

DISTRIBUTION OF THE COMMON SPECIES

Elphidium clavatum Cushman is very abundant. This species comprises at least 40 percent of the total population in all but 2 samples and has an average abundance of 58 percent in samples with more than 160 individuals. In samples with less than 50 individuals it averages 86 percent of the total population.

Elphidium orbiculare (Brady) is present in 15 samples and comprises 40 percent of the total population in 1 sample. It has an average abundance of 17 percent in samples with more than 160 individuals.

Cassidulina barbara n. sp. occurs in 11 samples. It is generally low in abundance, but in 2 samples it comprises 69 and 88 percent of the total population.

Elphidium varium n. sp. occurs in 12 samples. It comprises 29 percent of the total population in 1 sample, but has an average abundance of only 13 percent in samples with more than 160 individuals.

Buccella frigida (Cushman) comprises 15 percent of the total population in 1 sample, but averages less than 6 percent in samples with more than 160 individuals.

PALEOECOLOGY

Cushman (1944) recognized that a faunal boundary for the distribution of benthonic Foraminifera occurs at about the latitude of Cape Cod. The work of Parker (1948) and Phleger (1952) substantiates this. A few species are restricted in occurrence to either the north or the south of Cape Cod. According to Parker (1948) the boundary is characterized by a decrease in the number of species to the north. However, the species that cross the boundary tend to be represented by more individuals in the northern region. This northern fauna in turn grades into a true Arctic fauna which has even fewer species in common with the southern region.

Table 1 lists 12 of the species found in the Messalonskee clay with their reported occurrences in 3 faunal regions. The remaining species are not included because they are poorly represented in the Messalonskee clay and their synonymies are uncertain. All the species listed are reported from the Arctic, and most of them have also

TABLE 1.—*Distribution in 3 faunal regions of 12 species found in the Messalonskee clay. Note the decrease in occurrence of species to the south.*

Species	Arctic	North of Cape Cod	South of Cape Cod
Buccella frigida	×	×	×
Cassidulina barbara	×	×	?
Eggerella advena	×	×	×
Elphidium clavatum	×	×	×
E. orbiculare	×	?	×
E. varium	×	?	×
Globulina glaciallis	×	×	?
Nonionella auricula	×	?	...
Pateoris hauerinoides	×	×	×
Pyrgo williamsoni	×	?	...
Quinqueloculina seminula	×	×	×
Triloculina trihedra	×	?	?

been recorded as far south as the Cape Cod boundary. Two of the species have not been recorded from south of Cape Cod, and three others have only questionable occurrences south of the boundary. The comparison in table 1 shows that the Messalonskee fauna, in terms of species present, is most similar to the faunas from the Arctic and north of Cape Cod. If only presence or absence criteria are considered, it is difficult to pick one of these regions in preference to another. However, *Elphidium orbiculare* and *Cassidulina barbara* are relatively rare in the modern fauna north of Cape Cod, but are relatively common in both the Arctic and in the Messalonskee fauna. Thus, it appears that the Messalonskee fauna has closer Arctic affinities than the fauna off the present coast of Maine.

Bloom (1960) came to a similar conclusion by plotting the present latitudinal range of the mollusks found in the Presumpscot formation. He showed that a similar fauna could be found today 7 to 8 degrees of latitude farther north. He attributed the faunal shift to an increase of water temperature since the late Pleistocene and indicated that meltwater streams may have also had a cooling effect during the time of deposition of the Presumpscot formation.

The Messalonskee fauna is not exactly like any modern fauna that has been studied to date. It is, however, quite similar to faunas found in the upper part of Narragansett Bay (Said, 1951) and the near-shore areas of Long Island Sound (Buzas, 1963). In all these areas the assemblages are characterized by the great abundance of species of *Elphidium,* especially *E. clavatum.*

The Recent distribution and abundance of the five common species in the Messalonskee fauna will now be reviewed.

Elphidium clavatum Cushman has been recorded from all along the eastern coast of North America as well as from the Arctic. Parker (1948) has recorded this species from all depths south of Cape Cod, but has indicated that species of *Elphidium* are most abundant at depths of 0 to 15 m. Phleger (1952) has found that *E. clavatum* occurs only at depths of less than 30 m. in the Gulf of Maine.

Using the data given by Phleger (1952) for stations 338-523, Kendall's rank order correlation test was computed for the variables depth and abundance of *E. clavatum.* This is a distribution free test based on inversions. Bradley (1960) gives a detailed discussion of this statistic. In computation one of the variables (x) is ranked from 1 to n while the other (y) is arranged in increasing order of the x rank. The number of times a y rank is followed by a smaller y rank is defined as k. Kendall's rank correlation coefficient is defined as $\gamma = \frac{4k}{n(n-1)} - 1$. γ varies from -1 for perfect negative correlation to $+1$ for perfect positive correlation. Actually it is not necessary to compute γ because the equivalent statistic k has been tabled. Owing to the large n (55) in the present sample, a normal approximation instead of exact tables was used. The normal approximation is given by $\frac{k - \frac{n(n-1)}{4}}{\sqrt{\frac{n(n-1)\,(2n+5)}{72}}}$. Ties were treated in a manner least conducive to rejection of the null hypothesis. The results show a highly significant negative correlation between depth and the abundance of *E. clavatum* in the Gulf of Maine.

Loeblich and Tappan (1953) recorded *E. clavatum* from all depths off Point Barrow, Alaska. Unfortunately, they gave no data as to relative abundance. It is probably significant that in shallow-water samples, where only a few species are present in the Point Barrow area, one of them is *E. clavatum.* Said (1951) recorded this species in abundance from shallow depths in Narragansett Bay, Rhode Island. Examination of the 34 samples that he studied showed that *E. clavatum* was most abundant in 9 samples. The average depth of these samples was 6 m., while the average depth of all the samples was 16 m. Buzas (1963) has shown that *E. clavatum* comprises over 90 percent of the population in Long Island Sound in areas less than 10 m. deep. In deeper water farther from shore the relative abundance of this species decreases.

Elphidium orbiculare (Brady) has not been recorded with certainty off the present coast of Maine. Cushman (1944) recorded this species from the bays of Maine, but Parker (1952a) after examining the specimens found that they were not the same as the forms recorded from the Arctic and placed them in another species. Todd and Low (1961), however, have recorded this species from the shallow water off Martha's Vineyard but indicated that it is relatively rare in that area. Loeblich and Tappan (1953) have recorded this species from almost all depths off Point Barrow, Alaska. *E. orbiculare* is typically an Arctic species.

Elphidium varium n. sp. is identical with specimens from Hudson Bay identified as *E. incertum* by Cushman (1948b). It is possible that this species has been identified as *E. incertum* by other workers and may be widely distributed. It is present with low frequencies in Long Island Sound (Buzas, 1963).

Cassidulina barbara n. sp. is identical with specimens identified as *C. islandica* var. *minuta* which has been recorded in the "lower core" fauna of the Gulf of Maine (Parker, 1952a). Loeblich and Tappan (1953) have recorded this species (as *C. islandica*) from nearly all depths off Point Barrow, Alaska.

Buccella frigida (Cushman), like *E. clavatum,* is widely distributed. Parker (1948) reported this species from all depths off the coast of Maryland. Phleger (1952) recorded it in near-shore samples from the Gulf of Maine. Loeblich and Tappan (1953) recorded it from a wide variety of depths in the Point Barrow area. This species has also been reported from Narragansett Bay by Said (1951), and in Long Island Sound it is relatively common.

An examination of the Messalonskee fauna immediately rules out any possibility of its representing a marsh environment. Phleger and

Walton (1950) and Parker and Athearn (1959) have shown that marshes along the northeastern coast are characterized by certain species of arenaceous Foraminifera. None of these species is found in the Messalonskee area. A review of the data available on the distribution and relative abundance of the common species of this study indicates that the assemblage could either be from a near-shore open-ocean environment or a bay environment. Both of these environments are subjected to large amounts of runoff and subsequent reduction of salinity. The effects of such runoff, however, are usually more pronounced in the bays. The work of Parker (1952b) and Said (1951) has shown that *Elphidium clavatum* and *Buccella frigida* are two of the most common species in the larger bays along the northeastern coast. These same species are common along the open coast. However, in open-ocean near-shore areas these species are often intermingled with other forms which are typically more oceanic in their occurrence. Said (1951) believed that the lower salinities (25-28 o/oo) in the northern parts of Narragansett Bay were responsible for the high percentages of *E. clavatum* and the exclusion of most other species. It is probable that other factors in addition to salinity are important in near-shore bay environments. At any rate, faunas from stations 12, 14, 16, and 17 of Said (1951) from the northern parts of Narragansett Bay are comprised mainly of *E. clavatum* and *B. frigida* and are quite similar to the faunas of this study. As mentioned earlier the average depth of these Narragansett Bay samples is only 6 m. In Long Island Sound *E. clavatum* comprises 90 percent of the fauna in water less than 10 m. deep and becomes much less abundant in deeper water. In both of these areas arenaceous species are rare. In the Messalonskee clay *E. clavatum* has an average abundance of 58 percent in samples with more than 160 individuals. In all samples it has an average abundance of 71 percent. If we consider samples with more than 160 individuals, *Elphidium* comprises 88 percent of the total population. If we consider all samples, the percentage of *Elphidium* is even higher. The northern parts of Narragansett Bay and the near-shore areas of Long Island Sound, except for the lower abundance of *E. varium* and absence of *E. orbiculare,* are strikingly similar to the Messalonskee fauna. The comparisons made above indicate that the Messalonskee fauna lived in a marine embayment where ecologic conditions were similar to those found in the near-shore areas of Long Island Sound or the northern parts of Narragansett Bay and where the depth of water was certainly less than 30 m. and probably less than 15 m.

A glance at the Glacial Map of the United States shows that the late-glacial clay in the Waterville area is restricted to stream valleys and lowlands. The borings of this study were taken 90 miles inland across the valley of a tributary (Messalonskee Stream) to the Kennebec River. The geographic position of the borings and the distributional pattern of the marine clay support the idea that the Messalonskee fauna lived in a shallow marine embayment.

It is quite likely that meltwater streams entered the marine embayment in which the Presumpscot formation was being deposited in the Waterville area. The poor sorting, angular unweathered fragments, and lack of stratification of the sediment suggest rapid deposition of material derived from meltwater streams. The presence of scattered boulders indicates that floating ice was in the area. This meltwater must have reduced the salinity of the oceanic water in the marine embayments. No experimental data are available as to the salinity tolerance of any of the species found in the Messalonskee area. In Great Pond, E. Falmouth, Mass., Said (1953) found that a calcareous assemblage dominated by *Elphidium* could stand a wide fluctuation in salinity. This assemblage was found in the southern part of the eastern arm of Great Pond. As Said examined the fauna farther north in this arm, he found that the assemblage quickly changed to one dominated by arenaceous species. He suggested that although the calcareous species could withstand a great fluctuation in salinity, when the salinity dropped below 20 o/oo, arenaceous species became dominant and calcareous forms became very rare. It is probably safe to assume that although meltwater must have reduced the salinity of the marine embayments, it could not have reduced it far below the salinities found in Narragansett Bay and Long Island Sound today.

At Messalonskee Stream the number of foraminiferal specimens per sample is low. Either the area supported a sparse fauna or else sedimentation was sufficiently rapid to prevent any great accumulation of tests. The latter of these possibilities is supported by the fact that during late-glacial time a significant amount of sediment was being washed into the marine embayments by meltwater from the glacier farther north.

SUMMARY OF LATE-GLACIAL EVENTS IN THE WATERVILLE AREA

The series of late-glacial events that took place in the Waterville area may now be summarized. After the ice retreated, the land underwent a period of subaerial erosion as is indicated by the erosion of esker deposits. The sea gradually inundated the depressed land, and the stream valleys of the Kennebec and its tributaries became marine embayments.

The fauna at the base of the section contains a high percentage of *Elphidium clavatum,* which is indicative of Recent shallow water assemblages. We may envisage the Messalonskee environment at the outset as a shallow marine embayment. Glacial material washed into this set by meltwater streams was quickly flocculated, and deposition must have been rapid. As floating ice melted, it scattered boulders on the bottom.

Only two samples diverge from the characteristic high percentage of *Elphidium.* The relatively great abundance of *Cassidulina barbara* in these samples may represent a deepening of the marine embayment and at the same time its maximum extension. No data are available as to the depth tolerance of this species, however, and such a conclusion must be regarded as tentative.

Above the *C. barbara* horizon *E. clavatum* and other species of *Elphidium* once again dominate the fauna. Shallow depths (probably less than 15 m.) were again attained, and the marine embayment was retreating as the land underwent isostatic rebound. The fauna remains essentially the same until about 35 feet below the top of the section shown in figure 4. In this part of the section Foraminifera are very rare, and for the last 20 feet no Foraminifera occur at all. The top two samples in each boring are sufficiently altered so that one can assume that the Foraminifera have been leached out of these samples. However, since so many feet of the section are without Foraminifera, it is probable that the top 35 feet of the clay in the Messalonskee area represent the transition from the marine embayment of late-glacial time to a fluvial environment.

SYSTEMATIC DESCRIPTIONS

Phylum PROTOZOA

Class SARCODINA Butschli, 1882

Order FORAMINIFERA d'Orbigny, 1826

Family VALVULINIDAE

Genus EGGERELLA Cushman, 1933

EGGERELLA ADVENA (Cushman)

Plate 1, figure 1

Verneuilina advena Cushman, 1922, Contr. Canadian Biol., No. 9 (1921), p. 141.
Eggerella advena (Cushman) Cushman, 1937, Cushman Lab. Foram. Res. Spec. Publ. 8, p. 51, pl. 5, figs. 12-15; 1948b, Cushman Lab. Foram. Res. Spec. Publ. 23, p. 32, pl. 3, fig. 12.

Two small specimens found in B-109, S-8U are the only occurrence of this species observed in the Messalonskee fauna.

Family MILIOLIDAE

Genus QUINQUELOCULINA d'Orbigny, 1826

QUINQUELOCULINA SEMINULA (Linnaeus)

Plate 1, figures 2a, 2b

Serpula seminulum Linnaeus, 1758, *System Naturae.* 10th ed., Holmiae, Suicia (Swedin), impensis L. Salvii, p. 786.

Quinqueloculina seminula (Linnaeus) Cushman, 1944, Cushman Lab. Foram. Res. Spec. Publ. 12, p. 13, pl. 2, fig. 14.—Parker, 1952b, Bull. Mus. Comp. Zool., Harvard Coll., vol. 106, No. 10, p. 456, pl. 2, figs. 7a, b.

Although there is variation in size among specimens, all have a smooth polished wall and lack a neck. Specimens compare well with ones deposited at the U. S. National Museum by Cushman and by Parker.

Genus TRILOCULINA d'Orbigny, 1826

TRILOCULINA sp.

Plate 1, figures 3a, 3b

One specimen referable to this genus was found in B-118, S-11U. The specimen lacks any development of a neck and is similar in size and shape to *Q. seminula.* However, the chambers are triloculine in arrangement.

TRILOCULINA TRIHEDRA Loeblich and Tappan

Plate 1, figures 4a, 4b

Triloculina trihedra Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121 No. 7, p. 45, pl. 4, fig. 10.

Specimens found in the Messalonskee clay compare well with the types of this species from Point Barrow, Alaska. The pleistotypes of Cushman (1944) and Parker (1952a) identified as *T. tricarinata* also compare favorably with the Messalonskee specimens. Owing to lack of material and poor preservation, no further synonymy is attempted here.

A few specimens of this species were found in B-118, S-11U.

Genus PATEORIS Loeblich and Tappan, 1953

PATEORIS HAUERINOIDES (Rhumbler)

Plate 1, figure 5

Quinqueloculina subrotunda (Montagu) forma *hauerinoides* Rhumbler, 1956, Kiel Meersef., Kiel, Deutschland, vol. 1, No. 1, pp. 206, 217, 226, text figs. 167, 208-212.

Quinqueloculina subrotunda (Montagu) ? Cushman, 1948b, Cushman Lab. Foram. Res. Spec. Publ. 23, p. 35, pl. 3, figs. 20, 21, pl. 4, fig. 1.

Quinqueloculina subrotunda (Montagu) Parker, 1952a, Bull. Mus. Comp. Zool., Harvard College, vol. 106, No. 9, p. 406, pl. 4, figs. 4a, b.

Pateoris hauerinoides (Rhumbler) Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, No. 7, p. 42, pl. 6, figs. 8-12, text figs. 1a, b.

Specimens clearly show an early quinqueloculine stage and a later hauerine one. The aperture is always toothless. These specimens compare well with hypotypes of Loeblich and Tappan (1953) from Point Barrow, Alaska, as well as with plesiotypes of Cushman (1948b) from the Arctic and of Parker (1952a) from the Portsmouth, N. H., area.

This species was found in seven samples, but specimens were rare.

Genus PYRGO Defrance, 1824

PYRGO WILLIAMSONI (Silvestri)

Plate 2, figure 1

Biloculina williamsoni Silvestri, 1923, Accad. Pont. Romana Nuovi Lincei, Atti, Roma, Italia, vol. 76, p. 73.

Pyrgo elongata (d'Orbigny) Cushman, 1948b (not *Biloculina elongata* d'Orbigny, 1826), Cushman Lab. Foram. Res. Spec. Publ. 23, p. 39, pl. 4, figs. 7, 8.

Pyrgo williamsoni (Silvestri) Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, No. 7, p. 48, pl. 6, figs. 1-4.

Most specimens are elongate, but a few large ones are somewhat rounded. Specimens found in the Messalonskee clay average about 0.46 mm. in their greatest diameter. The figured specimens of Loeblich and Tappan from Point Barrow are larger and average 0.56 mm. in their greatest diameter.

This species appears in six samples, but specimens are rare.

Family OPHTHALMIDIIDAE

Genus CORNUSPIRA Schultze, 1854

CORNUSPIRA sp.

Plate 2, figure 2

A single broken specimen referable to this genus was found in B-118, S-9U. The test is planispiral and tubular, but only parts of the last two whorls are preserved. The two whorls are comparable in thickness and diameter to those of *C. involvens* (Reuss) as figured by Loeblich and Tappan (1953, p. 49, pl. 7, figs. 4, 5).

Family LAGENIDAE

Genus LAGENA Walker and Jacob, 1873

LAGENA CLAVATA (d'Orbigny)

Plate 2, figure 3

Oolina clavata d'Orbigny, 1846, Foraminifères fossils du Bassin Tertiaire de Vienne, Paris, Gide et Comp., p. 24, pl. 1, figs. 2, 3.

Lagena clavata (d'Orbigny) Cushman, 1944, Cushman Lab. Foram. Res. Spec. Publ. 12, p. 21, pl. 3, fig. 6.

The few specimens found in the Messalonskee clay agree well with d'Orbigny's figures and are identical with the specimen figured by Cushman from the New England coast.

This species is rare, but occurs in four samples.

Genus FISSURINA Reuss, 1850

FISSURINA cf. CUCURBITASEMA Loeblich and Tappan

Plate 2, figure 4

Specimens compare favorably with those figured by Loeblich and Tappan (1953, p. 76, pl. 14, figs. 10, 11) from the Point Barrow area. The material from the Messalonskee clay, however, is often frosty in appearance, and the character of the entosolenian tube is difficult to distinguish.

Six specimens of this species were found in three samples.

Family POLYMORPHINIDAE

Genus GLOBULINA d'Orbigny, 1839

GLOBULINA GLACIALIS Cushman and Ozawa

Plate 2, figures 5a, 5b

Globulina glacialis Cushman and Ozawa, 1930, Proc. U. S. Nat. Mus., vol. 77, art. 6, p. 71, pl. 15, figs. 6, 7.

Specimens compare well with the types of Cushman and Ozawa. This species occurs in 14 samples. Individuals are not common.

Family NONIONIDAE

Genus NONIONELLA Cushman, 1926

NONIONELLA AURICULA Heron-Allen and Earland

Plate 2, figures 6a, 6b

Nonionella auricula HERON-ALLEN and EARLAND, 1930, Journ. Roy. Micr. Soc., London, England, ser. 3, vol. 50, p. 192, pl. 5, figs. 68-70.—CUSHMAN, 1944, Cushman Lab. Foram. Res. Spec. Publ. 12, p. 25, pl. 3, figs. 26, 27.—LOEBLICH and TAPPAN, 1953, Smithsonian Misc. Coll., vol. 121, No. 7, p. 92, pl. 16, figs. 6-10.

In the material studied by Heron-Allen and Earland the greatest diameter of the specimens varied between 0.18 and 0.25 mm. The greatest diameter of the specimens in the Messalonskee fauna is about 0.32 mm. Loeblich and Tappan indicated that the greatest diameter of their specimens is about 0.70 mm. There is, therefore, a wide size range in this species.

Five specimens of this species were found in two samples.

Family ELPHIDIIDAE

There are various opinions regarding the relationships of *Elphidium* and allied genera to the Nonionidae. The *Elphidium* group has been considered a separate family with questionable relationships to *Nonion* by Loeblich and Tappan (1953), and as a family of different origin from *Nonion* by Smout (1955) and Reiss (1958). The differences in opinion are due largely to the emphasis placed on the significance of wall structure. Wood (1949) found that all the species of *Elphidium* that he examined have radial walls, while those of *Nonion* are granular. This seemed to indicate that there is a fundamental difference between these two genera and that their resemblance to each other is superficial. To some workers wall structure appeared to provide a sure method of distinguishing *Nonion* and *Elphidium* and also a way of disposing of the problematic forms with weakly developed retral processes, sutural pores, and multiple apertures which seemed to be intermediate in structure between the two genera.

Haynes (1956), however, found two species in the English Paleocene which resemble *Nonion* but have multiple aperture and radial walls. He believed that these species provided a link between *Nonion* and *Elphidium*. He set up the genus *Protoelphidium* for the species which he included in the subfamily Nonionidae. A modern representative of this genus, *P. tisburyensis* (Butcher), has been recorded by Parker and Athearn (1959) from the Recent sediments of Cape Cod. Parker and Athearn placed *Protoelphidium* in the family Elphidiidae.

In the Messalonskee fauna there are two species which are intermediate in structure and which further suggest linkage between *Nonion* and *Elphidium*. One of these, *Elphidium varium,* has retral processes, sutural pores, and a multiple aperture, but a wall that is granular. It is, in other words, superficially an *Elphidium,* but in wall structure a *Nonion,* just the reverse of *Protoelphidium*. This combination of characters casts much doubt on the infallibility of wall structure as a key to distinguishing *Nonion* from *Elphidium*. I have placed the species under *Elphidium* because of the dominance of the characters of that genus, particularly the retral processes. Aside from the *Elphidium* group, retral processes occur rarely in Foraminifera, and it is probable that their occurrence is of genetic significance.

The other intermediate species, *Elphidium orbiculare,* has a radial wall, a multiple aperture, a few sutural pores and faint retral processes which were observed on only a few specimens. The *Elphidium* characters are poorly developed, and the generic assignment of this species is somewhat arbitrary; it could, as easily, be referred to *Protoelphidium*.

Elphidium orbiculare is very similar in appearance to some specimens of *E. varium* and the superficial characters of both species are highly variable. The two species are in some cases difficult to separate, but are, nevertheless, distinct. Although the differences between them are minor, I did not observe any transitions between them. The difference in wall structure between the two species is very sharp, the structure being distinctly granular in *E. varium* and clearly radial in *E. orbiculare*.

Curiously, there appears to be yet another kind of wall structure characteristic of certain species of *Elphidium*. This is what Krasheninnikov (1956) has termed "indistinct radial wall." In this type of structure the wall is radial, but the crystals are collected in bunches and they bend in a complex wavy fashion; sometimes the crystals are oblique or even parallel to the wall surface. According to Krasheninnikov, the "indistinct radial wall" is characteristic of *Elphidium*. I examined one crushed specimen of *E. macellum* (type species of *Elphidium*) from the Mediterranean and it showed a very indistinct cross, being observable in only a few of the fragments. This is suggestive of the type of structure that Krasheninnikov describes.

Thus it appears that *Elphidium* cannot be so easily separated from

Nonion on the basis of wall structure. Clearly, the wall structures of many more species, particularly in oriented sections, need to be studied before the significance of this structure can be evaluated.

The species intermediate in structure between *Elphidium* and *Nonion* can hardly be considered ancestral forms, as they occur in Recent sediments. However, they do indicate a close relationship between the two genera. On the other hand, *Elphidium* and allied forms, in my view, comprise a large enough group to be considered a family separate from, though closely related to, the Nonionidae. The families, of course, are not phylogenetic, representing a single divergence in geologic time, but are probably no more polyphyletic than many other foraminiferal families.

Genus ELPHIDIUM Montfort, 1808

ELPHIDIUM VARIUM n. sp.

Plate 2, figure 7; plate 3, figures 1, 2a, 2b

Elphidium incertum (Williamson) CUSHMAN, 1948 (*non Polystomella umbilicatula* var. *incerta* Williamson 1858), Cushman Lab. Foram. Res. Spec. Publ. 23, p. 56, pl. 6, figs. 7a, b.

Diagnosis.—Test small to medium sized, planispiral, involute, slightly compressed; periphery rounded, margin moderately lobulate; 8 to 11 chambers in the final whorl, slightly inflated, gradually increasing in size as added; sutures distinct, depressed, often slitlike, poorly developed around the periphery, with sutural pores in a single row, sometimes extending to umbilical area; retral processes short, few, not developed on all sutures; wall calcareous, perforate granular, translucent to opaque; umbilicus fairly large, flush or slightly depressed, with very slight umbilical knob; aperture composed of a single row of small openings at the base of the apertural face.

Greatest diameter of holotype 0.56 mm.
Least diameter of holotype, 0.46 mm.
Thickness of holotype, 0.26 mm.
Greatest diameter of paratypes, from 0.38 to 0.64 mm.

Discussion.—The retral processes are poorly to moderately well developed in this species. They are most strongly developed in the early part of the test and can be clearly seen in the first two or three chambers of the final whorl. In the final few chambers, they are often barely perceptible.

The wall appearance is highly variable, with young forms being translucent and adult forms thick and opaque.

The walls of half a dozen specimens were examined under polarized light and all of them proved to be distinctly granular.

E. varium differs from *Polystemella umbilicatula* var. *incerta* Williamson (1858, fig. 82a) in that it has less curvature of the sutures, poorer development of retral processes, and a larger umbilical area. However, the specimen illustrated by Cushman (1948b, pl. 6, figs. 7a, b) as *E. incertum* is identical with the species described here. Other specimens deposited in the Cushman collection and identified as *E. incertum* from Fox Basin, Canada, and Greenland were also found to be identical. The wall structures of two specimens from Fox Basin, Canada, were examined. Both specimens are perforate granular.

Most other specimens identified as *Elphidium incertum* from eastern North America appear to represent a mixed bag, belonging to *E. clavatum, E. orbiculare,* and *E. bartletti* (Loeblich and Tappan, 1953, pp. 100-101).

Broadly rounded translucent specimens of *E. varium* closely resemble specimens of *E. orbiculare,* especially when the sutures of *E. varium* lack any development of retral processes. The two species can be separated by their external appearance, however, because the test of *E. orbiculare* is thicker in cross section and more circular in outline. Although some specimens of these two species resemble one another so closely that they are difficult to distinguish by their external appearance, they can be easily separated by their markedly different wall structure, for *E. orbiculare* is distinctly radial.

Some juvenile forms of *E. varium* are quite similar to some specimens of *E. subarcticum.* The two species are separable because *E. subarcticum* usually shows an opaque band on either side of its sutures. The wall structure affords a more striking criterion because it is distinctly radial in *E. subarcticum.*

Paratypes of *E. voorthuyseni* Haake deposited at the U. S. National Museum closely resemble some juveniles of *E. varium.* Haake's (1962) specimens are, however, much smaller than adults of *E. varium* and are narrower in the umbilical region. The paratypes of *E. voorthuyseni* were found to be granular in wall structure and the two species are probably closely related.

This species occurs in only about half of the samples that have Foraminifera. It usually accounts for less than 15 percent of the Foraminifera in any sample.

ELPHIDIUM CLAVATUM Cushman

Plate 3, figures 3a, 3b, 4a, 4b

Elphidium incertum (Williamson) var. *clavatum* Cushman, 1930, U. S. Nat. Mus. Bull. 104, pt. 7, p. 20, pl. 7, fig. 10.

Elphidium clavatum Cushman, emend. Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, No. 7, pp. 98, 101, 102, pl. 19, figs. 8-10.

Most of the specimens are yellow-brown in color and have moderately well developed retral processes. The tests are commonly biumbonate and very distinctly perforated. The specimens are identical with those described by Cushman and by Loeblich and Tappan, but are somewhat smaller. The average greatest diameter of 12 selected specimens from the Messalonskee clay is 0.24 mm. The largest single measurement was 0.30 mm. The hypotypes of Loeblich and Tappan (1953) range from 0.23 to 0.70 mm. in their greatest diameter.

This species is most abundant in the Messalonskee fauna. It appears in all samples and usually constitutes over 50 percent of the total population.

ELPHIDIUM ORBICULARE (Brady)

Plate 3, figures 5a, 5b; plate 4, figures 1a, 1b

Nonionina orbicularis Brady, 1881, Ann. Mag. Nat. Hist., ser. 5, vol. 8, p. 45, pl. 21, figs. 5a, b.

Nonion orbiculare (Brady) Cushman, 1930, U. S. Nat. Mus. Bull. 104, pt. 7, p. 12, pl. 5, figs. 1-3; 1939, U. S. Geol. Surv. Prof. Pap. 191, p. 23, pl. 16, figs. 17-19; 1948b, Cushman Lab. Foram. Res. Spec. Publ. 23, p. 53, pl. 6, fig. 3.

Elphidium orbiculare (Brady) Loeblich and Tappan, 1953, Smithsonian Misc. Coll., vol. 121, No. 7, p. 102, pl. 19, figs. 1-4.

Although originally placed in the genus *Nonion,* Cushman (1939, p. 24) stated: "The aperture tends toward that of *Elphidium,* and some specimens show what may be slight traces of retral processes." Loeblich and Tappan (1953) placed this species in the genus *Elphidium* because of the characters Cushman mentioned and because they found that the wall structure was radiate.

Specimens from the Messalonskee clay have few sutural pores and but faint retral processes which occur on rare specimens. The aperture always consists of a single row of openings at the base of the apertural face.

Specimens from the Messalonskee clay are smaller than those described by Cushman and by Loeblich and Tappan. Cushman indicated that the greatest diameter is 0.75 mm. while Loeblich and Tappan measured specimens which range from 0.55 to 1.0 mm. in diameter. My specimens average only 0.44 mm. in their greatest diameter. They are, however, identical in all other respects with those of both Cushman and Loeblich and Tappan.

This species occurs in over half of the samples; it averages less than 20 percent of the total population, but comprises 40 percent in one sample.

ELPHIDIUM sp.

Plate 4, figure 2

The material consists of six specimens which were found in B-1058, S-13U. The specimens are irregular, and some of the chambers are malformed. Possibly they represent abnormal individuals of *E. clavatum*.

Family ROTALIIDAE

Genus BUCCELLA Andersen, 1952

BUCCELLA FRIGIDA (Cushman)

Plate 4, figures 3a, 3b, 4a, 4b

Pulvinulina frigida CUSHMAN, 1922, Contr. Canadian Biol., No. 9 (1921), p. 2 (144).

Buccella frigida (Cushman) ANDERSEN, 1952, Journ. Washington Acad. Sci., vol. 42, No. 5, p. 144, figs. 4a-c, 5, 6a-c.

Specimens are identical with the hypotypes of Cushman and of Andersen. They lie within the normal size range of this species.

This species occurs in 10 of the samples, but individuals are not common.

Family CASSIDULINIDAE

Genus CASSIDULINA d'Orbigny, 1826

CASSIDULINA TERETIS Tappan

Plate 5, figures 2a, 2b, 3a, 3b

Cassidulina teretis TAPPAN, 1951, Contr. Cushman Found. Foram. Res., vol. 2, pt. 1, p. 7, pl. 1, figs. 30a-c.

The material consists of three specimens which were found in B-118, S-9U.

CASSIDULINA BARBARA n. sp.

Plate 5, figures 2a, 2b, 3a, 3b

Cassidulina islandica Norvang var. *minuta* Norvang, Parker, 1952 (non *Cassidulina islandica* Norvang var. *minuta* Norvang, 1945), Bull. Mus. Comp. Zool., Harvard Coll., vol. 106, No. 9, p. 421, pl. 6, figs. 21a, b.

Cassidulina islandica Norvang, Loeblich and Tappan, 1953 (non *Cassidulina islandica* Norvang, 1945), Smithsonian Misc. Coll., vol. 121, No. 7, p. 118, pl. 24, fig. 1.

Diagnosis.—Test small, biconvex, slightly compressed, periphery rounded; chambers alternate, four pairs in the final whorl, increasing in size as added, each chamber extending to the center on one side and forming a small triangular extension on the other; wall calcareous, translucent, perforate granular; aperture a triangular opening at the base of the apertural face, alternating from one side to the other as chambers are added, a flat tooth projecting into the aperture from the base of the chamber.

Greatest diameter of holotype, 0.22 mm.
Greatest thickness of holotype, 0.14 mm.
Greatest diameter of paratypes, 0.12 to 0.26 mm.

Discussion.—Norvang (1958) named the genus *Islandiella,* into which he placed some of the species formerly referred to the genus *Cassidulina.* The new genus is characterized by a radiate wall ". . . with an internal tooth extending back from the posterior edge of the aperture to the anterior corner of the foramen of the preceding chamber" (loc. cit., p. 26). *Cassidulina* was emended to include those species ". . . with a granulate wall and a tripartite aperture, often with up to two platelike lips fastened on the inwardbent wall along the rim of the aperture thus obstructing the passage through the aperture" (loc. cit., p. 25).

I have been able to observe the tooth which Norvang described in some of the species which he has referred to the genus *Islandiella,* although the structure is seldom clearly visible. *C. barbara* has a flat tooth which protrudes through the aperture. However, I have not been able to observe any attachment to the corner of the foramen of the preceding chamber. Instead the tooth appears to be attached near the base of the aperture through which it protrudes. None of the material from the Messalonskee area shows any trace of a groove which might represent the areal branch of a tripartite aperture. Externally I cannot distinguish between the flat tooth of *C. barbara* and the free tongue of the internal tooth of *I. islandica.*

C. barbara differs from *I. islandica* in that the latter is larger, more globular, has more inflation of its chambers, and is radiate in wall structure.

C. barbara differs from *C. crassa* d'Orbigny in its smaller size and in location of the aperture, which is discussed by Loeblich and Tappan (1953, p. 119).

The figured specimens of Parker (1952a) referred to *C. islandica* var. *minuta* are identical with *C. barbara.* The hypotypes deposited at the U. S. National Museum by Loeblich and Tappan (1953) and referred to *C. islandica,* although slightly larger, are identical with the new species described here. The wall structure of two of their hypotypes was examined and found to be granulate.

This species is generally low in abundance. However, in B-118, S-9U and in B 109, S-9U it comprises 69 and 88 percent of the total population respectively.

Family ANOMALINIDAE

Genus CIBICIDES Montfort, 1808

CIBICIDES cf. LOBATULUS (Walker and Jacob)

Plate 5, figures 4a, 4b

The material consists of two specimens which were found in B-1058, S-13U. The specimens compare favorably with those illustrated by Cushman (1948b, p. 78, pl. 8, fig. 14). However, since one specimen is broken and the other poorly preserved, positive identification is not possible.

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EXPLANATION OF PLATES

Plate 1

Fig. 1. *Eggerella advena* (Cushman). USNM 641122. ×148.
Fig. 2. *Quinqueloculina seminula* (Linne). USNM 641123. a, Edge view. b, Side view. ×93.
Fig. 3. *Triloculina* sp. USNM 641124. a, Side view. b, Edge view. ×65.
Fig. 4. *Triloculina trihedra* Loeblich and Tappan. USNM 641125. a, Edge view. b, Side view. ×93.
Fig. 5. *Pateoris hauerinoides* (Rhumbler). USNM 641126. ×65.

Plate 2

Fig. 1. *Pyrgo williamsoni* (Silvestri). USNM 641127. ×93.
Fig. 2. *Cornuspira* sp. USNM 641128. ×93.
Fig. 3. *Lagena clavata* (d'Orbigny). USNM 641129. ×93.
Fig. 4. *Fissurina* cf. *cucurbitasema* Loeblich and Tappan. USNM 641130. ×148.
Fig. 5. *Globulina glacialis* Cushman and Ozawa. USNM 641131. a, Edge view. b, Side view. ×93.
Fig. 6. *Nonionella auricula* Heron-Allen and Earland. USNM 641132. a, Edge view. b, Side view. ×148.
Fig. 7. *Elphidium varium* n. sp. Holotype. USNM 641133. Edge view. ×93.

Plate 3

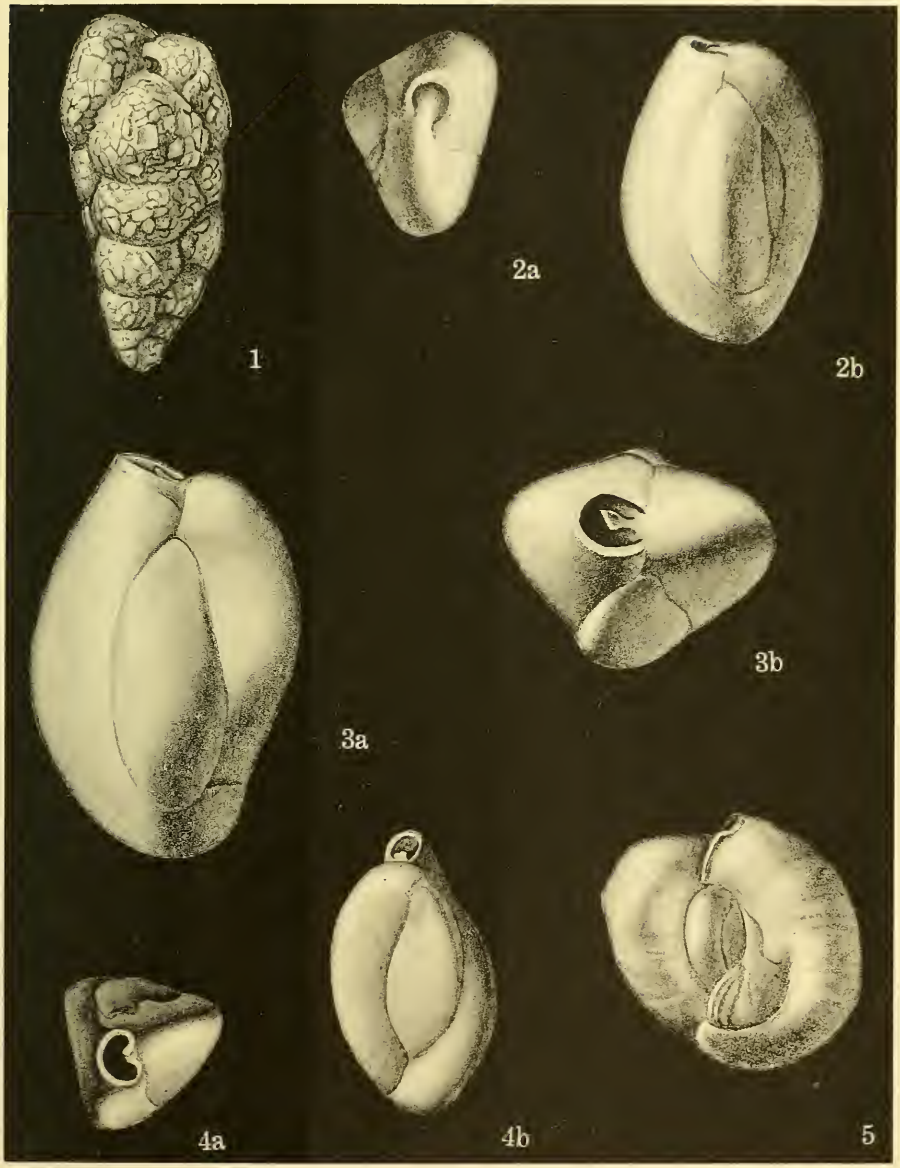
Fig. 1. *Elphidium varium* n. sp. Holotype. USNM 641133. Side view. ×93.
Fig. 2. *Elphidium varium* n. sp. Paratype. USNM 641134. a, Edge view. b, Side view. ×65.
Fig. 3. *Elphidium clavatum* Cushman. USNM 641135. a, Edge view. b, Side view. ×148.
Fig. 4. *Elphidium clavatum* Cushman. USNM 641136. a, Edge view. b, Side view. ×214.
Fig. 5. *Elphidium orbiculare* (Brady). USNM 641137. a, Edge view. b, Side view. ×93.

Plate 4

Fig. 1. *Elphidium orbiculare* (Brady). USNM 641138. a, Side view. b, Edge view. ×93.
Fig. 2. *Elphidium* sp. USNM 641139. a, Side view. b, Edge view. ×93.
Fig. 3. *Buccella frigida* (Cushman). USNM 641140. a, Edge view. b, Ventral view. ×148.
Fig. 4. *Buccella frigida* (Cushman). USNM 641141. a, Edge view. b, Dorsal view. ×148.

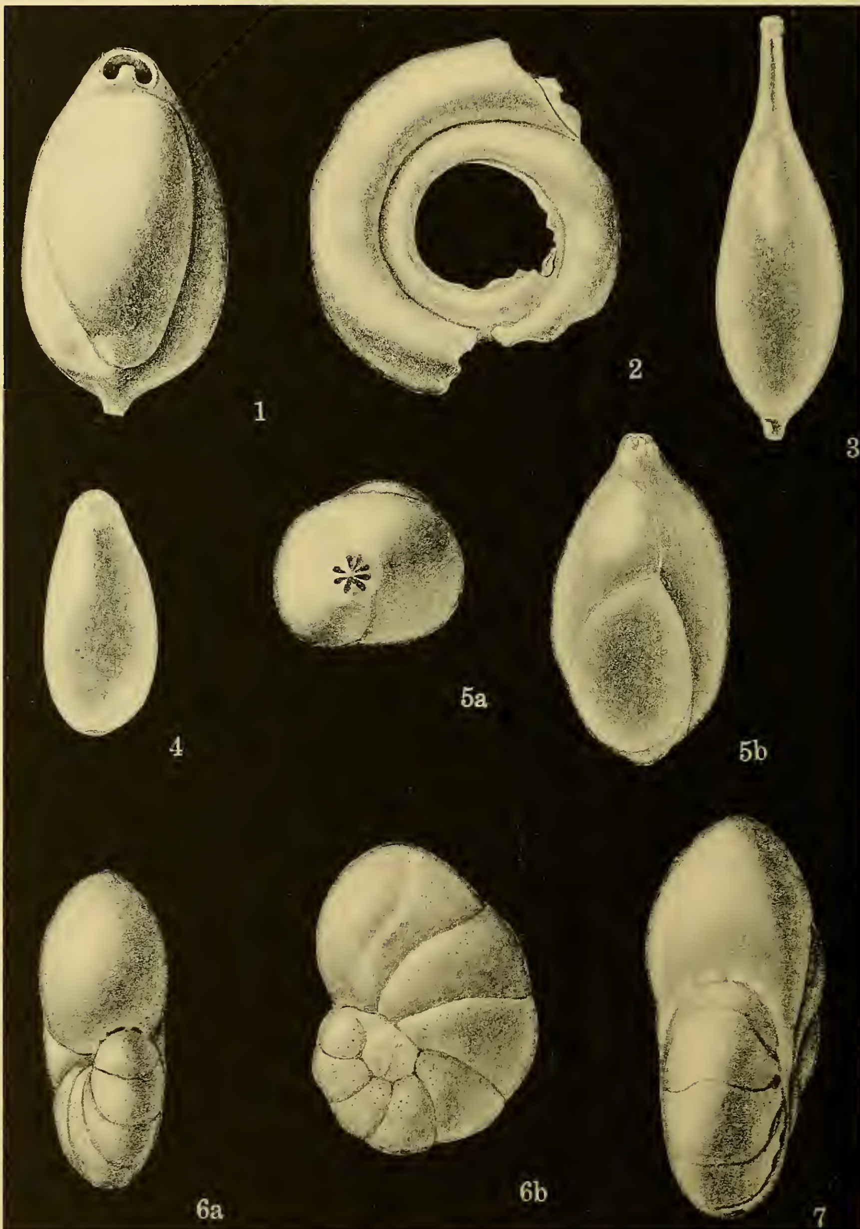
Plate 5

Fig. 1. *Cassidulina teretis* Tappan. USNM 641142. a and b, Side views. ×65.
Fig. 2. *Cassidulina barbara* n. sp. Holotype. USNM 641143. a and b, Side views. ×148.
Fig. 3. *Cassidulina barbara* n. sp. Paratype. USNM 641144. a and b, Side views. ×148.
Fig. 4. *Cibicides* cf. *lobatulus* (Walker and Jacob). USNM 641145. a, Edge view. b, Side view. ×93.



FORAMINIFERA FROM WATERVILLE, MAINE

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



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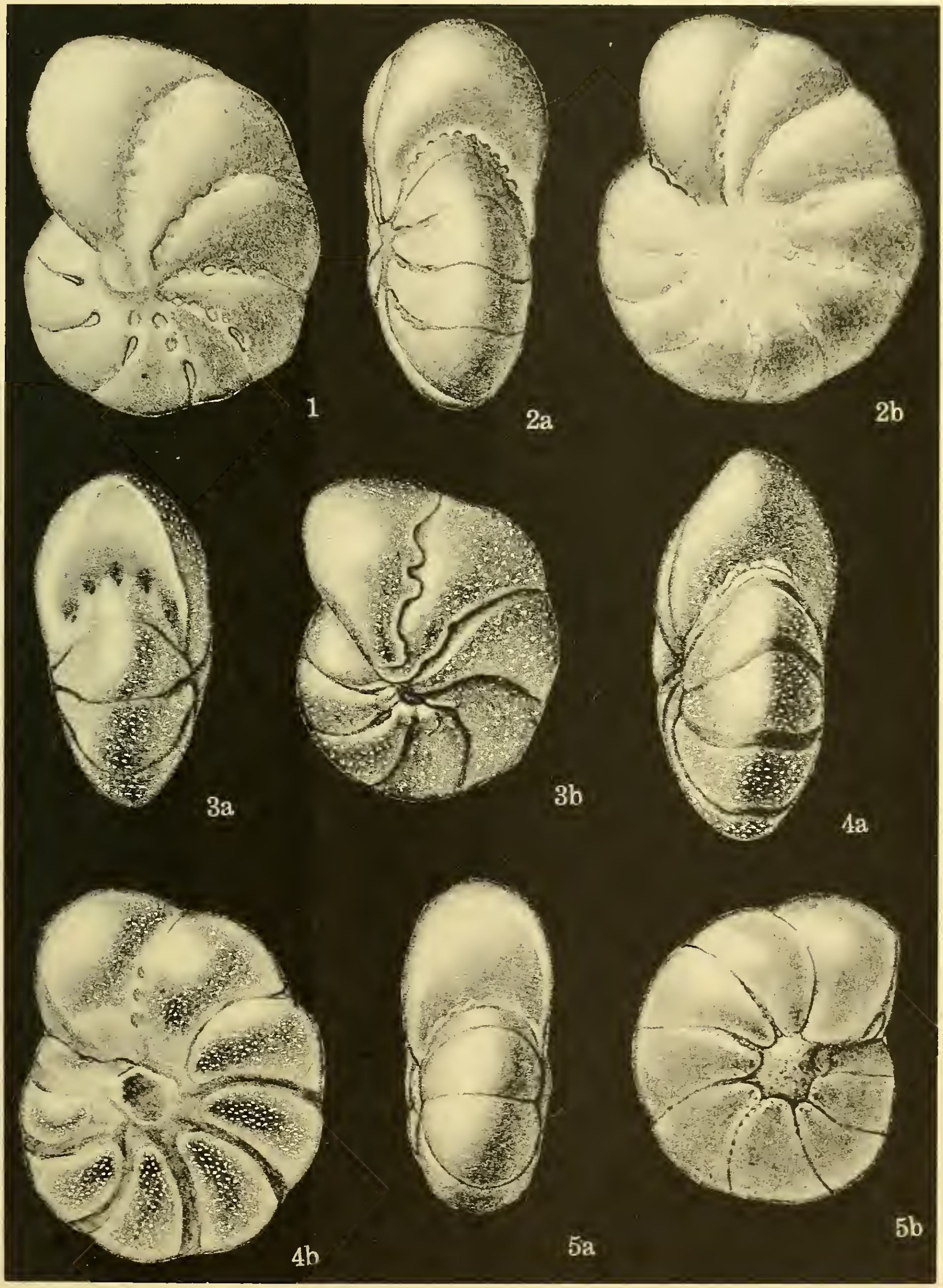

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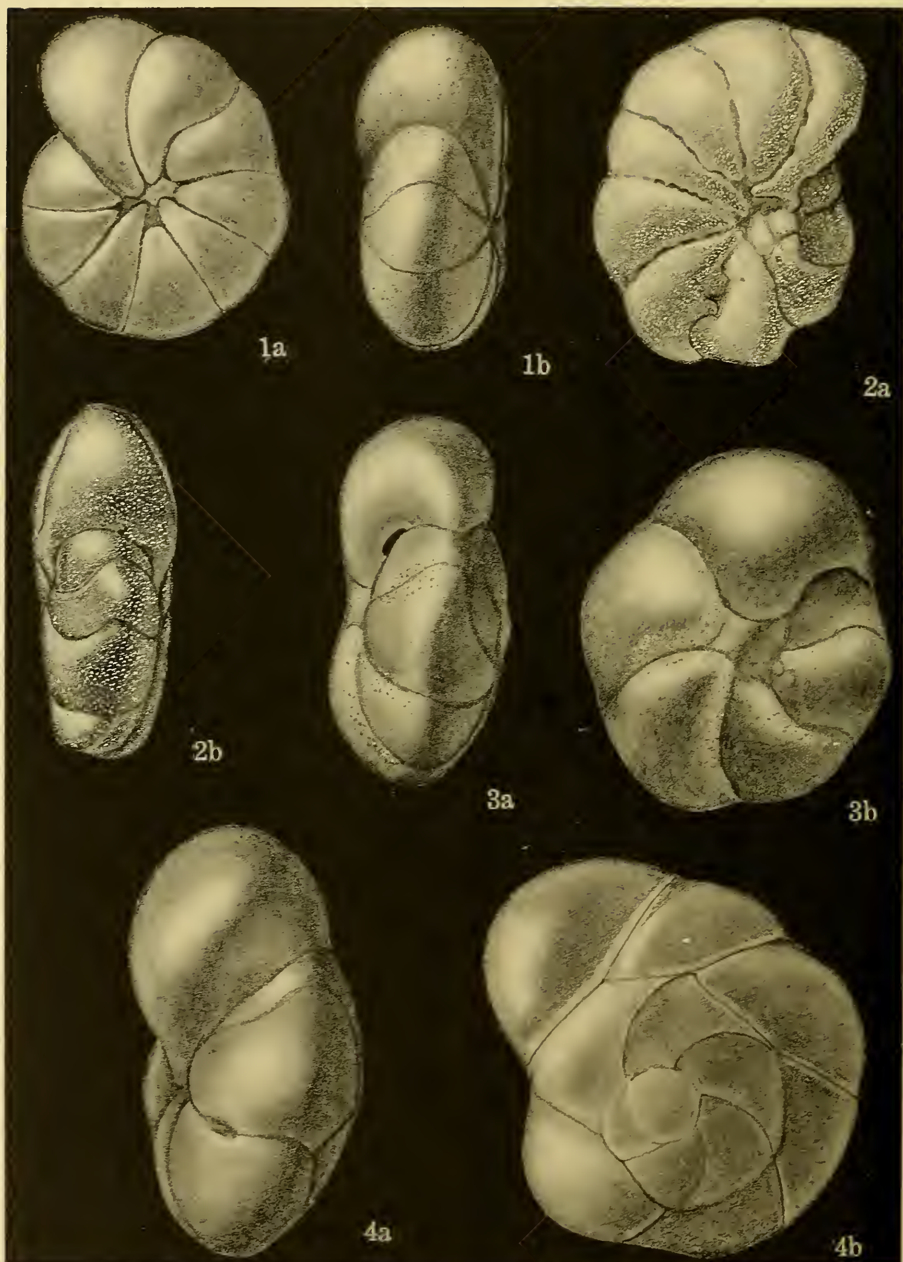

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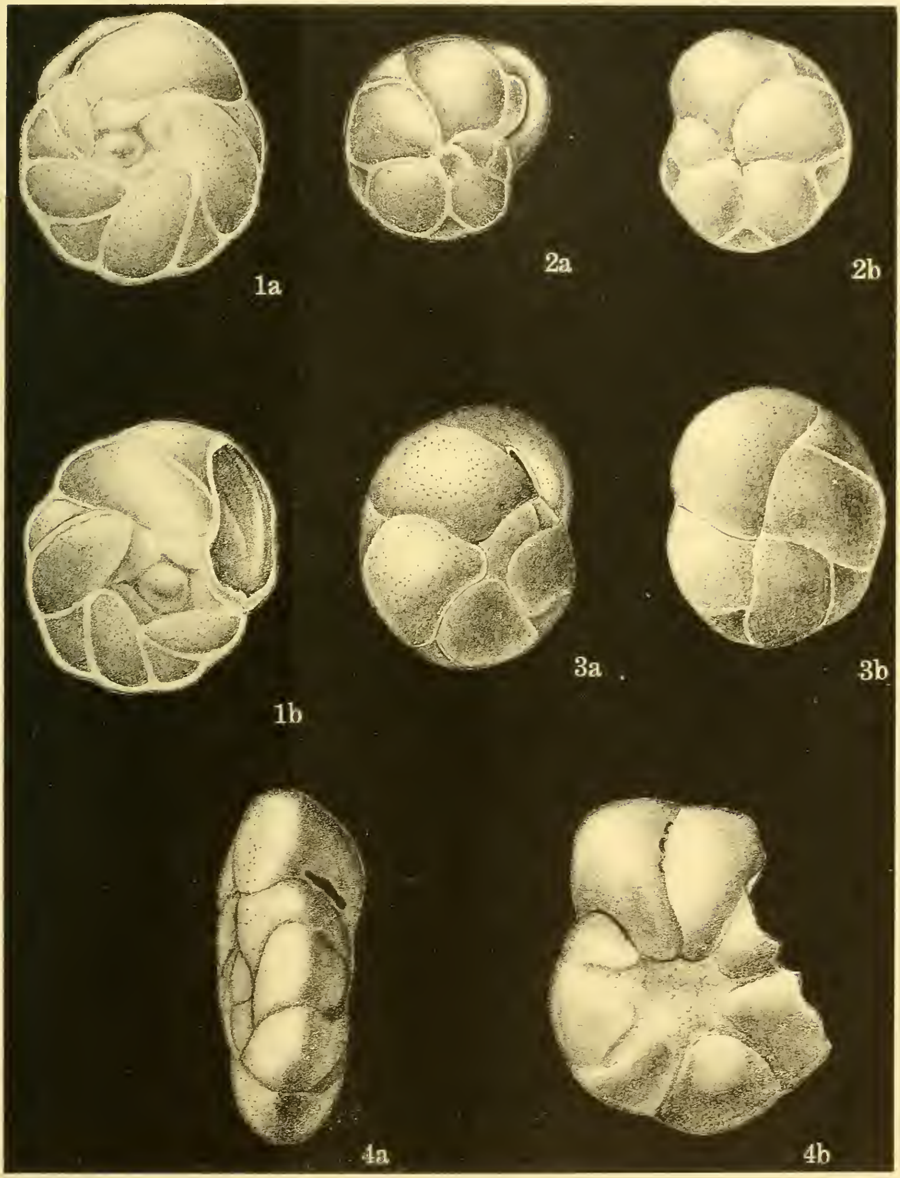

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