The Redwoods of California: The Past in the Present

By Prof. A. C. SEWARD, F.R.S.

THOUGH much has been written on the Big Trees of the Sierra Nevada and the Redwoods of the Californian Coast Range, the subject of these impressive examples of links with the past is by no means exhausted. It was my good fortune to wander in several Redwood groves in the spring of this year. Through the generosity of Dr. J. C. Merriam of the Carnegie Foundation and under

FIG. 1.—A, normal (two-ranked) foliage shoot; B, abnormal shoot of *Sequoia sempervirens* (½ natural size).

the expert guidance of Prof. Ralph W. Chaney of the University of California, Berkeley, visits were paid to the large groves north of San Francisco; and as guests of Prof. G. J. Peirce of Stanford University to the Big Basin south of San Francisco near the southern limit of the Redwood belt.

The two living species of *Sequoia* (Sequoyah, a Cherokee Indian who invented an alphabet), *Sequoia gigantea*, sometimes called *Wellingtonia*, the Big Tree, and *S. sempervirens*, the Redwood, are familiar as cultivated trees in British parks and gardens: it is the latter species with which this article deals. The Redwood was introduced into England soon after 1840 (the exact date is uncertain) and some specimens already exceed 100 ft. in height: this species is characterised by the red colour of the wood and soft, fibrous bark; foliage shoots with spirally disposed linear leaves, ¼–1¼ in. in length, recalling those of the yew, which in the normal lateral branches are twisted by the torsion of the short stalks into two rows in one plane. On some leading branchlets and occasionally on abnormal lateral branches the leaves are shorter, more ovate and spiky and retain the spiral disposition. Though the normal two-ranked shoots are readily distinguished from those of *Sequoia gigantea*, abnormal branches bearing more tapered and scale-like leaves are very similar to the typical branches of the Big Trees. The ellipsoidal cones of *S. sempervirens* are surprisingly small, ¾–1 in. long and ½ in. broad; they consist of 14–24 seed-bearing woody scales. The cones of *S. gigantea* are of the same form but rather larger. A typical foliage shoot and an abnormal shoot are shown in Fig. 1.

Extending more than half the length of the State of California lies a broad and relatively dry plain through which the Sacramento and San Joaquin Rivers flow respectively south and north into San

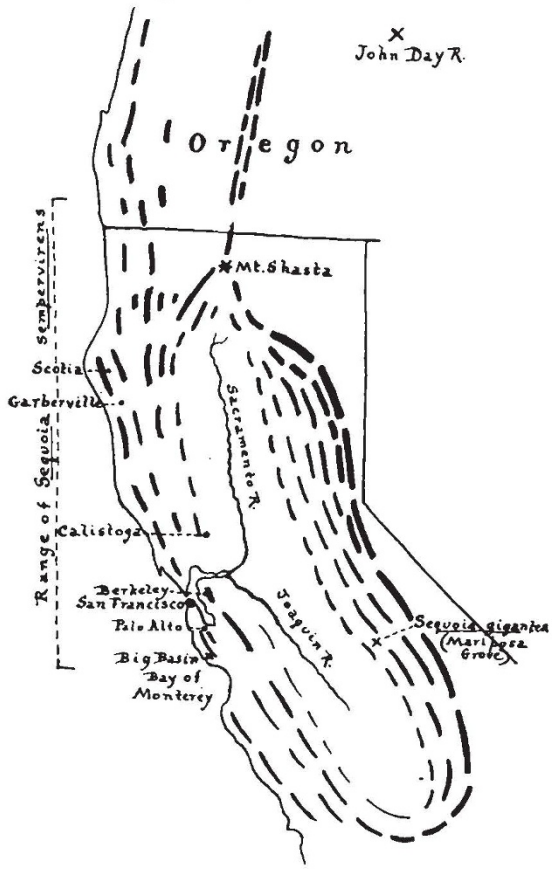

FIG. 2.—Sketch map of part of California and Oregon showing the Central Valley, the Coast Range, the western portion of the Sierra Nevada and, north of Mount Shasta, the Cascade Mountains, etc. Scale approximately 1 inch = 170 miles.

Francisco bay. The Sierra Nevada, including the highest mountains in the United States, form the eastern boundary, and the lower parallel ridges of the Coast Range lie between the western edge of the central valley and the Pacific Ocean. *Sequoia gigantea* is confined to a few localities on the Sierra Nevada, the most famous of which is the Mariposa Grove (Fig. 2): *S. sempervirens*, which has 'a

stronger hold upon existence', occupies a much larger territory to the west of the valley, from Monterey County in the south to a few miles north of the California-Oregon boundary, a distance of about 450 miles and with an average breadth of twenty miles. The Redwoods range from sea-level to an altitude of 3000 ft. Their distribution is not continuous. In some places the Redwoods form pure stands; there are forests in which the Douglas fir and other conifers are common associates; and areas in which the Redwood is absent either through human agency or from natural causes. A solitary giant by the side of the railway near Stanford University and the small town of Palo Alto (so named from the tree) is a conspicuous landmark.

A good road, the Redwood Highway, runs through the forests north of San Francisco and traverses a succession of groves which have been gradually acquired by the State, substantially aided by the Save-the-Redwoods League. Up to March of this year, nearly 30,000 acres of forest had been saved from destruction.

The climate of the Redwood belt varies within comparatively narrow limits; the temperature rarely falls below 15° F. and though it is said to rise to 100° F. or rather more, the average is 50°–60° F. From May to October is a dry season; actual precipitation as rain is confined to the wet season, November–April. The annual rainfall is usually between 20 in. and 60 in., though in places it occasionally reaches 100 in. During the dry months the forests bordering the coast receive an abundant supply of water from the dense clouds of fog which roll eastwards over the coast range hills. It is the summer fog—'the wet-winged angel of the rain'—which provides the humid atmosphere essential to the Redwoods.

Though surpassed by the Big Trees in girth, the Redwoods reach a greater height. One sees conflicting statements on the rival claims of the Redwoods and the Australian gum trees (*Eucalyptus*) to be described as the tallest in the world: the late Mr. J. H. Maiden of Sydney believed the Redwoods to be taller than the gum trees; some American botanists say that the Australian trees are the taller. But whether or not the Redwoods have longer stems, they are more majestic and make a stronger appeal to the imagination. It may be that in the future the alien eucalypts, which already play a conspicuous part in the Californian landscape, may exceed in height the native conifer. The highway on the north side of San Francisco bay passes through typical Californian scenery for several miles; low hills with smoothed rounded contours studded with clumps of live oak (*Quercus agrifolia*); on the lower ground sheets of the native blue and white lupin (*Lupinus bicolor*) and scattered patches of the glorious California poppy. Redwoods were first seen from the highway about thirty miles south of the small town of Garberville, with its typical 'main street', 230 miles north of Berkeley. Farther north we drove through miles of reserved forest areas, grove after grove of Redwoods with Douglas firs as their most striking companions. Between Garberville and Scotia, Redwoods are crowded on the hill slopes and along the deep valleys, where a fringe of alders, willows, and other trees forms the lowest zone of vegetation. Looking down from the steep hill-sides to the river-bed one sees weather-beaten and bleached stems and branches piled by the river in flood against obstructing rocks or stranded on banks of gravel, samples of contemporary vegetation on their way to entombment in river-borne sediment. Towering above the general level

FIG 3.—A Redwood forest: the large tree is 54 ft. in circumference, 6 ft. from the ground. (Photograph by Dr. A. A. Cannon)

of the forest on the high rocky ridges, spires of *Sequoia* and *Pseudotsuga* (Douglas fir) were silhouetted against the blue sky; the more drooping branches of the Redwood forming a contrast to the straighter arms of the fir.

The black oak (*Quercus Kelloggii*), the tan oak (*Lithocarpus densiflora*), the Californian lilac (*Umbellularia californica*), the Madrōno (*Arbutus Menziesii*), representing in the new world the strawberry tree of the Killarney Lakes and the Mediterranean flora, easily recognised by the red polished bark, the mountain dogwood (*Cornus Nuttallii*), maples and many other trees are some of the commonest neighbours of the Redwoods. A pink oxalis (*Oxalis oregona*), *Trillium*, the poison oak (*Rhus diversiloba*), irises, the red columbine (*Aquilegia truncata*), sword ferns (*Polystichum munitum*), the lady fern, and the far-flung bracken are a few of the abundant plants on the forest floor.

It is difficult to realise the height of the taller Redwoods in forests where there are few or no standards of comparison. Some of the giants, if

transplanted to the Close at Salisbury, would reach to within a few feet of the top of the famous spire. There are few trees equal to the Redwoods in resistance to fungus diseases, insect pests and forest fires: the thick fibrous bark and the wood, which in healthy trees lacks resin-ducts, are almost indestructible. The ordinary method of reproduction is vegetative, not from seed: the trees have remarkable capacity for regeneration by suckers from the roots. One often sees a ring of tall trees with a huge broken or charred stump in the centre of the circle: the moribund parent had developed a group of suckers which in course of time gained independence. A prone stem draped with nests of sword fern and many flowering plants may form a plinth bearing slender

FIG. 4.—The canopy in a Redwood forest showing the sky pattern. (Photograph by Dr. A. A. Cannon.)

columns of young Redwoods. In the Big Basin, one specimen known as the Chimney Tree is a hollow trunk 100 ft. high, in which several people can stand and look upwards to the sky through the open end: the wood has been almost completely destroyed by fire; the shell still bears many vigorous branches.

On many of the trees are large and small burls, rounded excrescences like great warts, which are sold as souvenirs; when sawn off and placed with the flat surface in a saucer of water and wet moss, the dormant buds grow into an encircling wreath of two-ranked foliage-shoots.

It was not until we came to Scotia that the preserved areas were seriously interrupted by hillsides bare of all but charred stems and comparatively young trees which had grown from the roots of felled parents: the older trees were being sawn in the mills of a lumber company into huge planks.

The Redwoods appeal to us by their superbly fashioned columns, impressive examples of perfect architectural construction, bearing tapering cones of massed branches (Fig. 3); tree separated from tree in the distant canopy by small fringed spaces open to the light of the sun and to the sea fogs from the west (Fig. 4)*. They make an appeal as living things—some of them have been growing where they stand for twenty to thirty centuries—linking the present with a prehistoric past: groups of trees already centuries old surrounding ancestral relics bear witness to the continuity of the race through ages still more remote. At Calistoga, seventy miles north of San Francisco, one sees striking examples of petrified Redwoods, more than 100 ft. in length and 8 ft. in diameter, in beds derived from some Pliocene volcano, and with the stems have been found cones and foliage indistinguishable from those of the living species. It is easy to visualise a continuous series of generations linking the present with the latter part of the Tertiary period. In places where a Redwood climate prevailed, there is no reason to assume any substantial change in the forest flora of western America through the many thousand years of this small fraction of geological history. Nor, as we shall see, is there any evidence of essential difference between the Redwoods and their forest associates and the trees and shrubs which lived in California and Oregon in the middle of the Tertiary period, say fifty million years ago.

From an intensive study of some of the older Tertiary floras in Oregon, Prof. Chaney has shown that the striking contrasts revealed by a comparison of the Oligocene and recent floras of Britain are not found in western America. The Oligocene and Miocene plants described by Prof. Chaney were collected from localities in the John Day basin a little to the east of the centre of Oregon (see Fig. 2). Two of the floras—the Bridge Creek flora of Oligocene age and the Miocene Mascall flora—suffice to illustrate the appropriateness of the application to the Redwood flora of the phrase, 'the past in the present'. These floras have much in common but the elements of the Mascall flora indicate less humid conditions and greater exposure to light. More than 20,000 specimens from the Bridge Creek beds were examined and tabulated; and for comparison 8000 specimens of leaves, twigs and other scraps gathered from contemporary stream deposits in a canyon in one of the preserved areas (Muir Woods), where sediment is being deposited at bends of the river. In the Bridge Creek flora there are four dominant species, *Sequoia Langsdorfii*, *Alnus carpinoides*, *Quercus consimilis*, *Umbellularia* sp., which make up 86·44 per cent of the whole: in the recent stream

* I am indebted to Dr. A. A. Cannon of Stanford University for the photographs reproduced as Figs. 3 and 4.

deposits the corresponding species, *Sequoia sempervirens, Alnus rubra, Quercus densiflora, Umbellularia californica* constitute 85·44 per cent of the total number of species.

It is customary to speak of the Tertiary *Sequoia* with two-ranked leaves as *S. Langsdorfii*; but it may well be specifically inseparable from the existing Redwood. The plants of the Mascall flora are preserved in diatomaceous shale above the Bridge Creek beds and separated from them by sheets of lava. Several trees, such as species of *Quercus, Sequoia Langsdorfii, Umbellularia, Salix, Acer, Cornus, Rhus, Cerocarpus*, and many others have representatives in the Redwood forests, while there are several other plants which have their modern counterparts in eastern America and elsewhere. The resemblance of the Bridge Creek flora to that of the present Coast Range forests is much closer: among conifers *Pinus, Tsuga, Sequoia* and *Torreya* are common to both; among flowering plants *Myrica, Corylus, Alnus, Quercus, Berberis, Umbellularia, Fraxinus, Acer, Rhamnus, Cornus* and many others, all linking the Oligocene and recent floras by closely related species.

In the course of the gradual desiccation, since the Oligocene age, of the northern part of the Great Basin—the region through which flows the John Day River—most of the characteristic Redwood associates have disappeared from Oregon, though they have survived in the more humid belt on the western seaboard. The Bridge Creek flora, which is one of many examined by Prof. Chaney and his co-workers, is an example of an association still found in the Redwood belt; and in essentials it agrees with Tertiary floras recorded from Switzerland, Greenland, Spitsbergen, Siberia and Manchuria. We know that *Sequoia* flourished in Mid-Tertiary England, in the arctic regions as far north as Ellesmere Land, over a large area in Europe and the Far East, and in many parts of the New World. Why is the genus now confined to a narrow strip of California? No satisfying answer has been given: Prof. Chaney believes, and he is probably right, that "emergence and the consequent withdrawal of epicontinental seas have played an important part in the restriction of the Redwood forests".*

It is impossible in a single article to do more than direct attention to the nature of the work now being done on the reconstruction of some of the Tertiary floras of the New World and their comparison with floras of the present day. From Alaska through British Columbia, Washington and the States farther south are scattered vast stores of plants waiting to be collected and described; there are also large collections in Canadian museums. This field of work is exceptionally rich in promise: it is certain that by adopting the methods so successfully and convincingly employed by Prof. Chaney, who studies the extinct side by side with the recent floras and follows the latter beyond the southern boundary of the United States into Central and South America, it would be possible to follow the development and vicissitudes of the plant-world over nearly the whole length of western North America. Abundant material is available; the workers are lamentably few.

* For fuller information on the Bridge Creek, Mascall and other Tertiary floras and their relation to the modern Redwood Forest, see R. W. Chaney's papers in Publication No. 349 of the Carnegie Institution, Washington, 1925. Also a paper in Publication No. 346, 1927.

Relations between Pure and Applied Science*

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THERE is still a certain amount of misunderstanding of what applied science means, especially on the part of those who draw a hard and fast line between pure and applied science, or of those who tend to regard applied science as of subordinate scientific interest and importance. There are some who treat applied science with a certain disparagement as being an attempt to adapt science to commercial purposes, a means of increasing wealth rather than of increasing knowledge. This attitude of mind is not perhaps so widespread as it used to be, but it still exists in Great Britain. Institutions such as the younger universities, which from the first seriously took up investigations which fall within the scope of applied science, have on that account been held to have derogated from the traditional conception of universities. Certainly up to recent years in Great Britain, no such problems were considered to deserve the attention of the academic mind. It was in fact for long held to be a recommendation and a merit that universities only taught and investigated subjects which could be studied in order to acquire knowledge for its own sake, and were useless otherwise except as promoting mental discipline.

It is instructive to observe that this narrow and indefensible outlook on knowledge is changing, and that the older universities are now taking a prominent and leading part in the advancement of applied science. We have only to recall in this connexion the important investigations carried on in both the older universities in the department of agriculture, and the work done in Cambridge to solve the difficult practical problems of cold storage. The institution, a few years ago, of the Department of Scientific and Industrial Research with its corollary, the setting up of the industrial research associations, is rapidly modifying and

* From a paper entitled "Applied Science in Yorkshire" read before Section L (Educational Science) of the British Association at York on Sept. 5. In addition to the extracts here printed, dealing with the relationships between pure and applied science, the paper outlined the development of technical instruction of all types in Yorkshire, and the work of the three industrial research associations which have their headquarters in the county, as well as that of special departments instituted in the Universities of Leeds and Sheffield to promote particular industries.