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THE WESTERN ISLES THROUGH THE MISTS OF AGES[1]

By Sir ALBERT SEWARD
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INTRODUCTORY

TWENTY-SEVEN years ago, when the British Association met for the second time in Dundee, Sir Edward Schäfer chose as the subject of his presidential address "The Nature, Origin and Maintenance of Life"; he discussed problems that will long continue to exercise the ingenuity and stimulate the imagination of biologists and chemists. A theme such as his is far beyond my reach. Seventy-two years ago the association met for the first time in this city. The Duke of Buccleuch occupied the presidential chair, and the opening words of his address are applicable to one who now finds himself in this privileged position; the Duke said: "No man has a title to state that he is unworthy of the post he is called on to fill, whatever may be his private feelings as to his fitness for the post. To state that he is unworthy to be there placed is not only a disparagement to himself, but is no great compliment to those who thought him worthy of being so placed."

This, in my opinion, is not an occasion on which it is desirable to follow the easier course and address oneself in technical language to fellow workers in the pursuit of natural knowledge. The position which it is my great privilege to occupy affords a rare opportunity of talking to a large and, I venture to hope, a sympathetic audience, including some at least who are repelled by the jargon of specialists. My intention is to speak in ordinary language on a subject of which I know enough to realize how little that knowledge is, and briefly to describe an example of the way in which, within one small patch of an illimitable field, a student asks questions of nature and does his best to interpret the answers.

[1] Address of the president of the British Association for the Advancement of Science, Dundee meeting, August 30, 1939.

An Excursion into the Past

I invite my audience to accompany me on an excursion of a kind which has substantially contributed to the enjoyment and enrichment of my own life, an excursion into a world that knew not man, with the object of deciphering from such records as we find in the rocks a few pages of the story-book of the earth. Each one of us can say with Shakespeare's soothsayer:

> In Nature's infinite book of secrecy
> A little I can read.

As that great Scotsman, Hugh Miller, wrote nearly a century ago: "We find the present incomplete without the past—the recent without the extinct." To reinforce his own opinion he quoted Samuel Johnson: "Whatever makes the past, the distant, or the future predominate over the present, advances us in the dignity of thinking beings." We shall try to reconstruct a small part of an ancient land, a remnant of which is now called Scotland, and envisage a scene at a stage in the history of the earth separated from the present by at least sixty million years, a stretch of time difficult for us who have been called "the afterthoughts of creation" fully to appreciate. When we substitute geological standards for the modest time-scale of the human period and remember that the earliest chapters of the world's history are recorded in rocks at least two thousand million years old, sixty million years dwindle to comparative insignificance. All that it is possible to do is to lift a corner of the veil separating us from the world as it was and view through dimly illuminated vistas the forests and undergrowth on an ancient continent that is now represented by a few widely scattered, dismembered pieces.

The History of Plant Life

The history of plant life in the sea and on land is a branch of natural knowledge not unworthy of consideration by us human beings who owe our existence to the vegetable kingdom. Green plants in one vital sense are our superiors: from air and water they build up the complex organic substances necessary to our life, a feat beyond man's power. As members of a subject race we should be interested in endeavoring to unravel the history of the plant kingdom—in trying to trace the origin and relations of the several classes and groups as defined by botanists. The documents that are the sources of the botanical historian are contained in the earth's crust: as a preliminary it is worth while to ask ourselves of what these documents consist; how they came to be preserved in the rocks. In order to bring to life the past we must take the present for our guide. "Speak to the earth, and it shall teach thee." There is no reason to think of nature's methods as other than continuous. If we stand by the bank of a river flowing past tree-covered slopes we see on the sand and mud by the edge of the channel or floating on the stream leaves, twigs and seeds that are random samples of vegetation scattered by wind or shed from overhanging boughs, debris swept along with offscourings from the rocks to be carried eventually to a delta or an estuary where the water-borne material comes to rest. Beds of old sands and mud, with included fragments of contemporary trees and other plants, exposed on the faces of cliffs and ravines, are layers of sediment that have been raised to a higher level. In addition to leaves, twigs and other scraps easy to see on the split surface of sandstone or shale, sediments of former ages, especially such as are peaty, occasionally furnish another valuable source of information invisible to the unaided eye. Minute grains of pollen may be carried by wind to places where conditions are favorable for their preservation: fortunately the grains or at least most of them, are protected by highly resistant coats and retain almost for all time their characteristic form and surface sculpturing. With hardly any exception it is possible for a specialist, by comparative microscopical examination of fresh material, to assign fossil pollen-grains to their generic and occasionally their specific position in the plant kingdom.

There is another natural agency to which students of extinct plants are not infrequently indebted: the formation of rocks by volcanic action. From time to time volcanoes that have long been dormant eject clouds of ash; these with streams of lava poured over the rim of a crater spread havoc among trees and shrubs that had colonized precarious sites during a peaceful interlude. Vulcanicity is not only destructive: paradoxical as it may seem, forces inimical to life have contributed to the reconstruction of life which they destroyed. Scotland is exceptionally rich in botanical treasures that are legacies from ages of fire, and indeed the fossil plants with which we are concerned this evening owe their preservation to volcanic forces.

The following botanical retrospect is based mainly on results obtained during the last two or three years, but not yet published, by the joint efforts of Mr. W. N. Edwards, keeper of geology in the British Museum; Dr. J. B. Simpson, of the Geological Survey, and myself.

Reconstruction of a Forest Scene

A. *The geological background*

(1) *Prolonged and intermittent volcanic activity.* In order to present in true perspective the scene which it is my aim to bring to life, it will be helpful to visualize the physical features of northwestern Europe some thousands of years antecedent to the phase of geological history chosen for closer examination. The chalk downs of England and part of the cliffs on the Antrim coast of Ireland are made of upraised calcareous material that was once a soft white ooze on the

floor of a clear sea, a sea which had swept slowly and irresistibly over an enormous stretch of land, embracing the greater part of England, northern Ireland and part of the region that is now western Scotland. With the uplifting of the chalky ooze from the ocean bed and the gradual recession of the waters a new land was born; a new chapter was inaugurated in the history of the earth. Following the great upheaval, as a consequential phenomenon, subterranean forces that had long been quiescent gained the upper hand: floods of semi-molten rock from deeply hidden reservoirs surged as a fiery deluge over the chalk downs, and over other and older rocks, converting thousands of square miles into barren lava-fields, extending over an area, not less than 2,000 miles from south to north, which reached far beyond the Arctic Circle. This unprecedented manifestation of volcanic energy, by no means confined to Europe and the arctic regions, but recorded on an equally titanic scale in the peninsula of India and elsewhere, is one of the wonders of geology; it is convincing evidence that the earth after the lapse of many hundred million years had not lost her youth; there was no sign of senescence. During the period we are considering most of Britain was land: we know that at a slightly later date a broad sea lay over the whole of what is now southern England. Travelers in the tube-railway in the London district may perhaps derive pleasure from the knowledge that they are being conveyed through a stiff clay upraised from the floor of that ancient sea. As an appropriate designation for the great northern land an American geologist suggested the name Thulean continent or province (see accompanying map). In the early days of the period called by geologists the Tertiary era, the greater part of the Thulean province was covered with sheets of sombre-colored lava in nearly horizontal layers, products of a series of outbursts from deep fissures rent in the earth's crust under the compelling strain of subterranean forces and from localized volcanic centers of eruption. The columnar basalts of the Giant's Causeway, the columns of the "cathedral of the sea" at Fingal's Cave, the basalts of Mull, Skye, Canna, Eigg and other western isles, weathered into step-like terraces, which form a characteristic feature of Hebridean cliffs, the flat-topped McLeod's Tables of Skye (1,600 feet), precisely similar basaltic platforms on the hills of Disko Island and the mainland of western and eastern Greenland—all these are parts of one stupendous whole, a plateau covering half a million square miles, that was once the Thulean continent. The wide-spread lava-flows represent one phase of volcanic activity in an age of exceptional unrest. Another phase is illustrated by more coarsely crystalline rocks, such as those of the dark Cuillin hills of Skye. They were not poured out as lava-streams over the land, but were forced upwards as great dome-like masses from a deeply seated subterranean source and, as their coarser texture proves, slowly cooled under the pressure of a thick superincumbent load: the comparatively large size of the crystals indicates gradual solidification from a molten mass. These two phases of prolonged rock-building help us to appreciate the immensity of geological time. Describing the lava-flows of Mull, Sir Archibald Geikie wrote: "On Ben More we can walk over each bed of basalt from the sea-level to the mountain top, a height of 3,169 feet." The basaltic lavas we see in the cliffs of Mull and many other islands are but a part of the original pile. Those that remain furnish an impressive example of rock construction which must have extended over an enormous period of time. The second phase, on the other hand, is an equally impressive example of rock destruction as a measure of geological time. We see the jagged peaks of mountains rising to a height of 3,000 feet above sea-level which, at no distant date as earth history is reckoned, were buried under a considerable thickness of younger rocks that have been utterly destroyed by the ceaseless operation of denuding agents.

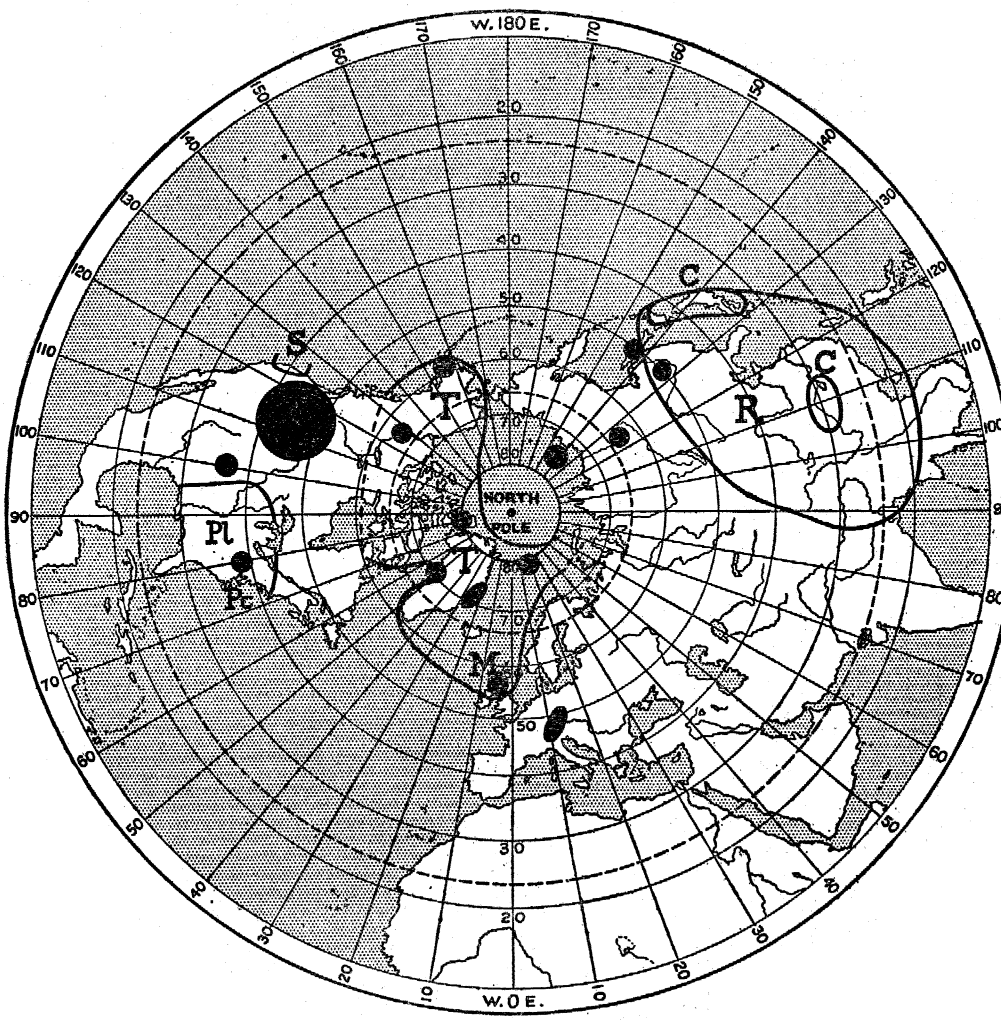
The world to our limited vision appears to be almost static; the mountains we have been accustomed to think of as symbols of eternity, seen through geological spectacles, take their place as episodes in a series of events which have moulded the changing features of the earth's face. The rocky covering of the world viewed by geologists, "foreshortened in the tract of time," reveals itself as a dynamic, mobile crust responding from age to age to constructive and destructive forces which have operated since the earth's early youth following a still earlier stage when, in the imagery of the poet,

> This world was once a fluid haze of light.

(2) *Plant-bearing sediments indicative of quiescent intervals.* So far the events chronicled in rocks of igneous origin have been spoken of as though there had been continuous outpourings of lava with occasional showers of ash and, in some districts, upwelling of molten material that remained hidden below the surface until in the course of time the covering rocks were removed by erosion. There is, however, clear proof that the extrusion of lava and other rocks was intermittent: intercalated among the lava-beds are layers of sedimentary material, hardened sand and mud, layers of coal and beds of fine-grained limestone containing beautifully preserved leaves, a few fruits and other plant fragments, also rare examples of insect wings and shells. The richest plant-containing layers occur near the base of the pile of basaltic lavas on Ardtun Head, the low "headland of the waves" near the southwestern corner of Mull, the island on which from his home on Iona—which has been aptly named "the light of the western world"—Saint Columba must often have gazed. Trees, shrubs and other plants were

able to colonize portions of the lava-field during the long pauses between recurrent outbursts of volcanic fires.

The association of sedimentary material with the basalts at Ardtun Head was noticed by Abraham Mills as long ago as 1790; but it was not until the middle of the nineteenth century that Mr. McQuarrie, of Bunessan, discovered the fossil plants, which were very briefly described by Professor Edward Forbes in an appendix to an important paper by the Duke of Argyll published by the Geological Society of London in 1851. The Duke spoke of the leaves as having been shed "autumn after autumn into the smooth still waters of some shallow lake, on whose muddy bottom they were accumulated, one above the other, fully expanded and at perfect rest." By far the richest collection of



MAP OF THE NORTHERN HEMISPHERE ILLUSTRATING SOME OF THE SUBJECTS DEALT WITH IN THE ADDRESS

C, C. The present geographical distribution of *Cercidiphyllum*, a Japanese and Chinese tree. *Black patches* mark localities and districts where fossil specimens of *Cercidiphyllum* have been found. Arctic and sub-Arctic regions: Alaska, Mackenzie River, Grinnell Land and Ellesmere Land, West and East Greenland, Spitsbergen, New Siberian Islands, Lena River. Canada and the United States of America: several localities from British Columbia and California, and east of the Rocky Mountains in Montana, Wyoming, Oklahoma, etc. The oldest examples of *Cercidiphyllum* leaves are from early Cretaceous rocks in Maryland—the Potomac formation (Pc). Others are recorded from Europe—Mull, Switzerland, Bohemia, Silesia; Eastern Asia; Sakhalin Island and the Bureja River. M. Mull and neighboring islands. Pl. The geographical distribution of the occidental plane. R. Approximate boundary of the area within which are the present homes of the majority of trees and shrubs most closely related to extinct species of the Hebridean flora. S. The present distribution of *Sequoia sempervirens* (Redwood) and *Sequoia gigantea* (Mammoth tree). T. Hypothetical boundaries of the Thulean province.

fossils was made by Mr. Starkie Gardner rather more than fifty years ago and partially described by him in a paper read to the Geological Society of London in 1887. Descriptions of several fossil plants from the Mull beds have also been published by Dr. T. Johnson. The main collection is now in the British Museum. Additional specimens have been obtained by other collectors in more recent years. The work of deciphering the botanical records from Mull, Skye and a few of the other islands is rendered mildly exciting by the danger of misinterpretation. Fossil leaves, we are often reminded, are very uncertain guides—records left by nature in a mischievous mood to mislead the unwary and over-confident student. Sir Joseph Hooker, in an address to the British Association at Norwich in 1868, spoke of fossil botany as "this most unreliable of sciences"; but he added by way of consolation—"the science has of late made sure and steady progress, and developed really grand results." One may cheerfully take the risk of being called an unscientific optimist by colleagues whose chief concern is with living plants. Botanists who confine their attention to recent plants have ample sources of information, not merely detached leaves but twigs bearing leaves, flowers and fruits. It is natural, therefore, that they should tend to underestimate the value of leaf-form and venation, characters that are often the only criteria available to the paleobotanist.

B. *The ancient flora of the Inner Hebrides*

What, then, is it possible to say about the ancient flora of the Inner Hebrides without transgressing the limits of probability? We know very little of the smaller and simpler plants which lived under the shade of the forest trees or clung to the surface of stems where they were washed by trickling rills of rain-water. The three smallest plants which have left recognizable fragments are a fungus and two liverworts or, as they are often called, hepatics, a group allied to the mosses but of simpler construction. The fungus was found by Mr. Edwards several years ago on some detached leaves of a conifer from the Mull plant-beds; the manner of its discovery illustrates an interesting technique often employed with success by students of fossil plants. In many instances leaves preserved on shale are covered with a very thin, black coaly film produced as the result of chemical change in the plant tissues after death. It is often possible, by detaching a piece of the film and treating it with certain clearing agents, to remove the carbonaceous matter and obtain a sample of the surface skin of the leaf that is brown in color, transparent and suitable for microscopical examination. After treatment the Mull leaves showed some minute dark spots on the surface film, and these on magnification were found to be circular discs made of rows of radially disposed cells. The discs were identified as organs of a fungus closely resembling reproductive structures of a living genus *Phragmothyrium,* a fungus now mainly tropical: the occurrence in Mull of a nearly allied form is, however, probably indicative of a moist rather than a tropical climate. One of the liverworts bears a close resemblance to a living species, *Pellia epiphylla,* which has a wide geographical distribution and is very common on damp earth in Britain; it has a flat green, forked body barely an inch in length. The other hepatic is a member of a different family, characterized by a slender thread-like stem bearing two rows of minute leaves; it bears a striking resemblance to some living species included in the order Jungermanniales. These two fragmentary remains of liverworts are worth mentioning because fossil examples of such plants are comparatively rare; also for another and a more important reason. A few years ago Professor J. Walton, of Glasgow, published a description of some liverworts discovered for the first time in rocks containing remains of plants which grew in the forests of the Coal Age about 200 million years ago. The interesting fact is this: the Paleozoic liverworts differ hardly at all in the construction of the delicate plant-body from the much later forms from the Thulean continent; both are essentially modern and yet both are surprisingly ancient. We do not know much about the history of these plants, but it is clear that some liverworts persisted through a succession of geological periods with practically no modification of their simple design.

The only fern so far discovered is very nearly related to the sensitive fern, *Onoclea sensibilis,* a familiar species in North America, ranging from Florida to Newfoundland and as far west as Saskatchewan; it occurs also in northern China, Manchuria, Japan and Corea; it has what is called a discontinuous geographical distribution. *Onoclea,* no longer a native of Europe, is often cultivated. The fossil fronds from Mull, both sterile and fertile, differ hardly at all from those of the living fern. Records of the rocks show that *Onoclea* formerly grew in northwestern Europe and in Greenland, regions where, through the vicissitudes of climate, it long ago failed to survive. Evidence furnished by fossils and the facts of geological history affords a clue to the present discontinuous range; in all probability *Onoclea* originated on the Thulean continent, perhaps north of the Arctic Circle, whence it spread radially into America, Europe and the Far East; in the European region it became extinct, sharing the fate of many other plants that were unable to survive the rigors of the Ice Age. Its territory was originally continuous; now it is restricted to North America and eastern Asia. Another member of the class to which the ferns belong is the familiar *Equisetum,* the horsetails: one species, closely comparable with the living *Equisetum limosum* —widely distributed in north temperate and arctic lands—has been found in the sediments of Ardtun

Head. *Equisetum* may be described as an emblem of changelessness: nearly related forms grew in Paleozoic forests at least 150 or 200 million years ago: less closely related plants in the same forests—the calamites—were comparable in size with trees. The slender horsetails of the Coal Age and their much more robust and woody allies remind us that in the course of evolution some of nature's early experiments survived unaffected by the production of new competitors, while others, less successful, left no direct descendants. As we follow the march of plant-life through the ages evidence of progress accompanied by retrogression becomes recurrently apparent: in the varying green mantle of the earth there can be traced threads running through the whole, changing very slightly as we follow them onwards and upwards, preserving all the time a remarkable uniformity in essential characters.

By far the greater number of fossils from Ardtun are leaves of trees or shrubs, which belong to one or other of the two great classes of seed-bearing plants. In Gymnosperms, including conifers and some other less familiar plants, the seeds are naked. In members of the other class, the highest, the most various and most abundant in the vegetable kingdom, the seeds are more efficiently protected and are contained in a closed case; hence the name Angiosperms. Conifers played a prominent part in the Hebridean forests, but their representatives were not such as we find in modern Europe. A single and well-preserved seed attached to a relatively large wing affords evidence of the occurrence of a conifer allied to the silver fir (*Abies pectinata*) and some other species commonly cultivated in Britain. Firs, using the term for trees belonging to the genus *Abies* and excluding the spruce fir (*Picea*), now occur in Europe, northern Africa, northern Asia and America; there is no British species of *Abies*. The Mull seed, it is important to note, agrees most closely with seeds of firs now living in China and Japan. Among other conifers discovered in the plant-beds of Mull and Skye are *Cephalotaxus, Cryptomeria* and *Sequoia*. Recent species of *Cephalotaxus* are comparatively small trees confined to the Far East; some kinds are cultivated in our gardens. The foliage of the Mull species bears a striking resemblance to that of *Cephalotaxus fortunei,* a small tree widely distributed in China. Another genus which we believe to have been a member of the Hebridean flora is *Cryptomeria;* the fossils from northern Ireland and the Isle of Skye include foliage shoots, cones and pollen-grains. The solitary living species is the Japanese *Cryptomeria japonica,* which occurs also in China—this is the tree of the famous avenue of Nikko in Japan, a notable memorial of a peasant who was too poor in worldly goods to contribute the usual building stone or a bronze lamp to the mortuary temple of an emperor, and instead offered to plant trees to protect visitors against the heat of the sun.

One of the most interesting of all living conifers is the genus *Sequoia,* of which there are two species confined within the narrow strip of hill ranges bordering Oregon and California on the Pacific coast—the Redwoods (*Sequoia sempervirens*) of the Coast Range, watered in the dry season by mists from the western ocean, and the Mammoth trees (*Sequoia gigantea,* often called *Wellingtonia*) of the Sierra Nevada (see map, S). *Sequoia* is an impressive example of the light thrown by fossil plants on the past history and wanderings over broad regions of the earth's surface of trees that, without man's protection, would be in danger of extinction. In earlier periods *Sequoia* was almost cosmopolitan; it ranged over wide spaces in the old and the new world and overstepped the limits of the northern hemisphere. Foliage shoots preserved in the sediments of Mull were in all probability borne by trees closely related to the living Redwoods, trees which are well worthy of inclusion among the wonders of the world; they attain a height of over 300 feet and the rings on cross-sections of giant trunks that have been felled bear witness to an age of 3,000 years and more. They were growing where they stand to-day 1,000 years before the Christian era. Trees next of kin to the Redwoods once lived within a short distance from the Polar Sea several hundred miles farther north than the present tree-limit. Another species of *Sequoia,* more nearly allied to the Mammoth tree, lingered on in Britain long after the disappearance of the Thulean forests: this we know from the discovery of fossil twigs and cones in the sediments of an old lake on the edge of Dartmoor in Devonshire. The two surviving species live in splendid isolation, dreaming of a greater glory that was theirs, their memories stored with secrets man can never know.

There was another naked-seeded tree in the forests into which we have intruded, a species of *Ginkgo,* the Maidenhair tree. The barbarous name *Ginkgo,* invented in 1712 by the German naturalist Kaempfer, is in the opinion of the Reverend Dr. Moule, formerly professor of Chinese at Cambridge, a false transcription of Sankyo, which probably means hill-apricot. Leaves perfect in form and venation were found in the chalky sediment of a lake that filled a hollow in the Hebridean lava-field; they differ from the foliage of the living tree only in a few minor features detected by the practiced eyes of Dr. Florin of Stockholm in the microscopical structure of the superficial cells. Dr. Simpson discovered *Ginkgo* pollen-grains at another locality. The story of the Maidenhair tree has recently been told[2] and the temptation to linger over it this evening must be resisted. *Ginkgo* of all trees furnishes

[2] *Science Progress,* January, 1938.

the most thrilling of a link with the past; its history, compiled from fossils of many geological ages and in many parts of the world, is an enthralling romance. This is but one of many histories recorded in nature's storybook which makes us share the thought of Edward Fitzgerald: "Yes, as I often think, it is not the poetical imagination but bare science that every day more and more unrolls a greater epic than the Iliad." It would be rash definitely to assert that the Maidenhair tree still exists under strictly natural conditions as a wild tree of the forest. Botanists who have searched for it in China, the country believed to be its last home, failed to discover convincing evidence of the occurrence of specimens which could not be ascribed to man's agency. On the other hand, a few years ago a Chinese botanist expressed the opinion that *Ginkgo* still grows wild in the province of Chekiang in eastern China. The oldest living examples occur in China and Japan, often in places where, as is fitting, they are venerated as trees endowed with healing properties. The history of *Ginkgo* has been traced to periods antedating by millions of years the Thulean forests. We do not know of what sort its progenitors were; but we know that it is a survival from an age too remote for us to measure in terms which we can fully appreciate. We also know that *Ginkgo,* now a lonely relic in the present world, is a primitive and isolated type, the sole representative of a large family, including many different members, all of which save the Maidenhair tree long ago fell by the way in the struggle for existence. When the tree lived in the Hebridean forests it was common in other parts of the Thulean continent from northern Canada to Greenland and Spitsbergen, in North America, Europe and Asia. It was as widely distributed geographically as oaks, pines and firs in the modern world. The history of *Ginkgo* is a record of endurance, of persistence with apparently little change in an unstable world. When we recall the amazing life-story of the tree and its forbears the autumnal color acquires a deeper significance—we see in the pale yellow of the leaves a reflection of the golden age of a family that left a precious legacy. Would that the Maidenhair tree were endowed with the oracular power of the oaks of Dodona and, in the trembling accents of its fluttering leaves, could tell us not of the future but of the varying fortunes of the family as age succeeded age.

The *Ginkgo* of Mull was not the last of its race in Europe. Well-preserved remains have been found in younger rocks in France and Germany proving that it survived in the western world, though probably only in a few places, to an age preceding by a comparatively short period the invasion of temperate Europe and North America by arctic ice-sheets and glaciers, which had a far-reaching effect upon the vegetation in the western world.

Leaving the naked-seeded plants, we pass to the flowering plants or Angiosperms. This class is more recent in origin than the Gymnosperms, at least so it would seem, and as in present-day floras so also in the Thulean forests, flowering plants contributed the greatest number of genera and species. We shall take first a few trees and shrubs which have descendants still living in Europe, and afterwards mention others that have no near relations in European floras. There were, we think, three or four kinds of oak, all different from those now living in Europe and America. The largest leaves from Mull assigned to the genus *Quercus* are oval, with a broadly rounded base and relatively small teeth; they resemble the foliage of a few Indian species, but the oak with leaves most closely resembling the fossil form is *Quercus serrata,* a native of China, the rain-forests of Assam, Japan, Corea and the Himalayas. A second species from Mull is closely comparable with other Indian and Far Eastern oaks; and a third form of leaf is very similar in shape and venation to a species that now has its home in China, Assam and the island of Formosa. It is noteworthy that none of the oaks of the Thulean forests conformed in pattern of the foliage to our familiar British trees.

One of the most conspicuous trees in the Hebridean woodland was a plane (*Platanus*) with large handsome leaves almost, but not quite, identical with those of the existing occidental plane of North America. The fossil evidence in this instance is supplied by male flowers and fruit-balls as well as leaves. As in all living planes the expanded base of the leaf-stalk enclosed and protected a bud. There is, however, one interesting feature in which the leaves of the Mull tree differ from those of any living plane: there were two fairly large leaflets attached to the long leaf-stalk between the main part of the leaf and the base of the stalk. The significance of this peculiarity need not be discussed; it is one of those botanical problems of academic interest which excite the specialist. A more important fact for us is that plane trees in the period we are considering occupied a territory which extended very much farther north than the present area of distribution. Remains of plane trees have been found as far north as Spitsbergen in rocks approximately equivalent in age to those of Mull. There are in the world to-day six or possibly eight different kinds of plane: the oriental plane (*Platanus orientalis*), the only species native in Europe, is one of the noblest living trees; it recalls the groves of the Academy in the golden age of Greece. One of the oldest specimens is the venerable stump bearing enormous arms in the market place on the island of Cos, where, legend would have us believe, Hippocrates, more than two thousand years ago, gave advice to his patients under the shade of the youthful tree. The oriental plane extends from Greece and the Aegean islands eastward to Asia Minor and the Caspian Sea; it is sometimes said to be wild in Persia and northern India, but more probably this eastward spread should be attributed to man. The most widely distributed species in the New World is *Platanus occidentalis,* growing usually in river valleys from Lake Ontario to Florida and west to Texas and Nebraska (see map, Pl.). On the western side of North America there are other species, in Mexico and along the Coast Range hills of California. The most familiar cultivated species in Britain is *Platanus acerifolia,* the so-called London plane: this favorite urban tree is regarded by some botanists as a hybrid between the oriental and the occidental plane; the time and place of its origin are not known with any certainty. The geological record of *Platanus* affords a striking example of contrasts between past and present areas of distribution. Some of the oldest known fossil leaves and fruits are from early Cretaceous beds in Greenland, at least 300 miles north of the Arctic Circle. The occurrence of these remains in sediments that were deposited in a remote northern estuary before the chalk of the British Isles had been upraised from the sea-floor affords definite proof that plane trees lived in arctic forests millions of years before they spread to the southern part of the Thulean continent. The birthplace of *Platanus* may have been in the far north, whence in course of time it spread to Iceland and Spitsbergen, from arctic to temperate North America and Europe, and wandered as far east as Sakhalin Island on the eastern confines of Asia.

One of the comparatively few trees in the Hebridean forests related to recent British species was a *Corylus* with leaves similar to those of our hazel but still more like the foliage of species now living in India and the Far East. Hazels were associated with planes not only in the ancient flora of Mull but in circumpolar forests from which they traveled, in response to the urge of climatic change, to fresh and more genial homes farther south. Another tree in the Thulean forests was a cornel, a species of the genus *Cornus,* which has a far-flung distribution, in arctic and sub-arctic countries, in North America, Europe and Asia. While fully conscious of the danger of placing excessive trust in leaves as evidence of affinity, we believe that a Chinese cornel (*Cornus chinensis*) agrees most closely in foliage with the Mull species. The cornels are members of an old stock represented in northern forests as long ago as the Cretaceous period.

Among the larger fossils from Ardtun Head are a few almost perfectly preserved leaves of a vine, which we believe to be specifically identical with specimens previously discovered in Alaskan rocks of approximately the same geological age as those associated with the lava-flows of Mull. Similar leaves have been described from Greenland, Iceland, Spitsbergen and more southern localities in America and Europe. Vines were widely distributed even as far back as the Cretaceous period. There is now only one European species, the wine-producing *Vitis vinifera,* but its leaves are unlike the fossils from Ardtun. The striking contrast between the present distribution of the vine in Europe and its former, much more extended distribution, which included arctic and north temperate regions, raises the difficult problem of changes in climate from one age to another. Vine scrolls are a fairly common ornament on early Northumbrian Anglo-Saxon crosses, a motif adopted in still earlier ages by Greek and Roman sculptors, which, after the lapse of centuries, reached the highest expression of naturalistic treatment in England in the last two decades of the thirteenth century. Millions of years before vine leaves and fruit were fashioned in stone, one kind lived in prehuman days on the Thulean continent; and it is noteworthy that its nearest counterpart in the modern world occurs in the Far East.

We turn now to trees and shrubs belonging to genera which are no longer living in Europe. The first tree to be considered furnishes a striking contrast, in the narrow limits of its present geographical area, to the widely spread cornels and oaks. *Cercidiphyllum* is now confined to Japan and mountain valleys in some parts of China (see map, C). The name *Cercidiphyllum* was chosen because of a superficial resemblance of the leaves to those of the Judas tree, *Cercis siliquastrum.* Only a single species, with a few varieties, has survived, *Cercidiphyllum japonicum,* familiar to many tree lovers who cultivate it for the sake of the exceptionally beautiful gold, pink and red parti-colored autumnal foliage. In common with some other trees of ancient lineage, *Cercidiphyllum* lacks any near relations in the present age; it is one of a select company of nature's anachronisms. Like the Maidenhair tree, it is an aberrant type, a relic living within a comparatively small area in the Far East; formerly it was one of the most widely distributed forest trees on both sides of the Atlantic Ocean. Several beautifully preserved leaves have been found in the plant-beds of Ardtun Head, leaves and occasionally fruits of *Cercidiphyllum* have been found in Grinnell Land and Ellesmere Land on the northeastern corner of the Canadian Archipelago, in Alaska and at several localities on the Pacific and Atlantic coasts of North America, in Greenland, Iceland and Spitsbergen, as well as in Switzerland and other parts of Europe (see map). Leaves, superficially at least indistinguishable from those of the existing species, are recorded from sedimentary beds in the valley of the Potomac River in Maryland assigned to the early days of the Cretaceous period when flowering plants were comparatively few in number and had not yet come into their own as the dominant class in the plant kingdom. When we remember the remote antiquity of *Cercidiphyllum* and its wanderings over the earth's surface during the passing of millennia, the autumnal glory of its foliage is enhanced a hundredfold and acquires a symbolic meaning.

The plant-beds on the headland of Ardtun have yielded very few recognizable fruits and seeds. Among the rare examples of fruits are some, about half an inch long, consisting of a slightly elongated seed-vessel surmounted usually by five leaflets, the enlarged and persistent covering of the young flowers, which served as efficient aids to dispersal by wind. The fossil winged fruits and associated leaves present a remarkably close resemblance to those of some living species of *Abelia,* a genus named after Mr. Clarke Abel, who discovered the shrub in China about one hundred and twenty years ago. *Abelia* is a member of the honeysuckle family (*Caprifoliaceae*); most of the existing species have their home in central China and are cultivated as flowering shrubs in European gardens. There are a few species in Japan, the Himalayas and Mexico. Fruits of a Chinese *Abelia* agree most closely with the fossil specimens. Similar though not specifically identical fruits were discovered thirteen years ago by Mrs. Clement Reid and Miss Chandler in a collection of fossil plants from Bembridge in the Isle of Wight. The Bembridge flora is younger geologically than the flora of Mull and indicates a warmer climate. Other examples were recorded long ago from southeastern France. It is therefore clear that shrubs next of kin to Abelias now living in China were once native in western and northern Europe. The introduction to British and continental gardens in our time of *Abelia, Cercidiphyllum* and other trees and flowering shrubs may be described as the reinstatement, through man's desire for horticultural novelties, of plants that had long been exiles from western woodlands where as natives they were never seen by human eyes.

So far attention has been confined to a selection of plants identified from leaves and a few fruits. If time permitted, the list could be substantially enlarged by inclusion of the interesting results of Dr. Simpson's intensive study of pollen-grains, which he found by microscopical examination of broken-up pieces of lignite and coal, associated with sandy beds in Mull and on the adjacent peninsula of Morven. The pollen-bearing layers of rock are below the basaltic lavas and therefore slightly older than the leaf-beds of Ardtun Head. Dr. Simpson discovered several conifers and flowering plants confirmatory of identifications based on leaves; he also made many additions to the list compiled from leaves, fruits and seeds. Three of his discoveries are selected for brief reference. He found pollen-grains of two kinds of alder (*Alnus*). The pollen of alders has a very characteristic structure and can easily be recognized. The occurrence of alders in the Hebridean flora supplies one of the few links between the extinct and the present European vegetation. The second genus chosen from Dr. Simpson's list is *Magnolia;* it is now represented by many species, both trees and shrubs, and is widely distributed on two sides of the Pacific Ocean—in Asia along the Himalayas and in parts of Tibet, over a large area in China, Japan and Corea, the Malay Archipelago and Indo-China; in America from southern Ontario as far south as Central America and Cuba. It was shown many years ago that *Magnolia* formerly lived in Europe and flourished as far north as latitude 70° N. in Greenland; we now know that it played a part in the adornment of the Thulean forests.

Finally a few words on the discovery of pollen-grains believed to belong to a species of *Nelumbium;* this genus is one of the most attractive water plants, a plant held sacred in ancient Egypt and venerated in the Far East. One of the living species is the sacred lotus, native in China and Japan and established as far west as the Caspian Sea; the other species has an extended range in North America, spreading as far south as the West Indies and Brazil. *Nelumbium* no longer grows in the Nile: long years ago it had a wide distribution in Europe, both in the Cretaceous period and in later ages. Looking backwards we see its great circular leaves spread over the still waters of a Thulean lake.

It is important to note that Dr. Simpson's comparative investigation of fossil and recent pollen shows a preponderance of eastern Asiatic species in the Hebridean flora.

FANCY WITH FACT

We have attempted to recreate a scene in the past, and it is natural to ask—how does our reconstruction compare with reality? As it is impossible to satisfy curiosity by an actual flight to the Thulean continent, we can at least imagine ourselves miraculously transported to a destination where the past has become the present. At a very early stage of the backward journey we should see the greater part of the land being gradually obliterated by a covering of snow and ice; glacial conditions would be succeeded by a climate becoming more and more genial. Human beings would be missed before one fiftieth of the flight had been completed. At last, after observing the moving panorama of land and sea, fluctuations in climate and changes in the character of the vegetation, let us imagine ourselves at the journey's end. Combining fact with fancy, we find ourselves, where in day-dreams we have often been, among the plants on the lava plateau. Thanks to the artistic cooperation of Mrs. Gwendy Caröe, it has been possible to give substance to our mental picture based on geological and botanical facts. It requires a special effort for us, who think of ourselves as overlords in nature's realm, to visualize a world in which man has no place. Alone in a world which for millions of years to come would be uninhabited by the human race, we could hardly fail to look upon the beauty of nature's pageantry with a strange and more penetrating vision:

> Beauty, the eternal Spouse of the Wisdom of God
> and Angel of his Presence thru' all creation.

We should realize as never before man's insignificance: on the other hand, our estimate of spiritual values would be raised to a higher level and we should experience a deeper sense of union with the infinite. Our tendency is to think of the past, as we think of the present—in relation to man; we forget his very recent participation as an actor in life's drama. As we look at nature as into a mirror our own image obtrudes itself into the foreground. Had man been a dweller on the Thulean continent he would have seen, as we see, the sun by day setting in motion the living machinery of trees and herbs; the splendor of the evening sky; he would hear the wind in the trees, the music of running water and the songs of birds. The beauty of nature is eternal. To the east and north beyond the lava-fields the Caledonian mountain ranges would be seen rising to greater heights than any of their peaks reach to-day; they were still to be exposed for millions of years to the destructive operation of nature's sculpturing tools. Making a fresh demand upon our imagination, let us take a longer view over the curve of the earth towards the heart of Europe and far to the east to northern India. We should look in vain for the Pyrenees, the Alps, the Carpathians and the Himalayas: these and other mountain ranges had not yet been lifted up; the time of their birth was not far off. We should see in their place a broad belt of water stretching from the Atlantic to the Indian Ocean, linking West and East. On the bed of this ancient sea—the Tethys Sea of geologists—sediments had long been accumulating, and these, with other rocks of igneous origin, would be involved at no distant date in a complete transformation of the earth's features and the crumpling of the crust into the "everlasting hills."

Returning to the Thulean continent at a place near the present geographical position of the Inner Hebrides, let us take a survey of the vegetation. We should be impressed by its luxuriance: at first sight the general aspect would seem familiar, but on closer examination of the trees and shrubs we should find only a few recalling modern European species; many would remind us of exotic plants of eastern origin. Despite the immensity of the time interval separating us from the world we had left, we should not be aware of any such marked contrast in the general character of the vegetation as we might have expected. The plants had already put on their familiar dress and would seem to us surprisingly modern. But—and this would be the deepest impression—we should feel that we were among trees and shrubs that were reminiscent of remote eastern forests. We should be conscious of the dynamic character of the plant-world; we should be driven to the conclusion that the forests were mainly composed of wanderers resting for a time in a temporary home whence, as conditions changed, they would pass to other stages in the long journey to their present refuges in Asia.

Evolution

There remains another question which is always asked by those who attempt to reconstruct the vegetation of past ages: What contributions do the records of plant-life make towards a better understanding of evolution? The riddle of evolution remains a challenge and, as knowledge increases, we make fresh guesses. As a Cambridge friend writes in a recent volume of "Provocative Verse":

> That life evolves was guessed of yore,
> Darwinians prove it true;
> Of how and why we know but little more
> Than old Lucretius knew.

The little more we know urges us to continue in hopeful expectancy the long and endless prying into nature's methods. What then do we learn from the ancient flora of the Western Isles? The facts do not substantially help us to trace the unfolding of life in the long interval separating the older part of the Tertiary era from the present time. There is little difference between the past and the present vegetation of the world as a whole in the nature of trees, shrubs and ferns; our knowledge of the earlier history of herbaceous plants is very meager. The fossil flora of Mull represents an early phase of what may be called the modern type of vegetation, which overspread the world in the later stages of the Cretaceous period and has persisted with few major modifications until now. Evolution seems to have been characterized by bursts of production when new and successful types exercised a transforming influence; and these periods of exceptional creative activity were separated by periods of relative stability. The early Tertiary floras belong to a stage when a new order had become well established and an older order had passed its prime. The one great difference that emerges from comparison of the Mull flora and the existing European floras is not a difference in the components of the world forests, but a contrast in the geographical positions occupied by the various genera in the northern hemisphere: for the most part a western home has been exchanged for a home in the Far East.

Drifting Continents

If we followed the vegetation on the southern part of the Thulean land farther to the north, we should be impressed by its apparent indifference to changing physical conditions as we traveled beyond the Arctic Circle; we should fail to notice any zonal distinguishing characters in the floras such as in our day reflect the passage from temperate to arctic regions. The evidence of fossil plants forces us to the conclusion that the vegetation on the Thulean continent, its northern boundary within a short distance of the polar sea, its southern border on the latitude of northern Ireland and western Scotland, was astonishingly uniform. How, we ask, can we explain this surprising and well-attested fact? There must, it is generally agreed, always have been climatic belts; high arctic and much lower temperate regions can not have supported closely comparable floras possessing several species in common. Some of us are convinced that changes in geography from one period to another, land connections where there are now arms of the sea, interference with paths of ocean currents and consequential changes in temperature are inadequate as explanatory causes. What then remains? Were it possible for us to make a survey of the Thulean continent as it was, we might find that the geographical relation of the northern part of the forest-clad land to the North Pole was by no means the same as it is now. It is difficult, it is probably impossible, to explain the facts without calling to our aid the hypothesis of drifting continents usually associated with the late Professor Wegener and recently discussed in an able book by Professor Du Toit, of South Africa. This is a controversial subject beyond the scope of my address. I can do little more than reaffirm adherence to the view that plant records from rocks of many ages raise problems which seem to be insoluble unless we postulate movement and sliding of the earth's crust. As icebergs are slowly drifted by ocean currents, as masses of cumulus clouds rapidly changing shape pass across a blue sky; so, the rate of travel enormously reduced, large slabs of the outermost rocky shell of the world may have shifted their position in the course of geological time. It must, however, be admitted that as yet refined methods of measurement have not furnished any evidence of crustal movement. Dr. Nörlund, of Copenhagen, has stated that longitudinal determinations, carried out by the Danish Geodetic Institute in 1927 and 1936 with a modern transit instrument, both times on the same pillar at a locality on the west coast of Greenland, gave practically the same result. In his presidential address at the Norwich meeting of the association in 1935 Professor W. W. Watts made an interesting and judicial reference to the Wegener hypothesis: he spoke of it as having been hailed by many classes of investigators as almost a panacea, and quoted one of several critics who called it a beautiful dream, the dream of a great poet.

Proof or disproof of the Wegener hypothesis will be forthcoming in the more distant future when the precision of modern methods of measurement has been available long enough to provide trustworthy data. Meanwhile we must be content to wait in sanguine expectation that an interpretation of the overwhelming evidence furnished by fossil plants will be provided by research workers in the geophysical field.

One of the most impressive examples of the bearing of fossil plants upon the fascinating problem of climatic conditions in the past has been furnished by Professor Harris, of Reading. The facts are briefly these: Several years ago Professor Nathorst, of Stockholm, described a large collection of fossil plants from rocks in Scania, the southernmost province of Sweden, demonstrating the existence of a flora many million years older than the one we have been considering. It was a very rich flora composed of numerous ferns, conifers and other plants; it probably lacked flowering plants. More recently Professor Harris made a still larger collection of fossils during a long visit to eastern Greenland in the ice-bound district of Scoresby Sound, where, under extreme arctic conditions, only a few stunted plants are able to exist. Nothing could be more striking than the present contrast between the floras of eastern Greenland and southern Sweden. The arctic fossil plants of the same age as those from Scania demonstrate the former existence of a flora even richer than that from southern Sweden; comparison of the two floras affords no indication of any difference in the size of individual plants and no difference in the vegetation as a whole. A luxuriant and uniform vegetation occupied an area stretching from central Germany to southern Sweden and a thousand miles farther north beyond latitude 70° N. The fossils preserved in rocks at localities within this far-flung geographical area from south to north give no indication of any such change in the plant communities as we should expect and as we find when we contrast arctic and temperate floras in the present world. This uniformity, I venture to think, is inexplicable unless we assume a very considerable movement and reshuffling of the earth's crust. The geological historian needs the cooperation of astronomers and physicists in his endeavor to reconstruct the world at the successive stages of its development; he looks to them to prevent him from making assumptions inconsistent with conclusions reached by workers in other fields. On the other hand, geologists and paleontologists contribute facts that are incontrovertible, however much they seem to be in opposition to the views of students whose primary interest is in geophysical problems.

NEGLECT OF EARTH HISTORY IN EDUCATION

There are still some people who ask, What is the use of the kind of information given in this address? My reply is that knowledge gained from a first-hand study of nature, both animate and inanimate, has a value beyond price. Enjoyment of the romance of creation as recorded in the life of the past and of the present is within the reach of all who have the desire to read the open pages of nature's book. In the rocks we find the soul of history: the whole world throbs with life, and the joy of it all is ours to share:

I said it in the meadow path,
I said it on the mountain stairs—
The best things any mortal hath
Are those which every mortal shares.

This evening we have caught through the mists a glimpse of a scene on earth's stage separated from the present by a small fraction of time in relation to the whole span of geological history. The Thulean forests which we have visited included trees, shrubs and other plants of surprisingly modern aspect, though it is not to be supposed that they were absolutely identical specifically with their living descendants; from the material available it is impossible to define or assess the difference. What we have seen throws little light on the evolution of the plant-world; it is equally true that the main conclusion forced upon us by our retrospect can not fail to convince us that it is impossible to understand the present distribution of plants over the earth's surface unless we extend our survey into the past. Darwin spoke of geographical distribution as a noble science, "almost the keystone of the laws of creation." The living world can not be fully appreciated as an expression of creative energy unless we free ourselves from the cramping influence of the environment in which we live.

As a botanist whose first love was geology, may I make a plea for wider recognition of physical geography and geology as branches of knowledge possessing an inestimable value as a means of bringing young people into close companionship with nature and as a source of refreshment, a stimulus and an inspiration. Most of us would probably agree with the spirit of a remark made a good many years ago by the late A. C. Benson: "I find it hard to resist the conviction that, from the educational point of view, stimulus is more important than exactness." Arguments in favor of introducing geology into schools were put forward in a "Report on Scientific Education" presented at the Dundee meeting seventy-two years ago, and in 1936 and 1937 the association published two reports on the same subject. Let me add another argument of no little value: Hugh Miller wrote in a letter to a friend, "geology is, I find, a science in which the best authorities are sometimes content to unlearn a good deal." That is worth much; geology helps us to cultivate the not too common virtue of admitting that it is possible to make a mistake. In conclusion, I can not do better than quote with whole-hearted agreement words spoken by Sir William Bragg in his presidential address to this association eleven years ago: "Some speak of modern science as tending to destroy reverence and faith. I do not know how that can be said of the student who stands daily in the presence of what seems to him to be infinite." These words apply with equal force to searchers after truth whose main interest is in the living world no less than to those whose objective is the elucidation of the structure of matter that is called by contrast dead and yet vibrates with life. The earth was once lifeless; when and how living protoplasm had its birth we do not know, nor do we know whereupon were the foundations of the earth laid. We can only echo in our hearts the voice out of the whirlwind:

Whereupon were the foundations thereof fastened?
Or who laid the corner stone thereof;
When the morning stars sang together,
And all the sons of God shouted for joy?

SCIENTIFIC EVENTS

THE FORESTS OF GREAT BRITAIN

ACCORDING to the report of the British Forestry Commission for the year ending September, 1938, approximately 54,000,000 trees were planted during the year. Forty-seven per cent. of these trees were Norway and Sitka spruces, 24 per cent. Scots and Corsican pines, 9 per cent. European and Japanese larches, 1 per cent. Douglas fir and 16 per cent. broadleaved species. The total addition to the woodland area of Great Britain as a result of the commission's operations during the year was 20,300 acres. Including reafforestation in the former Crown woods and replanting areas damaged by fire, 24,100 acres were planted, of which 21,600 acres were planted with conifers and 2,500 acres with hardwoods.

By the end of the forest year the commissioners had 125 forests in England and Wales and 107 forests in Scotland. The total area afforested is now 365,000 acres, and is being increased by some 30,000 acres a year. During the year 92,000 acres of land were acquired, including 64,100 acres of plantable land. The commission now controls 1,100,000 acres in Great Britain. The commission mainly plants conifers, principally because the demand for coniferous timber, called softwood, is about nine times the demand for hardwood, and the commission's policy is to afforest land of little agricultural value, which is generally unsuitable for hardwoods.

The year under review was one of the worst for forest fires, which burnt 2,100 acres of planted land and cost £39,900. The worst year on record was 1929, when the damage from fire amounted to £46,000.