THE EUCALYPTUS IN AUSTRALIA

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FOR SEVERAL MONTHS I have been traveling through Australia, a continent as large as the Continental United States, with a total area of 3,000,000 square miles. This is roughly the same area as is covered with coniferous forests over the whole world. In spite of its great differences in terrain, soil and climate, there is one feature which is universal in Australia: the Eucalyptus. It occurs in moist areas with over 50 inches of rainfall, but it also is found in semi-deserts with 10 inches of rain. It grows from sea-level to timberline on the Australian Alps, culminating in Mount Kosziusko, from the tropics at 10° SL in Northern Australia to the Southernmost part of Tasmania, at 42° SL. On soils with a hard-pan it forms shrub-thickets, but on deep rich soils in the mountains it grows into majestic forests of 300 ft. height. It grows in near-swamps, on rocky outcrops, in sand or on heavy clay. It forms excellent timber or can be used for paper fabrication; it is a source of oil, and has a hundred other uses. It seems as if all the other trees of the world in Australia have been rolled together into the 600 species of Eucalyptus. It is really amazing how the species of a single genus have so completely filled the very diverse ecological niches or requirements of a whole continent, at the virtual exclusion of other trees. Although Australia is geographically isolated from most of the rest of the world, restricting the exchange of plants from other areas, enough trees of other families have invaded Australia to have furnished material for the evolution of trees specifically adapted to the Australian environment. Yet it was the *Myrtaceae* which furnished the basis for most tree-needs here in Australia. As examples of other trees can be mentioned the rainforests along the Eastern mountain scarps where the tree genera have penetrated from New Guinea and the Asian tropics, and in the South the Beech (Nothofagus) forms forests. But against competition of these invading trees three quarters of all trees in Australia are Eucalyptus. There is no other part in the world of equal size which is so exclusively populated by trees of a single genus. Conifers are the only comparable group, but there we are dealing with many different genera in several families.

Although before arriving in Australia I had known about the importance of Eucalyptus, yet I was struck by its universality. For in California we know hardly more than a dozen species, and these seem to be overshadowed by *Eucalyptus globulus,* which is a species of minor importance in Australia. I saw it growing in Tasmania, as just one of a dozen of species, most of which seemed more vigorous. Of all the really beautiful Eucalyptus growing here in forests, only the *Eucalyptus viminalis* is popular in California too, but the 300-foot tall *E. regnans,* the most majestic of all I saw, or the rapidly regenerating *E. gigantea,* or the beautiful *E. goniocalyx,* or the highly frost-resistant *E. niphophila,* are never encountered with us. This seems strange, because of the very intensive introduction of Eucalyptus into California in the beginning of the century. The Los Angeles State and County Arboretum has started a very active program of introduction of other Eucalyptus species, and with the active cooperation of many foresters and scientists in Australia, and the vigorous efforts in Arcadia, we can look forward to a new era of success of Eucalyptus introduction in California.

It may be of interest to mention some of the conditions of growth of Eucalyptus in Australia, which might help us in our efforts to introduce more Eucalyptus and adapt them to growth in our country which is climatically so similar to Australia. The first point of interest is that here in Australia we seldom find a forest in which only a single species of Eucalyptus grows by itself. With the exception of *E. regnans,* 2 or 3 species always grow

together, perfectly mixed, with usually the trees alternating. Still more remarkable is that one of this combination is always a member of the sub-genus *Renantherae,* which we never grow in California. It seems as if these form sort of a complementary combination. In addition there is usually an *Acacia* such as *melanoxylon* or *dealbata* intermixed. There is a chance that the combination of an Acacia, a Eucalyptus of the *Renantherae* group and another one like *viminalis* or *fastigata* is a biological unit, of which the members stimulate each other in the sense that all together grow better than each separately. If this is actually the case there is an added reason for introducing *Renantherae* in California. For there is a good chance that we could obtain better growth of our Eucalyptus, now growing in California by itself, if we mixed the plantings with *E. gigantea* and an *Acacia.*

One of the reasons why none of the *Renantherae* of the genus *Eucalyptus* has been successfully introduced may lie in the presence of mycorrhiza in the roots of all its members, and that this has not been introduced. Mycorrhiza is a fungus which grows in and around the roots of many trees which does not harm them, but on the contrary stimulates the growth of the tree. In many cases trees normally having mycorrhiza, such as most pines, cannot be grown successfully without it. The fungus derives much of its food from the tree roots, whereas the roots receive growth promoting materials from the fungus, and in some cases the fungus seems to function as root hairs for the roots. Each tree species has its own fungus species with which it grows together. The fruiting bodies of the fungus are the mushrooms which are so abundant in the wet season in forests.

Most Eucalyptus are very fire resistant. There is hardly a natural forest in Australia of which the trunks do not show fire scars or which do not have fire-blackened bark. The old trees usually escape destruction by fire for several reasons. The driest Eucalyptus forests have a low undergrowth, which does not come up more than 3 feet, grasses, Banksia's and the typical Australian Grass Tree (*Xanthorrhoea*). A fire in such a forest remains close to the ground, and in this way the tops of the trees escape injury. This causes a typical openness of the forests through which one can see for a mile or more because of the lack of higher undergrowth. The bark of the trees is so thick that the living tissues inside are not injured. In the wetter Eucalyptus forests the shrub undergrowth is higher and a fire in such a forest usually develops into a crown-fire, burning all leaves and smaller branches. But buds buried deep in the thick bark of the heavier branches and trunks will resprout so that the trees survive, although they look rather ghost-like during the first years after the crown-fire.

The young Eucalyptus and the shrub species have another mechanism which makes them survive fires. This is the so-called ligno-tuber, a tuber-like swelling of the underground part of the stem, which survives after all above-ground parts have been consumed by fire, and from which new sprouts develop. This strong regenerative power can be observed in our *Eucalyptus globulus* which immediately resprouts after having been cut at ground-level.

The regenerative power of a Eucalyptus forest after a fire is truly remarkable. The young trees come up in very large numbers and do not seem to be crowded out by grasses or shrubs. In contrast with so many other trees they grow very rapidly when young and in a surprisingly short time they have formed a new forest after the old trees have been destroyed. But in a fully mature forest there usually are not many seedlings of Eucalyptus, except where the surface of the soil has been destroyed or in road cuts. And when young trees develop between the old ones they usually grow slowly and may die. This is definitely not due to lack of light, for Eucalyptus forests are remarkably light, partly because the crowns are not very dense and partly because the leaves hang down and thus do not take away so much light.

It is of course impossible to describe all the different types of Eucalyptus forest in detail, but I would like to say something more about the most impressive one I

have seen, the Mountain Ash (*E. regnans*) in Victoria, in the Dividing Range 40 miles N of Melbourne. Parts of this are protected as a watershed since it covers the areas from which Melbourne receives its water. The rainfall in this forest which is situated at 2000-3000 ft. altitude is about 40-50 inches per year, with another 8 inches produced by fog-drip when clouds surround the mountains. Unfortunately most of the *E. regnans* forests have been destroyed by fire or by man. But where it still stands untouched it is of an undescribable grandeur, the slender trunks without branches for the lower 150 feet, reaching straight up pale yellow or greenish towards its own light olive leaves. At their base most trees are 6-10 ft. wide, and their height varies between 260 and 300 feet. They dwarf stately tree ferns in the undergrowth. A curious sight is the number of broken branches which have plummeted down like darts, and stand upright in the ground under the trees. In between lie the long strips of bark which peel off like in our California Eucalyptus.

In looking up against these most graceful of all trees, one wonders what has made them grow so tall. One compares them of course with the California Redwoods which grow slightly taller, and with the Sierran Sugar pines, or the magnificent conifers in the Alpes Maritimes in Southern France. It is curious that nowhere in the tropics are there forests which can compare in size with the forests just mentioned, which all lie well outside the tropics, at about 40° N or S of the equator. And comparing the climates with each other, we find that all of them: Victoria, California and Southern France have winter rainfall and summer drought. During the drier months the forests all seem to be frequently surrounded by fog, which can be condensed by their needles or leaves to produce a considerable amount of precipitation, and in none of the localities the soil becomes really very dry. But the air is, especially during day in summer, very dry. This is surprising, because one might well suppose that in such tall trees the water supply would be a limiting factor in their growth. But we have seen already that in really moist tropical countries trees do not grow so tall. Therefore it is not the water supply which determines how tall a tree can grow.

Which other factor might become limiting in a tall tree? That is the translocation of food from the leaves to the root systems and to the growing cells of the stem. In work which I have carried out with tomato plants I found that the cooler the temperature, the better the sugar formed in the leaves was transported to other parts of the plant and the better it could grow. On the other hand the temperature during day had to be fairly high to obtain the highest rate of photosynthesis. When we compare now again the climates where the tallest trees grow, then we find that they are the summer drought areas, which means at the same time, that they have big temperature differences between day and night. The drier the climate, the bigger this diurnal temperature differential is. Therefore it is not so much the dryness of the summer, which makes these trees grow tall (we have already seen that the water at the disposal of their roots is always sufficient), but the warm days which produce lots of sugar in the leaves and the cool nights which are optimal for the removal of these sugars to the roots. In warmer or cooler or wetter climates we may get very large trees, but their size is not so much tallness but rather thickness, such as the enormous Kauri's (*Agathis australis*) in the forests of Northern New Zealand which reach a diameter of 30 feet, but are not over 200 feet high. The climate there is much wetter throughout the year and the big temperature differential of the summer drought areas does not occur there.

The tallest Eucalyptus trees are found in South-Westeren Australia, again in an area with summer drought, and with a total rainfall of 50 inches, which supports the suggestion put forth earlier in this article. And the *Eucalyptus regnans* which grows in Tasmania, with a considerably cooler climate and not such a pronounced summer drought is still a very tall tree, but does not go much above 200 feet.