spruce into the mountains. In the historic epoch, when the forests in the valleys were badly cut and abused, spruce descended again from the mountains into the valley. With the aid of material which was found in excavations, it was possible to determine that spruce was not present in the valley during the neolithic time, and that it appeared only in the helvetic period, that is, early in the middle ages. This, according to Engler, shows that it did not take such a long time for the spruce to acquire the biological characteristics which enabled it to grow in the valley.

This committee, therefore, firmly believes in the importance of the source of seed and in the extension of the range of valuable species as the most immediate possible means of adding to or of enriching our different regions and thus increasing the productivity of our forests.

FOREST SEED COLLECTION TO GAIN THE BENEFITS OF ENVIRONMENT

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The collection of forest seeds in Europe has been an important commercial business for a hundred years or more. In this country seed collection has been practiced for thirty or forty years, but the work had never been systematized until the Forest Service began planting on the National Forests. William T. Cox states on page 18 of Forest Service Bulletin 98 that during the autumn of 1910 the Forest Service collected 107,780 pounds of native seed. This large quantity was not sufficient for the needs of the government since 54,100 pounds of European seeds were purchased in addition to the native collection. This probably represents an expenditure of more than \$200,000 per annum by the Forest Service. That the collection of this vast quantity of seed should be done in such a manner as to secure the very best quality in each individual species is a self-evident truth.

It is proposed by the writer to point out in the following paragraphs some of the desirable effects of environment, the benefits of which may be gained by a proper regulation of forest seed collection. Prof. Charles S. Sargent observed thirty years ago in his ninth volume of the Tenth Census that the heaviest specimens of wood of a species usually grow in the southern part of its region of distribution. It

has also been repeatedly demonstrated that the strength of wood of the same structure increased with its specific gravity. If strength is a quality that is transmissible by heredity, then it would seem desirable to collect forest seeds for planting from the most southern region of the distribution of a species. Of course the collector must pay attention to frost resistance. Seed collected from the extreme southern range of a plant might produce seedlings that could not resist cold. If the species belongs to the Rocky Mountain region, there is not much danger from this cause because untimely frosts are about as common in the southern Rockies as in the northern.

Prompt germination is a very desirable quality in forest seeds. Mr. Cox has shown that the seed of *Pinus ponderosa* germinates most promptly when obtained from the eastern foot of the Rocky Mountains and germinates more slowly on proceeding westward to the Pacific Coast. The eastern type of this valuable pine is also very drouth resistant. Since planting on the National Forests is likely to be limited to those areas which because of inhospitable conditions cannot easily be restocked by natural seeding, the seed collectors should secure seed from those regions where the species is subjected to the most trying climatic conditions. It would seem by these facts that western yellow pine seed for reforestation purposes into the National Forests possesses the greatest qualities of hardiness when collected from the Black Hills and southward to the Mexican boundary.

Douglas Spruce is another very desirable western conifer that promises to reward the planter with good returns. Two types of this species are recognized, one common west of the Cascade and Sierra Nevada Mountains and the other scattered through the Rocky Mountains from Canada to Mexico. The wood of the former type is superior to that of the Rocky Mountain type, and for that reason seeds should be gathered from the superior type for planting in regions where abundant moisture is present. No doubt there are thousands of acres in the Rockies that are almost as well suited for the growth of the western type as is the Puget Sound country. The boundaries of such isolated tracts can be determined only by the industrious use of the rain gauge and the thermometer. As soon as such determinations have been accurately made, the planting of Douglas spruce seed from the western coast should be limited in the Rocky Mountain region to the most favorable localities and should be pushed forward as speedily as possible in these localities. Meanwhile, seed collectors in the Rocky Mountain regions have an excellent opportunity to get seed from the eastern type of the species in regions where

environment has compelled the trees to develop habits of drouth resistance and frost hardiness. It seems to the writer that the eastern type of Douglas fir is adapted to a much wider range of planting than the western. Together with western yellow pine, the Douglas fir is probably destined to be used very extensively by the government in reforestation of the denuded portions of the National Forests.

A recent bulletin from the Forest Service on chaparral conveys the impression that our native forest trees cannot be successfully made to replace the chaparral, but suggests the probable suitability of certain hardy species of *Eucalyptus* for this purpose. Here is a field for the experimenter. If species of *Eucalyptus* from regions of Australia possessing similar environmental conditions to our southern Pacific Coast region can be introduced and made to thrive on the mountain sides where nothing grows at present but the thorny chaparral, more than five million acres of what is now barren land can be reclaimed in the state of California alone. Our past importations of *Eucalyptus* have been of the more tender species which cannot endure the trying environment prevailing in the chaparral regions. Future collectors of foreign seeds should make an effort to bring us the *Eucalyptus* adapted to the more inhospitable mountain sides.

Forest seed collection and importation should be so regulated that each species and varietal type will reach when planted as nearly as possible the exact site best suited in environment for its thrifty growth. To make this possible the Forest Service will need to collect an enormous amount of data on climatology. Every ranger's station in the National Forests should be equipped with a full set of weather recording instruments. The rangers should be taught and required to use, read and care for these instruments and to record the data so obtained. There is such great variation in climate over small distances in mountain regions, that it will be impossible for us to know the possibilities and limitations of our different National Forests until such records have been kept for several years. Each ranger's station should also be a place for the testing of all sorts of new plants that may have promise of usefulness in the immediate vicinity. When the climatic averages and extremes are known for every ranger's district on the National Forests, the seeds collected in each locality can be used with a great deal more certainty of successful results from planting than prevails to-day.

It will then be possible to subdivide our country into seed collector's units each possessing its own peculiar climate and favoring the

growth of its own particular list of species. Nature has already set more or less definite limits about the collection of many of our species by her method of distributing the plants over our country, but man may often be able to extend the region of natural distribution of a species much to his own advantage. For instance Michigan, Wisconsin, and Minnesota would naturally be chosen as the regions in which to collect the seeds of White, Red, and Jack pines, but no one can tell today just how far those species may be safely planted outside of the region of the Great Lakes. Demonstration plantations of course would settle this question after many years of tedious waiting but such plantations are very costly. Systematic weather records together with soil studies would probably solve this problem much quicker than it could be solved by experimental planting alone.

The identification of the life zones and of their subdivisions is another aid that can be brought to the seed collector and seed distributor. The Bureau of the Biological Survey has done admirable work along these lines for the aid of agriculture, but it seems to the writer that the Forest Service might profitably devote more attention to this phase of scientific work. The ability to judge of environmental conditions by correlating the various types of life in a region is fully as desirable for the proper estimation of forest potentiality as is the knowledge of climate.

In conclusion I wish to say that by the study of the climatology and distribution of life in our different forest regions, forest seed may be collected very much more intelligently and its distribution to planters may be regulated in such a manner as to secure very much more effective results than can be secured by haphazard methods of collection.

AN EXPERIMENT ON THE METHOD OF CONDUCTING PLOT TESTS

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The difficulty of obtaining reliable results in the ordinary plot test is familiar to all who have had to do with grain breeding. The factors involved are numerous and complex making the problem one that can be solved only by their separate study with many experiments repeated under diverse conditions.