THE WORK OF THE CALIFORNIA FOREST AND RANGE EXPERIMENT STATION

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CALIFORNIA FOREST AND RANGE EXPERIMENT STATION*

IN CALIFORNIA'S total land area of 100 million acres, only about 13 million acres are cultivated or are occupied as town and city sites. The remaining 87 million acres are uncultivated. These wild lands, varying from the deserts of southeastern California, with their scanty vegetation, to the dense redwood forests of the northwest part of the state, constitute the field of endeavor of the California Forest and Range Experiment Station. It is the task of the Station to develop, through research, the techniques of use and management that can give to these lands permanent value.

Much of this land, although uncultivated, is used directly in producing wealth. It provides timber, range forage, and water, without which there could be no lumber industry, no range-livestock industry, and no irrigation agriculture, all vital to the economy of California. These industries provide the economic base for a large part of the state, and without them there could be little further growth and development.

Upon the basis of these three types of productivity the work of the Forest Experiment Station is divided into three broad fields, each with many ramifications, namely, forest research, range research, and forest-influences research (this last being the term applied to the study of the relation of vegetation cover and land use to the availability of water).

Through forest research the facts concerning the life of the forest are determined and from the information thus obtained practical methods of management of forest lands and of the timber stands growing on them are devised. Ways are developed to grow a forest, to protect it from such enemies as fire, insects, and disease, to inventory it and determine its rate of growth, and to harvest it by methods which will return a profit to its owners and at the same time prepare the way for the development of a succeeding forest.

In order to indicate the complexity of research in forest management, a brief account of the natural development of a forest may be of value. An even-aged forest has a definite starting point, in some form of complete destruction of the previously occurring forest, such as logging or fire, or frequently both. This establishes an area of forest soil devoid of forest growth. Over a period of several years, seedlings of the forest species indigenous to the region appear. At the end of this initial period of regeneration, forest-tree seedlings may occur at the rate of several thousand per acre. In the softwood forests of the western

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United States, a number of species of forest trees will generally be represented. Each species has its own characteristics, particularly in its demands for food, sunlight, and moisture, its rate and form of growth, and the character of its wood, which will ultimately make it of relatively high or low value for lumber.

As the young forest grows, the competition between the individual trees for sunlight, moisture, and plant food becomes increasingly severe. Many will succumb to this competition, and thus, as the years pass, each acre will contain fewer trees. Nor will the number of survivors be uniform over the entire area, for the rate of survival will depend upon such things as variations in soil moisture and fertility, the degree and direction of slope of the land, and the proportion of the various tree species represented.

Through the years the competitive forces within the forest will continue at work, resulting in a steady decline in the number of trees per acre. But the increase in size of the trees will more than offset the decrease in numbers, in the sense that the volume of wood will be continually increasing. Throughout the history of the forest, however, other natural forces will be at work, bringing other complicating factors. As they grow older, the trees will be subjected to an increasing degree of attack by parasitic fungi and insects. Some of these pests may be epidemic and achieve spectacular results, in a short time destroying nearly all the members of one or more tree species in the forest. Others will work unobtrusively, seldom killing vigorous trees, but retarding their growth or destroying the wood.

It is assumed that throughout this period the foresters have been continually alert to the danger of fire which might destroy in a few hours the entire forest stand and all the investments made in it. An adequate system of fire protection will have been set up and maintained at high efficiency to meet this danger. The cost of fire protection, together with the cost of the other protective and cultural practices applied, must be assessed against the value of the forest. Economic factors must be given due weight in determining the practicability of forest management and protection measures.

When this forest is ripe for harvesting, the several thousand original seedlings per acre will have been reduced probably to less than a hundred veterans which, if the vicissitudes of the life of the forest have been favorable, are of high value for lumber or other wood products. And this life of the forest will have extended over a period of fifty to more than a hundred years, depending upon man's judgment of biological and economic maturity.

It should be emphasized that we have no long experience in the management of forests from inception to maturity to guide us. American lumbering has mostly been conducted in the centuries-old virgin forests that the white man found ready for his axe and saw. Particularly in the far west the growing of forests under intensive forest management is a new venture. It still requires patient, long-time research to establish facts, principles, and working methods.

This brief description of the life of a forest will indicate something of the nature of research in forest management. Since it must include studies on the entire life of the forest, it is necessarily set up on a long-time basis. It deals with numerous variables, most of which can be controlled only to a limited degree.

Sound experimental design and mathematical analysis of the resulting data are clearly necessary.

The California Forest and Range Experiment Station now faces an interesting problem in forest inventory. The Forest Service has under way a nationwide extensive survey to determine the amount and location of the total timber supply and the rate of forest growth and drain, the information to be used for broad planning purposes. It is expected that the California portion of this national survey will be undertaken soon. New techniques are being developed by which timber acreages, as well as timber density, age, and condition, are determined from aerial photographs. From these photographs, areas of reasonably uniform conditions can be located on maps and the acreage determined. Thereafter ground surveys must be made within each type to determine volume, species composition, growth, and losses. Sampling techniques are obviously necessary in view of the fact that somewhat more than 16 million acres of land in California are involved in the survey. These sampling techniques must combine low intensity, to remain within established limits of expenditure, with the highest possible degree of accuracy of estimate. The importance of the result is apparent when we realize that upon it will rest plans and policies for the broad management of the forest resource of the state for years to come.

There are about 50 million acres of land in California which are used for grazing livestock. These lands provide feed for about 1 million of the 3 million 3 hundred thousand animal units of cattle and sheep in the state, the remainder being supported by cultivated pastures and crops. The forage feed growing on these lands consists of various mixtures of wild grasses, forbs, and shrubs. Since these lands occur from one end of the state to the other, and from seashore to mountaintop, they present a wide variety of conditions. Each major forage type—grassland, woodland, brush, and commercial timber type—and their many combinations represent different conditions, because of differences in soils, weather, and associations of plant species.

The objective in range management is to make use of this forage resource for feeding livestock so as to obtain the greatest meat production without reducing the production of forage on the land. The scientist in range management studies the factors concerned in order to develop the knowledge needed. His task is to determine, for the various forage types and conditions, how closely the range can be grazed each year without deterioration, that is, how much of the vegetative portion of the various plants can be removed each year without seriously weakening or killing them. Other investigations are carried on to determine the best season of grazing, judged by meat production and the ability of the range to maintain itself. In other words, are the range plants more susceptible to injury by grazing at one season of the year than another, and is there a seasonal difference in their nutritive value? And where ranges have been deteriorated by overuse, the scientist must develop methods for their recovery, through more conservative use, by complete protection for a number of years, or by artificial revegetation.

As in forest-management research, these studies must be carried on within very large areas representing a wide variety of conditions. The combinations of conditions of weather, as it varies in both time and place, soils, associations of plant species, and degree of past use by livestock are almost numberless. The investigations are painstaking and time-consuming, as they involve manipulation and study of numerous small plants. The establishment of large numbers of small plots or sample areas, and their observation for many years, is necessary. This is clearly a field of research in which poorly designed experiments could fail to obtain results, and hence waste both research time and money. Moreover, sound statistical analysis of the results is just as necessary as good experimental design, if the work is to succeed.

The amount of precipitation in various parts of California differs markedly. The average annual precipitation in the coastal region of northwestern California is from 40 to 70 inches. That of the interior valley is from 10 to 20 inches, whereas in the higher elevations of the Sierra Nevada directly to the east the precipitation is equal to that along the northwest coast. The coastal plain of southern California receives about 20 inches. Over most of the state the greatest precipitation occurs in the mountains, with less in the areas having greatest density of population and containing the principal agricultural and industrial development. Difficult problems of water supply result, necessitating conservation and storage of water in the mountains for use in the valleys below. This can be accomplished in two ways. Water which percolates into the mountain soils will form great underground reservoirs in the valleys from which it can be pumped. And runoff water in the mountains can be collected in surface reservoirs to be released through canals and ditches to the valleys, its flow often providing a valuable second product through the generation of hydroelectric energy.

To a considerable degree the rate of percolation into and runoff from the mountainous areas of high precipitation can be controlled by land-management practices. It is known that on mountain slopes bearing vegetation, with a layer of dead organic matter beneath that vegetation, the rate of percolation of water into the soil is relatively high and the rate of runoff correspondingly low. However, the vegetation that sets up this desirable condition uses some of the moisture in the soil in the life processes of the plants. Also, some types of soil and underlying geological structure favor percolation to a much greater degree than others.

In forest-influences research, studies are made of the various forces and factors which affect the rate of percolation and runoff of water and its use by native plants in the mountainous areas. This type of research is obviously one of great complexity. It is approached by resolution into a number of component studies, all of which must finally be integrated into comprehensive results that can be translated into recommendations for suitable management practices for vegetation, soil, and water. A brief description of the more important of these studies will indicate the scope of the entire field.

Rainfall studies are set up to develop accurate methods for measuring amount and determining distribution of rainfall. This involves determination of the number, distribution, and exposure of rain gages needed to obtain results of required accuracy.

Infiltration studies are made to determine the rate at which rainfall will percolate into the soil, as influenced by such factors as differences in soil type, soil moisture, slope and exposure, vegetative cover, and land use.

Interception and consequent loss of rainfall by vegetation is studied to determine the water loss from interception by different types of vegetation, as influenced by rate, amount, and character of rainfall and the age and density of the vegetation.

Studies in plant ecology yield determination of differences in vegetation types and their successional tendencies, as influenced by soil, slope, exposure, elevation, and fire occurrence.

The complexity of these fields of research, of the relationships between them, and the number of variables subject to very limited control indicate the necessity of mathematical treatment for their solution. Here again the forest research worker turns to the mathematician for guidance and help.

It has been the purpose of this paper to give a brief, general description of the nature of the research work done by the California Forest and Range Experiment Station. Its undertakings, whether in the field of forest research, range research, or forest-influences research, have certain elements in common. All pertain to phenomena of nature which have extended through rather long periods of time. Many of the experiments set up are therefore long-time projects. They are characterized by the presence of numerous variables. In the outdoor laboratory, in which much of the work is done, these variables can be controlled only to a limited degree and in many instances with great difficulty. This difficulty of control is much more pronounced in this type of research than in most agricultural research, which deals mostly with plants growing on cultivated lands. Failure to design experiments in forest research so that the effect of the numerous variables may be properly evaluated and the experimental data analyzed to bring out clear results will cause loss of many years of valuable time as well as dissipation of the slender financial resources generally available. Mathematicians have made notable contributions to the work of the Forest Experiment Station in both experimental design and analysis of results. We are grateful for the help received in the past, and bespeak their continuing interest in our problems.