MEASUREMENTS OF THE EFFECTS OF FOREST COVER UPON THE CONSERVATION OF SNOW WATERS.

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The large treeless openings or "parks" in the western yellow pine forests of the southwest, which form a well known characteristic, afford an excellent opportunity for a comparative study of the effect of a forest canopy upon local snow conditions. During the late winter and spring of 1909, the writer had an exceptionally favorable opportunity for observing the progress of snowfall and subsequent melting in a virgin stand of western yellow pine near the base of the San Francisco peaks on the Coconino National Forest in northern Arizona.

The observations include the measurement of each successive snowfall, and the total depth of snow at intervals of seven days under two entirely different forest conditions, namely, in a virgin stand of mature timber and on an adjacent treeless park, covering an area of several square miles. The observations were taken during the period from February 26 to April 25, at an altitude of approximately 7,500 feet.

On March 11, the average depth of the snowfall from a two days' storm was 4.0 inches in the park, as compared with 5.0 inches in the forest, a difference of 25 per cent. in favor of the forest. A snowfall on March 23 measured 10.8 per cent. deeper in the forest. These may be taken as fair examples of the difference under the two conditions. As an explanation, it seems probable that the sweep of wind across the park carries along a certain excess amount or *load* of snow from the snow gauge, which under the quieter atmospheric conditions prevailing in the forest is ordinarily deposited—a phenomenon corresponding in many respects to the well known laws governing the deposition of silt by water currents. Over a forested area broken by parks the maximum deposition occurs at the margin of the parks, the normal deposition in the forest body, and the minimum over the parks and larger openings.

Contrary to the usually accepted fact, during the *early* spring, melting commences earlier and progresses more rapidly in the forest than in the open treeless areas. This is due to difference in radiation. Records taken in both situations show a much higher average temperature in the forest, due to the fact that the night temperatures are from 5 to 15 degrees warmer than in the adjacent parks. Early in March it was noted that the soil beneath the snow in the forest generally contained no frost and consisted of soft mud. The origin of the soil is from decomposing "malpais," a basaltic lava bed. At this time, however, a thick ice layer had formed beneath the snow in the open park and was constantly thickening, due to the low daily minimum temperatures. By April 1, the ice layer had reached a thickness of 3 to 6 inches, and it is safe to say that during the month of March a relatively small amount of water from the surface melting reached the soil throughout the park.

On March 17, the average depth of snow in the forest was 11.5 inches, and of snow and ice in the park 19.5 inches, with water equivalents of 5.2 and 9.4 inches, respectively. The figures are significant, when it is recalled that the measurements show considerably less snowfall in the park than in the forest. The disproportion of the ratio caused by the high water content in the park will be noted.

The distribution of snow was uniform in the smooth, open park, while in the forest the ground surface was exposed in many places and snow banks from 2 to 4 feet deep occurred in the natural openings and lanes between tree groups. The depth for the forest was obtained by averaging measurements taken at ten snow stations spaced about 50 feet apart on a due north and south line. A similar line of stations was established and used in obtaining the park measurements.

The surface run-off in the two situations is interesting from the standpoint of water conservation. By April 1, bodies of water overlying the ice sheet had collected in the depressions in the park, and a good-sized stream was flowing at the outlet. No perceptible surface run-off from the forest (over the locality under consideration) occurred during March. The days of April 1, 2 and 3 were unusually warm and quiet, and resulted in the only run-off from the forest during the entire spring. The amount was insignificant compared to the total water content of the snow mass. It is well to state, incidentally, that the writer made dailv trips between the two measuring stations, which afforded an opportunity for noting the conditions.

A spell of warm weather occurred during the first half of April. By April 8, the depth had decreased to an average of 8.5 inches in the park (6.5 inches of snow and 2.0 inches of ice), and 3.8 inches in the forest. In the following five days, of high temperature and strong southwest winds, practically all of this snow and ice disappeared from the park, accompanied, it is needless to state, by an excessive run-off which continued for a few days after the period. On April 15, no snow existed in the park, while throughout the forest there remained considerable snow distributed in banks and ridges over the north slopes and level surfaces as well. Photographs shown on the frontispiece give a good idea of the appearance on this date of the measuring stations in the park and forest, and the remaining snow, banks of snow, on northerly slopes in the mature timber. In the timber throughout this region there remained on April 25 a considerable quantity of snow in sheltered situations favorable for late melting, while the last trace of snow had disappeared from the park by April 12.

The progress of accumulation and later melting of snow in the two comparative situations may be *summarized* as follows:

(1.) The total snowfall in the forest is somewhat more than over the open parks, due chiefly to accelerated wind velocity over the parks, resulting in a lighter deposition of snow, a case similar to the deposition of silt in stream courses.

(2.) Due to protection afforded by the forest cover against extremes of cold resulting in a higher average temperature, the process of melting during the spring commences considerably earlier in the forest than in the adjacent open park.

(3.) The low minimum daily temperatures in the park account for the formation of a thick layer of ice at the base of the snow during the early spring. This in turn serves to retain the moisture above the soil.

(4.) During the month of March, the park remained almost entirely covered with a deep and quite uniform layer of snow and ice, while in the forest the snow cover was much broken along rock ledges and banked high in the natural tree avenues, and the total amount of snow and water content above the soil surface was decidedly less per unit of area in the forest than in the park.

The condition strongly suggested an apparent advantage of a treeless over a forested area in conserving the winter snowfall and storing a supply of moisture for distribution in the late spring when most needed.

(5.) With rising spring temperatures and absence in the park of protection against extremes of heat, a point is reached—the usual "warm spell"—when the layer of snow and ice in the park "breaks up" very rapidly and the water goes off with a rush, resulting in a very small underground storage, and the further consequence of a rapid drying or baking of the soil.

(6.) In the forest, due to the high efficiency of the tree canopy in modifying surface temperatures, and of the forest cover in checking the velocity of the winds which at this season of the year are strong and from the southwest, and blow with the regularity of the "trades," the progress of melting proceeds more uniformly and is prolonged into late spring or early summer with a minimum loss of water by surface run-off and evaporation and a relatively high storage in the forest soil.