Snow Management Research in High Sierra Range[1]

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Californians have become increasingly aware of the importance of the water needed for agriculture and the industries of their state. They have prepared a thorough, forward looking plan (Calif., 1957) to develop and transport water to the far reaches of the state. Included in the plan is the intensive management of California's mountain watersheds. The State of California, Department of Water Resources, and the U. S. Forest Service, California Forest and Range Experiment Station, have joined hands in a program to conduct research into methods of improving water yield from the snow zone of the state. The program is called the California Cooperative Snow Management Research (Anderson, 1956).

Management of the snow zone for water production may significantly influence the available summer range and hence range management in the Sierras and Cascades.

The present emphasis on snow zone research results from the importance of this zone to the water yield of the state. According to Colman (1956), 95 percent of California's water comes from the forested and brush covered lands—42 percent of the State's area:

1. Forty-four percent of the State's water comes from the commercial forests below the snow pack and the foothill brushlands.
2. Thirty-eight percent comes from the commercial forests within the snow zone.
3. Thirteen percent comes from the alpine part of the snow zone above the commercial timber belt.

The snow zone occupies only 12 percent of the land area yet yields 51 percent of the State's water. This high yield and the fact that it produces water later in the year than the other zones makes the snow zone the most valuable and most important water producing area in the State.

The snow research program aims to develop ways of managing land for improved water production. Improvement can take the form of:

1. Increasing the total streamflow.
2. Changing the timing of streamflow.

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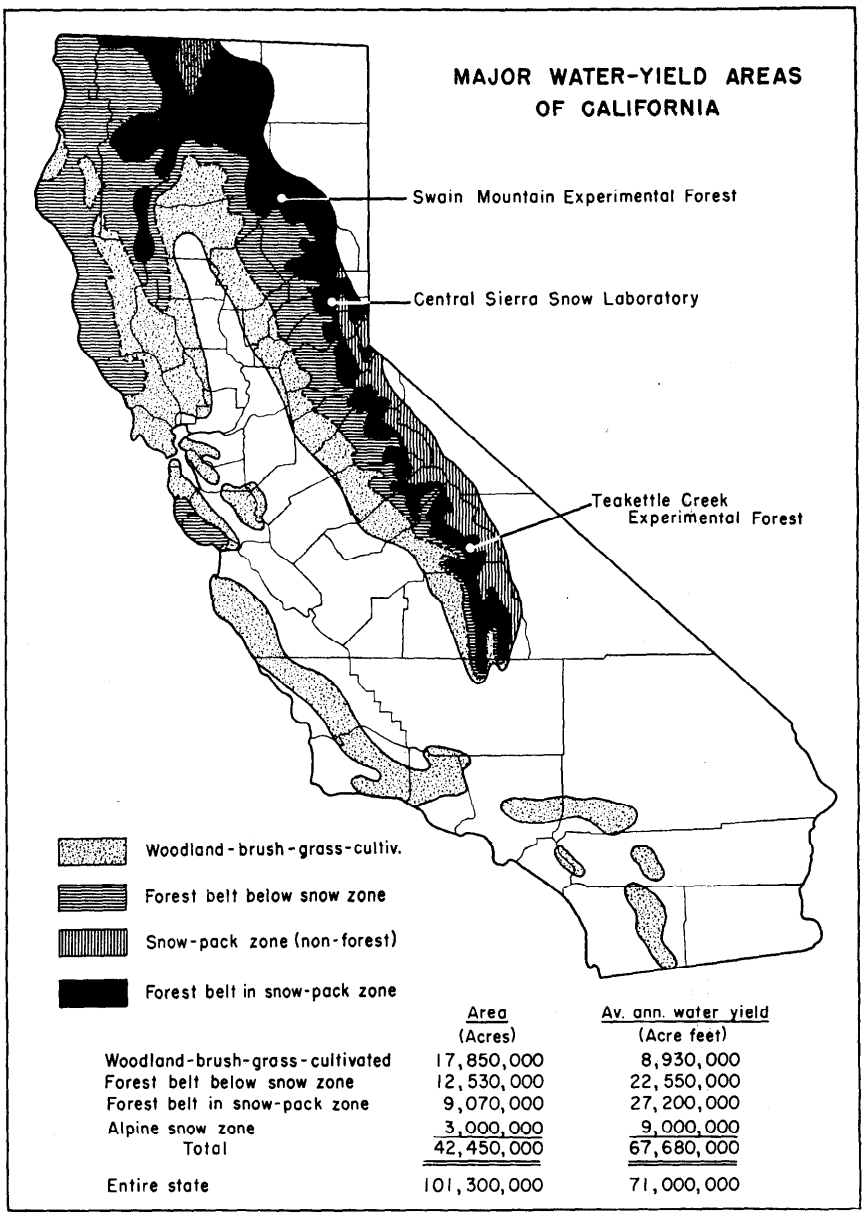
[1]*Paper presented at the December 1957 meeting of the California Section, American Society of Range Management.*



	Area (Acres)	Av. ann. water yield (Acre feet)
Woodland-brush-grass-cultivated	17,850,000	8,930,000
Forest belt below snow zone	12,530,000	22,550,000
Forest belt in snow-pack zone	9,070,000	27,200,000
Alpine snow zone	3,000,000	9,000,000
Total	42,450,000	67,680,000
Entire state	101,300,000	71,000,000

FIGURE 1. Major water-yield areas of California showing the location of the study areas for the cooperative snow management research program.

3. Improving or maintaining water quality.
4. Reducing local flood and sedimentation damages.

Experimental Areas

Three locations are being used in the Snow Management Research Program. One study area is the Teakettle Creek Experimental Forest, in the headwaters of the Kings River about 75 miles east of Fresno. Here we are calibrating the performance of five matched experimental watersheds. Typical of Sierra high country forests, Teakettle Creek is dominated by virgin stands of true fir *(Abies magnifica* and *A. concolor)* and has patches of mixed conifers scattered throughout the area on the drier sites. Wet meadows cover about 8 percent of the Teakettle basin, mostly along the streams in the upper reaches of the watersheds. These meadows account for most of the carrying capacity of the summer cattle range on the experimental area.

Second of the three is the Swain Mountain Experimental Forest in the headwaters of the Feather River. Here forest management studies will cut forests of red fir *(Abies magnifica)* in strips of several widths and in blocks of various sizes. We are measuring the effects of this logging on snow accumulation and melt.

Red fir is one of the dominant species in the snow zone. It typically grows in very dense stands which intercept a sizable proportion of the snow falling on the forest. Some of this is lost to the atmosphere by evaporation without ever reaching the ground. More moisture is lost by evapo-transpiration. We would like to know how to cut the forests in a way that causes the maximum amount of snow to reach the forest floor and a minimum amount to be lost through evapo-transpiration. The studies at Swain Mountain are aimed at finding out what patterns of cutting are best and how snow can be deposited in shade of the surrounding timber to delay melt.

Most of our field staff is at the third area, near Donner Pass—the Central Sierra Snow Laboratory. Four reservoirs and gaging stations were constructed in the summer of 1957 on the branches of Onion Creek in the headwaters of the American River. They will be used to measure streamflow and sediment production and thus evaluate the performance of the experimental watersheds.

The Onion Creek Experimental Forest is not so heavily forested as Teakettle and Swain Mountain. About half the area supports timber. This stand is a mixed-conifer type containing a good deal of Jeffrey pine *(Pinus jeffreyi)* and sugar pine *(P. lambertiana)*. The higher elevations in most of the drainages contain wet and dry meadows grazed by sheep.

The experimental watersheds at both Onion Creek and Teakettle Creek will require at least 5 years of undisturbed operation

FIGURE 2. Because of the large amount of open land in the High Sierra, range managers as well as foresters are interested in snow management research.

before we can start timber cutting and test land management measures. It will take this long for us to learn the characteristics of the flow of each of the streams. Then we can evaluate the changes in water yield caused by logging and other land management measures.

Basic Studies

In the meantime, at the Central Sierra Snow Laboratory, basic studies are underway to help select the most promising management techniques for water production. Here we will attempt to correlate forest environment with the accumulation and melt of snow. Studies are underway to evaluate the effect of solar radiation, wind, topography and vegetative cover. Summer and winter evapotranspiration losses are also being investigated to increase our knowledge of soil-moisture storage and losses for various soils and on different sites in the snow zone. Taken together, these studies will tell us how much snow falls in various locations, what happens to it after it falls, and what effect the different parts of the environment have on the accumulation and melt of snow. The most promising methods of delaying snow melt and increasing water yield suggested by these studies will be tested by cutting small plots. Finally from these plot studies, techniques will be selected for application to entire experimental watersheds.

Inventories

Another part of the snow research is inventorying the present water yields and land conditions in the Sierra Nevada. These studies will insure that no important management segment of the Sierra is overlooked in our research program. They will also indicate the extent of the area to which any particular treatment could be applied and show what would be the impact of such treatment upon the hydrology of a particular watershed.

The first inventory analyzes the hydrologic characteristics of about 130 Sierra Nevada river basins. It describes the topography, water yield, and timing of water yield of each basin and its component watersheds. We have reasoned that water produced by different watersheds and by the same watersheds at different times of the year has different values. Because of the lack of summer rain in California, water gets more valuable as the season progresses. We are trying to discover on which watersheds the delay of snow melt will produce usable water latest in the spring and summer.

Another inventory, using aerial photographs and topographic maps, describes the slope, aspect, elevation, and vegetative cover of about a thousand 40-acre plots on the west side of the Sierra. The plots are located at the intersection of every 5 minutes of latitude and longitude from Lassen Peak to the Tehatchapi Mountains. A preliminary analysis of the first 124 plots above 5,000 feet in elevation (Richards, 1957) has yielded some interesting and unexpected results. For instance it appears that the Sierra Nevada is not nearly as heavily forested as we once thought. On the contrary, tree crowns cover only 23 percent of the area. The remainder is open land, either between the tree crowns or in larger open areas. Forty-six percent of the openings were greater than 1,000 feet in diameter. Another fact uncovered that might not be so startling to the range manager as to the forester: 29 percent of the openings were brush covered, 29 percent were bare, and only 16 percent supported grass or forbs.

Questions for Range Workers

Californians look to the snow zone for most of their water. Range managers as well as foresters will help solve its hydrologic problems. Because of the large amount of non-forested area within the snow zone, the range man will help answer several important questions. For instance: Will the water produced from a mountain meadow become more valuable than the livestock it can support? If water were more valuable, would the draining of a meadow to increase water yield result in the invasion of shrubs or trees, and how much water would they use? Or is the water used by meadow plants outweighed by the meadow's value in retarding streamflow? How will openings logged to trap snow affect the availability

of grass and browse? How will the management of brush fields for water production affect their carrying capacity for livestock and game? In the years to come the increased demand for water will have a profound influence on the management of the summer ranges in the Sierra Nevada.

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