DEPARTMENT OF METEOROLOGY

FOR THE YEAR ENDING JUNE 30, 1915.

J. E. CHURCH, Jr.

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The Mount Rose Observatory was founded privately by University men in 1905, because of the utter lack of any knowledge of the winter climate of the high mountains along the Pacific Coast, and upon the passage of the Adams Act in 1906 was made a department of the Experiment Station. Since that time three projects have been developed, two of which are approaching conclusion.

Project I - Forecasting Frost from Mountain Tops (Adams Fund).

This project was undertaken to determine whether the low temperatures that regularly occur on mountain tops during storms are followed by a corresponding fall in temperature in the valleys below. On several occasions cold waves on Mount Rose of 3 to 7 degrees F. above zero had been followed from 12 to 36 hours by killing frosts in the valleys. It seemed probable that such phenomena would be found to be a regular occurrence or that their exceptions could be readily forecasted. Apparent success in a similar experiment, but on a far smaller scale on Mount Royal had meanwhile been announced by Professors McLeod and Barnes of McGill University, Montreal, and the verification of their theory would mean much for Nevada and the mountain states.

In order to obtain a continuous record of the weather on Mount Rose without maintaining an observer there, an instrument was finally perfected by Professor Fergusson, at that time assistant at Blue Hill Observatory affiliated with Harvard University. This instrument records automatically the humidity, temperature, pressure, wind direction and velocity for a period of six to eight weeks without attention. This is accomplished by a series of pens which trace one above the other their record on a band of paper mounted on a series of drums. The motive power is a long-period lever clock enclosed in one of the drums. A small frame structure nested in the rocks on the summit provides shelter for the observers and a protected place in which to reset the instrument.

Owing to the necessity of making several minor improvements to prevent ~~the~~ blizzards from penetrating into the instrument and strengthen the masts and vane against the persistent accumulation of ice fins, it was not until the autumn of 1910 that continuous records could be obtained.

Since that time the instrument has been kept running with but few intermissions, both summer and winter, parties having climbed the mountain on the average of once a month during this period.

Meanwhile base stations of similar character, except that the instruments ~~were~~ are reset every week, ~~were~~ have been maintained at Truckee and Fallon on either side of the mountain to determine the nature of each storm as it approached and passed the summit. The station at Truckee ~~was~~ is cared for by Mrs. C. A. Sackett at the nominal charge of $5.00 per month, while that at Fallon ~~was~~ is maintained by the Federal Experiment Farm on the Truckee-Carson Project free of cost.

During the present year, the records of approximately thirty cold waves ~~accumulated~~ occurring during the past four years have been analyzed with the following results:-

Of these cold-waves about one-half were accompanied by nearly synchronous changes at the base stations; one-third were followed within 48 hours by lower minimum temperatures at the base stations; one-sixth were followed by a slight rise of temperature at the base stations. These synchronous changes occur when ~~the air on the valley floor is thoroughly stirred by wind and mixed with the air above~~ there is wind at all levels and the air is nearly homogeneous. The one-sixth, in which the temperature on the valley floor rises slightly while the temperature on the summit is falling, are probably mostly due to the presence of clouds or fog below the summit. The one-third, in which a falling temperature on the summit was followed within 48 hours by a lower minimum temperature on the valley floor, represent the clearing of the sky after a storm when the temperature in the valleys is still further lowered by radiation.

It seems probable that many of the cold waves that failed to result in frosts did so because of cloudiness or increased humidity at the close of the storm. This feature of the problem should be further investigated as more pressing problems permit.

The continued maintenance of the observatory on Mount Rose will be inexpensive. On the other hand, being situated above the local disturbances caused by the network of valleys and mountain ranges, it will furnish the only reliable data from which the weather of Nevada and the inter-mountain region can be studied in its relationship to the general storms crossing the country. It will also provide data of temperature and wind for the study of the distribution and melting of snow on the watershed.

By-Products

Three important by-products have been obtained from this project:-

(1) A compact meteorograph, or instrument for recording the various elements of the weather, has been developed for studying mountain meteorology and the climate of forests and cattle ranges.

This instrument may come into use at fire-lookout stations in the National Forests.

(2) A considerable amount of data has been accumulated on the action of wind currents in the mountains, and has been made accessible to officials of the Forest Service in perfecting their system of fire protection.

(3) A tracing machine has been constructed which is capable of quickly reducing meteorograph records in various linear scales to a common standard for visual comparison. This is an important consideration where instruments of various types are necessarily employed, for the time formerly spent in copying and comparing records is reduced two-thirds.

Project II - The Relation of Mountains and Forests to the Conservation of Snow (Adams Fund)

This project is the outgrowth of the smaller problem in the Relation of Forests to the Conservation of Snow. On account of the bitter dispute regarding the value of forests for the conservation of moisture and the control of floods, this department undertook to study that part of the problem that pertained to the conservation of snow, upon which the agriculture of the State largely depends. Since the forests are situated in the mountains and the influence of the two is readily confused, both are included in the problem.

Not only methods but instruments have had to be devised as the work has progressed. A snow sampler and a weigher have been perfected, by which the water content of the snow can be quickly determined to a depth of twenty to twenty-five feet, the greatest depth yet found on the watershed. Although a sampler was devised in France a year before our own was invented, so efficient is the latter that it has been purchased for use in studying the deep snows of the Alps. Evaporation pans also have been perfected for determining the evaporation of the snow on the ground and in the trees; also a snow thermograph for determining the influence of soil and sun temperatures on the melting of snow.

Mount Rose and the basin of Lake Tahoe are ideally situated, and forested by these studies. To obtain access to them in all weathers, a sandbag hut was constructed at the elevation of 9,000 feet on Mount Rose and a small motor boat with tent was used on the Lake until prudence and efficiency necessitated the construction of a cabin cruiser.

The work was begun privately in the Spring of 1906 with camera and note-book. In 1908 it became a formal project under the Adams Act, and the meteorologist's entire time for two years was devoted to preliminary studies. During this time forests of various types and at various elevations were visited and courses

for the exact measurement of the snow were carefully laid out. Since 1910, owing to the absorption of most of the meteorologist's time in teaching, the studies have been carried on by a local observer at Lake Tahoe and by occasional trips from Reno to Mount Rose, except that during 1910-11 and 1912-13, the work at Lake Tahoe was practically discontinued. For this reason, the project has progressed slowly, though surely, and is only now entering upon its final stage.

Although some features of the work yet remain to be investigated and a large amount of data must be analyzed, the general conclusion has been reached that forests are a direct protection to the snow, those trees being most effective which allow the snow to reach the ground and yet protect it from the sun and wind. Fir trees have been found much superior to pine as conservers of snow, and forests with glades more satisfactory than continuous forests. Wind-breaks on the lips of canyons and on exposed slopes are indispensable for holding the snow. Because of its hedge-like character, young growth of moderate height seems to be as important for protection as the taller trees. Since fir grows best on the shaded northern slopes, where the snow is conserved longest, and the pine on the southern sunny slopes, where the snow melts early despite the forest cover, the interests of the lumberman and the irrigationist can be harmonized without great loss to either.

Snow Surveying and Forecasting Stream Flow

One of the early outgrowths of the snow studies is the surveying of the snow cover of watersheds in the spring to determine the amount of water available for irrigation the following season. In characteristic parts of each watershed definite courses are laid out along which measurements of the water content of the snow are made at intervals of 25 to 100 feet, according to the irregularity of the snow and the length of the course. Because of the uneven precipitation that occurs in the Tahoe watershed and adjoining portions of the Truckee basin, twenty major courses have been laid out, varying in elevation from 6225 to 10,800 feet. These courses can be surveyed by two persons in two weeks.

The method of making estimates based upon the snow survey is shown in the following bulletin issued the present season to the users of water in the Tahoe-Truckee basin and to property owners around the Lake:-

Seasonal Snow Survey of Lake Tahoe Basin and Estimate of the Maximum Rise of the Lake Spring of 1915.

Method I. Based on high-level measurements and "percentage relationship" to the season of 1914.

WEST SIDE OF LAKE TAHOE

	1914 In. Water Content	1915 In. Water Content	Percentage of 1914.
1. Ward Creek (7000 feet elev.)	52.8	40.9	77.5
2. Blackwood Creek (6950 ")	37.8	25.7	68.0
3. Rubicon Range (8100 ")	63.1	35.7	56.6
4. Mt. Tallac (8200-9750 ")	44.9	30.2	67.3
Gilmore Lake (8200 ")	65.9	35.6 (but snow was rapidly melting)	54.0
Lake Lucile (8200 ")	~~No Meas.~~	37.7	--
Glen Alpine (6800 ")	26.6	15.8	59.8
		Average percentage of 1914 -	63.89

for West Side

EAST SIDE OF LAKE TAHOE

	1914 In. Water Content	1915 In. Water Content	Percentage of 1914.
5. Mount Rose (9000 feet elev.)	48.1	25.1	52.1
Summit of Mt. Rose (9000-10500 elev.)	32.7	21.0	64.2
6. Marlette Lake (8000 elev.)	~~No Meas.~~	20.0	—
7. Spooner's Ranch (7000 ")	" "	8.8	—
		Average percentage for East Side -	58.2
		average percentage for entire basin	~~60.9~~ 61.1

Based upon measurements on Rubicon Range, the present season (1915) is 96 percent of 1910 or 86 percent of normal.

Actual Rise in level of Lake Tahoe of 1914 (including water discharged during Spring)	5.15 feet	
Estimated Rise in level of Lake Tahoe 1915 (on basis of ~~63.5~~ 60.9 percent of 1914)	~~3.27~~	" 3.15
Minimum Level (Jan. 13, 1915)	6226.90	"
Estimated Maximum Level (subtracting .25 feet drawn off, but adding .2 feet from storm of May 1-12)	~~6230.12~~ 6230.00	" 6229.98
Height of Dam	6230.0	"
Present Height of Lake (May 12)	6228.25	"
Estimated Additional Rise in the Lake	~~1.75~~	" 1.75

Method II. Based on the Land Area and the Water Content of the Snow Cover, April 1.

		Area	Water Content
Below 7000 ft., Area 122.6 sq.mi.	West Side	74.6 sq.mi.	15.3 in.
	East Side	48.0 " "	4.8 "
Above 7000 " " 168.3 " "	West Side	87.2 " "	33.8 "
	East Side	81.1 " "	18.7 "
		Average Water Content -	~~17.1~~ " 18.2

Total Land Area, 290.9 sq.mi.
Area of Lake Surface, 192.7 sq.mi.

192.7 : 290.9 :: ~~33.3~~ 18.2 : estimated rise of lake.

Estimated Rise of Lake 27.5 in or 2.29 feet.

Lake Level, April 1 - - - - - 6227.70 feet
~~Estimated Rise in Lake - - - - - 2.15 "~~
Estimated Max. Height (without reference to loss of snow by evaporation) - 6229.~~85~~ 99 "

and seepage

However, the precipitation of May 1-12 should offset evaporation while the Lake is filling up. The Lake, therefore, should be practically level full the present season as it was during the season of 1914.

TRUCKEE BASIN

	1915	
Summit Station (above Truckee)	Snow 86.4 in.	Water 40.0 in.
Marlette Lake	" 49.4 "	" 20,0 "
White & Galena Creeks	64 percent of 1914, and	
and	112 pc. of 1910, or normal.	

* The rise of the Lake-level was several tenths of a foot below the estimate made, altho the seasonal estimate has usually been accurate within two-tenths of a foot.

It has since been found by a study of Lake-level data, tabulated by Mr. H.F. Alciatore, Meteorologist of the U.S. Weather Bureau, that the run-off during abnormal years, such as 1913-14, does not afford a safe standard of comparison. A re-estimate made by taking 86 per cent, the relation of the season to normal as based on measurements made on Rubicon Range, and 2.98 feet, the normal annual rise of Lake Tahoe, gave a corrected rise of 2.56 feet and a maximum level of 6229.46, which was within three-tenths of a foot of the maximum actually attained. Further refinements since made have given still closer results.

Lake Level, April 1 - - - -	6227.70 feet
~~Estimated~~ Rise in Lake - - - -	2.15 "
Estimated Max. Height (without reference to loss of snow by evaporation)-	6229.85 "

(see page)

However, the precipitation of May 1-12 should offset evaporation while the Lake is filling up. The Lake, therefore, should be practically level full the present season as it was during the season of 1914.

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	1915	
Summit Station (above Truckee)	Snow 86.4 in.	Water 40.0 in.
Carlette Lake	" 49.4 "	" 20.0 "
Cite & Galena Creeks	64 percent of 1914, and 112 pc. of 1910, or normal.	

and

insert

Owing to the unusually slow melting of the snow caused by the late spring and to the long-continued evaporation, to which the snow fields and Lake's surface were consequently exposed, the rise of the lake level was several tenths of a foot below the estimate made. The seasonal estimate has usually been accurate within two-tenths of a foot.

The usual snow-scale methods of measurement, in which a few graduated stakes are set up on each watershed to show the depth of the snow, is extremely inaccurate not only because the stakes give no clue to the water content of the snow, but also because in wind-swept mountainous regions they afford little evidence even regarding the average depth of the snow. The variations in the following measurements made consecutively every hundred feet on Mount Rose will illustrate:

15.3 inches, 47.8, 71.5, 113.0, 45.0, 19.5, 19.0, 88.6, 29.3, 35.9, 88.6, 70.6, 31.2, 89.6, 14.2, 55.8, 98.6, 112.5, 57.0, 80.5, 119.3, 94.2, 88.7, 26.6, 25.6, 13.1, 24.6, 50.2, 48.2, 72.2, 85.5, 42.6, 42.0, 66.6, 43.0, 86.5, 34.1, 7.0, 16.6, 24.1, 106.1, 100.4, 67.3, 54.5, 19.5, 8.2, 71.8, 73.8, 27.0, 35.7, 80.0; average depth 56.4 inches.

Of these measurements only a few are near the average depth of the entire course. And while readings on stakes at those few chance points would have been of value on that year, in another year with different wind conditions, readings on the same stakes might readily have been worthless. The average water content of the snow over the entire course was 22.2 inches; the relative density was 39.4 percent.

During the coming year, accumulated data in the snow studies will be prepared for publication, and studies of the evaporation of snow and the forecasting of stream flow will be carried so far as possible toward conclusion.

The study of the evaporation of snow has special importance in furnishing the means of estimating one of the chief losses on the watershed. For this reason, even the fragmentary data so far obtained have been sought by the Geological Survey in making a preliminary study of the Walker River Basin with a view to the establishment of a reclamation project there. Evaporation data are particularly needful where the water content of the snow cover is estimated in acre feet rather than in its percentage relationship to a previous season's snow cover and runoff.

By-Products

The chief by-product of this project is a small tubular recording snow and soil thermograph or thermometer, which can easily be inserted down a sampler hole to any desired point in the snow or soil. This instrument has a period of ~~five~~ seven days and is especially valuable in determining the possibility of premature runoff, due to unfrozen ground, and the relation of freezing temperatures to the destruction of soil bacteria, particularly the eel-worm.

Project III - The Temperature Survey and Relation of Topography to the Occurrence of Frost. (State and Private Funds.)

In 1911, under State appropriation a temperature survey of the agricultural lands of the State was begun to determine the intensity and duration of frost with a view to finding more satisfactory sites for orchards and the amount of orchard heating that must be done to save a crop. So pessimistic had the Nevada rancher become regarding the possibility of saving his fruit that little effort was put forth to protect it.

This survey is being made by means of a series of fifteen recording thermometers and two maximum and minimum thermometers placed at suitable points from the highest land under irrigation ditches to the lowest lands of the valley. Thus far the survey has been confined to the basin of the Truckee River and to the Truckee-Carson Project. The instruments are cared for and the record sheets changed mostly by voluntary observers. At the end of four years the stations are moved to a new location, except that a central station is maintained in each district to correlate the temperature there with that at the University. In connection with the survey, semi-official experiments in orchard-heating have been made by the meteorologist to determine the feasibility of protecting fruit against frost.

The results obtained early in the survey were published in Bulletin No. 79 of the Nevada Agricultural Experiment Station, "The Avoidance and Prevention of Frost in the Fruit Belts of Nevada", which has found an unexpectedly wide demand in this country and abroad. Later data confirm earlier conclusions that with elevation above the valley floor, there is a decrease both in the number of frosts and in the number of hours of orchard heating required, the decrease in the number of frosts with increase in elevation of 250 feet in the Truckee Meadows having been found to be from fourteen to five and in duration of freezing temperatures from at least forty hours to sixteen. Also, except in abnormal years or in the coldest places, an average of two heatings each season will save the fruit. Moreover, it seems probable that at 28°F. or higher, except ~~possibly~~ when the fruit is setting, no heating will be necessary to assure a moderate crop. The selection of late-blooming trees of good quality, some of which have been found already acclimated during the survey, should make it comparatively easy for the Nevada rancher to establish at least a home orchard that would require but little protection.

A simple rule has been devised for forecasting the probable maximum intensity of frost, namely, to subtract from the maximum temperature of the day on which the forecast is made the fall in temperature that normally occurs during the night when the weather is clear. In the Spring at Reno this fall in temperature is 30 - 32°F. Therefore, ~~For example~~, with a maximum temperature of 65°F., the minimum temperature should not be lower than 33°F.

A method apparently similar has since been proposed by Professor J. Warren Smith, Agricultural Meteorologist of the U. S. Weather Bureau.

Moisture in the air, particularly in the form of clouds, and wind, will greatly decrease the fall of temperature. On the other hand unusual dryness will increase it considerably. For this reason the fall of temperature at night in the autumn is much greater than in spring, and to make a satisfactory forecast 44 - 46°F. should be subtracted from the maximum temperature of the day.

The accuracy of frost forecasts can be readily increased by making a series of observations on the relative influence of clouds ~~and winds~~ of various densities and velocities in checking frost. Only once in recent years in the Truckee Meadows and probably in western Nevada has frost occurred during the prevalence of wind.

The present season, after consultation with the horticulturist, a study of the effect of local situation on the development and destruction of blossoms was begun. A few orchards were selected where ~~the~~ stations of the temperature survey were maintained. The blossoms were carefully graded into five classes according to their degree of unfolding, and the development of the blossoms was carefully noted each week.

The frost, referred to above occurred May 3rd and by its widespread damage afforded an opportunity to study the relative hardiness of blossoms. The temperature near Reno was 26°F, and where the orchards were protected from the wind by hillsides or other screens, the amount of injury was far less than where the exposure was complete. Blossoms that were small to medium in size generally escaped, but the more developed blossoms, except the peach which is hardy, were to a large extent destroyed. A peach tree that had lost as high as six-sevenths of its blossoms bore two-thirds of a crop and the fruit was little if any inferior to normal fruit.

Near Steamboat and at Verdi the temperature fell to 18° and even the small blossoms of all kinds were completely destroyed. At Lewers' Ranch, the temperature fell to 22°F., but the later fruit was still in small blossom and escaped. Near Sparks, one orchard of late trees came into bloom just after the frost and was consequently unaffected by it.

The varieties of fruit that passed through this frost with least damage were:

Snare's Ranch: (Temperature 26°F.).

Pewaukee 2/3 crop; Winesap 3/4; Northern Spy 3/4; Delicious (?) 1/3 - 1/2; Ben Davis 2/3; Walbridge 3/4 to full; Crawford Peach 2/3; Red Egg Plum 3/4; Green Gage 3/4; Sour Cherries approx. 2/3.

Mason's Residence, Reno.

Large Red Peach (in full bloom at time of storm) 1/2 - 2/3 crop.

Lewers' Orchard, Franktown: (Temperature 22°F.)

Late apples came to maturity as follows:

All stone fruits and early apples and pears were destroyed.
Apples in full crop: Little Lady, York Imperial, Seek-no-Farther, Buckingham, Wine Apple, Wagoner, Pilot, and Golden Pippin.
Apples bearing 2/3 crop: Newton Pippins, Rome Beauty, Summer Sweeting, and Smith Cider.
Apples bearing 1/2 crop: Jonathan, Gloria Mundi, Van der Veer.

Although 1/5 to 1/2 of the blossoms of two pear trees survived, the fruit was dwarfed. One of the hardiest of the apples that was unaffected by the frost is the Pilot. The apples are large, have very little core, and are good keepers. The trees grow to a large size and bear well. However, they mature slowly, taking from 15 to 20 years to reach their bearing stage.

If the frost had occurred two weeks later, the destruction of fruit would have been much greater. However, the intensity of frost in western Nevada is so slightly below what the fruit can endure, that only minor adjustments in the selection of sites for orchards and fruit to plant in them are necessary to restore confidence in at least the home orchard.

The further study of the relation of topography to the occurrence of frost and its effect on fruit should be made the main project of the department and, if possible, be financed from the Hatch Fund. To this project should be added the development of a simple system of frost forecasting for the isolated farmer, so that frost need not come upon him unawares.

During the coming year, four of the temperature stations now in the Truckee Meadows will be placed at Pyramid Lake, Lahontan, The Island, and Stillwater to complete the temperature survey of the Truckee-Carson Project. Because of the influence of large bodies of water in moderating the temperature, it seems probable that very favorable locations for horticulture may be found.

The temperature survey will be concluded in the Truckee-Carson basins before publication on this unit is made. The general plan is to map the basins into zones according to the intensity of the frost and the hours of heating required, to study the progress of temperature changes with a view to local forecasting, and to compare the thermal intensity of the growing season on slopes and in valley bottoms.

Publications

1. "The Value of High-Level Meteorological Data in Forecasting Changes in Temperature" -- S. P. Fergusson, Station Bulletin -- In Press.

This bulletin presents the results of experiments conducted on Pike's Peak, Mount Royal, Blue Hill, and at Mount Rose. Of approximately thirty cold waves at the latter place, five-sixths are felt both on the mountain and in the valley, but only one-third of these occur sufficiently early on the mountain to give adequate warning below.

2. "Snow Survey Provides Basis for Close Forecast of Watershed's Yield: Rapid and Economical Methods of Measuring Large Areas of Snow at High Altitudes Prove Useful at Lake Tahoe, Nevada, -- J. E. Church, Jr., Engineering Record, April 17, 1915.

This article outlines the methods of snow surveying and sets forth the advantage both in accuracy and in economy of field measurements of snow over measurements at a single station, or even group of stations. For example, in the Spring of 1913 at Tahoe City, the principal snowfall station of the U. S. Weather Bureau on Lake Tahoe, the local measurements of precipitation indicated an excess of 86.6 percent over 1912, and the average of the measurements at the eight stations of the Weather Bureau on the Lake 44.4 percent. On the other hand, the snow survey of the Experiment Station indicated an excess of only 33.5 percent, and a corresponding lake level, which was within 3.1 percent of the level actually attained.

of the Tahoe Basin

Furthermore, the expense of the survey was considerably less than one-half of the amount necessary to maintain the eight snowfall stations there. "It is, of course, true that these stations furnish climatic statistics of precipitation, measured storm by storm, and of snow on the ground, measured month by month, which the snow survey, if restricted to the time of melting, can not do."

3. "Suggested Changes and Extension of the U. S. Weather Bureau Service in California: A discussion." -- J. E. Church, Jr. To be published in Proceedings of American Society of Civil Engineers.

This article discusses favorably a report by engineers of Southern California to the American Society of Civil Engineers, urging that the U. S. Weather Bureau reorganize its snowfall and temperature services so as to obtain data in each of the large watersheds of California on precipitation, evaporation, and melting of snow; the relation of topography and forests to melting and runoff; and the snow available each spring for irrigation and power; also that the temperature records of the voluntary observers receive closer inspection. The successful experience of the Experiment Station's department of meteorology, in establishing such a service in snow-fall and frost in Nevada, is related and suggestions for re-organization by the Weather Bureau are made.

3 4. "Motor Boating 6,200 Feet above Sea Level: A Defoe Cruiser, Built for Cruising in Winter", -- Arthur L. Smith -- Motor Boating, March 15, 1915. Describes the construction of the "Mount Rose", a home-built cabin cruiser, and its value for snow studies and winter cruising on Lake Tahoe.

4 5. "Horticulture in Nevada", -- J. E. Church, Jr., -- Standard Cyclopedia of Horticulture, Vol IV., In press. This article sets forth in a general way the topography and climate of Nevada, the relative importance of its agricultural industries, and, in detail, the nature, problems, and possibilities of its horticulture.

Cooperation

The year has been one of large and practical cooperation. Data on the precipitation and evaporation of snow were placed at the service of the Geological Survey in making a report on the feasibility of establishing a Federal reclamation project on Walker River.

In return for the seasonal snow survey of the Tahoe Basin, the Reclamation Service has given the Department the use of land and adequate buildings for headquarters at the outlet of the Lake and is sharing in the maintenance of the snow observer.

Close cooperation is being planned by the Nevada Section of the U. S. Weather Bureau with a view to assisting in the extension and completion of the snow studies inaugurated by the Department and to the ultimate application of our methods by them to snow surveying in all of the watersheds of the State.

of snow surveying thus developed.

Officials of the Forest Service also have consulted with the Department in formulating plans for the study and charting of air currents in the National Forests with the view to improving present methods of fire protection; they have also made enquiries regarding the meteorograph on Mount Rose with the view to obtaining a similar instrument to record the climate in the more inaccessible parts of the forests.

Finally, the Experiment Farm of the Bureau of Plant Industry at Fallon has extended its cooperation by taking charge of four additional temperature stations, placed at Pyramid Lake, Lahontan, The Island, and Stillwater, which, with the Mount Rose base station at Fallon and a temperature station at Fernley, should furnish an accurate record of the climate of the Truckee-Carson Project.

THE VALUE OF A DEPARTMENT OF METEOROLOGY

1. To perfect methods of determining the amount of water available on the various watersheds for irrigation each season.

Most of the water used for irrigation in Nevada falls in the form of snow on the high mountains and its amount varies with elevation and situation. Only five percent is stored in reservoirs. Experiments already made by the Station have demonstrated that close forecasts of run-off can be made sufficiently early to permit the adjustment of crops to available water.

The department's methods are now being adopted by the U. S. Weather Bureau in Nevada. Cooperation is being arranged with the purpose of ultimately applying such a forecast service to all parts of the State.

2. To study Nevada climate with reference to agriculture.

A mountain State like Nevada has a complex climate as compared with the States of the plains. This is especially true in regard to temperature. In 1915 the orchards of Fallon and Glenbrook, sixty miles apart and having a difference of 2,500 feet in elevation, blossomed fully two months apart. The fruit at Fallon was injured by an untimely freeze; because of its lateness, that at Glenbrook escaped.

The study of the climate of Nevada should be directed along the following lines:

(1) The climatic survey of basins and slopes to determine the relative intensity of the growing season of each both day and night; the frequency, intensity, and length of frosts with a view to the economical protection of gardens and orchards; the relative humidity and the effect of wind with reference to the winter killing of fruit trees and alfalfa; the progress of temperature changes on bottom lands and slopes to facilitate the forecasting of frost; and, finally, the comparison of the climatic elements found here with those found in other states to facilitate the introduction of congenial plants.

The most pressing need is the development of the home orchard, by selecting frost-resistant and late blooming plants and trees, and learning how to protect them easily and economically. The survey being conducted in the Truckee-Carson basins indicates that on the average not more than two heatings will be required each season to save a full crop and that except when the fruit is setting, ~~above 28°F.~~, no heating will be required to save a crop sufficiently large for home and local consumption. So valuable is this latter observation, if true, that its accuracy should be thoroughly verified.

Local experiments of this nature are too detailed to be conducted by the U. S. Weather Bureau, and the instruments employed by their voluntary observers are not adapted to the work.

(2) In cooperation with the Departments of Biology and Agronomy, attention should be given to the relation of climatic factors to plant growth, not only the climate of the air but the temperature of the soil, especially as affected by irrigation. Such studies might be valuable in experiments now in progress on the Experiment Station Farm, especially the effect of winter temperatures on the control of the eel-worm.

(3) In similar cooperation with the Department of Animal Husbandry, studies could be made of the effect of out-door wintering on the milk production of dairy herds, particularly the effect of rain, snow, mud, winds, etc.

(4) It may be possible to increase our present limited knowledge of the climate of the stock range, particularly the temperature, precipitation both of rain and snow, and relative humidity, for their possible bearing on its improvement.

Through the efforts of Professor Fergusson, Associate Meteorologist, who is an experienced designer and maker of meteorological instruments, the department is well equipped to conduct the studies outlined and can furnish further apparatus at a nominal cost. This advantage is of utmost importance, for instruments adapted to the work are both difficult to obtain and are expensive. Furthermore, Professor Fergusson is a trained meteorologist, having resigned as first assistant at Blue Hill Observatory, Harvard University, to have a share in the pioneer work here.

3. ~~(5)~~ To teach agricultural students and others the value of instruments and the meaning of climate, particularly the relation of local weather to general storm movements.

4 ~~(6)~~ To advance the general science of meteorology:

(a) Along agricultural lines of more remote interest than the preceding, as (1) the nature of frost phenomena, and (2) the study of mountain winds in their relation to the spread of forest and brush fires.

(b) Along pure lines, as the study of the climate of the Great Basin and upper air phenomena as affected by the topography of the Great Plateau, and in assisting in procuring data for world meteorology.

5. Finally, as at present constituted, the Department is particularly fitted

(7) To design and repair instruments for other departments of the University.

These are the reasons why we urge the establishing of the Department of Meteorology on a permanent footing in the Experiment Station and University. Dean Knight strongly favors giving instruction in Meteorology in the College of Agriculture. The College of Engineering has made use of the Department in designing and testing instruments.

For the immediate future, the continuance of the Department is imperative, for the data on the Relation of Mountains and Forests to the Conservation of Snow are yet to be prepared for final conclusions and publication, and the records being obtained in the temperature survey of the Truckee-Carson Basins must be tabulated and analyzed.

When the larger projects now under way are concluded, as they should be by the summer of 1917, and possibly sooner, the Department can probably be maintained for $2,500.00 per annum, providing $500.00 can be apportioned from the College of Agriculture for instruction in Meteorology and $300.00 by the University for designing and repairing instruments in the colleges of the University. If necessary, Professor Fergusson can earn one-fourth to one-third of his salary by devoting a proportionate amount of time to outside work. However, the work that should normally fall to the Department would occupy his entire time.

~~Respectfully submitted,~~

~~J. E. CHURCH, JR.,~~
~~Meteorologist.~~

Report 1916-17

Year spent in completing and analyzing data.
Student assistance very large and helpful
during part of year. so long as funds were available.
Thru their assistance M.S.S on Evap. and Snow Surveying
in final stages and when finished should be credited to this year.

Data completed

Evaporation -
Technique { Sunk pans + Exposed pans. 1/1 + 1/4 - Twice a day. Evap + Topog + Forestation - Ice - { Merlette L. Mt. Rose Tahoe City.
General normal for semi-arid West.
Relation to Tides + Snow.
" " Snow Forecasting.

Snow Surveying and Forecasting of Stream Flow.
Courses plotted and photographed.
Result of wind and Choice of Sampling Stations { Mt. Tallac Mt Rose
Effect of Weather on Stream Flow.
1916 -
1917 - } Similar in some respects, yet divergent in others.
Cold weather 1916 frozen open thru
1917 back and spring
Precip. abnormal + variable.
Loss 1916, small loss 1917.

New phase of subject emphasized and requires study.
Summer surveys make to comp. loss in snowfields
with gain in stream flow. Meas. in 1916 + in 1917.

Tables on stream flow in form of mss. copy for
comp. with tables of water, partic. precip. and temperature,