were practically coincident with those of the Sacramento watershed, but by the close of the month all streams had receded to the extreme low-water stages.—*N. R. Taylor, Local Forecaster.*

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EXPERIMENTS IN FROST PROTECTION.

By Prof. ALEXANDER G. MCADIE.

In the Monthly Weather Review for June, 1909, page 224, in a short article upon "Frost damage prevented by the use of covers," there is given a discussion of the question frequently asked by fruit growers whether the heat or the smoke developed by fires and smudges of various frost-fighting devices now in general use prevents the injury, and which is the more efficient and economical, other things being equal.

Frost fighting by means of coal baskets, oil burners, orchard heaters, and various other types of fuel burners, has been practiced in California for 15 years with marked success. Indeed, it may be said that all of the modern methods of frost fighting had their origin in the cooperative work of the

Antifrost cover made of prepared paper. Weight, 5 pounds; area covered, 60 square feet.

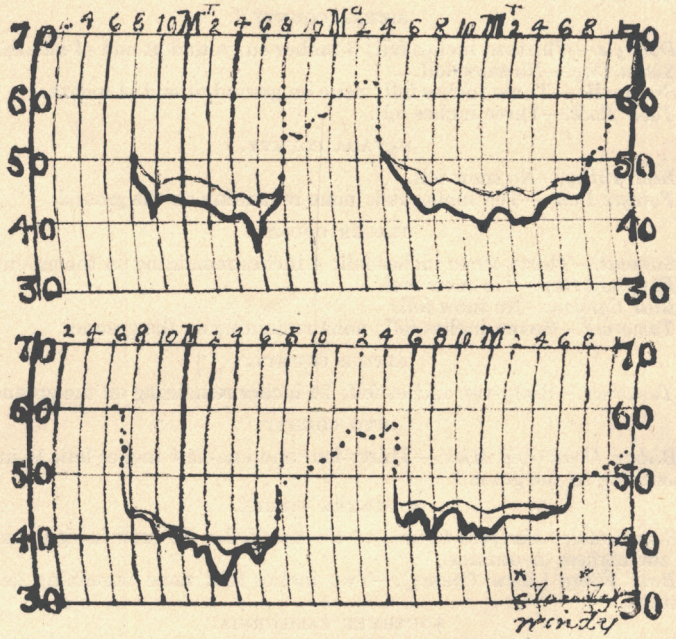
Weather Bureau and the fruit growers in California. In numerous publications issued by the Weather Bureau, the whole problem of protection has been so discussed and developed, both with regard to the general underlying principles and the special requirements of certain localities and individual crops, that vast good has been accomplished, and the interest taken in the work is now widespread and of national importance.

No one method can be laid down as universally the best; and it is plain that a device best suited for cranberries or garden truck may not be equally applicable for the protection of oranges. Nor will the method best suited for lemons necessarily be best for pears or apples. In the cranberry sections draining, clearing, and sanding are found to be the most efficient agencies. In the citrus fruit belts, heating devices and (where the fall in temperature is not too great) smudging devices are best. For the protection of vines and small fruits, nothing is as good as a cover. In each locality the grower must determine what method best suits his crop and locality.

In the present article the writer gives the result of some preliminary experiments made during the month of November, 1910, with antifrost cover. Following up the suggestion made in the Monthly Weather Review above quoted, also the line of argument given in the Monthly Weather Review for July, 1910, page 1107, it appears that a large amount of the heat used with oil pots, orchard heaters, coal baskets, and especially open fires, is wasted—that is, it does not directly (and, if indirectly, only to a small degree) aid the fruit. The trouble is that the rate of conduction of heat through air is small, and, owing to ascensional currents, most of the heat is by convection carried to a level where there is nothing to protect. If we could establish horizontal currents at the desired level, the efficiency of the heating devices would be greatly increased. Therefore, it seems to us that none of the forms of heaters on the market at the present time do as effective work as they could be made to do if provided with auxiliary devices in the shape of fans or flues for directing and delivering heat to the spot where most needed.

As a result of considerable experimentation, we have come to the conclusion that open fires or fuel burned in wire baskets, in pots, or in stoves, whether wood, coal, oil (crude or distillate), as used on the ground, will not under severe conditions afford absolute protection, especially to young and tender vegetation. Of course, by doubling the number first usually employed, the degree of protection can be increased. In ordinary practice, however, where from 30 to 40 fires or pots per acre are used, a fall in temperature to 20° F. and a continuation of the low temperatures for 4 or 6 hours will not be offset by the heat provided. The oil pot is objectionable, too, unless the combustion is perfect, because there may be a deposit of soot upon the blossoms.

As stated in the Monthly Weather Review, June, 1909, the ideal method of frost protection would be a combination of a cover device and a heating device. Aside from its own value, the cover as an auxiliary to the heater permits of an economical use of fuel. By itself the cover, when properly placed, utilizes the earth's heat, which, after all is said and done, must remain the cheapest fuel possible. It is of course the sun's heat reemitted.



Thermograms showing differences in temperature—Heavy line shows outside temperature.

The reemitted heat waves have a wave length from three to four times longer than the first waves. Therefore a suitable cover, preferably black, serves to prevent the escape of the heat into space and there is a further reemission. This second-hand sun heat is, as we may express it, trapped and held where needed. By conserving this heat we use the very cheapest heat energy that can be obtained, nothwithstanding that the initial cost of the cover may be considerable. It also furnishes the additional protection of screening or shielding the chilled fruit or vegetable tissue from sudden warming. Of course, the condition of the plant is all important. A tree that is backward or not in a tender condition will go through a temperature change uninjured which would seriously affect another tree in a more sensitive condition. It has been shown in various papers that the exposure to the sun's rays in the morning is of great importance and that the rise in temperature following the fall must be guarded against. The cover lets us do this better than any other device.

The illustration herewith shows a new form of cover as used in the protection of deciduous fruit trees. It is also suitable for the protection of citrus fruit trees, and, in somewhat modified form, affords a certain protection for vines, garden truck, flowers, and ground crops. The cover consists of a reasonably cheap and light-weight material, yet sufficiently tough to withstand out-of-door exposure, and is rainproof. It is essentially a paper cover, and the principle, indeed, is the same as used by many housekeepers and gardeners to protect favorite plants, namely, by covering them with newspapers or cloths. The waterproof paper used is of various makes, but in the illustration shown was of the kind known commercially as "Keepdry." The material can be made in double sheets with an intervening air space, which gives a very high

degree of protection. For ordinary use a single layer will suffice. In the illustration the cover used weighed 5 pounds and protected a surface of 60 square feet, which area could be extended to 80 square feet. The covers can be made in any size. There is a small central frame of wood, cross braced, to which the paper is tacked. From the central frame flaps of the cloth paper extend, and there are suitable lacing strings provided to bring the ends of the flaps together and also to fasten the cover edges to the tree trunk, so that the cover remains in place should wind aries during the night hours.

The thermograms herewith show the difference in temperature during nights when frosts occurred, on the inner and outer side of the cover. The records were obtained by two similar thermographs and show that on an average there is a gain of 4° F. even where no special effort is made to wrap the tree closely. Nor was the cover placed in position until 8 p. m., when of course there had been a considerable loss of heat, except on November 19, when the cover was in place a little before 5 p. m.

Prof. E. J. Wickson makes the following editorial comment on the above paper:

Mr. McAdie is going back to test out the practicability of saving sun heat enough by checking radiation, which was perhaps the earliest horticultural recourse, and was employed, as he says in his essay, before men thought of the possibility of heating all out of doors. It is exceedingly desirable to have this thing accurately measured as Professor McAdie is doing it. Readers will doubtless be surprised that so much heat can be saved by such a slack shelter. Our correspondent who asked recently whether he could cover the orange trees nearly as tightly as they do for fumigation without injury to the tree, may take from Professor McAdie's demonstration the hint that it is not at all necessary to muffle his trees to closely to hold the temperature up enough degrees to avert frost. If she proposition works out as well as the preliminary experiments promise, there will remain, of course, much to be done in the way of contriving covers which will be in themselves cheap and cheap also in their handling. In this line the California inventive genius may be expected to work as great triumphs as it has in other phases of fruit protection. While the matter is still in its experimental stage, many of our readers may like to undertake experiments with various covers and give us their results for publication.

FOG AND FROST IN THE SAN GABRIEL VALLEY.

By ALEXANDER G. MCADIE.

One of the most important districts in California is that lying immediately south of the Sierra Madre and sometimes known as the Great Valley of southern California. Extending from the Pacific Ocean, in the vicinity of San Pedro Bay, eastward a distance of more than 60 miles to the foothills of the San Bernardino Range, it embraces an area particularly well suited for citrus fruit growing. The land is gently rolling for the most part, but traversed by the Puente Hills and the Santa Ana Mountains, running in a northwest-southeast direction. The San Gabriel Mountains lie to the north and rise somewhat abruptly to elevations exceeding 5,000 feet. Some of the best known peaks, such as Mount Lowe, Mount Wilson, 5,800 feet, and San Antonio, commonly known as old Baldy, 10,080 feet, can be seen from elevated places in the valley. On the eastern side the area is bounded by the San Bernardino Mountains, with an average elevation exceeding 6,000 feet. Some of the best known peaks in this range are San Bernardino, 10,630 feet, and San Gorgonio, 11,485 feet. There are numerous cities and towns in the district, including Los Angeles and its various suburbs, also Pasadena, Alhambra, Sierra Madre, Monrovia, Azusa, Glendora, San Dimas, Covina, Lordsburgh, Pomona, Ontario, Chino, Corona, Riverside, Redlands, and San Bernardino.

The southern half of the whole district is drained by the Santa Ana River, which has its source in the San Bernardino Mountains, traversing San Bernardino Valley and breaking through the Santa Ana Mountains between Rincon and Yorba, after which it is diverted for irrigation in the comparatively level lowlands around Orange, Santa Ana, Anaheim and Fullerton. The northern portion is drained by the San Gabriel River, which rises near the backbone of the Sierra Madre and flows westerly through various canyons, reaching lower levels near Azusa. It then flows southerly through the San Gabriel Valley and the Los Angeles Valley, emptying into the Pacific Ocean in a delta east of Long Beach. A third stream is the Los Angeles River, formed by a number of small creeks uniting east of Los Angeles and entering the Pacific west of Long Beach.

It is thus plain that the topography favors a drainage of the air from the mountains seaward at certain hours and a return flood, or movement of the surface air from the sea inland at certain other hours. In other words, the conditions are extremely favorable for the development of air streams which reverse their direction at least twice in each 24-hour period.

In general the lower air flows to the southwest during the night and early morning hours and to the northeast during the afternoon hours. During the winter months when areas of high pressure pass over the Great Basin, the surface air apparently moves south crossing the northern flank of the Sierra Madre and descending with some momentum into the Great Valley. The wind movement is particularly marked in the vicinity of the mountain passes, a good illustration being near Cajon Pass, 3,823 feet. During these so-called "northers," also locally known as Santa Anas, the temperature rises and the humidity falls. The existence of a low pressure area south of the Valley of the Colorado seems to intensify the condition. Heavy frosts occur as a rule after a period of boisterous north wind; and are undoubtedly traceable to the displacement of the warm air of the valley by air that is not quite so warm, but remarkably dry and comparatively free from dust. During the stillness of the morning hours and before the return flow of air from the sea can be effective, the soil, which in places consists principally of river wash, coarse sand, and gravel, or else a light sandy loam, loses heat rapidly by radiation through the dust-free dry air; and it is not unusual on January mornings to have temperatures of about 26° F. in the orange orchards. At many points, especially in the lower lands, care must be taken to protect oranges and lemons from both the fall in temperature and the rather rapid rise which occurs about 8 o'clock in the morning. In various papers published by the Weather Bureau the best methods of protecting fruits have been discussed.

On November 26, 1910, the general conditions of pressure temperature and humidity were somewhat as above described, although not as pronounced as those likely to prevail later in the season. The accompanying photograph, "Fog in the San Gabriel Valley," showing conditions about 8 a. m. is reproduced through the courtesy of Director Hale of the Solar Physics Observatory on Mount Wilson, Cal. The photograph with many others was made by Prof. Ferdinand Ellerman of the Observatory, who states that the fog enveloped the mountain about half an hour after the photograph was taken. The view is looking south and the line of fog close to the ground passes over the Arcadia race track. The Puente Hills project above the blanket of fog beyond. The temperature near the Snow telescope was 38.1°. The temperature at Los Angeles at 5 a. m. was 46°, the wind northeast and frost was reported.

The photograph in addition to being one of the most beautiful of fog pictures, is of extreme interest as showing the condensation of the water vapor at various levels, from the ground to 2,000 meters. Attention is called to the sharply marked plane of condensation of the line of cumuli clouds at the top of the picture. The main blanket of fog lies rather close to the ground, averaging about 200 meters for the upper surface. The fog in the foreground, over the orange grove, shows stream lines in the lower air.

The photograph clearly shows the existence of air currents at different levels and the mixing of the same. While we lack accurate records of temperature and water content of the air at various levels, it is something to be able to look down upon the condensed vapor and have a permanent picture of the process of cloud condensation in the free air at critical times.