

I commend this proposed exhibit to our organizations and to our people."

The Florida State Horticultural Society, as an organization and through its members as individuals, has been most helpful to our state in

the presentation of these exhibits which have brought thousands of people and millions of dollars into our state. The Florida National Exhibits requests a continuation of that same fine and much appreciated support.

FLORIDA'S FROST PROBLEM

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Contrary to general public belief frosts are not at all uncommon in peninsular Florida. Serious frosts of the freeze type do not occur every year, nor even every few years, yet their visitations are frequent enough so that they hardly fall into the class of unusual phenomena. Five such freezes have occurred during the lifetime of a man now 42 years old, while the real old-timers in Florida can remember many more that do not appear in the official records. Ordinary frosts which cause considerable damage to tender truck and sometimes affect hardy truck and citrus in limited acreages in the colder places occur frequently during the average winter season. Seldom does a year pass without the occurrence of damaging frost at some point in the main citrus and trucking belts of central and southern Florida. Most of these frosts are experienced during the interval from the middle of December to the middle of February in central Florida, although early and late frosts are not uncommon. Many of these ordinary frosts, although harmful to truck, are beneficial to citrus causing a hardening of the trees and improving the flavor, quality and color of the fruit. When the temperature falls below the critical or freezing point of citrus fruits, however, fruit damage is caused in varying degree depending on the number of hours the temperature remains at dangerous levels. When the fruit has been severely injured the temperature usually has been low enough to cause damage to the tree itself.

During the 1935-36 winter season just past the first killing frost of the season occurred late in November and the last on February 12th. During this interval there were 25 nights on which frost was experienced at some place in central Florida where official temperature stations were maintained. The lowest temperature registered at any of the official stations this season was 20.5° on December 28, 1935, and there were several occasions when the temperature dropped lower than 24° at official stations. There was extensive damage to truck and a slight amount of citrus fruit damage as well as a slight amount of damage to succulent growth on citrus trees in the coldest places. There is nothing unusual to mark this past winter in the weather records and certainly nothing unusual in the general statement that frost is a frequent visitor in the central fruit and truck belts of the State.

Severe freezes are experienced at long intervals, probably about ten years on the average. Usually lasting only two days at a time, these freezes cause damage to citrus and truck running into millions of dollars. The effect of these hard freezes is carried over into following years resulting in greatly decreased production due to severe tree injury. Sometimes, of course, the trees are killed outright in hundreds of acres and the growers have no other recourse except to plant new trees if they are to stay in the citrus business.

Major freezes in the past have exerted consid-

erable economic influence on the citrus industry. Many hundreds of millions of dollars in losses have been sustained by Florida growers and shippers. Those of you who have lived in the State for many years have seen the citrus industry driven from the fertile regions in the northern part of the State further to the southward where temperature conditions are not so severe. They are not yet safe from attacks even though the conditions are more favorable, as shown by the 1934 freeze. Freezes have occurred in the past and will occur again in future. This possibility always must be faced.

The economic events that follow the freezes always seem to run in the same cycle and it might be worth our while to examine this cycle. I will not bore you with statistics though they could be given by the pageful. As soon as it becomes apparent there has been considerable frost damage to citrus there is much activity among the growers and shippers. Fruit is picked and rushed to the market as rapidly as possible in order to dispose of as great a quantity as possible before drying out occurs. This flooding of the market with frost damaged fruit depresses the price so that scanty returns are obtained, in many cases not sufficient to pay the freight costs. The consumers, of course, receive very little for their money and the reputation of Florida fruit receives a severe setback and the market for Florida fruit suffers almost irreparable damage. When no more inferior fruit can be shipped the growers appraise their damage. Their frost losses are not only from the total destruction of a part or all of the crop but also from the killing of fruit-bearing wood as well. Young trees have been killed outright or injured to such an extent they are practically worthless. On mature trees it is evident that production will be quite seriously affected for some time to come.

The sudden loss of a large crop ready for the market has affected the operation of the agencies engaged in packing, shipping, and marketing the fruit. Contracts for packing material and services concerned with moving the crop to market are cancelled resulting again in widespread losses, especially to the railroads.

Other indirect losses follow in rapid succes-

sion. Many citrus properties revert to mortgage holders. Among the more fortunate still able to hold on are many whose reduction in working capital as a result of the freeze is such that their groves suffer further deterioration by neglect in fertilizing, pruning, pest-control, and other farm operations. In fact, in some sections orchard values decline because of widespread neglect. Community payrolls suffer by reason of unemployment of citrus workers and the loss of purchasing power carries the freeze damage into the ranks of business and professional men not otherwise connected with citrus production.

Economists tell us that if the market developed for Florida fruit is to be held against competition from fruit produced in other parts of the country the Florida citrus industry must be prepared at all times to supply the market with the required quantity of good quality fruit. This factor becomes of more importance if, as is now being done, vast sums in national advertising are expended to develop special markets. In view of recent organization since the 1934 freeze it is extremely doubtful if growers will be permitted to ship frozen fruit in future. Florida must now provide some means of being able to supply this newly developed market with a steady flow of fine fruit irrespective of weather conditions. California has done this; so, too, can Florida. Effective grove heating is the answer.

The bright spot in this program of grove heating is that the costs will be by no means as high as in California. The average grove needing frost protection in California burns heaters about 29 hours a year on a ten-year average. In Florida I doubt if the corresponding figure would exceed five hours. The greatest expense here would be in depreciation and in the setting out and taking in of the heaters, an operation that must be done each season so that the heaters will be in place when needed. There are certain economic laws that determine the feasibility of adding to the production costs the overhead expense of heating. The essential factors are the overhead and operating costs and the probable savings that will result. Operating costs can be estimated with a fair degree of accuracy if the average number of hours of heating per season is known. The

probable savings are more difficult to figure since they bear on the production per acre and the price received for the fruit.

By effective grove heating I do not mean that every citrus property in Florida should be provided with heaters, but that a sufficient producing acreage should be equipped so that the market will not suffer during freeze years. There are undoubtedly some citrus properties in Florida where severe frost damage, even during the freezes, occurs so seldom that the savings to the grower brought about by the use of heaters would not, in the long run, equal the cost of grove heater operation. There are also probably many marginal citrus properties in Florida where the average annual return is so small that the expense of heating could not be borne. At the same time there are probably many groves so situated that the capital invested in grove heating work would pay handsome dividends on the investment. My present impression is that about 25% of Florida citrus properties profitably could be equipped with some form of adequate frost protection.

There are no halfway measures with grove heating. Either it must be done right or not at all, else the costs of heating be added to other frost losses. In my examination of the State I am sorry to say that I have found many hundreds of acres equipped with insufficient equipment for good frost protection work. It is small wonder that many growers feel that grove heating is a snare and delusion for that is exactly what it is in many Florida groves at present.

The weather conditions under which these major freezes occur are well known to meteorologists, as each time events happen in much the same sequence. The initial stage of a Florida freeze is the formation of a huge mass of extremely cold air over the polar regions of northern Alaska and Canada. This condition is almost always accompanied by high barometer. Therefore the appearance during winter of a strong high pressure area in western Canada accompanied by abnormally low temperatures is a potential threat of severe frost shortly later in central Florida.

These polar masses drift at varying speeds across the country in erratic paths from west to east and sometimes in their passage do not sweep

far enough to the southward to affect Florida. Although each polar air mass carries a potential threat of frost damage for Florida, the percentage that actually reach into central Florida is not large. Last winter eight polar cold waves threatened Florida, that is, actually passed far enough southward to strike into Alabama and Georgia, but not one actually reached into central Florida to cause general severe temperature conditions. It is only when an energetic low pressure area forms or passes over the Gulf of Mexico and follows a path northward or northeastward over the Atlantic Coast States on the foreward, or advancing side of a strong polar air mass, that the cold air flows into the peninsula bringing low temperatures to central and southern Florida. Even then a major freeze is not so apt to occur if the wind continues to blow with sufficient force to keep the surface air well stirred, thus preventing a large fall in temperature during the night. The most serious freezes occur when the wind dies out after large quantities of excessively cold and abnormally dry air have been brought over the peninsula. Under these conditions the temperature which has remained low all during the day falls with alarming rapidity after sundown, reaches damagingly low levels early in the night and stays there for many hours. As there is no great diversity in topography in central and southern Florida these freezes are likely to be quite general and cause severe losses in all sections of the State. Such freezes ordinarily last two days at a time, with the second night colder than the first, and although they happen on the average only after lapses of several years cases have been known to occur where two hard freezes occurred during the same winter season spaced about a month apart.

Although the conditions that occasion the great freezes are known and understood the actual forecasting of their arrival is a more difficult matter since many different weather elements have to be estimated correctly before the minimum temperature can be determined. An error, even a slight one, in estimating the humidity, direction and force of the wind, cloudiness, or pressure gradients may cause an error of sev-

eral degrees in the forecast of minimum temperature.

Prior to the winter of 1935 a specialized frost protection service had never been in operation in Florida. During these years frost warnings for the citrus and truck areas in Florida had been handled as a part of the general weather service by the District Forecaster located at the Forecast District Center at Washington, D. C. In order fully to understand the situation that existed in Florida subsequent to the winter of 1935 it may be well to review briefly the organization of the Weather Bureau as regards the general forecasting service. The entire United States was divided into five large areas known as forecast districts, each district comprising many States. At each forecast district center an official designated as the District Forecaster is charged with the responsibility of making all weather forecasts and issuing all weather warnings within the confines of his own district. That is to say, all the weather forecasts issued for the entire United States were prepared by five men, one in each forecast district. As might be expected, these men are selected with great care after many years of experience in practice work and are given for their work the utmost in facilities the Weather Bureau can command.

At each Forecast District Center comprehensive weather charts are prepared at least twice each day based on wire reports from a large number of stations spread in a network over the United States, Canada, Mexico, and from ships at sea. Upper air observations by pilot balloons and airplanes are at the forecaster's disposal. From the weather maps prepared from these numerous data the daily forecasts are made.

Under the scheme of organization just outlined the forecasts for the State of Florida were prepared by the District Forecaster in Washington based upon the general weather map and verified by reports from the several first and second order Weather Bureau stations in Florida whose wire reports were used in the construction of the forecaster's weather map. These Florida reporting stations are Pensacola, Apalachicola, Jacksonville, Titusville, Tampa, Fort Myers, Miami, and Key West. It is evident that all of these

stations are located upon or near the immediate coast. Also the thermometers at each of these stations, as is quite customary, mostly were located on the tops of tall buildings in the business sections of these larger cities. Thus the District Forecaster was largely guided in his temperature forecasts by the reports of temperature at elevated city locations in coastal cities. The forecasts so issued showed a high percentage of verification.

Temperature conditions in the various portions of the citrus and truck belts of Florida, however, can be determined only by accurate temperature records taken with properly exposed recording thermometers located in the groves and truck gardens at strategic points in the different portions of the district. Except by so doing is there any way that the lay of temperatures accurately can be determined. Readings from thermometers exposed at elevated stations on tops of tall buildings in the business districts of large cities are virtually useless for such purposes, yet it is a fact that prior to the establishment of our service such records formed the very backbone of temperature survey work in Florida. Equally useless are the readings from scattered points from stations deliberately placed in the warmer parts of the local areas to provide favorable comparisons with other communities. Such stations usually are not representative of more than a few per cent. of the total acreage of commercial crops in the areas they are supposed to cover. Also there are some stations maintained in or near groves by individuals with privately owned equipment from which occasional observations are taken. In many such cases the records are largely unreliable because of faulty thermometers, faulty exposures, and unsystematic observations. To gauge temperature conditions in a great agricultural area by means of a network of such stations as I have described is nothing more or less than a form of delusion, and as proper knowledge of temperature conditions in important parts of the citrus and truck belts was not to be had it is small wonder that growers and shippers expressed such continual dissatisfaction with the forecasts of the District Forecaster. Such forecasts covering worlds other than their own had no par-

ticular value to them in their actual frost protection work.

In the endeavor to supply the particular kind of forecasting service so greatly needed by Florida producers and shippers and at the same time to assist the growers in their efforts to protect their crops against damage by frost, the Horticultural Protection service was established last winter by co-operative Federal-State appropriations totalling \$25,000. The service is a joint effort of the United States Department of Agriculture, Weather Bureau, and the Agricultural Experiment Stations of the University of Florida.

Generally regarded as the most important of the various projects of the Horticultural Protection Service at present is that of the temperature survey. This will take at least ten years to accomplish, possibly longer, although it becomes more valuable as each season's data are compiled and we do not have to wait until the full estimated ten years have elapsed before the information so collected can be put to use. So important is the temperature survey that of the five men engaged on the fruit-frost work last winter, four spent practically all their time on this part of the project.

The object of the temperature survey is to determine the lay of temperature over the district on cold nights; that is, to find out the variations in temperature in different parts of the district. Its ultimate object to the forecaster is to show him definitely the distribution in temperature that will exist under differing weather conditions so that after the 24-hour weather changes have been estimated in advance he can carry the forecast into the different parts of the citrus and truck belts to the extent of stating exactly the temperature conditions that will prevail at any particular station in any portion of the district. To the grower the temperature survey will provide a knowledge of the areas where it will be on the average either profitable or unprofitable to grow certain crops because of temperature conditions. If he needs frost protection the temperature survey will show him this fact and provide the means of calculating the expense of operating grove heaters, which, in turn, enables him to determine whether the addition of grove heat-

ing costs to his other production costs will pay him dividends. To the marketing agencies the temperature survey will provide the necessary information to form a rough but fairly accurate estimate of the amount of damage to be expected following a spell of damaging temperatures. Suppose, for example, it was desired to know the extent of damage to citrus following a freeze. If the temperature that causes damage to citrus is known, and such temperatures can be determined, then the amount of damage that will result is directly related to the number of acres of citrus in the areas where the temperature was below this critical point for the required time. The California Fruit Grower's Exchange have calculated formulas to estimate within a few hours after the temperature survey records are available, damage to citrus based on this simple principle and the results have been so closely verified by the grove to grove checking of field men that this formula now is used to regulate the administration of the Exchange in the selling and advertising fields almost as soon as the frost occurs. The temperature survey will make possible such damage estimates for Florida marketing agencies. So from the standpoint of the individual growers and shippers there is much to be gained from an accurate temperature survey which will show temperature conditions in their own local areas.

To accomplish the temperature survey a comprehensive network of temperature stations was established last winter in as large an area in central Florida as our available funds would permit us to cover. These stations were placed in the various agricultural sections in farm exposures; citrus stations were elevated to a point four and one-half feet above the ground, truck stations were located about one foot from the ground. Except for a few stations especially placed in extremely warm and cold spots, all stations were located so as to be representative of considerable nearby acreage with the average station covering the temperature conditions over about 30% of the groves in the vicinity, this 30% being in the colder sections. Although the temperature survey has been planned to lean toward the colder side, provision has been made

to include the higher ground acreage by the addition of temperature inversion experimental work. A steel tower 125 feet high was erected at the Lake Alfred Citrus Experiment Station by Dr. A. F. Camp, and at spaced intervals on this tower temperature records were obtained from the ground up to the 112 foot level. Another series of temperature inversion stations were maintained between Waverly, Highland Park, and the Bok Tower near Lake Wales. The purpose of these experiments was to determine the degree of warmth afforded by elevation on cold nights and the modification to be applied to survey station readings to represent high ground conditions.

Each temperature station was equipped with a properly designed fruit-region thermometer shelter in which were exposed accurate recording thermometers. About 120 stations were so established last winter and in addition to the thermometers about half of the stations were equipped with automatic clock thermometers so that continuous records of temperature were traced on a ruled sheet of paper. Thermograms so obtained provided us with the duration of each degree of temperature at selected stations. At a few stations automatic records of relative humidity were obtained by the use of an instrument technically called a hygrograph. Each shelter has a wire screen front which faces toward the north so that the instruments within are visible at all times to all comers. The public is invited to make use of the stations at all hours of the day or night in connection with their frost protection work and several thousand dollars worth of high grade equipment was available for public use. Most of the stations were placed in the hands of cooperative observers who were instructed in the care and reading of the instruments. Each station was visited at frequent intervals by a staff member of the Horticultural Protection Service, to insure the accuracy of the temperature readings and the continuity of the records. The State owes a debt of gratitude to this large army of voluntary observers who by their excellent cooperation assisted so materially in the prosecution of temperature survey work.

From the stations of the temperature survey network about 40 were selected to serve as fore-

cast stations in the central Florida area. In most cases the colder stations representative of about 30% of the local acreage were chosen. Definite minimum temperature forecasts were issued for each of these stations when the temperature was expected to drop to 32° or lower. Thus the forecasts were issued for the coldest temperatures to be expected close to the ground in the colder part of the area served by the forecast stations. Most of the acreage in the immediate vicinity, of course, was expected to have higher temperature than the forecast station. This temperature difference between high and low ground may amount to as much as 28° during ordinary frosts in the case of long hillside slopes, or may amount to more during exceptional conditions that sometimes do occur. But no grove near the station on low ground will show a much lower temperature than that recorded at the forecast station for the reason that the forecast station was chosen to represent the colder grove exposures.

We offer, however, a very simple and practical means of changing the temperature forecast to fit any high ground grove in the area served by the forecast station. That is to say, any grower who so desires easily can change the minimum temperature forecast to make it fit stations on his own property even right down to his own back yard. All he has to do is to establish a temperature station in the desired spot, equip it with a tested thermometer of the minimum recording type in a small shelter which will screen it from the sky, and make a record of daily readings of minimum temperature. He then compares his temperature readings with those taken on the same day at the forecast station to determine the difference. Suppose, for example, that a grower in Winter Park has compared his minimum temperature readings with those of the Forest City forecast station, which serves his area, and has found that on the average the temperature at his station is 6° higher. He then changes the minimum temperature forecast for the Forest City station by adding six degrees to it to make it fit the station on his own property. Now a forecast of 25° for the Forest City station does not cause cold chills to chase up and down his spine in the horror of contemplating some known disas-

ter. He merely changes the forecast to 31% for his own station and derives a feeling of security that warms the cockles of his heart. If he is a Christian man the next morning he probably feels some compassion for his less fortunate neighbor who might have suffered, instead of an all-consuming ire that prompts him to pen for publication a letter condemning the Weather Bureau for alarming the countryside with frost warnings that did not come to pass. I mention this matter for no other reason than that we have had a certain amount of this sort of thing to contend with.

Occasionally we are asked why we do not locate our forecast stations in the warmer instead of the colder part of each section so that the outside world will not gain the impression that a certain district is colder than other districts. The answer to this is simple. If the forecast stations were chosen in the warm spots then we would be forced to issue "no danger" forecasts on many occasions when damaging frosts would be experienced on low ground. Such forecasts not only would be valueless but actually mislead some growers into the loss of their crops in case they were prepared to protect them. We find it necessary, therefore, to locate our forecast stations in the colder places where the minimum temperature forecasts will have the greatest value.

Some timid souls have been fearful lest the broadcasting reports for Florida would prevent the tourist trade from prospering in the State. There is nothing to fear from this. When frost occurs in Florida the temperatures in the North are at such low levels that the tourists are glad to be here to read in the Florida papers about the terrible cold ways at home. Frost has not yet driven tourists from Florida and is not likely to do so now. What really discourages the tourist trade is to have the visitors come to Florida expecting nothing but mild weather and then find that adequate provision has not been made for their comfort during the occasional cold spells that do occur.

Naming of the expected minimum temperatures for each station brings a definiteness to the frost forecasts that is entirely new to Florida. The old method of forecasting frosts in such vague and

indefinite terms as light, heavy, killing, freezing temperatures, cold wave, and the conditional terms in forecasts such as probably, possibly, if, have been discarded, let us hope, forever. Obviously a killing frost for truck might be a temperature that actually would be beneficial to citrus. When the lowest temperature is named as a definite figure in the forecast there is no doubt as to the exact nature of the frost that is expected to occur at the forecast station.

As a price for these definite statements by the forecaster, however, a factor of safety sometimes is written into the forecasts so that the errors, if any, are on the safe side. Most growers have expressed themselves as desiring to be overwarned rather than underwarned, and to have something definite to go by rather than something that leaves them wondering just what really was expected. These growers take the position that if there is any guessing to be done about the weather it is better that the forecaster take this responsibility. They are willing to tolerate the factor of safety in some of the forecasts when reasonable doubt exists, for the sake of the added security it gives them. From many years' experience with growers on frost protection work the leaders of the Horticultural Protection Service subscribe one hundred per cent. to this proposition. The forecaster continually is working to make his forecasts of the greatest value to the users of the service and trying to reduce the number of errors to the smallest possible amount. There have been but few complaints on the forecasts issued during the first year of operation, and these mostly from growers in warm locations who care little if their neighbors suffer, and from a small group who feel it is to their advantage to conceal the truth about temperature conditions from properties they are trying to sell.

Rigid official rules are used in the verification of all Weather Bureau forecasts. It is by these rules that the accuracy of the season's work in forecasting can be quickly judged. All the forecasts issued by the Lakeland office daily last winter have now been officially verified.

At each of the four forecast stations, Sarasota in Sarasota County; Brooksville in Hernando County; Mammoth in Polk County; and Forest

City in Seminole County, covering the key situations in the four frost districts, the forecasting record has been determined by considering all forecasts issued during the operation of service, November 22, 1935, to April 1, 1936. During this interval 131 forecasts were issued. At the Sarasota station 123 of these, or 93%, were without error; 96% were within 1° of being correct; 99% within 3°, and 100% within 4°. The greatest miss of the season was on February 1, 1936, when 30° was forecast for this station and a verifying temperature of 26° was experienced.

At the Brooksville station 88% of the forecasts were without error; 92% within 1° of being correct; 93% within 2°; 97% within 3°; and 100% within 5°. The greatest miss of the season was on December 25, 1935, when a forecast of 31° was followed by a verifying temperature of 26°.

At the Mammoth station 88% of the forecasts were correct; 92% within 1° of being correct; 96% within 2°; 97% within 3°; 98% within 4°; 99% within 5° and 100% within 7°. At this station the greatest miss was on Jan. 21, 1936, when a forecast of 25° was followed by a verifying temperature of 32°.

At the Forest City station 91% of the forecasts were correct; 94% within 1° of being correct; 97% within 2°; 99% within 3°; and 100% within 4°. The greatest miss of the season was on January 24, 1936, when a forecast of 28° was followed by a verifying temperature of 32°.

These four stations have been selected to show a cross section of the forecasting record for last winter. These four stations are the key stations for each district and the most important on the forecast list. The forecasting record for the 36 other forecast stations are included in the statistical report now on file at County Agents' offices for public examination. At these other sta-

tions cold nights only were considered in verifying and the percentage figures are somewhat lower than those recited here but on the same basis the forecast verifications are about the same.

As the Horticultural Protection work is entirely new in the State of Florida there is a great deal of pioneering work that must be done before the service can function to its maximum degree. Data must be accumulated and studied before the variation in temperature in different parts of the district can be determined and before the forecasting for the many stations can reach the desired degree of accuracy, which is, of course, 100% of all forecasts correct. It will take at least five years to collect enough data of this sort before the forecasting can be regarded as out of the experimental stage and at least ten years before detailed temperature survey maps can be prepared. Meanwhile, owing to strong demands for immediate service, the forecasting is being handled largely on the basis of experience gained in other sections of the country. There is need also for much experimental work to determine what can be done in the matter of frost protection in Florida. Experiments designed to determine the freezing points for the several varieties of fruits and vegetables produced in Florida must be planned and executed. The relative costs of grove protection with the different fuels available for grove heating in Florida also will form an extensive branch of research. For the immediate present the big job ahead is to accumulate information and experience locally, and to use the results of research as rapidly as they can be formulated, thus gradually improving the character of the service. We cannot offer a finished project at this time but the work is being planned to accomplish as much of the vital work as possible in the briefest time.