Project No. 80-P7
(Continuation of Project No 78-Q6)

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Project: Tree and Crop Research
Environmental Variables and Crop Production

Objectives: To use environmental variables to produce an early, accurate forecast of the almond crop. To identify and understand the relevant conditions and use them to develop an accurate forecasting methodology.

Progress: Aspects of temperature and water availability are the most important factors in determining crop conditions. Low temperatures in the spring must be followed carefully along with the cooling in winter. High temperatures and averages are also important in terms of stress and nut development. There is a causal relationship between environmental conditions and the subsequent almond crop.

Research has been in the areas mentioned above, with emphasis changing from year to year as some problems are solved and new questions arise. Solar radiation and temperature patterns in May and June seem to be the most profitable topics just now. Progress over the years has been substantial. Forecasts in 1979 were much better than those of the handlers but each forecast, seemingly high at the time, was followed by one somewhat higher from the Crop Reporting Service.

During the period this project has been running early season estimates have been more accurate than those issued by the Crop Reporting Service in five out of the past six years. While progress has been very substantial, the methodology has not been perfected.

Plans: To continue generally along the same lines as in the past. More attention will be given to May-June temperatures. A concentrated effort will be made to develop a model for use in forecasting. Further work toward the construction of an "event tree" type of model is planned.

Almond Industry Participation $6,000

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Interpretive Summary: The emphasis during the 1980 forecasting season was somewhat different from earlier years. Much more effort went into attempts to model the forecasting methodology, or at least put it into a more nearly objective formula (see attachment 1).

Experimental Procedure The experimental procedure has two parts; the portion having to do with the actual forecast was carried out much as in past years. Data on temperatures, precipitation, solar radiation, wind, etc, are gathered and analyzed and compared to both normal and "optimal" conditions. Acreage data, county yield figures, and yields by variety are compiled and analyzed; these data are the basis for the forecasts. This portion was carried out much as in past years.

In 1980 more time was spent looking for a model or attempting to develop one. Relatively little work has been carried out on yield modeling and virtually all of that is on annual crops in areas with wet summers. As the year began I was concentrating on an "event tree" type of model but have now moved to what could be called a "Crop-weather analysis model," a type of model based on agrometeorological information. As with other models, this one is used most widely on annual plants in areas of summer rain.

Results Five forecasts were produced between March 15 and June 27. The first two were satisfactory, coming that early in the season. The third

March 15	300,000,000 lbs
April 13	300,000,000
April 25	312,000,000
June 16	312,000,000
June 27	294,000,000

forecast, on April 25, was very good for so early in the crop year. The forecast of June 16 was also satisfactory. The last forecast, on June 27, is disappointing; not only is the forecast less accurate than those delivered but it was moving in the wrong direction. It appears that the best forecasts will be in error by about 3 percent and the worst in error by about 9 percent.

Discussion In preparing the June 27 forecast I produced three different figures; these ranged from 287 million pounds to 295 million pounds. Each alternative was too low a forecast. The point to be determined is why the

June 27 forecast was reduced below the earlier ones.

There seem to have been two reasons for the reduction. First, the set was very poor so the crop was much reduced; while I did allow for larger nut size I perhaps should have assumed even a larger size. Secondly, temperatures in May and June were abnormally low. May temperatures in Modesto were 6°F below 1979 and 7.5°F below normal in Bakersfield; the latter station did not reach 100°F until June 29. The low temperatures in the two months caused me to reduce the forecast by 18 million pounds. Now almost seven months later, it is easy to see that it should have been increased by half that much.

I would have to conclude that the first five forecasts were good to very good but the last one was less than satisfactory.

Publications

1. "White Corn in Africa" for U.S. Department of Agriculture, January 1981, Unpublished

Bc

Crop yields vary considerably from year to year. Extreme events, as frost, can be responsible for severe diminution in yields. More often the fluctuations are due to normal variations in precipitation, temperature, solar radiation, humidity, etc. Almond trees and other plants are more able to combine the environmental conditions into a growth and yield pattern than we are able to understand. We have long thought that if we could somehow determine the weight of each input it would then be possible to develop a forecasting model.

My work in forecasting has not involved modelling, although there is careful attention given to each relevant variable. Other researchers say that I have been using a model without realizing it. In any event, the method has not been in a formal, reproducible form.

Most crop modelling is for long-term economic analysis and does not relate to any single year. These provide data on employment, incomes, taxes, etc., for periods several years in advance but do not purport to forecast yields for any given year.

Several yield models have been developed. Virtually all of these are used on annual plants in areas of summer rainfall. There appear to be three basic groupings of crop-weather models.

1. <u>Crop growth simulation models</u>

   A crop growth simulation model may be defined as a simplified representation of the physical, chemical, and physiological mechanisms underlying plant growth processes. If the basic plant processes are properly understood and modelled, the response of the plant to the environmental conditions can be simulated.

2. <u>Empirical-statistical models</u>

   In this approach, the weighting coefficients in the equations are obtained in an empirical manner using standard statistical procedures. This type of model is used in areas of homogeneity; almonds are grown over a large area having quite a bit of diversity.

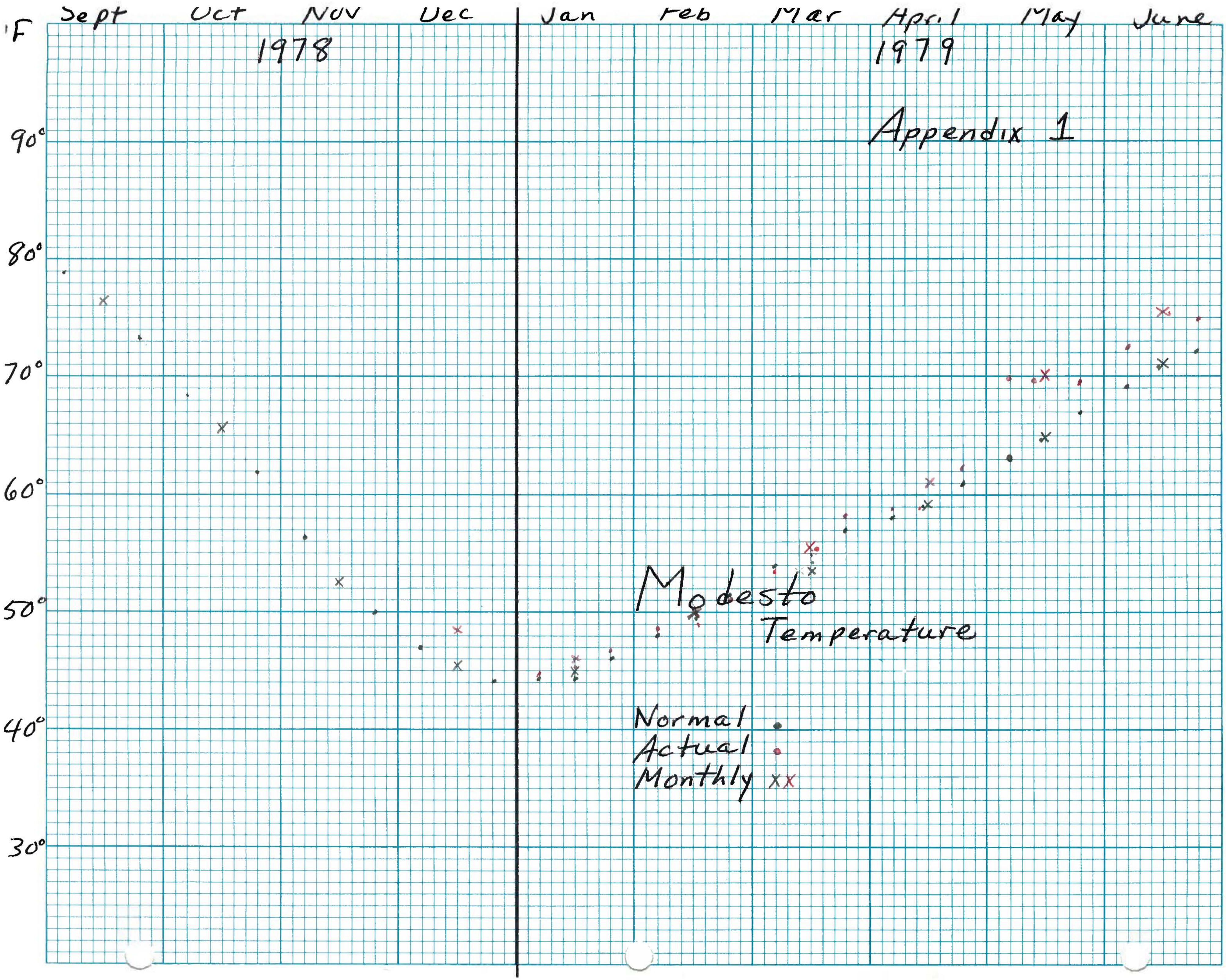
3. <u>Crop-weather analysis model</u>

Crop-weather analysis models use agrometeorological data in forecast development. Crop-weather analysis models are practical research tools for the analysis of plant responses to environmental conditions when only such data are available. Inputs can be selected; one variation uses soil moisture, temperature, and solar energy. Events such as frost (damage) must be treated subjectively. This type of model seems to be most appropriate to almonds in California.

Temperature and solar radiation are plotted by decade, as illustrated on appendix 1. All environmental conditions are followed on a daily basis with the effects of very low humidity or strong wind at bloom or frost at a critical time being very important, even though they might not be apparent if averaged over a 10 day period. As conditions develop they are evaluated on a linear basis, with values being ascribed to each as it occurs. Appendix 2 indicates the sequence of important events during the almond year up until the late June forecast. Stress at and beyond harvest can influence production the following year. Heavy rainfall in late October-early November is very helpful to the crop; heavy rain in 1973 was instrumental in developing the 1974 crop. A period of dormancy is needed for proper development and helps concentrate the period of bloom; the winter of 1977-78 was quite warm, an important factor in the small 1978 crop. Conditions at bloom must be followed and evaluated. Conditions during this short period are critical; adversity here in 1980 probably caused a loss of at least 60 million pounds of almonds. Growing conditions after bloom, primarily temperature and solar radiation are plotted and analyzed. The conditions in May-June of the past two seasons have been very different, although it is not yet clear what the influence was in 1980

While far from complete, this is the beginning of a model which should be appropriate for almonds in California.

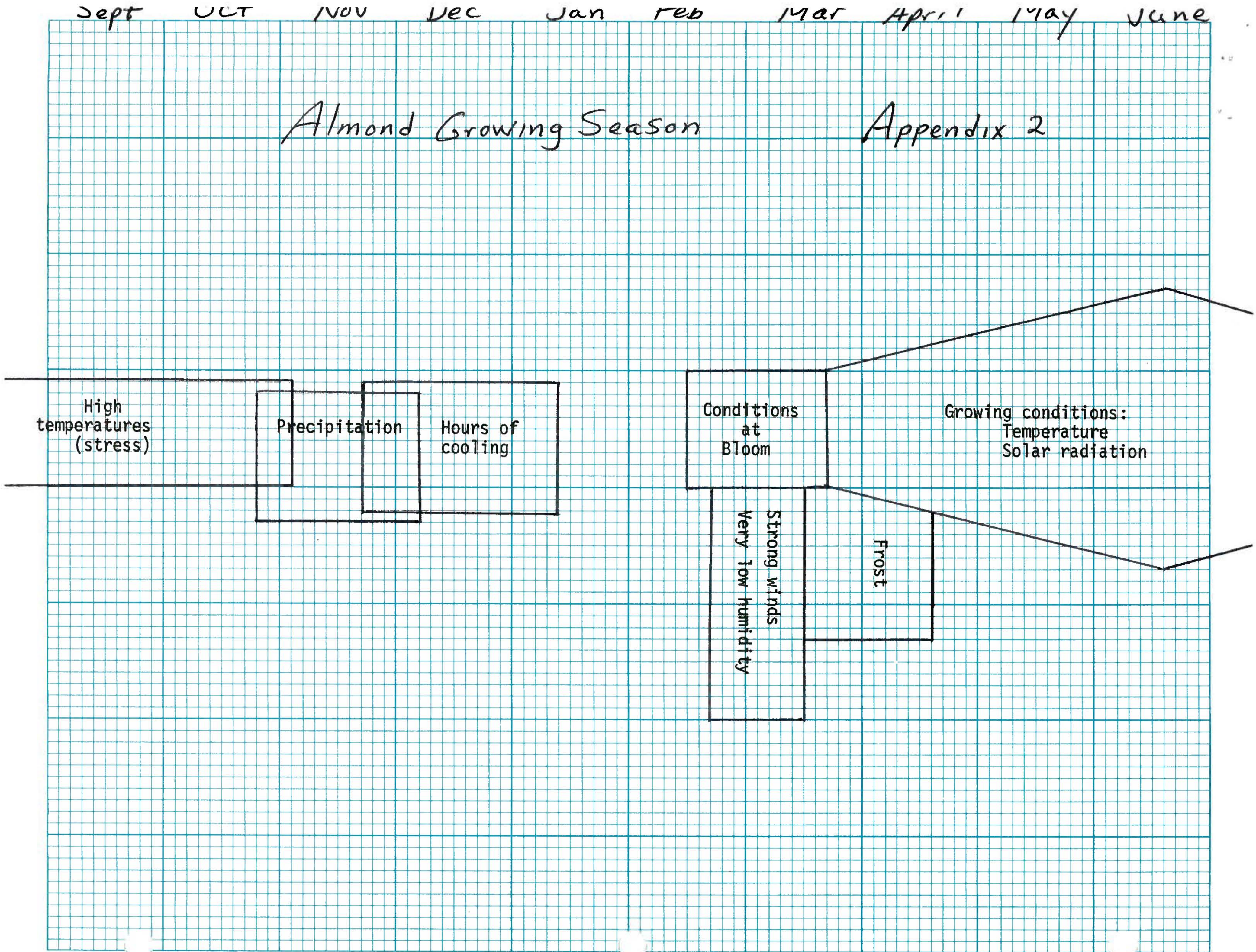
Appendix 1

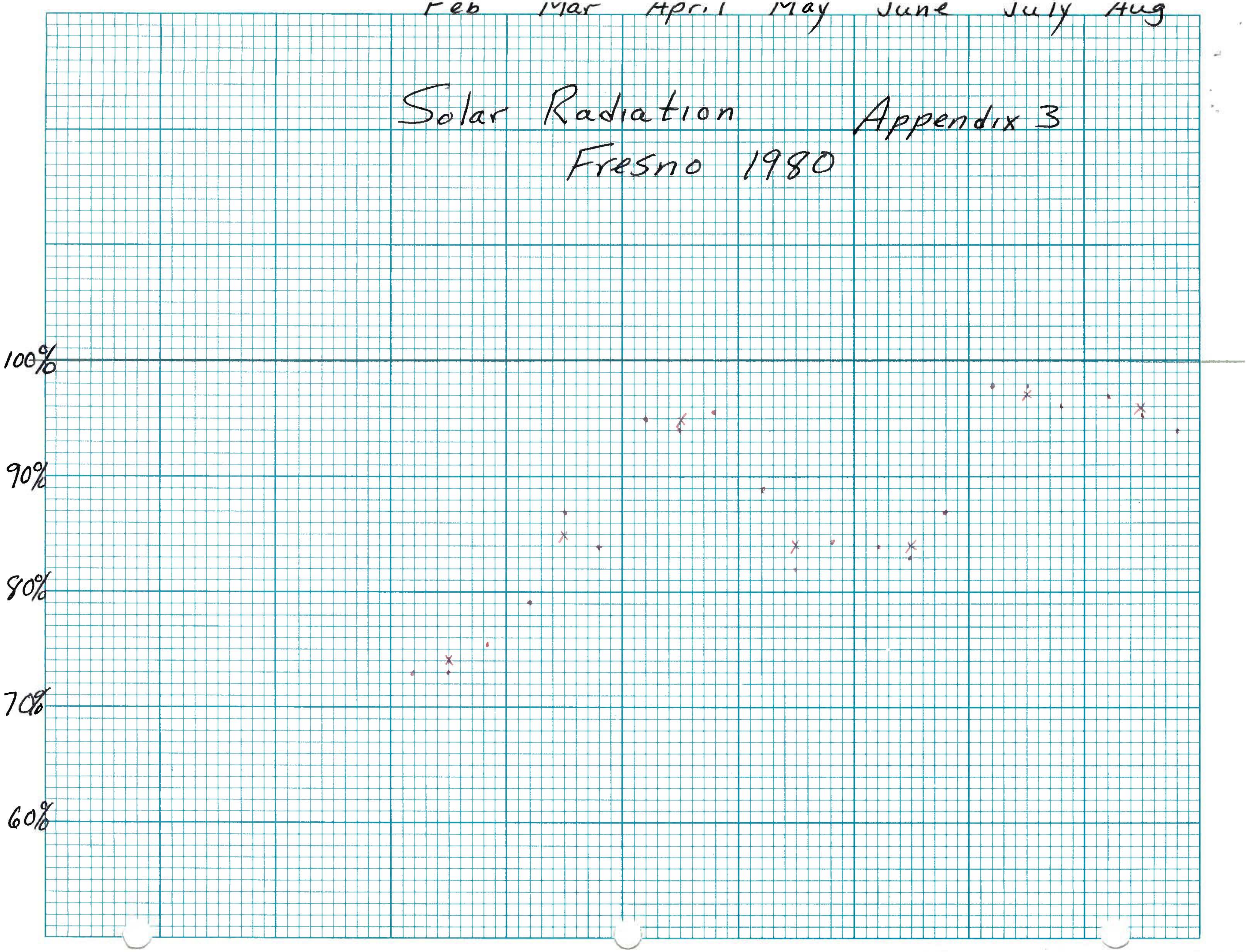


Modesto Temperature
1978
1979
Sept
Oct
Nov
Dec
Jan
Feb
Mar
April
May
June
°F
90°
80°
70°
60°
50°
40°
30°
Normal
Actual
Monthly

Almond Growing Season

Appendix 2




Solar Radiation
Fresno 1980
Appendix 3
Feb
Mar
April
May
June
July
Aug
100%
90%
80%
70%
60%