A Decision Theory Approach to a Resource Management System in Corn Production

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A DECISION THEORY APPROACH TO A RESOURCE MANAGEMENT SYSTEM IN CORN PRODUCTION

by

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ABSTRACT

A Decision Theory Approach to a Resource

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The major purpose of this study is to make additional information available to the farm manager through the use of decision theory. This will enable him to improve the decision-making process relating to corn production. The goal is to use the resources at his disposal more efficiently and profitably. This study is primarily concerned with factors that influence planting date and corn variety selection. Within the framework of decision theory analysis, a priori and a posteriori probabilities are employed to calculate the losses that may occur to corn crops in the Cache Valley area of Utah because of harmful spring frosts under optional corn varieties. The alternative of replanting is also added to the model. A brief discussion is included regarding the impact of water shortage on planting date and corn variety selection. A discussion of factors influencing harvesting decisions is included.

The "seventy growing degree day" method is employed as a criterion for planting date selection. The planting dates are matched with four different season length Utah hybrid corn varieties to formulate the courses of action available to the farm manager. The states of nature are the degrees of damage that would occur due to various frost intensities.

The decision theory approach of this study identifies the short-season variety as the optimal corn crop for Cache Valley, unless planting can be done during the first week in May. This study indicates that planting a shorter season variety than most Cache Valley farmers have been using in the past would be profitable. Replanting after a frost is found to be unprofitable in marginal cases, but necessary in the case of a killing frost of sufficient duration.

The problem of a short water supply adds a constraint as to what varieties can be planted where the time required to reach the third stage of growth is most critical in obtaining potential yields. Finally, it was found that the risk of increased precipitation interferring with harvesting operations becomes almost a certainty if attempts to lengthen the season pushes the harvest too far into October.

(131 pages)

INTRODUCTION

Risk and uncertainty are conditions that are recognized and lived with as part of agricultural life in the mountain west. The capriciousness of nature makes it very difficult to predict changes in weather conditions with any degree of certainty. Most farmers rely on their own intuitive feelings to make important decisions when dealing with the weather. The farm manager may improve his success ratio by putting his decisions in the proper framework through a systematic scientific approach to the decision problem. Corn production in the State of Utah is a process that could benefit by the use of this systematic approach. The systematic approach used in this study is that of Bayesian Statistical Decision Theory.

If one speaks strictly in terms of absolute advantage, raising corn is probably best suited to areas other than Utah. The growing season for corn in Utah is hampered by late spring and early fall frosts, and, in some cases, lack of water. Because corn is a high yield, high profit crop, however, the farmer is willing to take some risk in order to enjoy the possible benefits. With the many hybrids available today, it is possible to vary the choice of action and be reasonably certain of yielding a profit.

This study is mainly concerned with Cache County because of data accessibility and because the frost constraints that are present there are a significant factor in the decision process. In order to evaluate water shortage as a factor in corn production, data have been drawn from Sevier County where the water problem is much more acute than in Cache Valley.

Decision theory, under certain circumstances, cannot provide any sure answers, but can only hope to improve the ratio of success and thus improve profits.

There are several goals to be reached in improving corn production: (1) selecting an optimal planting date, (2) choosing the best variety of corn to be used, (3) deciding what action to take in case of frost, (4) establishing an initial date for irrigation during critical periods, and (5) arriving at a harvest date. Two options are possible in arriving at these goals: If data can be gathered to predict in advance what the state of nature will be, then a posteriori probabilities will be used; if positive prediction is not possible, then a "no data" problem classification is necessary and a priori probabilities are employed.

STATEMENT OF THESIS PROBLEM

Justification

The decision-making process is one of the most common activities in our lives. Many decisions are simple and require little or no effort on our part. It usually does not take long to decide to get up in the morning, nor do we have any trouble deciding when to eat. Other decisions such as what should I wear, should I play tennis or golf are somewhat harder. These everyday decisions involve only a few variables and are relatively easy to make, usually involving only a few seconds or minutes of thought and very little planning or investigation. On the other hand, there are some decisions that are relatively complex, involving many variables. The final outcome of some of these decisions may have great impact upon those involved. Production of corn in Utah is such a problem. Furthermore, there are uncontrollable factors that may affect these above variables such as length of season, late spring and early fall frosts, etc.

In the past, many of these decisions have been made based only upon the experience of the farmer involved or his feeling about what is best. There is room for improvement in this area. The farm manager could make better decisions if he had better information available.

A decision theory approach would help to yield a more efficient use of the resources involved. Little has been done in this sector of the farm management scene. Decision theory as a method would take advantage of the most up-to-the-minute information as the time for each decision approaches. Since there is some uncertainty involved, special methods must be employed to handle the process.

One key issue will be the cost of information obtained versus the increased profit due to better choices. A purpose of the thesis is to show whether it is worth the time and effort to obtain the information. This work will test whether a systematic approach will yield better results than relying merely on past experience or intuitive feelings as to what the best decision might be.

Objectives

The objectives of this study are:

1. To determine the best variety of corn to be used, given the information that is available in that growing season,
2. To determine an optimum planting date,
3. To estimate the irrigation requirements necessary under the given natural conditions,
4. To determine optimal time of harvest,
5. To provide for the changes that might be necessary in any of these decisions due to changes in the states of nature, and
6. To list all significant strategies that might be employed so that the farm manager may pick the one best suited for his situation.

Methods of procedure

Following is a general outline of the steps in the decision theory method that will be used:

1. Determine the available actions that can be taken.

2. List the various states of nature which can occur.
3. Consider the consequences (gain, losses, utilities) of each combination of action and state of nature (state-act pair).
4. Design an experiment or other device for obtaining knowledge about the state of nature. An experiment consists of:
   a. Possible observations that are related to the state of nature and which are observable at the time a decision is made.
   b. Estimation of a relationship that shows the dependence of the observations upon the states of nature in probabilistic terms.
5. Evaluate the available strategies or recipes telling the decision maker which action to take in the event of a particular observation from the experiment.
6. Study the consequences of each strategy for each state of nature, as determined by the action probabilities.
7. Establish a choice criterion by which the decision maker solves the final problem.

This approach is designed to solve for the most economically efficient operation. This point is by no means fixed; as the states of nature continue to vary, the choices will also vary.

There are several available actions that must be given consideration. One of the most important variables is the variety of corn to be planted. With so many hybrids available today, it is possible to vary the length of season to maturity. The available varieties can be categorized according to length of season required for maturity such as: long, medium, short, and very short. Another action that is open to the farm manager is to vary the planting dates. The third set of available actions is irrigation. In this area, the method of application, quantity to be applied, frequency of application, and timing in critical periods are all sets of actions that can be taken by the manager. Fertilizer treatment is the last general area of available actions that is suggested.

The states of nature are almost as complex as the available actions open to the farm manager. The length of season is not to be considered on a basis of days only, but with a relative heat factor added. This heat factor is measured in growing degree days. Because corn is quite a delicate plant, frosts at the beginning and end of the season are a significant factor in Utah. The soil type, depth, and need for fertilizer are also factors to be considered. The next general state of nature to consider is the amount of water available excluding irrigation. This includes the spring water storage in the soil and the rainfall, both quantity and timing.

It is apparent from a brief look at the complex available actions and states of nature that this model would be too difficult to work out entirely by hand and is really best suited for a computer analysis. After the fixed costs of the model are recovered, the variable costs of information to the manager should be quite low in comparison to the increased profits it will yield.

The remaining steps three through seven are those where the actual work of the decision process takes place. A major portion of the input for this model will be drawn from information, experimentation, and data gathered in other projects.

By applying these data to the decision theory model, the objectives should be reached and more efficient decisions applied to the production of corn in Utah. With minor adjustments, such a farm management system could also be applied to other areas.

SURVEY OF THE AREA UNDER DISCUSSION

Cache County is located in the northeast corner of the Utah panhandle. The arable land of the county is located in Cache Valley which is a mountain valley about thirty to thirty-five miles in length and about ten to fifteen miles wide. A variety of seasons can be found in the valley. The bench and canyon mouth areas have the longer growing season, while the valley floor has a shorter growing season. Canyon winds protect some local areas from frosts.[1]

There are two main locations where weather data are available: Logan and Lewiston. Lewiston has an elevation of 4,480 feet, thus giving a weather recording station to yield data for the valley floor. Logan's elevation is 4,785 feet giving a view of the weather in the canyon mouth and bench areas. The frost-free growing season varies from 80-100 days to 160-180 days.[2] This characteristic of the study areas makes it difficult to have one policy to handle the problem of predicting frost dates.

Water in Cache Valley is plentiful. It is doubtful that there is ever a serious water shortage, except in certain canyon mouth areas. To illustrate a water shortage problem, a study conducted on that subject in the Sevier Valley was selected. Since the Sevier Valley is much like Cache Valley, the intent of this paper is to draw comparisons

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[1] E. Arlo Richardson and Gaylen L. Ashcroft, "Freeze-Free Seasons of State of Utah", Map and Table, (Published jointly by Utah Agricultural Experiment Station, Utah State University, Logan, Utah, and Department of Commerce, ESSA, Environmental Data Services).

[2] Ibid.

between the two and discuss a hypothetical situation assuming Cache Valley were ever to have a water shortage or that a similar area was short of water. Cache Valley has ample precipitation during the winter and spring. Precipitation decreases during the summer months and increases again in the fall. There is a sufficient supply of irrigation water during the summer months to supplement the scant rainfall.[3] The Sevier Valley has a relatively constant rate of precipitation during the year, but it is generally far less that of Cache Valley. The area is dependent largely upon irrigation during the growing season, thus snowpack and reservoir storage are critical.[4] The shortage years experienced in Richfield, Utah in the Sevier Valley lend credence to the assumption that it will be helpful to apply a hypothetical shortage to Cache Valley for illustrative purposes.

One of the necessary criteria for any study is the availability of data. There is a generous amount of weather data recorded in Cache Valley. The first records in Cache Valley begin in the late 1800's and continue, with few exceptions, to the present.[5] There are data available for this location in corn trials as well. Rex F. Nielson

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[3] U. S. Department of Commerce, Weather Bureau. Climatological Summary, Climatography of the United States No. 20-42, Utah State University, Logan, Utah, 1941-1970.

[4] U. S. Department of Commerce, Weather Bureau. Climatological Summary, Climatography of the United States No. 20-42, Richfield, Utah, 1925-1954.

[5] U. S. Department of Commerce, Weather Bureau. Logan, Utah, 1941-1970.

has corn trials published for the years between 1953 and 1966.[6] DeVere R. McAllister has also conducted some corn trials for this area.[7]

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[6]Rex F. Nielson, Corn Trials, 1953-1966. Department of Soil Science and Biometeorology, Utah State University, Logan, Utah.

[7]DeVere R. McAllister, Grain and Silage Corn Trials for Utah--1973, Plant Science Department, (Mimeographed), Utah State University, Logan, Utah, 1974.

DeVere R. McAllister, Silage Corn Trials--1974, Plant Science Department, (Mimeographed), Utah State University, Logan, Utah, 1975.

REVIEW OF LITERATURE

There have been many publications of a general nature in the area of decision theory, but no studies have been found which used a decision theory approach to select planting dates and varieties of hybrids for optimal corn production. Included in this review is a discussion of two significant books on decision theory and a source where a more general discussion of the history of decision theory may be found.

Bayesian decision theory had its beginnings in 1762 with the writing of Bayes.[8] In more modern times, there have been several significant books and articles written on the decision theory technique. Two of these books proved more helpful than others in gaining a facility with decision theory. The first of these is a basic work written by Albert N. Halter and Gerald W. Dean called Decision Under Uncertainty.[9] This book outlines a step-by-step approach to decision theory with simple examples along the way. The primary aim of the book is the implementation of decision theory. The second book, Elementary Decision Theory by Chernoff and Moses,[10] is helpful in explaining the theoretical

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[8] A. N. Halter, "A review of decision-making literature with a view of possibilities for research in decision-making processes of western ranchers, Economic research in the use and development of range resources, Development and evolution of research in range management decision making", Committee on the Economics of Range Use and Development of Western Agricultural Economics Research Council, Rep. No. 5, Laramie, Wyoming, (July 1963), p. 1.

[9] Albert N. Halter and Gerald W. Dean, Decision Under Uncertainty, (Cincinnati, Ohio: South-Western Publishing Co., 1971), p. 143.

[10] H. Chernoff and L. E. Moses, Elementary Decision Theory, (New York: John Wiley and Sons, Inc.), 1959.

approach to Bayesian Decision Theory. Chernoff and Moses move through the theory of the "no data" problem and the use of a priori probabilities in a step-by-step manner. With the addition of a posteriori probabilities, they turn to a discussion of the optimal Bayes strategy in a simple tabular calculation. This expansion to the "data" problem shows the contrast of situations when data may or may not be available in making decisions under uncertainty.

A satisfactory review of other general publications in decision theory can be found in the Economic Research in the Use and Development of Range Resources, Report No. 5.[11]

[11] "A review of decision-making", pp. 1-28.

THEORETICAL FRAMEWORK AND STUDY ASSUMPTIONS

Decision model

This section contains an outline of the general decision theory process, in a theoretical sense, which will be used in the later sections. This will follow the same seven general steps found in the "Statement of Thesis Problem".[12]

The first step includes the list of available actions open to the farm manager:

$$a_1, a_2, \ldots a_i$$

Some actions need to be excluded for simplicity as the model can become too complicated if all possible available actions are included.

Step two is similar to the first step in that it is the listing of the states of nature:

$$n_1, n_2, \ldots n_j$$

As in the courses of action, only a limited bracketing of states of nature are included to avoid complication. (See Table 1.)

In the third step, a gain-loss table (Table 1) is generated to show the consequences of each combination of action and state of nature. In this table, the values of U = Utility are listed. These are the gains or losses relative to each combination of available action and state of nature.

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[12]Halter and Dean, Decision Under Uncertainty, p. 9.

Table 1. Gain-loss relationship for each combination of action and state of nature

	Available actions				
States of nature	a_1	a_2	.	.	a_i
n_1	$U(n_1, a_1)$	$U(n_1, a_2)$	.	.	$U(n_1, a_i)$
n_2	$U(n_2, a_1)$	$U(n_2, a_2)$	.	.	$U(n_2, a_i)$
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
n_j	$U(n_j, a_1)$	$U(n_j, a_2)$	.	.	$U(n_j, a_i)$

Step four separates what is known as the "data" problem from the "no data" problem.[13] An experiment or other device is organized to gain information about the states of nature. Observations are made in the experiment that are related to the states of nature. It is then possible to make those same observations just prior to the actual decision. An actual relationship in probabilistic terms between the observations and the states of nature is made, thus making it possible to draw some conclusions about what the state of nature will be depending on the observation. If it is not possible to conduct such an experiment or make observations just prior to the decision, then the only choice is to deal with the situation as a "no data" decision problem.

As the experiment is conducted and the observations are made, the probabilities given in Table 2 are generated.

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[13] Chernoff and Moses, Elementary Decision Theory, p. 167.

Table 2. Probability of making observation o_k when n_j is the state of nature

	Observations				
States of nature	o_1	o_2	.	.	o_k
n_1	$P(n_1, o_1)$	$P(n_1, o_2)$	.	.	$P(n_1, o_k)$
n_2	$P(n_2, o_1)$	$P(n_2, o_2)$	.	.	$P(n_2, o_k)$
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
n_j	$P(n_j, o_1)$	$P(n_j, o_2)$	.	.	$P(n_j, o_k)$

These probabilities are then used to calculate the optimal strategy in the steps to follow before the decision must be made. This table can be updated as more information becomes available over successive periods of time.

The "no data" decision problem. Even in the case where it is not possible to make an observation that yields an updated prediction on the state of nature, decision-making ability may be improved by using *a priori* probabilities. This is called the "no data" problem. In other words, the probability of a state of nature may be formulated by using the data of all past periods. An example of this in weather data is the *a priori* probability of frost occurring on a certain spring day calculated by the Weather Bureau from the data of past years. These data usually cover a minimum thirty-year period. Probabilities of n_j states of nature may be stated as in Table 3.

Table 3. A *priori* probabilities

$P(n_j)$
$P(n_1)$
$P(n_2)$
.
.
.
$P(n_j)$

With the use of the gain-loss table and the *a priori* probabilities, it is now possible to arrive at the best option under available actions or the best decision of an available action, considering there is no further information. See Table 4.

After conducting the operations in these tables, it is possible to pick the optimal action. If it is a loss table, the optimal action will be the minimum of the sums from a_1 to a_i,

$$\sum_{n=1}^{j} [U(n_j, a_i)] [P(n_j)].$$

If it is a gain table, the optimal action will be the maximum value in the sums. In any case, the optimal action is indicated.

Table 4. Calculation of the "no data" problem

	Loss-gain table				Probability table
	Available actions				A priori probabilities
States of nature	a_1	a_2	. .	a_i	$P(n_j)$
n_1	$U(n_1,a_1)$	$U(n_1,a_2)$	. .	$U(n_1,a_i)$	$P(n_1)$
n_2	$U(n_2,a_1)$	$U(n_2,a_2)$	. .	$U(n_2,a_i)$	$P(n_2)$
.	.	.	. .	.	.
.	.	.	. .	.	.
.	.	.	. .	.	.
n_j	$U(n_j,a_1)$	$U(n_j,a_2)$	. .	$U(n_j,a_i)$	$P(n_j)$

Loss-gain table with probabilities considered

Available actions

a_1	a_2	. .	a_i
$[U(n_1,a_1)][P(n_1)]$	$[U(n_1,a_2)][P(n_1)]$	. .	$[U(n_1,a_i)][P(n_1)]$
$[U(n_2,a_1)][P(n_2)]$	$[U(n_2,a_2)][P(n_2)]$	. .	$[U(n_1,a_i)][P(n_2)]$
.	.	. .	.
.	.	. .	.
.	.	. .	.
$[U(n_j,a_1)][P(n_j)]$	$[U(n_j,a_2)][P(n_j)]$	. .	$[U(n_j,a_i)][P(n_j)]$
$\sum_{n=1}^{j} [U(n_j,a_1)][P(n_j)]$	$\sum_{n=1}^{j} [U(n_j,a_2)][P(n_j)]$	. .	$\sum_{n=1}^{j} [U(n_j,a_i)][P(n_j)]$

<u>The "data" decision problem</u>. Now that the "no data" situation has been briefly discussed, the "data" problem will be considered with the commencement of step five. The available strategies are tabulated, including all possible actions which the decision maker might have, given the observations o_1 through o_k. (See Table 5.) Table 5 would give all possible combinations of actions with each possible observation o_k.

Table 5. List of possible strategies

	Actions taken with given observations				
Strategies	o_1	o_2	.	.	o_k
s_1	a_1	a_1	.	.	a_i
s_2	a_1	a_2	.	.	a_i
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
s_m	a_2	a_3	.	.	a_i

The sixth step determines the consequences of each strategy for each state of nature as determined by the probabilities in Table 2. This computation gives the average gain or loss for each strategy and the possible states of nature (see Table 6).

Table 6. Average utility for each strategy and respective state of nature

States of nature	Strategies s_1	$\ldots s_m$
n_1	$P(n_1,o_1)\cdot U(n_1,a_i)+P(n_1,o_2)\cdot U(n_1,a_i)+\ldots P(n_1,o_k)\cdot U(n_1,a_i)$	....
n_2	$P(n_2,o_1)\cdot U(n_2,a_i)+P(n_2,o_2)\cdot U(n_2,a_i)+\ldots P(n_2,o_k)\cdot U(n_2,a_i)$	....
.	.	....
.	.	....
.	.	....
n_j	$P(n_j,o_1)\cdot U(n_j,a_i)+P(n_j,o_2)\cdot U(n_j,a_i)+\ldots P(n_j,o_k)\cdot U(n_j,a_i)$	....

The last step includes multiplying the average gains or losses of each state of nature in the preceding step by its respective <u>a priori</u> probability and totaling the results to yield one gain or loss figure for each strategy. The decision maker is then able to choose the optimal strategy. This approach has the advantage of including all possible solution strategies. It may be a disadvantage to calculate all strategies if only the optimal one is wanted. In this case, there is a short-cut using what is called the <u>a posteriori</u> probabilities. Detailed and practical examples of the above "data" method can be found in <u>Decision Under Uncertainty</u> by Halter and Dean.[14] No new information is needed to calculate the <u>a posteriori</u> probabilities. The letters z_1 through z_j will represent these <u>a posteriori</u> probabilities.

[14] Halter, <u>Decision Under Uncertainty</u>.

The first step in calculating the a posteriori probabilities is to multiply the probability of states of nature with respect to the observations by the corresponding a priori probabilities (Table 7). The resulting sums of the products relative to each observation are then totaled. The sums corresponding to o_k are divided into the relative members of the joint probabilities matrix as performed in Table 8. The a posteriori probabilities are then multiplied by the corresponding figures in the loss-gain table. These values are then totaled for each available action as shown in Table 9.

If a loss table is used, the object is to find the minimum $B(\bar{z}, a)$, or Bayes strategy for the observations.[15] If a gain table is used, then the maximum should be found. The above procedure may be followed to find the optimal course of action for each observation o_1 through o_k. These optimal available actions for each observation become the Bayes strategy.

Growing degree days

Many crops in the past were rated according to number of days to maturity, such as 119-day corn. Since the growth that takes place in any given day varies widely, that system has been replaced for many crops with a term called "growing degree days". Growing degree days takes into consideration the heat factor since growth is dependent upon heat over a restricted temperature range. The growing degree days calculation used in this model is that referred to as the U.S. Weather

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[15] Chernoff, Elementary Decision Theory, p. 167.

Table 7. Computation of the a posteriori probabilities

States of nature	Observations				A priori probabilities
	o_1	o_2	. .	o_k	$P(n_j)$
n_1	$P(n_1,o_1)$	$P(n_1,o_2)$	. .	$P(n_1,o_k)$	$P(n_1)$
n_2	$P(n_2,o_1)$	$P(n_2,o_2)$	. .	$P(n_2,o_k)$	$P(n_2)$
.	.	.	. .	.	.
.	.	.	. .	.	.
.	.	.	. .	.	.
n_j	$P(n_j,o_1)$	$P(n_j,o_2)$	. .	$P(n_j,o_k)$	$P(n_j)$

Joint probabilities
$P(n_j)\ P(n_j,o_k)$

o_1	o^2	.	.	o_k
$P(n_1)\ P(n_1,o_1)$	$P(n_1)\ P(n_1,o_2)$	.	.	$P(n_1)\ P(n_1,o_k)$
$P(n_2)\ P(n_2,o_1)$	$P(n_2)\ P(n_2,o_2)$	.	.	$P(n_2)\ P(n_2,o_k)$
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
$P(n_j)\ P(n_j,o_1)$	$P(n_j)\ P(n_j,o_2)$	.	.	$P(n_j)\ P(n_j,o_k)$
$\sum_{n=1}^{j} P(n_j)\ P(n_j,o_1)$	$\sum_{n=1}^{j} P(n_j)\ P(n_j,o_2)$	.	.	$\sum_{n=1}^{j} P(n_j)\ P(n_j,o_k)$

Table 8. A *posteriori* probabilities

	Observations				
A posteriori probabilities	o_1	o_2	.	.	o_k
z_1	$\frac{P(n_1)\,P(n_1,o_1)}{\sum_{n=1}^{j} P(n_j)\,P(n_j,o_1)}$	$\frac{P(n_1)\,P(n_1,o_2)}{\sum_{n=1}^{j} P(n_j)\,P(n_j,o_2)}$	.	.	$\frac{P(n_1)\,P(n_1,o_k)}{\sum_{n=1}^{j} P(n_j)\,P(n_j,o_k)}$
z_2	$\frac{P(n_2)\,P(n_2,o_1)}{\sum_{n=1}^{j} P(n_j)\,P(n_j,o_1)}$	$\frac{P(n_2)\,P(n_2,o_2)}{\sum_{n=1}^{j} P(n_j)\,P(n_j,o_2)}$	.	.	$\frac{P(n_2)\,P(n_2,o_k)}{\sum_{n=1}^{j} P(n_j)\,P(n_j,o_k)}$
.	.	.	.	.	.
.	.	.	.	.	.
z_j	$\frac{P(n_j)\,P(n_j,o_1)}{\sum_{n=1}^{j} P(n_j)\,P(n_j,o_1)}$	$\frac{P(n_j)\,P(n_j,o_2)}{\sum_{n=1}^{j} P(n_j)\,P(n_j,o_2)}$	.	.	$\frac{P(n_j)\,P(n_j,o_k)}{\sum_{n=1}^{j} P(n_j)\,P(n_j,o_k)}$

Table 9. Bayes strategy

	Observation o_1				
	a_1	a_2	.	.	a_i
$B(\bar{z}, a)$	$\sum_{n=1}^{j} z_j \ U(n_j, a_1)$	$\sum_{n=1}^{j} z_j \ U(n_j, a_2)$	.	.	$\sum_{n=1}^{j} z_j \ U(n_j, a_i)$

Bureau 50-86 method suggested by Gilmore and Rogers in 1958[16] and expressed as:

$$GDD = (TH/2 + TL/2) - 50$$

where

GDD = growing degree days for a given day in degrees fahrenheit.

TH = maximum daily temperature in °F. (If TH $\geq$ 86°, then TH = 86°.)

TL = minimum daily temperature in °F. (If TL $\leq$ 50°, then TL = 50°.)

Since the corn plant begins growth at about 50° fahrenheit, this temperature is used as the lower limit in the equation. In other words, no appreciable growth takes place when the temperature is below 50° fahrenheit. Growth of the corn plant also tapers off above an upper limit set at 86° F. Additional heat units much above that point may even impair growth. Consider the possible growth curve represented in Figure 1:

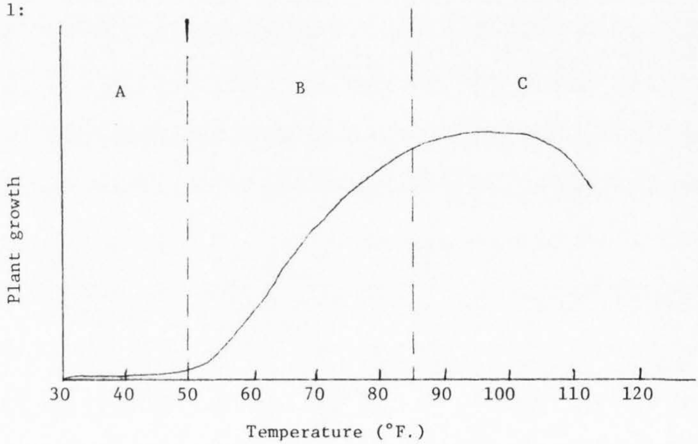

Figure 1. Possible plant growth function

[16] R. W. Hill, R. J. Hanks, J. Keller, and P. V. Rasmussen, "Predicting corn growth as affected by water management: An example", Department of Agricultural and Irrigation Engineering, Utah State University, Logan, Utah, Report No. 211(d)-6, (September, 1974), p. 3.

In section A, little or no growth is taking place. In section B, the growth of the plant is proportional to an increment in temperature. In section C, the growth has tapered off and there could even be some damage as shown by the downward arc of the curve.

Growing degree days are cumulative from the date of planting through maturity. Modeling and trials currently in process make it possible to predict growth stages and maturity by this method, provided other variables are held constant.

Total digestible nutrients

It is not sufficient when considering feasibility and profit to look only at tons per acre yields since the value of a ton of corn silage can vary significantly. Two of the more important factors are percent dry weight and degree of maturity. In this study, these factors will be taken into account by use of a term call Total Digestible Nutrients (TDN). As silage corn becomes more mature, it increases in percent dry weight and in TDN, thus becoming more nutritious and yielding more feed value to animals.

Consider the following quote by Dr. DeVere McAllister, Extension Agronomist with Utah State University:

> The total feeding value of corn increases right up to the time the grain is mature. But the digestibility of the leaves and stalks and the keeping quality of the silage decline somewhat earlier. If chopped when only one-fifth of the kernels are dented, you harvest only 50% of the potential. With half the kernels dented, you get only 70%. With all dented and in hard-dough or early glaze stage, you get 90% of the possible feed value of the grain. At this latter stage (early glaze), the ear contains two-thirds and the stalk and leaves one-third of the TDN in the whole plant. The ear is the important thing.[17]

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[17] DeVere R. McAllister, "More and Better Corn Silage", p. 1.

An estimate of the effect of maturity on TDN is shown in Table 10.

Table 10. Time of harvest, effect on pounds TDN at various yields

	Pounds TDN		
	Green weight tons		
Maturity stage	16	20	26
Milk	4800	6000	7800
Dough	6080	7600	9088
Late dent	7040	8800	11,440

Source: DeVere R. McAllister, More and Better Corn Silage Through Timely Harvest, "It's the Grain that Counts", Plant Science Department, Utah State University, Logan, Utah (August 1974), p. 1.

An index of the maturity values for field trials on corn is recorded in Appendix B Tables 37 and 38.

For purposes of this study, TDN rather than total tons of silage per acre is considered in order that benefits may be more properly assigned. In support of the above information are some figures published in Table 11 for four types of corn silage. It would appear from this report that mature grain is most important to the yield as far as TDNs are concerned.

Table 11. Comparative yields and livestock produced per acre from different methods of harvesting and storing the corn crop (based on a yield of 100 bushels [56 cwt.] per acre)

Corn harvesting system	Acreage		Yield	Total TDN	TDN per acre	Cattle fed per acre	Beef produced per acre
Regular corn silage	100		1800 tons	712,800 lbs.	7,128 lbs.	2.57	1,540 lbs.
Corn silage and high moisture shelled corn	100	42 acres corn silage	760 tons	299,376 lbs.	5,491 lbs.	1.86	1,116 lbs.
		58 acres high moisture shelled corn	5570 bu.	249,758 lbs.			
				549,134 lbs.			
High moisture ground ear corn	100		10,000 bu.	491,904 lbs.	4,919 lbs.	1.60	958 lbs.
Corn ear and center-cut silage	100		1320 tons	607,200 lbs.	6,072 lbs.	2.20	1,320 lbs.

Source: "Modern Corn Production", The Farm Quarterly, (1966), p. 290.

ANALYSIS AND DECISION MODEL APPLICATION

Planting date criteria

In the past, several methods of determing an optimal planting date have been recommended to the farmer. Two of these methods are considered here as to which would be best suited to this decision problem.

One of these methods consists of determining the first seven consecutive spring days for which the growing degree days (GDD) as computed according to the formula on page 24 total 70. The earliest planting date would be the day on which the cumulative GDD for the previous 7 days reaches this total. Optimal planting dates determined according to this method for the years 1959-1966 are presented in Table 12. These years are selected because they are the ones from which the main body of data for this study are drawn.

Table 12. Dates when the sum of GDD for seven consecutive spring days first reached 70 as recorded at U.S.U. Agricultural Experiment Station, 1959-1966

Years	Date
1959	May 14
1960	May 10
1961	May 22
1962	May 6
1963	May 6
1964	May 15
1965	May 16
1966	May 3

Daily mean 1959-1966 reached on May 16

Some indication of the relative success of this method of planting date selection can be gained by examining the records of spring frost activity for the eight years in question. Table 29 of the Appendix gives the dates and intensities of late spring frosts for those eight years. Using the figure of about seven days to emergence, it can be noted that crops for the years 1961, 1963, 1964, and 1965 would have received no frost damage, those for the years 1959 and 1962 would have received some damage, and those for the years 1960 and 1966 would have received extensive frost damage. If the mean optimal planting date of May 16 had been used for each of the eight years, 1959 and 1966 crops would have received no frost damage, 1962 crops some damage, and only those for 1960 would have received extensive frost damage. Frosts for both 1962 and 1960 occurred in June and would have been difficult to avoid or anticipate.

Another method of planting date selection is the use of mean soil temperature. This method recommends planting when the mean soil temperature reaches 50° F. Although the data for this method are relatively recent, some conclusions can be drawn. Table 13 gives those dates for the years 1969-1975 when the spring mean soil temperature for Cache Valley first reached 50° F. According to the data of Table 13, this method would have the farmer in Cache Valley plant on or about May third. Applying this date to the years 1959-1966, we note that crops for the years 1963, 1964, and 1965 would have received no frost damage, those for 1961 and 1962 would have received some damage, and those for 1959, 1960, and 1966 would have received extensive frost damage (Table 28, Appendix). A direct comparison cannot be made, however, since data are not available for those years. Applying this criterion for planting to the years 1969-1975, it can be noted from the data of Table 29, Appendix B that 1970 crops would have received some frost damage and those for 1975 would have had major frost damage.

Table 13. Dates when the spring mean soil temperatures equal 50° F at U.S.U. Agricultural Experiment Farm, 1969-1975 (depth = 4 in.)

Years	Date
1969	May 1
1970	May 4
1971	May 2
1972	May 3
1973	May 6
1974	May 2
1975	May 3

Source: U.S. Department of Commerce, Weather Bureau. Climatological Data, Utah, 1952-1975.

It is not immediately apparent which is the better of these two methods; however, it appears that the GDD method provides a safer margin for avoidance of frost damage. Comparing the two methods for the years 1969 to 1975, one sees that the 70 GDD method is a little more conservative. See Table 14 for dates when the 70 GDD criterion is achieved. In the two years between 1969 and 1975 where frost damage occurred, the 70 GDD method, because of a later optimal planting date, would have avoided part of the damage in each case.

Many farmers select their planting date by the field conditions, planting as soon as it is feasible to till and work the fields. Other

Table 14. Initial date when the total GDD for seven consecutive days reached 70 as recorded at U.S.U. Agricultural Experiment Station, 1967-1975

Years	Date
1967	May 20
1968	May 7
1969	May 6
1970	May 7
1971	May 5
1972	May 7
1973	May 12
1974	May 5
1975	May 15

farmers plant on the basis of past experience and some merely according to intuitive feelings, neither of which are very reliable methods. Either of the temperature based systems is to be preferred over such arbitrary selection techniques.

A closer examination of the growing degree day method is of some interest. By applying the criterion of 70 GDD in seven consecutive days and calculating the corresponding date of emergence, the severity of frosts affecting corn crop planting could be more closely quantified. From the information on maturity in Appendix Table 33 and the formulation of growth stages in Appendix Table 36, it is possible to predict the time of emergence once the planting date has been selected. The corn plant will emerge 80 GDD after planting. Suppose that the various planting dates or courses of action are labeled a_1 through a_i, where

$$a_1 = \text{May 2-7}$$

$$a_2 = \text{May 8-13}$$

a_3 = May 14-19

a_4 = May 20-25

a_5 = May 26-31

These courses of action are applied in the data of Table 15. Conclusions can be drawn as to the relative success of this criterion for determining the course of action for planting dates, since hindsight is much better than foresight.

The states of nature n_1-n_j in Table 15 reflect the state of nature with respect to frost, where

n_1 = no frost

n_2 = mild frost (32°-29° F)

n_3 = hard frost (28° F and below)

It is evident from Table 15 that the GDD method is successful in the avoidance of frost in seventeen out of twenty-three years from 1952, the first full year when data were recorded at the Utah State University Experimental Farm, to 1974.[18] While improvement is still possible, a record of 83 percent success in avoiding major frost damage would be desirable. Late spring frosts in Cache Valley cannot be easily predicted in every case and sometimes come without warning. As a general rule, then, the GDD method is more reliable in selection of the optimum planting date to avoid these frosts. There is, of course, the constraint of field conditions due to wet or adverse weather to be considered. Some information relative to how wet the soil generally will be is presented in Table 38 (Appendix) which shows amounts of precipitation accumulated over a two-week period. Field conditions were not added to the planting date

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[18] E. Arlo Richardson, Utah State Climatologist, Department of Soil Science and Biometeorology, Utah State University, Logan, Utah, Personal interview, (August 1975).

Table 15. 70 GDD planting dates and potential dates of emergence

Year	70 GDD reached	Planting date action a_i	Emerge 80 GDD after plant	State of nature n_j
1974	May 5	a_1	May 11	n_1
1973	May 12	a_2	May 18	n_1
1972	May 7	a_1	May 16	n_1
1971	May 5	a_1	May 14	n_1
1970	May 7	a_1	May 19	n_1
1969	May 6	a_1	May 12	n_1
1968	May 7	a_1	May 18	n_1
1967	May 20	a_4	May 25	n_1
1966	May 3	a_1	May 8	n_3
1965	May 16	a_3	May 24	n_1
1964	May 15	a_3	May 21	n_1
1963	May 6	a_1	May 14	n_1
1962	May 6	a_1	May 12	n_2
1961	May 22	a_4	May 27	n_1
1960	May 10	a_2	May 16	n_3
1959	May 14	a_3	May 30	n_1
1958	May 6	a_1	May 16	n_1
1957	May 5	a_1	May 15	n_1
1956	May 8	a_2	May 19	n_1
1955	May 10	a_2	May 19	n_2
1954	May 8	a_2	May 14	n_3
1953	May 31	a_5	June 9	n_1
1952	May 4	a_1	May 12	n_3

model in this study since this would introduce several new variables such as wind conditions, evaporation, and precipitation probability.

Planting decisions

The most important planting decision to be considered is selection of the variety of corn to be planted. Modern technology applied to the breeding of the corn plant has made significant improvement in productivity, and thus increased the options available to the farm manager in terms of what variety to plant. Hybrid corn offers a wide range of growing season varieties by which farm managers may now more optimally match growth to climate conditions for their area. Most regions presently enjoy the options of long, medium, short, and very short-season varieties.

Four such hybrids were selected for purposes of this study and applied to growing conditions for Cache Valley. These varieties are: Utah Hybrid 680 (long season), Utah Hybrid 544 (medium season), Utah Hybrid 330 (short season), and Utah Hybrid 216 (very short season). Table 33 in the Appendix gives the growing degree days to maturity and provides a more exact method of measuring relative time to maturity. These designations are of one particular company. Other companies would have a similar list of varieties. Because of the competitive nature of the corn-breeding industry, there is continual experimentation to develop new and improved strains. For the sake of simplicity, however, this discussion will be confined to the four varieties mentioned above. In the decision model, these four varieties will be labeled v_1 through v_4, where

v_1 = Utah Hybrid 680

v_2 = Utah Hybrid 544

v_3 = Utah Hybrid 330

v_4 = Utah Hybrid 216

In the following analysis, potential green weight yields (based on Table 36, Appendix) were assumed to be twenty-six tons per acre for Utah Hybrid 680, twenty-five tons per acre for Utah Hybrid 544, twenty-three tons per acre for Utah Hybrid 330, and sixteen tons per acre for Utah Hybrid 216. The prices used in figuring the profit or loss are taken from Table 32 in the Appendix. The budget cost information comes from budgets worked out at Utah State University.[19] Both prices and budget information are for the year 1973.[20]

Allowing for all possible combinations of planting dates and varieties, there are twenty courses of action that are open to the farm manager. Using the growth data in Table 36, Appendix, the GDDs to maturity found in Appendix Table 34, and the above assumptions, values of TDN per acre may be calculated for each combination of course of action and state of nature (Table 16). This table is the profit or gain table as referred to in the decision model. The growing degree days in Table 16 are figured from Utah State University Experiment Station data recorded during the years 1959-1966.

In the first planting period, a_1, if there is no frost, Utah Hybrid 544 yields the highest profit, but by the next planting period, a_2, Utah Hybrid 330 has a higher profit yield. Utah Hybrid 544 is a longer season variety than Utah Hybrid 330 and has a higher potential yield, but it

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[19] Rondo A. Christensen, Lynn H. Davis, and Stuart H. Richards, "Enterprise Budgets for Farm and RAnch Planning in Utah", Agricultural Experiment Station Research Report No. 5, Utah State University, Logan, Utah (April 1973), p. 24

[20] Statistical Reporting Service, U.S. Department of Agriculture, (Salt Lake City, Utah: Utah Agricultural Statistics, 1973).

Table 16. Profit table with all possible combinations of planting dates, varieties, and states of nature (based on 1973 prices and costs)

	States of Nature								
	n_1			n_2			n_3		
Courses of action	GDD	TDN*	Profit in $/acre	GDD	TDN	Profit in $/acre	GDD	TDN	Profit in $/acre
a_1v_1	2318	5.67	214.15	2278	5.56	207.82	2220	5.41	199.19
a_1v_2	2318	5.70	215.88	2278	5.60	210.12	2220	5.44	200.92
a_1v_3	2318	5.59	209.55	2278	5.59	209.55	2220	5.51	204.95
a_1v_4	2318	3.89	111.73	2278	3.89	111.73	2220	3.89	111.73
a_2v_1	2259	5.51	204.95	2219	5.40	198.62	2158	5.24	189.41
a_2v_2	2259	5.55	207.25	2219	5.43	200.34	2158	5.26	190.56
a_2v_3	2259	5.59	209.55	2219	5.51	204.95	2158	5.33	194.59
a_2v_4	2259	3.89	111.73	2219	3.89	111.73	2158	3.89	111.73
a_3v_1	2199	5.35	195.74	2159	5.24	189.41	2091	5.07	179.63
a_3v_2	2199	5.39	198.04	2159	5.26	190.56	2091	5.08	180.20
a_3v_3	2199	5.46	202.07	2159	5.33	194.59	2091	5.15	184.23
a_3v_4	2199	3.89	111.73	2159	3.89	111.73	2091	3.77	104.83
a_4v_1	2137	5.18	185.96	2097	5.07	179.63	2015	4.87	168.12
a_4v_2	2137	5.21	187.68	2097	5.10	181.35	2015	4.88	168.70
a_4v_3	2137	5.27	191.14	2097	5.16	184.81	2015	4.93	171.57
a_4v_4	2137	3.86	110.00	2097	3.78	105.40	2015	3.61	95.62
a_5v_1	2065	4.99	175.02	2025	4.89	169.27	1935	4.66	156.04
a_5v_2	2065	5.02	176.75	2025	4.92	171.00	1935	4.68	157.19
a_5v_3	2065	5.07	179.63	2025	4.96	173.30	1935	4.72	159.49
a_5v_4	2065	3.71	101.37	2025	3.63	96.77	1935	3.45	86.41

*TDNs in tons/acre.

Source: GDD taken from Appendix Tables 31 and 32; prices taken from Appendix Table 33; costs from: Christensen, "Enterprise Budgets for Farm. . ."

could seldom, if ever, realize its complete potential in Cache Valley. This would be possible in some of the relatively frost-free years if planting were early and harvest were late. Hard frosts that affect the first planting period would also give the advantage to Utah Hybrid 330 over 544. If an extra 120 GDD over the mean could be obtained, then that first period would look more like this:

	GDD	TDNs	Profit
a_1v_1	2438	6.01	$233.72
a_1v_2	2438	6.04	235.44
a_1v_3	2438	5.59	209.55
a_1v_4	2438	3.89	111.73

A further increase in GDD would give the advantage to Utah Hybrid 680. It can be concluded from the foregoing that it is best to use the corn hybrid with the longest possible growing season and still come close to the potential of the crop. Thus, it can be seen that the grain development during the final growth stage is quite important.

The data of Table 17 have been prepared to show the probability of each state of nature occurring in combination with each available action.[21] These are the <u>a priori</u> probabilities for the three states of nature, given any one planting date a_1 to a_i, figured on the basis of the thirty-year period 1931-1960.

Where there are no experimental means of predicting with any degree of accuracy the state of nature that will affect the decision in the immediate future, the situation becomes a "no data" problem to be solved by use of the <u>a priori</u> probabilities and the profit or gain table. Although this approach to the decision process is incomplete, it is

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[21] Richardson, Freeze-Free Seasons of State of Utah--Map and Table.

Table 17. A *priori* probabilities of the states of nature in relation to each course of action (based on 1941-1971 normals)

	States of nature		
Actions	n_1	n_2	n_3
a_1	.3	.45	.25
a_2	.45	.4	.15
a_3	.6	.3	.1
a_4	.75	.2	.05
a_5	.85	.14	.01

better than having no help at all. Table 18 gives the results of this process as calculated from the data in Tables 16 and 17.

From Table 18, the optimal time to plant would be the first period in May, a_1. It would be unwise to plant prior to May in Cache Valley as the probabilities of a killing frost are too high and the GDD or heat units decrease rapidly. The optimal choice in this first period would be a_1v_2. If it were not possible to plant in that first period, then a_2v_3 would be the next best choice. The optimal variety for each planting period is boxed in Table 18.

Now, turning to a discussion of the "data" problem, observations are taken and a posteriori probabilities are calculated. The first operation is to obtain the probability of success of the observation over an experimental period. From 1952-1974, there were seventeen years in which the frost problem was successfully avoided (n_1), two years with minor frost damage (n_2), and four years with major frost damage

Table 18. "No data" profit table with solutions

States of nature	Available actions				A priori prob. $P(n_j)$
	a_1v_1	a_1v_2	a_1v_3	a_1v_4	
n_1	214.15	215.88	209.55	111.73	.3
n_2	207.82	210.12	209.55	111.73	.45
n_3	199.19	200.92	204.95	111.73	.25
Total	207.56	[209.55]	208.40	111.73	1.0
	a_2v_1	a_2v_2	a_2v_3	a_2v_4	
n_1	204.95	207.25	209.55	111.73	.45
n_2	198.62	200.34	204.95	111.73	.4
n_3	189.41	190.56	194.59	111.73	.15
Total	200.09	201.98	[205.47]	111.73	1.0
	a_3v_1	a_3v_2	a_3v_3	a_3v_4	
n_1	195.74	198.04	202.07	111.73	.6
n_2	189.41	190.56	194.59	111.73	.3
n_3	179.63	180.20	184.23	104.83	.1
Total	192.23	194.01	[198.04]	111.04	1.0
	a_4v_1	a_4v_2	a_4v_3	a_4v4	
n_1	185.96	187.68	191.14	110.00	.75
n_2	179.63	181.35	184.81	105.40	.2
n_3	168.12	168.70	171.57	95.62	.05
Total	183.80	185.47	[188.90]	108.36	1.0
	a_5v_1	a_5v_2	a_5v_3	a_5v_4	
n_1	175.02	176.75	179.63	101.37	.85
n_2	169.27	171.00	173.30	96.77	.14
n_3	156.04	157.19	159.49	86.41	.01
Total	174.03	175.75	[178.54]	100.58	1.0

(n_3). (See Table 15.) The probability of each state of nature occurring after the observation of 70 growing degree days for the first time in seven consecutive days would be:

n_1 .739

n_2 .087

n_3 .174

These observation probabilities are multiplied by the corresponding a priori probabilities of Table 17 to derive the joint probabilities shown in Table 19. The columns have also been summed. Each a_i, n_j value in the matrix of Table 19 is divided by its corresponding sum at the bottom of each column to generate the values for the a posteriori probabilities (Table 20). It now becomes a simple operation to replace the a priori probability column from Table 18 with the a posteriori probability values from Table 20 and to multiply those values by the corresponding profit figures to generate the pay-off figures of Table 21.

If the seven consecutive days GDD total reaches seventy in the first planting period, then Utah Hybrid 544 would be the recommended crop for planting. If the seventy growing degree days are reached in the later periods in May, then Utah Hybrid 330 would be the recommended variety to plant. Utah Hybrid 544 would have a higher yield and higher profit, but the season is not quite long enough. The mean season in Cache Valley is about one-hundred GDD short of that required for the 544 variety, but it is ideal for the 330 variety. In a year with an exceptionally long growing season, the 544 variety would provide an extra profit for the farm manager, even above the figures of Table 21, as they are mean values. The potential yields and potential profits for the four crops under consideration (based on 1973 prices) are shown in Table 22.

Table 19. Joint probabilities

States of nature	$P(n_j) \cdot P(n_j, o_k)$				
	a_1	a_2	a_3	a_4	a_5
n_1	.222	.333	.443	.554	.628
n_2	.039	.035	.026	.017	.012
n_3	.044	.026	.017	.009	.002
Total	.305	.394	.486	.580	.642

Table 20. A *posteriori* probabilities

States of nature	Available actions				
	a_1	a_2	a_3	a_4	a_5
n_1	.728	.845	.912	.955	.978
n_2	.128	.089	.053	.029	.019
n_3	.144	.066	.035	.016	.003
Total	1.0	1.0	1.0	1.0	1.0

Table 21. Pay-off table, given the possible planting dates and varieties

States of nature	Available actions				A posteriori prob.
	$a1_v1$	a_1v_2	a_1v_3	a_1v_4	
n_1	214.15	215.88	209.55	111.73	.728
n_2	207.82	210.12	209.55	111.73	.128
n_3	199.19	200.92	204.95	111.73	.144
Total	211.19	**212.99**	208.89	111.73	1.0
	a_2v_1	a_2v_2	a_2v_3	a_2v_4	
n_1	204.95	207.25	209.55	111.73	.845
n_2	198.62	200.34	204.95	111.73	.089
n_3	189.41	190.56	194.59	111.73	.066
Total	203.36	205.53	**208.15**	111.73	1.0
	a_3v_1	a_3v_2	a_3v_3	a_3v_4	
n_1	195.74	198.04	202.07	111.73	.912
n_2	189.41	190.56	194.59	111.73	.053
n_3	179.63	180.20	184.23	104.83	.035
Total	194.84	197.02	**201.05**	111.49	1.0
	a_4v_1	a_4v_2	a_4v_3	a_4v_4	
n_1	185.96	187.68	191.14	110.00	.955
n_2	179.63	181.35	184.81	105.40	.029
n_3	168.12	168.70	171.57	95.62	.016
Total	185.49	187.19	**190.64**	109.64	1.0
	a_5v_1	a_5v_2	a_5v_3	a_5v_4	
n_1	175.02	176.75	179.63	101.37	.978
n_2	169.27	171.00	173.30	96.77	.019
n_3	156.04	157.19	159.49	86.41	.003
Total	174.85	176.58	**179.45**	101.24	1.0

Table 22. Potential yields and profits for four corn varieties in Cache Valley, Utah

Variety	Potential yield	Profit
	Tons TDN/acre	$/acre
#680	6.32	$ 251.55
#544	6.08	232.74
#330	5.59	209.55
#216	3.89	111.73

Replanting

To this point, states of nature n_2 and n_3 have been discussed only in the light of temporary frost damage where the corn plant is retarded for a period of time and eventually recovers to its normal strength. Sufficiently low tenperatures over an extended period of time cause permanent crop damage beyond the point where recovery is possible. Although a temperature of 28° F is considered a killing frost, this is a marginal point and the plant may still recover. It may even recover from a 27° F frost, but a 26° F frost of one hour or more duration will kill the plant.[22] When the temperature drops below 26° F, permanent damage is certain. If, however, the sun comes up shortly after a 26° F low and the temperature climbs rapidly, then there will not be permanent damage as there would be if the frost were maintained.[23] Replanting becomes an important consideration in this situation.

[22] Kenneth Wilford Hill, Professor of Plant Science, Utah State University. Personal interview, August 12, 1975.

[23] Ibid.

The farm manager in Cache Valley faces the possibility of finding himself in this situation, and in some localities there is a much greater chance than in others. Figure 2, for example, shows that for the different locations where weather data are collected, there is a wide range of probabilities for frost occurrence and intensity. Lewiston, Utah, located in area II, has 100-120 frost-free growing days. The Utah State University Experimental Farm, located in area IV, has 140-160 frost-free growing days. The Utah State University is within area V where there are 160-180 frost-free growing days.

The probabilities of a heavy frost occurring are different for each of the numbered areas in Figure 2. For example, there is a 50 percent chance of a 24° F frost in Lewiston on April 25, at the Utah State University Experiment Farm on April 5, and at Utah State University on March 26.[24] On any given date early in the growing season, the farmer in Lewiston runs a higher risk of a killing frost than the farmer in the area of the Utah State University Experimental Farm. Table 23 records the dates in Cache Valley from 1952-1974 on which killing frosts occurred which would have come after the date of emergence if the 70 growing degree day criterion for planting had been used. This table shows that over the 23-year period there have been several examples of killing frost at the three recording stations mentioned which would have resulted in crop damage.

There are times in this mountain valley when frost damage is severe enough that replanting would be more profitable than nursing along a severely damaged crop. If the temperature reaches a 28° F minimum, then

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[24] Richardson, Freeze-Free Seasons of State of Utah—Map and Table.

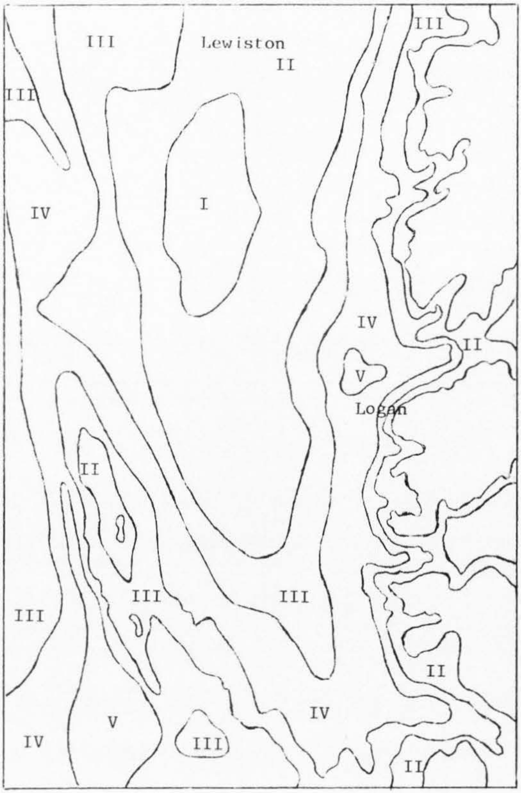

Figure 2. Freeze-free season in Cache Valley

Key:

No. of days	Area
80-100	I
100-120	II
120-140	III
140-160	IV
160-180	V

Source: Richardson, Freeze-Free Seasons of State of Utah—Map and Table.

Table 23. Killing frosts in Cache Valley, 1952-1974

Year	Emergence date emerge 80 GDD after planting	Lewiston		Logan USU		Logan USU Exp. Station	
		Date	Temp.	Date	Temp.	Date	Temp.
1952	May 12					May 16	26°F
1953	June 9						
1954	May 14	May 28	25°F			May 28	28°F
1955	May 19	May 28	26°F				
1956	May 19						
1957	May 15						
1958	May 16						
1959	May 30						
1960	May 16	June 21	27°F				
1961	May 27						
1962	May 12						
1963	May 14						
1964	May 21						
1965	May 24						
1966	May 8	May 23	26°F			May 23	27°F
1967	May 25						
1968	May 18						
1969	May 12						
1970	May 19						
1971	May 14						
1972	May 16						
1973	May 18						
1974	May 11						

the crop will probably bounce back and one should not worry too much about replanting unless damaging temperatures existed over a long period of time. If, however, the minimum temperature reaches 27° F or lower, and is maintained for an hour or more, then replanting should be strongly considered.

The experimental corn trials performed at Utah State University in 1966 provide an interesting case study with regard to this marginal area of frost damage where replanting may be an alternative. The data from Table 29 (Appendix) show that a 27° F minimum temperature was recorded at the Utah State University Experiment Station on May 23, 1966. According to Table 28 (Appendix), emergence would have taken place on May eighth. A basis for comparison is established in this case because part of the experimental crop was left in the ground while the rest was replanted. As might be predicted from the 27° F minimum, this proved to be a marginal case where some varieties did slightly better on replanting while other varieties did better by leaving the original plant for recovery. There were some varieties which showed no apparent difference in yield between the replanted sector and that left for recovery. Table 24 shows a comparison of total digestible nutrients for the two cases in question.

The minimum temperature recorded at Lewiston, Utah on May 23, 1966 was 26° F (Table 29, Appendix). Since corn trials were not being conducted in that area at the time, one can only speculate. It is likely, though, that the results would have strongly favored replanting.

While the decision to replant is a matter of individual judgment in these marginal cases, there are times when this decision is unquestionably

Table 24. A comparison of yields in TDNs for a number of varieties of corn in Cache Valley, 1966, when part of the corn was left in the ground after a hard frost and part was replanted

Corn variety	Yield in tons Re*	Yield in tons Pl**	in tons Re-Pl	Maturity Re	Maturity Pl	TDN in tons Re	TDN in tons Pl	TDN in tons Re-Pl
DeKalb								
805 A	8.1	7.4	+0.7	2.8	2.4	5.2	4.8	+0.4
664	7.9	7.9	0	3.8	3.5	4.6	4.7	-0.1
1051	7.4	7.9	-0.5	4.8	4.0	3.7	4.4	-0.7
Exp. 613	7.4	7.1	+0.3	3.6	3.3	4.4	4.4	0
640	7.1	6.8	+0.3	3.5	3.4	4.3	4.1	+0.2
XL 385	7.0	7.7	-0.7	4.0	2.9	3.9	4.9	-1.0
XL 369	7.0	6.7	+0.3	3.6	3.5	4.1	4.0	+0.1
XL 361	6.7	6.9	-0.2	3.0	2.8	4.3	4.4	-0.1
XL 362	6.7	6.8	-0.1	2.6	1.9	4.3	4.5	-0.2
XL 65 A	5.9	5.9	0	3.0	3.0	3.8	3.8	0
Funks								
G 4680	7.4	7.2	+0.2	4.1	3.9	4.0	4.1	-0.1
G 4601	7.1	7.2	-0.1	3.1	3.4	4.5	4.4	+0.1
G 4697	7.1	6.9	+0.2	2.6	3.0	4.6	4.4	+0.2
G 4390	6.6	6.6	0	3.3	2.5	4.1	4.3	-0.2
G 91	6.6	7.0	-0.4	3.0	3.0	4.2	4.5	-0.3
G 17 A	6.3	5.6	+0.7	1.0	1.0	4.4	3.9	+0.5
Golden								
450	6.9	6.4	+0.5	2.5	1.8	4.5	4.3	+0.2
Portwalco								
PW 120	6.7	6.4	+0.3	4.5	4.0	3.2	3.6	-0.4
PW 100	6.7	6.2	+0.5	2.8	2.8	4.3	4.0	+0.3

Table 24. Continued

Corn variety	Yield in tons Re*	Pl**	in tons Re-Pl	Maturity Re	Pl	TDN in tons Re	Pl	TDN in tons Re-Pl
Kingscrost								
PX 616	7.4	7.2	-0.2	2.4	3.3	4.8	4.7	+0.1
KT 623 A	7.0	6.3	+0.7	2.4	2.5	4.6	4.1	+0.5
PX 610	6.7	6.0	+0.7	2.6	1.6	4.3	4.1	+0.2
PX 676	6.7	6.4	+0.3	3.3	2.5	4.1	4.2	-0.1
KM 589	6.5	5.6	+0.9	2.6	2.6	4.2	3.6	+0.6
KE 497	6.5	4.9	+1.6	2.1	1.0	4.3	3.4	+0.9
PX 674	6.4	6.4	0	3.6	3.1	3.8	4.0	-0.2
KT 665	6.3	6.9	-0.6	3.1	4.0	4.0	3.9	+0.1
KE 449	4.9	4.3	+0.6	1.4	1.0	3.4	3.0	+0.4
P.A.G.								
SX 29	7.4	7.7	-0.3	4.0	4.0	4.1	4.3	-0.2
395	6.7	6.3	+0.4	3.8	2.8	3.9	4.1	-0.2
437	6.7	6.2	+0.5	3.6	2.6	4.0	4.0	0
Utahybrid								
33-30	7.2	7.9	-0.7	2.6	2.2	4.7	5.2	-0.5
680	6.7	6.4	+0.3	2.0	2.0	4.4	4.2	+0.2
54-40	6.6	6.0	+0.6	2.1	2.5	4.3	3.9	+0.4
544 A	5.8	5.5	+0.3	1.6	1.0	3.9	3.9	0
216	4.4	3.8	+0.6	1.4	1.0	3.0	2.7	+0.3

*Re = Crop frozen and replanted

**Pl = Crop was frozen, but left in the ground and not replanted resolved. For example, a 25° F frost was recorded at Lewiston, Utah on May 28, 1954 (Table 29, Appendix). Computed by the 70 GDD method, emergence would have been on May fourteenth. This definitely would have been a killing frost for corn and replanting would have been a necessity.

In the majority of cases, these late killing frosts come without warning. The cost of replanting, if it becomes necessary, is about twenty dollars per acre.[25] A new factor must be considered in the profit computations of Table 21 in order to account for the cost of replanting. This term is designated by a_6 through a_{11}, depending on the replanting period, where:

a_6 = May 14-19

a_7 = May 20-25

a_8 = May 26-31

a_9 = June 1-6

a_{10} = June 7-12

a_{11} = June 13-18

The state of nature requiring replanting is designated as n_3'. Table 25 shows the schedule of profits per acre where replanting is necessary. Utah Hybrid 680 is not considered as a variety for replanting because of its long growing season. Utah Hybrid 330 is the best variety of the four to use in this case.

Water shortage as a factor in corn variety selection

Cache Valley is not an area characterized by water shortage. Generous amounts of precipitation occur during the spring months and there is an

[25]Christensen, "Enterprise Budgets", p. 24.

Table 25. Profit for replanting corn after a hard killing frost

	Replant after bad frost n_3' (Assume no frost after)		
Available actions	GDD	Yield TDNs in tons/acre	Profit in $/acre
a_6v_2	2179	5.32	174.01
a_6v_3	2179	5.40	178.62
a_6v_4	2179	3.89	91.73
a_7v_2	2117	5.16	164.81
a_7v_3	2117	5.22	168.26
a_7v_4	2117	3.82	87.70
a_8v_2	2043	4.96	153.30
a_8v_3	2043	5.02	156.75
a_8v_4	2043	3.67	79.07
a_9v_2	1965	4.76	141.79
a_9v_3	1965	4.80	144.09
a_9v_4	1965	3.51	69.87
$a_{10}v_2$	1880	4.53	128.56
$a_{10}v_3$	1880	4.57	130.86
$a_{10}v_4$	1880	3.34	60.08
$a_{11}v_2$	1788	4.30	115.32
$a_{11}v_3$	1788	4.33	117.05
$a_{11}v_4$	1788	3.16	49.73

abundance of stream flow from several rivers making supplemental irrigation water plentiful.[26] Only a few high bench areas have ever experienced water shortages in the past. In order, then, to consider the effects of water shortage on corn variety selection, reference is made here to a 1970 study conducted in Sevier County, Utah, where water is not as abundant as in Cache Valley.[27]

In that study, irrigation water available to the Sevier County farmer was estimated by a snowpack and reservoir storage measurements taken on April 1. Using this information and the decision theory process, predictions were made as to whether the water supply for that year would be poor, fair, good, or excellent. According to this study, annual supplies of water can be categorized into one of these types of water years: poor—1.84 acre feet (22.1 acre inches) per acre of land, fair—2.67 acre feet (32.0 acre inches) per acre of land, good—2.95 acre feet (35.4 acre inches) per acre of land, and excellent—3.25 acre feet (39.0 acre inches) per acre of land.

Comparative consumptive use requirements for the Cache and Sevier Valleys of Utah, shown in Table 26, have been calculated from data compiled by Milo E. Lyon.[28]

The work of R. W. Hill, et al., emphasizes the importance of timing in the application of water to maximize yields when the water supply is

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[26] U. S. Department of Commerce, Weather Bureau. Climatological Summary, Climatography of the United States No. 20-42, Utah State University, Logan, Utah, 1941-1970.

[27] Suwaphot Lakawathana, "An Application of Statistical Decision Theory to Farm Management in Sevier County, Utah", unpublished MS thesis, Utah State University Library, Logan, Utah (1970).

[28] Milo E. Lyon, Watershed Planning Staff Engineer, Salt Lake City, Utah. Consumptive Use Computer Program, 1970.

Table 26. Consumptive use schedule for the Cache Valley and Sevier Valley

	Month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Cache Valley	Water (inches)											
Normal consumptive use	0.10	0.13	0.22	0.51	1.19	2.78	5.98	6.01	2.26	0.48	0.17	0.13
Effective precipitation	1.08	0.93	1.12	1.34	1.36	1.04	0.48	0.81	0.67	1.02	0.95	1.08
Normal net irrigation requirement	-0.98	-0.80	-0.90	-0.83	-0.18	1.73	5.50	5.20	1.60	-0.54	-0.78	-0.95

Note: Soil moisture capacity 5.2 inches
Growing season = May 17 to Sep. 16 (122 days)

Sevier Valley	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Normal consumptive use	0.14	0.17	0.32	0.57	1.52	3.27	6.40	6.43	3.30	0.56	0.22	0.15
Effective precipitation	0.38	0.40	0.59	0.47	0.54	0.48	0.73	0.70	0.35	0.43	0.38	0.41
Normal net irrigation requirement	-0.24	-0.23	-0.26	0.10	0.98	2.79	5.66	5.73	2.95	0.13	-0.16	-0.25

Note: Soil moisture capacity 5.2 inches
Growing season = May 9 to Sept. 23 (137 days)

short.[29] Their investigations show that the third growth stage, tassel to silk, is the critical time to meet the water requirement of the plant and to not put it under stress of insufficient moisture. If the corn plant has its full water requirement up to the end of the third growth stage, better than 90 percent of its potential yield will be realized even if the water supply is then cut off.

From the data of Tables 15, 30, 31, and 35, it is possible to predict when the third growth stage, tassel to silk, will occur. Estimations of those dates for each of the previous choices of action a_1 through a_{11} are recorded in Table 27.

In Sevier County, the soil moisture would probably accommodate the net irrigation requirement for the month of May. Beyond that point, this requirement can be met by applications of two to three inches of irrigation water every seven to ten days.[30] Four lines have been drawn on Table 27 to represent the four types of water supplies: poor, fair, good, and excellent. From the April 1 snowpack and storage readings, the farmer will know what type of water supply to expect for that year. Any of the actions above the line in Table 27 corresponding to the predicted water supply will provide water to the end of the third growth stage of the corn plant and thus assure 90 percent or better of the yield potential of the variety planted.

There is one case where the farm manager would not have a choice of action above the corresponding line on Table 27. This situation would occur if a poor water supply was predicted and after planting there was a

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[29] Hill, Hanks, Keller, and Rasmussen, "Predicting Corn Growth", p.

[30] Lyon, Consumptive Use Computer Program.

Table 27. Dates when third growth stage of corn is reached for various planting dates and varieties with lines drawn to show when water runs out with different water supplies

Available actions	Growth stages v_4 Tassel	to silk	v_3 Tassel	to silk	v_2 Tassel	to silk	v_1 Tassel	to silk	
									Poor water supply
a_1	July 10	July 30	July 12	Aug. 1	July 16	Aug. 3	July 17	Aug. 6	
a_2	July 13	Aug. 2	July 15	Aug. 4	July 19	Aug. 6	July 20	Aug. 8	
a_3	July 16	Aug. 5	July 18	Aug. 7	July 22	Aug. 8	July 23	Aug. 11	
a_4	July 19	Aug. 8	July 21	Aug. 10	July 25	Aug. 11	July 26	Aug. 14	
a_5	July 22	Aug. 11	July 24	Aug. 13	July 28	Aug. 15	July 29	Aug. 17	
a_6	July 16	Aug. 5	July 18	Aug. 7	July 22	Aug. 8	July 23	Aug. 11	
a_7	July 20	Aug. 9	July 22	Aug. 11	July 26	Aug. 12	July 27	Aug. 15	
a_8	July 23	Aug. 12	July 25	Aug. 14	July 29	Aug. 16	July 30	Aug. 18	Fair water supply
a_9	July 26	Aug. 15	July 28	Aug. 17	July 31	Aug. 18	Aug. 1	Aug. 22	Good water supply
a_{10}	July 30	Aug. 18	Aug. 1	Aug. 20	Aug. 4	Aug. 24	Aug. 5	Aug. 27	
a_{11}	Aug. 3	Aug. 21	Aug. 5	Aug. 23	Aug. 8	Aug. 30	Aug. 9	Sept. 3	Excellent water supply
GDD	880-1228		918-1283		996-1394		1035-1450		

killing frost which only left action a_7 open. The farmer is then unable to pick an action which is above the line corresponding to the poor water supply. It would be best in this situation to plant a short season variety.

It can be noted from Table 27 that an excellent water supply permits the choice of any variety in combination with any course of action. Even with a fair water supply indication, most combinations of actions and varieties are open to the decision maker. The greater latitude of choice is open where a fair prospect exists. Only a few more choices are opened by good and excellent indicators over a fair reading.

As indicated in Table 28, the average annual precipitation in Cache Valley is over twice that of Sevier County.[31] Cache streamflows are much higher and last longer into the season, thus allowing most farmers to irrigate throughout the entire season. The discussion on water shortage as a factor in corn variety selection has been presented as a reference for the farm manager in the event that an abnormally dry year should occur in Cache Valley or a similar region and as an illustration of the method.

Harvest considerations

There has been much discussion and perhaps even a little dispute about the best time for harvesting corn. Some of the key areas for consideration are: precipitation, fall frosts, maturity, and silage moisture content.

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[31] U.S. Department of Commerce, Weather Bureau. Logan and Richfield, Utah.

Table 28. Normal precipitation (inches) for Cache Valley and Sevier Valley, 1941-1970

Area	Month												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Lewiston	1.70	1.43	1.60	1.96	1.99	1.92	0.46	0.98	1.02	1.38	1.59	1.61	17.64
Logan (USU)	1.36	1.45	1.74	2.12	1.86	1.78	0.34	0.87	0.94	1.43	1.79	1.64	17.59
Richfield (KSVC)	0.57	0.65	0.79	0.79	0.72	0.61	0.78	0.72	0.69	0.66	0.59	0.59	8.16

Precipitation. Snow and rain are possible constraints on the growing season in Cache Valley. Although it could be a problem, snow does not generally stay on the ground long enough to interfere with the harvest. One of the earliest snows on record occurred on October 1, 1971, but the snow did not stay long enough to damage the harvest (Table 40, Appendix). According to Arlo Richardson, Climatologist at Utah State University, snow in Cache Valley does not begin to accumulate until late November or early December,[32] and frosts would have stopped the growth of the plant long before that time.

Rain is more of a problem than snow. The rain itself does not damage the corn, but if the soil gets too wet, the heavy equipment used for harvesting is unable to function properly. When cooler fall temperatures prevail and there is very little solar radiation, soil dries very slowly. With a one-inch rainfall and temperatures of about 60° F, the soil will take a week or two to dry sufficiently for harvesting the corn.[33] Table 38 (Appendix) gives moisture accumulations in the fall months near an expected normal harvest time. From these data, it is evident that there are not too many times when the farm manager can harvest and avoid the heavy moisture. A mid-September harvest would have been possible all of the years from 1952 to 1966 with the exception of 1965. Harvesting this early would minimize the risk of wet weather but would also shorten the growing season. The farm manager takes more of a risk by waiting until the last week of September to harvest, but he will also increase the yield. If harvest is delayed past the first few

[32] Richardson, Utah State Climatologist, personal interview.

[33] Ibid.

days of October, the risk factor is greatly increased. After the first ten days of the month, precipitation begins to accumulate more rapidly (Table 40, Appendix). This action is consistent with the recommendations in the planting date and planting sections of this study.

Fall frosts. Cool nights can be expected in the fall months in the valleys of northern Utah. By the last week in September, the probability of a 32° F frost is 50 percent, and by October 11 the probability of a 28° F frost is 50 percent.[34] The ideal situation is for the corn to reach maturity and be harvested without a frost, but this is not always possible in this climate since frosts are not always one hundred percent predictable. What can be done to minimize losses and maximize profits if an unpredicted frost hits? DeVere R. McAllister, Extension Agronomist at Utah State University, suggests three procedures that will help:

1. "If the corn was in the eary glaze stage when frosted, harvest as soon as possible as further drying will make packing more difficult.

2. If corn is immature (milk, early dough—partially dented), let it be, if the frost nips only the tops above the ears. Periodically check for the early glaze stage and harvest when ready. More growth will occur.

3. If corn is immature (milk or early dough—partially dented), and is frosted to below the ears or to the ground, let it dry several days in the field under bright, clear weather or a week in damp, cloudy weather. There will be no further growth during this delay but the moisture level in the stalks and ears will decrease allowing better storage and diminished leakage from the silage mass. The leaves on a mature, unfrosted corn plant make up only 15 percent of the total weight. Should they frost and blow off, you still have from 85 to 90 percent of the total left."[35]

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[34] Richardson, Freeze-Free Seasons of State of Utah—Map and Table.

[35] McAllister, "More and Better Corn Silage", p. 3.

One of the real dangers of frost is that too much drying can take place. Most sources have stated that the ideal moisture level is between 60 and 70 percent for compacting and storage.

Maturity. All of the efforts expended during the growing season are culminated in the harvest. Determining the proper degree of maturity is an important factor in optimizing crop yield. There have been several methods suggested for testing maturity from extensive research done on this subject in recent years. The Northrup King Company, for example, suggests:

> "One good way to determine whether or not your corn has matured is to split a kernel from tip to top (illustration B). It has completed its growth cycle when a tough black layer has formed just above the tip, (illustration A), which seals off the embryo and starchy endosperm. Once it reaches this state, corn will start to dry out naturally. No further grain development occurs."[36]

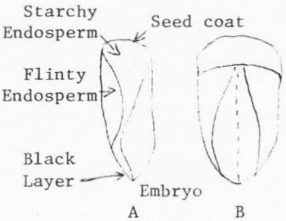

Figure 3. Sign of maturity, showing one method of determining maturity of the grain in corn silage.

DeVere R. McAllister, Extension Agronomist at Utah State University, makes the following suggestion on how to tell the corn is mature:

> "The ideal time to harvest for safe storage and maximum milk or meat per acre is when the kernels begin to glaze, which is well past the time when hernels are just dented. It is later than you think by just looking at the plant and the outside of the ears. You can afford to let some of the lower leaves die and fall off rather than rush harvesting

[36]Northrup King Company, personal correspondence.

> the crop with the grain still growing. In late August or early September, go into the field at least once a week and break the upper half off of several ears from scattered locations leaving the butt of the ear on the plant. Now examine the kernels around the ring of the broken upper half of each ear. Using your fingernail, a pencil, a nail, or other pointed object, pierce the lower part of each kernel around the ring. If juice comes out, you are too early as starch is still being deposited in the kernels and maximum starch accumulation has not occurred. When the kernels have reached the hard-dough or early glaze stage, no juice will be evident and growth will have ceased—go ahead and harvest."[37]

Another method that has proven accurate and that is easy to use is the accumulation of growing degree days. This measure gives the farm manager up-to-date information as to how his crop is maturing and provides him with a means of making some projections as to what he will have to do at harvest. Will the crop reach full maturity? Through the accumulation of heat units, it can be noted whether or not the season has been as hot or as long as normal. If the season has been hotter than normal, the farmer can expect an early harvest. From Tables 33 and 35 in the Appendix, it is possible to predict the time of maturity by accumulating heat units. The growing degree day formula (page 24) is simple to use and calculations can be easily handled.

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[37] McAllister, "More and Better Corn Silage", p. 1.

SUMMARY AND CONCLUSIONS

In summary, this study has been accomplished for the purpose of aiding the farm manager in making better decisions with regard to the choices of action that will yield the best results in corn production when the constraints of variable nature are imposed. Although the unpredictability of weather conditions preclude any cut-and-dried answers, a foreknowledge of the states of nature that can occur and the relative advantages of certain courses of action to take when they do occur is a requisite for improving the decision process and, consequently, profit yield.

The process of corn production is analogous to playing the game of chess. It is impossible to predict exactly how the opponent will move, but it is possible to study his alternatives and to plan the strategy of a move to any one of those alternatives. So it is with corn production. The farm manager does not know when or how nature is going to move to thwart or aid him, but by studying the alternatives and planning a strategy for each, he stands a much better chance of making the right move when a given constraint is imposed at random.

Specifically, this study has considered the various states of nature that are likely to occur in any given year that will condition corn production, particularly in the Cache Valley area (e.g., water shortage, late planting date, spring or fall frosts, precipitation at harvest time). The study further evaluates each alternative course of action for these states of nature and makes recommendations pertinent to three major concerns of corn producers: when to plant, what variety to plant, and when to harvest. Treatment is also given the matter of replanting after a damaging spring frost.

The April 1 observation of snowpack and water storage readings are the first indicator to have a bearing on planting decisions. The only way in which these decisions would be affected is if the reading predicted a poor water year, in which case the short-season varieties such as Utah hybrids 216 and 330 would be the only two that would have sufficient water to reach third stage, and hybrid 330 would bring in the most profit of the two (see Table 26). With a poor water supply indication, the farm manager would be better off to risk crop loss by frost and plant on the first planting date that he can get his equipment on the field. The longer the wait, the greater the chance of running out of water before third stage is reached, even with short-season varieties.

In the event of either a fair or a good water supply reading, the only actions affected would be if a replant became necessary. Since the longer season varieties would be the shortest on water, it would be wise in the case of a replant to use a short season variety. An excellent water supply reading, such as is normal in Cache Valley, has no effect at all upon the actions to be taken.

The planting date criterion suggested in this paper is the seventy growing degree days accumulated in seven days method. Two significant advantages of this system are the simplicity in making measurements and the safer margin which it provides for avoidance of early frost damage. The only equipment needed by the farm manager serious about using this method for collection of data is a minimum-maximum thermometer for monitoring growing degree days in his own locality. This is important because the growing season can vary significantly over a small area.

Along with a planting date, it is important to select an appropriate variety of corn to plant (see Table 21). Within the limits of the growing conditions imposed, the best variety would be either Utah Hybrid 544 or Utah Hybrid 330. (Other comparable season length varieties of other brand names are available for selection.)

The next major decision, that of replanting, is a consideration only when a damaging frost occurs. If the frost is a killing one (28° F or below and of sufficient duration), then it is most profitable to replant as many of the plants in the field will have been killed. Table 24 shows the profitability of the Utah Hybrids 544 (medium season), 330 (short season), and 216 (very short season). From the table, it is apparent that the short-season variety (Utah Hybrid 330) is the most profitable for replanting in Cache Valley.

The final decision, that of when to harvest, is contingent upon all of the preceding decisions and their outcomes. The chances are remote that there will be no setbacks during the growing season and that selection of a harvest date will merely be a matter of checking for optimum maturity. It is more reasonable to suppose that some of the factors mentioned earlier (frost, late planting date, precipitation) will have interferred with maturity so that it now becomes necessary to extend the growing season. This is a prime consideration since starches are deposited in the corn during the last growth stage.

There were three methods discussed in the previous section for determining the degree of maturity of the corn plant. This study recommends use of the accumulated growing degree days (GDD) to maturity for determining the approximate date of maturity. As this date approaches, it is recommended that the farm manager use one of the two field tests discussed in order to determine exact harvest time.

Although the farmer in Cache Valley might be tempted to harvest by mid-September, it is recommended that harvest be deferred until at least the last week of September to allow for greater maturity, but not pushed beyond mid-October. The farm manager would be pressing his luck to go past the first ten days of October as precipitation begins to accumulate more rapidly after that date.

The threat of frost is probably not as serious as is the problem of excessive precipitation. Fall frosts will not force early harvest unless the plant is frosted in the stalks below the ears. Excessive precipitation, on the other hand, may render fields impassable by heavy harvesting equipment.

Trying to pinpoint an exact time of harvesting is like trying to predict on the stock market exactly when to sell a given stock—it can't be done. About all one can do is to study the indicators, be appraised of the risks involved, and know what risks they are willing to take in return for the potential of increased benefits. This study has attempted to equip the farm manager with a set of criteria that will enable him to employ a more systematic approach to the decision problems that, in the final analysis, he alone must make.

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APPENDIX

Table 29. Yields compared with frost dates and their intensities for the years 1959-1966

Frost dates	Temp. (Degrees F)	GDD between last spring and first fall frosts	Planting date	Emergence	Harvest date	GDD between planting and harvest dates	Yield (tons/acre) variety 680 DW	680 TDN	544 DW	544 TDN	330 DW	330 TDN	216 DW	216 TDN
1966 May 23	27	2177.5	May 3	May 8	Sept. 21	2412.0	6.4	4.2	-	-	-	-	3.8	2.7
1966 May 23	27	2177.5	May 24	May 29	Sept. 21	2177.5	6.7	4.4	-	-	-	-	4.4	3.0
1966 Oct. 4	27													
1966 Oct. 5	32													
1966 Oct. 10	29*													
1966 Oct. 13	32													
1966 Oct. 14	21													
1965 May 3	30	1962.5	May 3	May 16	Sept. 21	1985.0	8.3	5.5	6.9	4.5	7.0	4.9	4.6	3.2
1965 May 5	30													
1965 May 6	25													
1965 May 7	26													
1965 Sept. 17	32													

Table 29. Continued

Frost dates	Temp. (Degrees F)	GDD between last spring and first fall frosts	Planting date	Emergence	Harvest date	GDD between planting and harvest dates	Yield (tons/acre) variety 680 DW	680 TDN	544 DW	544 TDN	330 DW	330 TDN	216 DW	216 TDN
1965 Sept. 18	24													
1965 Sept. 19	32*													
1965 Sept. 20	28*													
1965 Sept. 24	32													
1964 May 2	30	1771.0	May 11	May 17	Sept. 14	1992.5	6.5	3.8	5.9	3.8	6.2	4.3	5.5	3.9
1964 May 3	25													
1964 May 4	25													
1964 May 5	32													
1964 Aug. 30	32													
1964 Sept. 19	31*													
1964 Sept. 27	31*													
1963 Oct. 24	29*	2381.0	May 8	May 17	Oct. 2	2381.0	9.4	6.5	7.2	5.0	7.1	5.0	5.7	4.0
1963 Oct. 27	25													

Table 29. Continued

Frost dates	Temp. (Degrees F)	GDD between last spring and first fall frosts	Planting date	Emergence	Harvest date	GDD between planting and harvest dates	Yield (tons/acre) variety							
							680		544		330		216	
							DW	TDN	DW	TDN	DW	TDN	DW	TDN
1963 Oct. 28	26													
1963 Oct. 31	30													
1962 May 1	30*	1769.0	May 4	May 10	Sept. 10	1990.5	7.1	4.0	6.6	4.3	6.6	4.4	4.9	3.4
1962 June 7	30													
1962 Sept. 9	30													
1962 Sept. 30	29													
1961 May 3	31*	2222.0	May 4	May 16	Sept. 24	2288.0	7.9	5.5	8.3	5.8	9.1	6.4	7.9	5.5
1961 May 5	24													
1961 May 6	26													
1961 May 8	32*													
1961 May 13	30													
1961 Sept. 14	32													
1961 Sept. 22	30*													

Table 29. Continued

Frost dates	Temp. (Degrees F)	GDD between last spring and first fall frosts	Planting date	Emergence	Harvest date	GDD between planting and harvest dates	Yield (tons/acre) variety							
							680		544		330		216	
							DW	TDN	DW	TDN	DW	TDN	DW	TDN
1961 Sept. 24	30													
1961 Sept. 25	30*													
1961 Sept. 27	30*													
1960 May 18	32	1735.5	June 21	June 26	Sept. 23	1735.5	-	-	5.3	2.8	5.6	3.2	4.7	3.1
1960 May 19	32													
1960 May 24	31*													
1960 June 21	31*													
1960 Oct. 9	32													
1960 Oct. 13	32													
1960 Oct. 14	28*													
1960 Oct. 15	27													
1960 Oct. 16	30*													
1959 May 3	28*	2019.0	May 8	May 16	Sept. 17	2125.5	5.8	3.7	6.0	4.1	6.2	4.3	4.8	3.4

Table 29. Continued

Frost dates	Temp. (Degrees F)	GDD between last spring and first fall frosts	Planting date	Emergence	Harvest date	GDD between planting and harvest dates	Yield (tons/acre) variety 680 DW		544 DW		330 DW		216 DW	
							DW	TDN	DW	TDN	DW	TDN	DW	TDN
1959 May 5	27													
1959 May 7	30													
1959 May 10	30													
1959 May 21	28													
1959 May 22	29													
1959 Sept. 29	32*													
1959 Sept. 30	30*													
1959 Oct. 2	30*													
1959 Oct. 3	31													
1959 Oct. 8	27*													

*Locally heavy frosts

Source: Data compiled from Tables 30,31,32, and 37.

Table 30. Minimum and maximum daily temperatures for selected weather stations in Cache Valley for key months in the growing season, 1952-1975

Station		Daily temperatures — Day of month 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
																															May 1952	
Lewiston	Max	76	81	71	72	75	75	74	58	63	69	77	82	76	77	59	57	66	69	73	63	55	54	73	77	77	70	77	80	75	78	79
	Min	43	39	40	39	36	37	36	46	42	33	37	40	46	34	30	42	34	32	39	48	42	39	38	41	42	42	36	39	51	33	41
Logan USU	Max	68	73	80	80	72	76	74	72	58	61	68	76	80	76	74	57	52	65	70	71	63	51	53	70	77	79	69	75	80	75	72
	Min	48	51	54	43	43	46	45	45	42	43	45	50	51	45	35	40	44	41	43	48	44	40	41	48	49	49	45	48	53	42	47
Logan USU	Max	73	80	81	74	75	74	79	72	62	68	77	80	72	75	59	54	65	70	72	67	53	51	70	75	78	70	74	80	79	72	81
Exp. Sta.	Min	41	42	51	40	39	40	39	44	41	37	41	44	52	39	31	26	40	35	43	43	43	39	40	44	47	42	40	42	52	38	42
																															May 1953	
Lewiston	Max	47	52	58	64	72	75	69	51	47	45	55	60	60	68	69	69	69	67	57	56	57	60	62	52	66	69	74	73	54	72	76
	Min	33	28	27	26	29	34	38	33	37	32	31	33	37	35	35	37	37	42	43	43	41	33	38	36	28	39	37	37	37	38	39
Logan USU	Max	46	51	53	58	64	71	75	67	54	46	42	55	56	68	71	63	68	68	64	62	58	56	59	56	53	69	70	72	72	48	64
	Min	33	31	33	35	38	44	48	35	35	30	31	32	37	42	48	43	44	44	46	43	42	37	46	37	33	40	41	50	41	37	42
Logan USU	Max	47	53	53	63	71	75	73	58	46	44	55	56	61	67	65	68	68	65	63	56	58	60	60	54	68	69	72	73	65	65	75
Exp. Sta.	Min	32	29	28	29	32	37	46	34	35	28	31	30	39	36	42	40	40	43	47	42	42	35	40	33	30	43	40	49	39	35	35
																															June 1953	
Logan USU	Max	74	64	66	71	69	67	67	66	79	83	85	85	81	79	73	86	85	85	85	74	82	84	85	84	74	76	77	86	88	90	
Exp. Sta.	Min	43	42	38	38	46	41	37	44	41	55	49	60	48	46	43	42	49	48	50	43	45	45	47	48	36	42	40	45	48	64	
																															May 1954	
Lewiston	Max	45	56	66	73	78	76	78	83	85	73	74	80	81	83	86	80	84	86	88	90	70	63	68	77	77	66	54	64	64	74	66
	Min	28	25	32	34	39	39	39	40	47	50	40	39	41	41	42	43	40	42	43	45	50	45	35	35	53	37	31	25	31	43	32

Table 30. Continued

Station		Daily temperatures: Day of month 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Logan USU	Max	48	46	56	68	72	78	75	78	84	85	71	73	79	80	80	85	82	82	84	86	87	74	60	67	78	76	65	56	63	73	59
	Min	27	29	36	43	45	46	46	52	56	54	47	48	49	50	52	53	54	53	54	55	57	44	40	45	56	40	35	33	38	43	39
Logan USU Exp. Sta.	Max	44	55	64	72	74	74	76	81	83	83	73	78	78	77	77	83	81	83	84	84	77	57	68	75	75	61	60	62	66	66	64
	Min	27	26	32	39	41	41	39	42	52	53	43	43	42	44	48	47	46	42	48	50	49	44	38	38	48	38	32	28	34	42	35
																														May 1955		
Lewiston	Max	63	56	56	71	77	78	82	70	64	74	76	77	79	71	77	70	65	71	79	84	83	71	75	63	62	66	62	69	81	79	51
	Min	40	33	38	31	34	37	39	49	35	32	35	36	45	40	32	32	36	35	35	39	46	49	33	48	40	41	37	26	30	38	36
Logan USU	Max	74	69	57	57	70	78	79	79	69	63	70	76	79	80	68	68	58	63	70	77	81	82	68	76	63	60	65	57		78	80
	Min	48	36	36	38	44	45	47	48	38	39	44	48	48	39	31	32	39	38	43	50	54	49	43	48	42	43	39	35	41	51	37
Logan USU Exp. Sta.	Max	71	54	51	68	77	76	76	74	63	71	75	78	75	74	56	57	63	70	77	81	81	73	74	74	58	63	60	66	78	76	72
	Min	47	35	37	35	39	41	40	50	35	33	38	38	50	39	32	32	39	37	38	44	51	49	38	48	43	41	38	30	36	42	37
																														May 1956		
Lewiston	Max	65	69	71	74	63	69	73	71	70	56	49	48	47	60	68	74	80	85	81	82	82	82	84	80	79	79	70	67	70	82	88
	Min	32	41	46	43	40	45	45	41	40	42	41	35	30	28	33	37	37	42	50	44	48	48	44	51	48	50	50	46	49	42	45
Logan USU	Max	66	65	69	76	71	64	69	75	73	72	57	48	47	52	62	68	74	79	84	81	82	83	82	81	78	77	79	71	62		80
	Min	35	39	46	47	39	42	48	45	44	44	39	33	31	32	39	43	44	48	57	56	54	53	52	52	51	49	51	47	47	48	54
Logan USU Exp. Sta.	Max	63	68	71	73	65	70	75	71	71	65	55	46	52	60	69	74	79	80	80	81	82	82	81	79	78	78	69	64	70	81	87
	Min	33	44	47	46	40	44	49	43	40	41	38	34	31	29	36	35	39	46	55	46	51	51	48	53	48	51	50	46	50	43	48
																														May 1957		
Lewiston	Max	73	77	68	72	75	80	77	70	68	68	56	56	58	58	65	63	62	69	59	51	50	58	62	60	67	62	76	79	77	79	79
	Min	37	38	36	31	36	37	44	48	48	41	45	44	44	46	40	46	40	40	40	39	37	37	36	39	39	40	42	41	46	47	45

Table 30. Continued

Station		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
		Daily temperatures — Day of month																														
Logan USU	Max	65	76	78			77	80	78	70	65	71	55	57	59	62	63	64	65	71	64	47	52	59	62	64	67	73	77	79		78
	Min	45	49	39	36			52	51	49	48	47	43	45	43	40	45	43	45	44	38	36	38	39	41	40	45	47	48	52		49
Logan USU Exp. Sta.	Max	73	75	75	65	75	77	77	70	67	68	60	56	59	60	61	61	66	68	68	51	51	58	62	55	67	73	77	79	76	76	80
	Min	39	46	38	37	42	41	56	48	47	44	44	44	45	43	39	44	43	43	42	39	35	38	37	40	38	42	44	44	47	48	46
																														May 1958		
Lewiston	Max	65	68	72	75	75	82	74	72	75	80	70	69	64	58	69	75	81	84	87	88	85	85	86	88	90	89	89	85	89	78	82
	Min	28	30	32	36	36	38	40	43	38	45	45	46	39	39	35	37	39	40	40	46	52	48	45	45	45	45	44	47	42	42	38
Logan USU	Max	65	66	73	76	78	84	80	66	66	74	78	74	59	64	57	69	76	80	84	88	87	84	83	84		88	87	86	85		85
	Min	37	40	43	45	46	56	44	40	44	47	51	44	41	41	41	43	46	50	51	52	54	55	54	53	55	56	54	52			47
Logan USU Exp. Sta	Max	63	70	71	74	77	76	76	66	69	76	75	58	61	61	65	74	77	82	86	87	87	83	82	83	83	85	85	85	81	76	74
	Min	32	35	30	41	41	51	41	42	41	46	44	43	41	38	39	39	43	44	47	51	57	51	50	49	53	50	50	57	48	48	42
																														May 1959		
Lewiston	Max	75	52	58	58	58	60	65	68	70	60	70	80	85	79	79	60	62	58	51	54	65	62	65	70	68	60	53	61	62	62	66
	Min	43	38	26	41	26	39	30	34	36	32	34	35	37	54	41	38	37	34	34	34	27	44	38	34	40	39	41	31	40	38	32
Logan USU	Max	76	75	49	58	58	60	61	67	71	73	64	70	81	84	80	80	60	62	61	55	54	66	60	62	72	71	64	57	65	68	68
	Min	45	39	29	34	32	40	41	43	44	35	40	40	47	53	50	39	41	37	35	35	31	38	45	41	45	41	40	38	43	42	39
Logan USU Exp. Sta.	Max	75	75	50	58	58	56	64	66	66	56	68	78	83	83	75	73	56	56	53	45	58	58	61	69	69	60	53	61	60	58	66
	Min	39	39	28	40	27	41	30	38	39	30	37	39	40		49	36	39	35	34	34	28	29		38	42	40	41	34	41	40	36
																														June 1959		
Lewiston	Max	74	79	83	81	85	88	72	79	82	71	85	93	90	86	81	86	88	92	84	89	91	91	92	93	91	68	67	67	59	69	
	Min	35	36	39	46	42	46	50	42	45	38	36	42	47	52	54	43	45	46	56	49	53	54	50	53	52	49	45	41	43	37	
Logan USU	Max	69	75	78	84	82	87	90	72	80	84	73	84	93	87	90	82	85	88	88	83	89	92	91	91	90	88	68	67	69	57	
	Min	43	46	49	52	52	59	49	48	56	44	46	49	59	55	62	52	54	56	55	58	60	62	59	61	60	50	53	46	49	39	

Table 30. Continued

Station		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
		Daily temperatures — Day of month																														
Logan USU Exp. Sta.	Max	72	77	82	80	86	87	87	77	83	83	84	91	90	89	88	86	87	86	85	93	91	90	94	91	88	88	67	58	60	69	
	Min	38	41	42	48	47	57	47	46	58	42	40	48	59	64	54	49	51	50	60	54	57	59	56	58	57	51	50	45	48	39	
																														July 1959		
Lewiston	Max	80	89	86	87	86	88	78	76	86	89	92	94	91	90	87	93	96	91	94	94	95	95	98	94	95	96	95	85	90	93	83
	Min	39	45	53	37	39	46	52	37	38	40	45	49	58	51	57	52	50	55	52	48	51	50	45	51	55	56	53	54	39	47	61
Logan USU	Max	71	81	84	83	79	87	88	79	76	85	92	90	94	91	90	89	93	97	91	94	93	94	95	96	92	95	95	94	86	88	92
	Min	47	52	56	47	57	58	58	44	49	49	54	60	63	61	59	60	59	57	63	59	58	61	56	57	59	64	64	56	52	57	55
Logan USU Exp. Sta.	Max	80	78	79	79	86	86	86	71	84	89	90	90	90	87	83	92	94	90	91	92	91	92	95	97	97	93	91	91	89	88	89
	Min	43	49	59	45	45	52	53	39	43	48	50	54	62	60	61	55	56	59	57	55	58	57	53	59	59	58	58	56	47	53	71
																														Aug. 1959		
Lewiston	Max	89	89	90	91	91	93	94	95	92	93	95	87	76	82	86	89	93	81	79	78	79	78	83	83	83	80	85	85	83	83	81
	Min	61	55	57	50	51	45	48	39	55	43	49	55	50	34	39	40	42	57	52	51	45	41	39	42	48	47	43	47	41	39	45
Logan USU	Max	83	88	88	90	90	90	93	92	93	92	92	94	87	76	83		88	91	70	80	80	80		83	84	82	81	84	85	85	84
	Min	63	60	61	58	56	58	55	53	61	59	58	57	55	47	46		55	59	54	53	51	50		49	53	55	52	51	47	52	55
Logan USU Exp. Sta.	Max	85	85	82	82	78	90	91	94	93	91	92	82	82	80	83	86	91	90	74	76	79	79	82	83	81	81	83	81	80	78	78
	Min	63	58	59	57	57	53	54	49	58	53	58	58	55	40	46	49	50	62	52	54	50	47	45	49	54	52	49	57	48	46	49
																														Sept. 1959		
Lewiston	Max	77	80	87	83	81	83	90	81	83	93	89	89	85	80	64	66	61	70	65	67	58	64	61	63	58	59	50	49	54	56	
	Min	37	37	38	47	43	44	44	47	34	39	49	53	49	50	49	53	43	39	48	43	37	30	34	39	44	43	41	36	29	28	
Logan USU	Max	81	75	81	86	84	80		89	83	86		89	85	82	80	65	67	64	71	66	69	60	65	64	64	60	55	54	55	53	
	Min	44	48	45	56	51	48		57	45	48		55	60	55	51	44	46	47	50	45	49	37	43	44	45	43	40	35	32	33	
Logan USU Exp. Sta.	Max	75	78	85	85	83	83	87	86	81	89	89	85	85	80	73	62	62	61	61	65	65	60	60	61	61	58	54	45	52	51	
	Min	44	43	45	50	41	47	45	58	37	45	54	60	57	53	51	44	45	42	47	42	48	43	41	43	46	44	35	36	32	30	

Table 30. Continued

Station		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
		Daily temperatures — Day of month																														
																													Oct. 1959			
Lewiston	Max	58	59	65	69	72	71	58	49	54	57	68	59	64	64	69	63	66	71	65	64	58	60	68	72	67	61	62	52	46	51	59
	Min	32	27	29	29	30	38	40	23	37	45	37	39	28	32	30	41	24	25	32	27	25	41	50	33	43	23	29	23	30	35	19
Logan USU	Max	57	59	63	65	67	73	70	49	51		62	69	64	63	64	72	63	65	70	65	66	58	58	65	73	71	61	62	52	45	48
	Min	33	32	35	34	34	43	38	31	34		42	45	35	38	41	40	34	35	40	40	33	34	44	43	47	34	36	30	30	32	28
Logan USU	Max	52	56	61	67	70	68	65	45	51	56	66	66	61	63	66	66	62	61	60	62	60	56	65	70	70	58	57	57	47	45	50
Exp. Sta.	Min		30	31	34	36	47	38	27	40	46	40	44	32	34	34	38	30	30	26	33	28	42	50	39	47	28	33	27	30		23
																													May 1960			
Lewiston	Max	63	65	60	59	63	66	71	69	77	85	88	88	72	66	72	71	66	47	58	70	57	60	65	67	67	75	62	73	78	82	82
	Min	30	46	39	40	39	34	34	39	38	40	43	47	43	30	29	40	30	33	30	32	47	34	38	30	32	34	49	34	34	41	44
Logan USU	Max	62	62	66	65	63	66	70	71	71	79	85	88	86	65	68	74	71	69	44	59	70		66	65	68	69	75	62	73	81	84
	Min	38	42	39	40	36	40	40	43	43	50	53	55	42	37	40	46	37	33	32	37	52	32	44	35	37	43	51	41	45	52	51
Logan USU	Max	64	64	63	60	65	68	70	70	77	83	88	86	83	67	72	70	67	60	57	69	69	61	63	65	66	75	72	70	80	82	82
Exp. Sta.	Min	34	46	40	42	35	35	38	41	40	43	47	56	41	33	33	46	35	32	32	33	44	33	40	31	34	37	49	38	37	46	46
																													June 1960			
Lewiston	Max	76	79	82	79	75	78	75	72	65	65	70	72	80	79	71	76	75	81	76	69	67	74	74	78	86	81	82	82	84	82	
	Min	41	37	38	38	35	37	44	48	36	38	37	38	38	45	52	43	51	42	44	37	25	32	42	36	38	42	44	42	39	39	
Logan USU	Max	82	81	84	87			86	81	81	78	74	73	81	82	81	76	81	78	85	83	72	70	80	80	85	89	87	86	88	87	
	Min	51	51	52	51			48	53	47	49	48	50	52	55	57	52	56	50	57	53	37	40	49	51	54	56	56	57	53	55	
Logan USU	Max	80	83	84	85	81	84	80	77	77	72	76	80	85	83	80	80	77	86	85	80	70	79	80	85	90	85	86	89	87	87	
Exp. Sta.	Min	47	47	47	44	42	46	55	51	43	46	44	47		51	51	49	61	49	55	49	31	40	45	46	48	50	51	50	49	48	
																													July 1960			
Lewiston	Max	91	87	84	88	86	87	85	88	90	87	89	92	93	94	96	95	97	96	99	99	99	97	90	89	94	100	97	96	95	93	86
	Min	45	50	50	45	47	54	54	47	48	58	47	56	57	52	47	48	48	51	53	53	53	54	59	50	51	50	61	58	59	65	62

Table 30. Continued

Station		Daily temperatures — Day of month 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Logan USU	Max	87	89	84	81	87	87	89	86	90	89	88	90	92	94	94	95	95	97	98	98	99	100	97		90	94	96	97	92	95	91
	Min	56	57	56	55	60	59	59	57	59	62	59	56	57	64	58	55	64	67	65	61	65	62	65		60	64	57	67	64	65	66
Logan USU	Max	90	89	83	86	83	87	87	89	91	87	88	91	95	94	95	96	95	95	97	98	99	97	95	92	93	99	97	95	95	95	89
Exp. Sta.	Min	49	52	54	49	54	59	55	51	53	58	51	49	62	55	52	52	54	59	58	57	58	58	66	54	56	56	65	62	63	66	63
																														Aug. 1960		
Lewiston	Max	83	88	94	92	93	91	92	90	91	93	96	94	93	93	85	70	74	85	90	94	92	85	63	67	69	80	82	70	83	90	87
	Min	58	47	49	47	47	49	44	50	47	52	50	49	55	59	58	44	37	41	43	46	50	42	34	42	35	36	36	34	34	39	35
Logan USU	Max	84	87	86	93	90	92	89	92	91	91	95	93		93	93	84	56	76	84	90	93	92	82	66	66	70	84	75	74		91
	Min	61	54	53	58	57	60	58	56	61	59	61	60		62	59	46	40	45	50	56	63	71	37	42	41	48	49	43	45		55
Logan USU	Max	85	88	95	91	91	90	92	91	91	94	95	95	92	94	85	76	75	85	90	95	93	91	65	66	71	83	81	73	84	90	87
Exp. Sta.	Min	60	49	53	54	52	54	52	52	51	60	55	56	59	63	55	46	37	45	48	52	55	44	35	43	36	40	47	38	38	46	56
																														Sept. 1960		
Lewiston	Max	75	81	85	83	83	85	83	80	77	86	87	88	86	77	79	84	75	78	82	82	67	70	76	74	81	85	86	79	81	78	
	Min	56	56	58	54	53	48	50	39	38	36	46	42	48	41	41	38	55	37	36	38	50	46	36	35	39	42	38	42	36	37	
Logan USU	Max	87	78	84		85	85	84	83	76	81	81	77	87	84	77	78	82	81	79	82	81	71	69	73	74	80	83	82	77	81	
	Min	57	58	61		54	54	57	48	50	49	57	55	56	47	47	48	51	50	47	50	50	48	43	46	48	50	49	54	49	47	
Logan USU	Max	80	85	83	85	84	85	82	80	81	84	87	87	86	83	79	83	78	79	84	83	79	70	73	75	82	85	85	79	82	80	
Exp. Sta.	Min	59	57	58	55	52	52	50	45	50	44	49	46	53	45	45	44	53	41	40	46	49	48	40	40	43	43	43	48	41	43	
																														Oct. 1960		
Lewiston	Max	76	75	78	76	79	79	75	62	41	50	53	51	49	50	58	62	69	67	64	66	67	70	71	67	64	70	54	45	46	48	54
	Min	38	31	31	32	32	33	46	40	32	33	36	40	31	26	26	25	27	33	29	30	32	33	30	33	27	28	26	34	37	16	21
Logan USU	Max	77	78	76	78	76	77	77	71	49	47	52	56	55	49	51		60	66	67	63	61	67	70	71	67	64	68	54	49	47	49
	Min	47	43	47	45	45	47	51	48	33	33	37	42	33	29	33		30	39	40	40	43	43	41	44	34	38	32	34	37	24	29

Table 30. Continued

Station		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
		Daily temperatures — Day of month																														
Logan USU	Max	78	77	79	79	79	79	75	64	44	52	51	55	50	50	60	62	69	67	66	70	67	74	72	66	65	71	65	49	47	50	56
Exp. Sta.	Min	42	39	38	41	39	39	48	42	32	35	36	41	32	28	27	27	30	37	33	35	36	36	34	37	30	31	28	34	36	18	24
																													May 1961			
Lewiston	Max	73	62	69	60	52	59	59	65	76	80	63	53	65	63	55	56	71	65	75	68	70	80	83	85	85	81	78	85	80		
	Min	32	41	26	33	23	25	38	27	32	40	36	39	33	30	35	38	31	43	41	48	39	39	41	42	43	48	46	48	48		
Logan USU	Max	72	77	64	71	64	55	61		67	77	81	69	56	69	63	52	61	72	69	77	75	76	81	86	85	87		86	77		
	Min	41	41	37	39	27	30	38		41	52	40	38	36	41	41	38	39	43	42	55	46	47	52	50	52	56		57	54		
Logan USU	Max	74	72	67	65	52	60	60	65	71	80	67	60	67	65	58	57	71	69	76	76	73	80	83	84	84	81	79	84	83	74	79
Exp. Sta.	Min	36	40	31	38	24	26	38	32	37	49	38	39	30	34	33	37	34	42	40		42	42	45	51	52		47	49	56	49	39
																													June 1961			
Lewiston	Max	80	66	67	66	70	75	78	82	84	90	86	77	72	76	75	82	84	88	88	88	89	88	84	88	89	90	88	89	86	81	
	Min	42	36	39	36	41	37	40	40	42	39	42	44	35	39	40	40	41	43	42	43	43	42	49	44	46	45	56	44	56	34	
Logan USU	Max	73	80	61	65	70	72	83	82	88	86	88	88	77	79	83	84	86	92	94	93	94	93	94	90	92	93	90	91	89	92	
	Min	58	45	44	47	47	49	54	54	52	55	55	56	48	50	59	56	58	60	62	60	60	59	61	59	60	60	66	61	61	65	
Logan USU	Max	78	67	66	67	70	80	85	86	85	87	85	75	79	80	82	87	92	93	92	91	94	94	92	89	92	92	93	92	91	87	
Exp. Sta.	Min		40	40	47	47	45	45	48	47	49	50	53	44	46	49	50	52	50	48	53	53	53	55	55	54	54	63	54	53	49	
																													July 1961			
Lewiston	Max	90	93	91	76	84	90	90	94	92	92	84	88	90	94	97	96	91	92	91	87	91	92	95	95	88	93	90	96	94	92	91
	Min	42	39	46	60	50	55	56	53	52	50	48	46	46	56	49	53	56	49	49	54	51	46	52	56	62	56	58	54	60	58	57
Logan USU	Max	85	87	93	87	68	84	91	90	94	93	92	88	88	91	90	92	95	91	92	90	90	86	91	93	91	90	90	93	91	92	91
	Min	52	55	61	60	56	58	66	61	61	60	58	58	58	62	59	61	60	62	58	60	59	58	62	65	64	65	66	64	68	67	65
Logan USU	Max	85	93	90	78	85	88	90	93	92	91	87	86	88	89	91	93	90	90	90	87	85	90	92	98	88	90	90	93	92	91	90
Exp. Sta.	Min	45	45	53	61	52	58	62	54	55	54	51	51	53	60	55	57	59	54	56	59	56	52	50	51	50	59	62	56	64	63	60

Table 30. Continued

Station		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
																													Aug. 1961			
Lewiston	Max	94	96	98	100	95	86	85	88	89	91	91	82	85	89	93	81	88	90	95	87	89	90	90	79	83	82	89	90	77	80	80
	Min	51	54	53	54	59	62	56	56	55	56	52	61	54	47	49	53	48	47	48	64	52	48	49	50	55	51	48	50	56	48	49
Logan USU	Max	87	93	95	96	93	91	85	84	89	86	93	85	81	88	86	84	78	81		96		88	92	88	80	83	84	90	90	87	81
	Min	58	64	67	64	67	65	59	59	57	63	62	60	58	56	61	57	56	59		64		61	61	61	61	55	59	58	62	58	55
Logan USU Exp. Sta.	Max	93	95	96	96	92	85	86	86	87	90	90	88	86	88	90	81	87	93	96	92	90	91	90	88	83	83	90	91	89	81	81
	Min	54	60	58	58	63	62	57	60	55	57	56	60	55	52	51	57	50	52	57	69	57	53	54	59	57	54	52	54	68	51	52
																													Sept. 1961			
Lewiston	Max	77	68	71	75	80	84	85	82	75	75	78	65	70	77	84	73	76	60	59	57	50	53	53	55	61	65	68	62	52	59	
	Min	59	42	33	33	36	44	45	43	53	44	51	36	33	29	47	46	50	51	44	41	40	27	32	28	27	33	26	35	41	28	
Logan USU	Max	80	81	64	72	76	78	81	81	82	75	75	77	69	72	77	82	70	77	56	55	54	52	57	60		64	68	69	62	55	
	Min	63	43	39	41	48	55	54	53	52	50	53	40	40	40	54	58	54	49	44	44	41	34	35	34		33	37	37	45	34	
Logan USU Exp. Sta.	Max	82	78	67	75	80	85	85	81	74	74	77	78	72	77	84	81	75	69	59	58	58	53	58	53	65	69	70	67	67	60	
	Min	58	42	34	36	41	50	46	43	53	48	52	38	36	32	50	55	53	47	43	44	40	30	34	30	30	36	30	39	41	30	
																													May 1962			
Lewiston	Max	64	68	74	76	76	78	75	81	76	77	73	70	67	57	58	63	58	65	75	65	45	59	70	59	63	64	63	57	63	73	71
	Min	27	34	41	51	41	40	43	44	48	39	45	36	42	38	37	38	41	33	41	41	36	36	33	44	35	38	41	40	45	39	41
Logan USU	Max	56	67	72	72	78	81	81	75	78	82	78	76	68	64	55	58	65	58	70	74	63	62	59	72	64	59	66	63	58	65	75
	Min	35	41	42	52	50	50	49	54	54	56	54	40	41	43	38	39	44	39	46	41	35	40	39	46	39	40	43	42	43	46	44
Logan USU Exp. Sta.	Max	65	69	74	76	78	79	80	81	81	77	73	68	62	62	56	64	63	68	74	73	55	60	70	66	60	64	63	58	64	73	70
	Min	30	38	45	49	44	45	48	49	53	43	48	37	41	38	37	36	43	34	42	39	35	41	35	42	38	38	43	40	41	43	43
																													June 1962			
Lewiston	Max	67	72	67	55	63	52	64	73	80	85	83	82	84	79	65	70	73	84	86	82	86	84	87	90	93	94	92	88	87	89	
	Min	41	39	47	32	40	39	29	34	38	40	43	45	43	41	47	36	38	42	44	56	45	48	49	51	47	48	49	48	47	53	

Column heading over days 1–31: Daily temperatures — Day of month

Table 30. Continued

Station		Daily temperatures, Day of month: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Logan USU	Max	73	79	75	76	59	66	52	68	73	80	81	86	84	82	80	69	72	74	78	86	82	85	84	88	90	92	93	92	89	76	
	Min	47	46	55	33	37	42	34	40	47	53	54	54	51	48	54	42	44	53	51	51	55	56	58	58	60	57	66	57	59	59	
Logan USU	Max	74	73	73	58	64	65	63	70	78	85	85	83	85	86	75	69	73	83	86	82	84	85	89	90	92	92	91	90	89	85	
Exp. Sta.	Min	43	42	48	34	40	40	30	35	38	46	58	50	46	53	51	46	40	45	49	57	49	52	54	54	52	52	58	53	50	55	
																													July 1962			
Lewiston	Max	90	85	85	83	91	91	92	92	91	93	94	92	75	77	81	83	88	87	84	92	94	86	85	90	85	87	84	86	89	88	85
	Min	54	48	47	40	43	51	52	46	49	46	49	61	54	48	46	44	47	46	49	46	49	45	58	51	51	51	50	48	43	46	51
Logan USU	Max	87	83	83	85	82	88	87	88	93	89	89	91		70	82	81	82	88	87	85	91	94	78	82	91	79	86	81	85	89	89
	Min	63	53	54	53	54	58	57	57	54	58	57	59	54	48	51	52	54	57	55	55	57	62	56	59	57	58	55	53	56	59	60
Logan USU	Max	86	86	83	82	87	88	88	92	90	89	92	92	87	75	82	83	87	88	84	90	93	91	83	89	85	84	80	85	87	87	85
Exp. Sta.	Min	60	50	50	47	46	55	52	53	51	52	51	68	51	47	47	48	52	50	50	52	49	59	61	64	55	53	51	48	50	51	53
																													Aug. 1962			
Logan USU	Max	86	85	85	90	85	86	84	86	90	84	75	87	91	93	95	97	89	88		83	91	89	80	71	73	89	90	79	76	75	73
	Min	54	54	59	61	56	50	56	63	70	50	53	58	60	59	61	59	61	62		57	57	62	45	46	51	59	63	46	48	43	43
Logan USU	Max	84	87	88	86	81	83	88	89	89	86	83	91	92	94	96	94	86	88	87	90	86	80	75	80	88	89	82	77	75	70	75
Exp. Sta.	Min	48	49	55	61	49	45	51	57	69	50	46	49	51	51	52	57	57	56	52	49	56	57	39	39	41	50	51	38	45	37	34
																													Sept. 1962			
Logan USU	Max	76		86	85	86	88	85	84	59	69	77	78	80	78	83	82	84	84	84	87	83		76	81	81	78	80	65	71	65	
	Min	48		51	50	52	54	48	41	35	43	46	48	50	51	51	50	50	49	51	50	49	50	50	48	47	48	53	50	46	37	
Logan USU	Max	82	86	85	85	86	85	83	79	67	78	80	85	81	83	84	85	85	88	88	86	74	79	82	81	81	82	75	71	67	64	
Exp. Sta.	Min	40	42	41	43	44	46	42	38	30	34	53	42	41	42	43	44	41	40	52	55	46	42	40	40	45	40	49	47	45	29	
																													May 1963			
Lewiston	Max	69	55	60	70	72	76	80	73	70	63	71	61	54	68	72	70	75	79	77	78	79	79	78	77	66	62	73	75	80	80	79
	Min	39	37	38	45	36	38	48	46	51	35	35	36	31	38	38	36	38	42	37	38	37	45	44	52	47	39	40	40	48	41	43

Table 30. Continued

Station		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
		Daily temperatures — Day of month																														
Logan USU	Max	72	58	65	70	73	79	81	72	70	65	73	58	58	70	77	72	71	78	80	79	79	76	84	71	65	66	75	79	80	81	72
	Min	43	40	42	46	48	48	55	47	48	38	39	38	38	44	44	42	45	48	48	46	51	56	56	51	48	45	46	49	53	49	50
Logan USU	Max	67	64	68	72	77	80	80	72	70	71	65	63	68	74	71	70	75	78	77	78	80	82	75	70	67	74	77	81	79	79	78
Exp. Sta.	Min	41	38	39	44	42	41	50	48	48	37	35	37	33	39	43	36	41	45	43	41	44	48	48	51	47	42	42	43	49	44	44
																													June 1963			
Logan USU	Max	72	75	67	61	64	65	67	68	68	63	76	81	80	70	66	79	80	80	83	82	80	75	83	85	80	81	88	86	84	79	
Exp. Sta.	Min	46	48	46	44	45	41	40	40	41	48	49	42	64	50	45	51	49	47	51	54	57	41	43	44	40	41	47	50	41	35	
																													July 1963			
Lewiston	Max	79	93	92	93	90	90	83	94	93	89	89	82	86	88	85	89	85	91	85	90	92	94	92	94	95	89	80	84	89	90	89
	Min	37	54	48	51	50	47	50	56	57	54	45	46	46	51	54	48	44	47	44	45	51	59	56	56	49	46	39	39	48	43	43
Logan USU	Max	79	82	91	92	90	88	84	94	93	90	85	82	81	87	87	88	88	87	85	90	91	95	92	95	92	87	82	84	89	90	90
	Min	51	56	62	63	62	56	60	70	64	65	53	51	55	59	58	58	57	56	55	60	62	67	66	69	59	50	48	53	58	58	55
Logan USU	Max	91	90	90	88	88	88	93	93	87	87	84	85	85	85	86	85	90	90	89	90	92	90	94	92	91	87	84	88	90	89	92
Exp. Sta.	Min	42	63	53	63	52	51	55	46	52	57	50	48	49	54	50	52	48	52	48	53	56	62	61	57	55	47	57	46	51	52	47
																													Aug. 1963			
Lewiston	Max	90	89	90	89	88	92	89	88	90	89	89	90	91	95	94	93	93	88	89	89	86	84	83	83	84	85	85	86	85	89	76
	Min	48	45	57	56	48	53	61	55	61	58	52	50	48	51	53	47	54	48	48	58	45	45	45	51	54	43	40	40	40	49	54
Logan USU	Max	89	90	84	88	88	87	88	82	90	90	93	92	88	94	87	86	86	90	90	93	87	78	84	80	85	86	86	87	84	89	73
	Min	60	56	64	62	59	63	62	62	66	64	64	60	62	64	63	59	62	60	59	57	59	57	59	65	62	56	56	54	52	59	56
Logan USU	Max	91	90	89	88	91	89	88	90	90	89	90	92	95	95	93	92	94	89	88	87	87	81	81	84	85	85	86	85	90	88	75
Exp. Sta.	Min	55	51	60	61	52	60	64	59	65	61	55	56	56	57	57	52	57	54	56	51	48	48	51	50	59	48	48	47	47	57	56
																													Sept. 1963			
Lewiston	Max	73	74	83	85	90	88	77	80	84	86	86	88	90	65	69	80	65	70	62	77	78	65	75	72	75	79	83	85	84	83	
	Min	45	43	45	40	45	54	56	45	42	45	43	45	56	46	36	49	45	48	48	48	46	40	42	35	36	38	35	37	36	37	

Table 30. Continued

Station		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
		Daily temperatures — Day of month																														
Logan USU	Max	74	80	79	85	82	84	69	81	86	86	82	87	87		72	80	75	69	61	74	76	69	75	75	73	76	80	81	81	81	
	Min	55	53	54	54	56	63	59	56	55	57	58	59	56		50	50	48	53	51	54	48	48	48	45	49	49	51	52	53	54	
Logan USU	Max	76	81	86	88	87	78	81	86	88	87	90	91	85	71	80	68	71	65	76	76	67	77	74	75	80	82	83	83	83	85	
Exp. Sta.	Min	51	48	49	46	50	62	58	52	53	52	49	51	55	48	43	42	47	51	49	50	48	44	45	43	42	42	42	44	43	44	
																													Oct. 1963			
Lewiston	Max	84	83	82	82	81	84	82	80	76	78	77	78	64	52	65	71	73	74	71	62	66	63	69	55	56	63	58	55	57	60	42
	Min	43	37	38	42	37	39	36	38	38	32	34	40	41	31	33	31	30	34	34	39	29	30	32	25	30	33	22	21	26	35	28
Logan USU	Max	79	81	76	80	81	75	78	79	78	75	75	77	64	52	63	70	71	70	71	63	65	63	68	57	55	67	59	54	63	63	44
	Min	54	50	53	55	57	51	51	52	52	44	48	48	42	41	42	42	42	46	45	45	41	41	47	33	34	40	29	32	34	36	31
Logan USU	Max	84	83	84	81	76	78	80	80	78	78	80	73	53	66	70	73	73	74	69	78	67	70	64	58	68	65	59	56	64	50	50
Exp. Sta.	Min	45	42	44	50	55	47	44	43	54	48	43	52	43	35	38	36	37	40	40	42	36	37	45	29	43	38	25	26	40	33	30
																													May 1964			
Lewiston	Max	64	56	50	46	61	42	57	54	55	65	62	59	68	79	77	79	86	73	79	84	84	80	76	72	77	78	77	72	55	61	72
	Min	41	35	38	25	31	32	38	39	34	30	37	33	42	43	42	42	45	38	42	46	43	49	46	38	38	48	45	43	42	44	43
Logan USU	Max	65	49	38	46	59	39	59	57	57	64	65	60	72	81	80	81	86	75	80	88	87	80	78	72	80	81	77	74	54	60	64
	Min	43	30	26	29	33	32	35	39	40	43	38	38	45	49	49	56	52	44	48	57	51	52	48	46	54	53	48	44	42	44	46
Logan USU	Max	60	45	45	56	56	56	67	55	62	64	68	69	77	76	78	83	81	78	84	83	81	77	71	76	78	77	75	59	61	65	72
Exp. Sta.	Min	40	30	25	25	32	38	37	40	40	47	36	32	45	45	43	43	48	39	43	45	48	49	43	38	55	50	37	41	40	43	43
																													June 1964			
Lewiston	Max	71	75	78	74	76	75	82	56	58	67	67	65	70	76	71	72	65	53	64	60	65	60	66	76	80	86	91	85	83	83	
	Min	42	43	48	41	54	51	46	46	43	41	46	40	35	42	43	50	48	43	41	36	41	40	42	43	45	51	57	54	53	50	
Logan USU	Max	74	78	80	76	79	77	78	56	61	67	70	67	74	68	75	70	65	50	67	66	67	58	68	77	83	89	89	85	85	84	
	Min	45	53	49	48	54	53	46	44	42	43	42	44	43	46	51	51	47	43	42	41	45	40	45	50	51	60	63	57	57	57	

Table 30. Continued

Station		Daily temperatures — Day of month 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Logan USU	Max	77	78	75	78	75	75	71	60	67	68	65	71	69	74	72	70	62	65	62	66	64	67	76	82	89	91	84	84	85	86	
Exp. Sta.	Min	43	56	48	43	54	51	47	44	45	42	45	41	48	43	48	50	47	43	40	38	43	39	42	44	48	52	64	55	52	53	
																													July 1964			
Lewiston	Max	85	88	88	87	89	80	87	91	91	85	87	92	93	90	89	89	89	93	93	92	92	94	93	91	85	88	92	94	94	90	93
	Min	46	48	48	47	47	45	47	48	55	47	51	57	57	59	53	48	50	55	49	48	51	52	54	45	44	45	50	54	59	56	56
Logan USU	Max	87	87	87	88	89	83	84	92	93	85	88	90	93	88	88	90	90	92	93	93	91	93	91	88	88	90	92	92	94	86	92
	Min	56	58	54	60	53	53	57	60	63	54	57	59	63	67	62	58	53	54	61	61	62	58	59	54	54	57	60	64	62	63	61
Logan USU	Max	89	93	87	88	85	87	91	93	92	87	90	93	92	87	88	88	94	93	92	90	90	90	91	89	89	90	93	93	93	94	95
Exp. Sta.	Min	47	51	49	47	48	48	51	50	60	49	54	59	59	63	55	51	53	58	52	51	55	55	58	49	47	50	55	59	60	60	57
																													Aug. 1964			
Lewiston	Max	90	89	89	91	93	87	91	92	91	93	92	87	87	85	86	90	81	88	91	68	68	74	81	87	86	86	80	67	63	65	78
	Min	59	47	45	52	63	51	57	52	52	51	54	49	52	48	46	56	48	48	54	35	35	37	40	41	43	47	35	40	30	29	46
Logan USU	Max	86	88	88	92	90	90	87	92	92	95	88	82	81	86	83	89	84	90	87	71	68	76	83	89	84	87	82	71	63	67	78
	Min	67	56	59	63	67	60	65	66	63	62	67	61	56	57	57	59	57	61	55	41	42	49	54	57	52	55	43	49	40	40	50
Logan USU	Max	86	87	91	95	93	90	92	90	93	90	88	86	85	85	87	85	87	88	85	68	73	81	85	86	85	80	70	67	75	76	80
Exp. Sta.	Min	64	50	52	56	61	56	60	62	57	56	52	54	54	51	51	59	51	51	55	38	40	43	47	51	47	48	39	44	35	32	41
																													Sept. 1964			
Lewiston	Max	83	70	65	74	80	83	84	81	83	78	78	80	82	83	80	75	77	81	68	66	69	68	70	74	78	81	66	69	75	78	
	Min	53	35	30	31	33	35	39	39	44	34	32	33	33	42	46	35	34	46	26	28	42	31	34	34	39	35	26	34	39	34	
Logan USU	Max	80	66	69	75	82	85	86	83	78	79	79	82	83	84	83	70	74	80	67	67	68	68	70	73	72	80	66	70	75	77	
	Min	62	41	41	44	48	48	50	56	49	46	47	49	49	53	51	47	49	50	36	39	41	41	44	45	49	39	37	40	48	48	
Logan USU	Max	79	66	74	81	83	83	81	81	79	78	81	83	84	81	79	78	80	77	66	68	70	71	74	77	82	81	71	77	79	77	
Exp. Sta.	Min	54	38	35	36	39	40	43	39	47	37	38	39	42	47	47	41	40	49	31	34	40	36	39	39	39	35	31	39	41	40	

Table 30. Continued

Station		Daily temperatures — Day of month 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
May 1965																																
Lewiston	Max	69	66	65	66	65	44	45	52	47	54	61	69	73	65	70	71	68	66	72	73	62	68	71	61	60	64	61	67	72	77	81
	Min	36	39	29	33	36	27	25	35	35	36	33	35	38	44	45	41	46	33	38	48	48	48	39	43	43	42	31	36	38	43	49
Logan USU	Max	74	71	56	63	63	42	42	47	45	53	59	65	71	66	68	74	79	64	71	73	62	66	71	61	58	60	58	65	70	76	80
	Min	49	38	31	40	36	27	27	33	35	40	39	44	45	46	46	48	48	40	48	52	47	45	43	39	42	42	39	43	47	53	53
Logan USU	Max	72	70	65	65	62	44	49	47	55	62	68	72	71	70	72	78	77	72	74	70	68	72	68	60	63	61	65	72	78	82	80
Exp. Sta.	Min	47	39	30	34	30	25	26	34	36	39	33	37	41	45	46	43	43	32	40	50	48	42	38	38	43	39	33	38	40	47	51
June 1965																																
Lewiston	Max	70	72	76	76	76	76	79	79	81	82	74	78	80	67	72	72	65	68	75	78	80	85	86	87	60	72	66	60	73	78	
	Min	47	41	39	42	38	44	50	45	42	50	46	49	47	47	45	47	40	38	41	43	45	47	46	57	51	45	46	40	44	47	
Logan USU	Max	69	71	71	75	73	74	79	78	79	79	73	78	80	66	71	72	65	67	75	78	78	82	85	86	60	72	63	64	71	77	
	Min	46	49	46	48	48	51	54	47	55	55	54	55	47	51	49	49	49	46	48	51	53	55	57	55	50	47	46	44	49	53	
Logan USU	Max	73	73	78	76	76	81	80	80	81	75	80	83	74	72	73	68	68	75	88	86	85	87	87	82	73	65	66	73	79	85	
Exp. Sta.	Min	43	43	41	44	42	45	52	48	50	54	51	53	45	50	45	48	41	40	42	47	49	50	48	55	50	45	46	40	46	48	
July 1965																																
Lewiston	Max	85	78	78	84	84	82	88	87	87	89	93	87	79	84	90	91	86	85	84	82	82	88	81	86	88	77	86	89	92	96	78
	Min	46	44	46	48	45	45	48	50	56	50	51	49	41	46	49	53	56	57	60	52	52	55	50	47	59	50	52	51	52	64	61
Logan USU	Max	85	77	76	82	86	81	84	86	87	88	88	87	79	83	89	91	84	84	82	81	82	88	78	82	84	75	84	87	92	91	74
	Min	52	49	53	58	60	50	59	56	65	59	61	56	50	41	49	62	61	59	60	55	56	60	57	55	60	54	59	61	62	69	63
Logan USU	Max	85	79	84	88	88	87	87	87	88	88	89	88	85	91	92	86	86	86	81	81	87	87	85	86	81	86	90	93	94	91	85
Exp. Sta.	Min	48	46	49	52	48	49	53	52	63	52	57	51	43	47	53	57	56	58	58	53	53	57	53	51	60	52	55	56	49	66	62
Aug. 1965																																
Lewiston	Max	86	85	86	83	81	85	85	90	93	93	90	91	89	82	84	83	87	83	73	71	81	68	73	73	80	80	78	82	83	75	71
	Min	52	52	49	50	45	43	44	46	50	55	57	59	60	50	53	48	55	52	50	46	53	45	53	43	45	43	44	43	40	36	32

Table 30. Continued

Station		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
		Daily temperatures, Day of month																														
Logan USU	Max	83	84	84	84	82	84	84	89	92	92	88	90	89	79	81	80	83	79	71	72	79	67	73	75	80	81	77	84	82	72	68
	Min	64	55	56	55	55	52	56	60	64	62	65	66	61	56	59	57	62	58	52	52	53	49	54	52	58	51	54	56	49	38	41
Logan USU Exp. Sta.	Max	86	87	86	86	84	86	91	93	94	89	92	91	85	84	83	87	84	78	72	81	75	74	75	82	80	78	85	83	80	72	75
	Min	59	54	57	52	50	49	47	53	55	56	60	62	60	52	57	53	59	55	49	47	53	45	53	46	51	46	46	48	47	35	35
																													Sept. 1965			
Lewiston	Max	75	78	80	79	72	69	55	70	68	67	74	77	75	76	70	68	48	42	51	56	62	59	66	67	76	73	76	75	49	54	
	Min	34	39	48	33	41	49	42	45	39	36	40	39	36	36	49	36	30	22	29	26	32	36	37	28	33	39	46	40	39	27	
Logan USU	Max	72	77	79	78	71	76	55	68	67	68	74	77	75	76	67	67	40	40	49	53	58	54	67	63	67	74	76	75	48	52	
	Min	47	52	54	42	48	49	47	47	44	49	52	51	47	50	50	37	31	26	31	33	38	43	42	37	42	48	51	40	38	35	
Logan USU Exp. Sta.	Max	78	80	79	75	77	64	70	68	69	75	78	76	76	75	68	65	41	51	56	61	57	69	67	71	76	75	75	66	54	63	
	Min	37	45	49	36	43	50	44	45	40	40	44	44	40	46	50	36	32	24	32	28	36	39	39	32	38	44	55	38	38	31	
																													May 1966			
Lewiston	Max	65	72	78	83	83	83	83	82	82	75	62	52	57	64	58	66	69	69	68	73	78	81	55	61	74	81	84	87	86	88	83
	Min	29	31	35	40	38	40	44	46	52	46	38	34	42	41	33	50	38	32	34	38	44	46	26	31	37	39	41	49	46	46	51
Logan USU	Max	63	71	78	81	82	83	82	81	81	72	61	48	57	63	59	68	69	63	67	73	78	79	53	59	72	78	81	84	83	83	81
	Min	39	43	46	50	51	52	51	50	55	44	37	36	42	45	33	47	41	36	40	45	49	46	31	36	45	49	52	56	56	54	56
Logan USU Exp. Sta.	Max	73	79	83	83	84	84	82	82	74	60	60	58	65	65	68	70	66	68	74	78	80	70	60	75	81	84	87	84	85	81	80
	Min	35	37	41	41	43	43	47	50	53	48	38	39	44	44	35	49	41	35	37	41	60	37	27	34	40	43	47	55	52	66	58
																													June 1966			
Lewiston	Max	79	78	78	72	64	67	75	68	73	77	77	69	68	77	85	86	84	84	87	89	89	83	67	76	71	75	86	91	95	95	
	Min	38	37	37	34	30	33	50	49	41	52	42	34	34	41	45	46	46	45	48	49	54	51	36	46	35	39	45	46	58	53	
Logan USU	Max	77	78	77	71	64	67	73	67	71	75	75	68	67	70	83	82	83	82	81	88	87	85	67	77	71	73	86	90	93	91	
	Min	47	46	52	41	36	40	54	50	51	52	50	42	44	50	50	53	54	55	58	57	62	51	43	50	39	48	53	58	59	64	

Table 30. Continued

Station		Daily temperatures — Day of month 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Logan USU	Max	79	78	78	70	69	75	73	74	78	77	76	68	76	83	85	85	82	86	87	87	85	75	76	73	75	87	91	95	92	90	
Exp. Sta.	Min	41	58	48	42	34	38	57	50	45	57	45	39	39	45	51	33	51	50	50	52	69	50	39	57	36	47	48	54	57	63	
																													July 1966			
Lewiston	Max	91	89	90	80	87	90	93	92	87	85	87	88	89	88	90	92	90	94	95	95	95	91	92	93	92	91	92	93	95	96	92
	Min	59	56	41	43	42	43	47	53	47	49	53	52	49	46	45	49	58	54	50	51	60	50	49	52	57	51	49	52	46	57	65
Logan USU	Max	88	85	87	80	86	88	94	91	86	87	87	86	89	88	89	91	88	92	94	95	95	89	90	91	92	90	91	92	94	93	94
	Min	65	65	50	53	55	54	61	65	60	60	62	63	60	59	60	62	67	63	62	65	64	60	58	62	65	64	63	64	61	62	67
Logan USU	Max	83	86	81	86	89	94	91	89	88	87	88	89	89	89	90	91	93	95	95	98	95	93	98	94	92	94	95	95	95	96	87
Exp. Sta.	Min	68	69	45	47	50	49	55	60	57	54	58	65	53	59	61	55	64	63	63	61	66	56	53	59	62	52	55	59	52	52	67
																													Aug. 1966			
Lewiston	Max	90	90	93	87	88	91	89	91	87	87	87	89	84	87	86	90	94	94	87	82	78	77	83	87	89	91	89	74	84	86	82
	Min	56	58	64	49	50	47	43	42	41	44	47	46	39	47	43	43	48	59	59	46	36	33	37	40	40	52	37	36	45	43	44
Logan USU	Max	85	88	90	74	87	90	88	89	91	86	86	88	81	86	84	88	92	93	87	83	74	75	81	84	88	91	86	73	85	85	83
	Min	63	65	67	55	61	57	57	54	64	57	58	54	51	58	56	57	62	62	60	55	46	49	51	57	58	62	49	50	52	53	53
Logan USU	Max	90	92	85	89	92	89	90	92	90	88	90	83	88	87	90	94	95	94	84	78	77	83	86	90	92	90	78	86	86	83	79
Exp. Sta.	Min	59	62	65	53	52	52	50	49	60	50	54	49	45	52	49	51	53	52	58	52	40	40	43	45	47	67	42	43	58	48	48
																													Sept. 1966			
Lewiston	Max	68	64	65	80	83	84	85	86	87	88	85	80	81	78	57	53	69	79	85	81	83	86	87	87	83	79	64	69	73	75	
	Min	49	51	39	39	39	43	42	46	41	45	53	43	38	35	36	35	36	36	44	44	42	41	43	50	45	40	37	37	39	45	
Logan USU	Max	69	64	65	78	82	85	85	85	86	87	84	80	80	76	59	52	69	79	82	79	83	83	87	87	85	79	62	65	71	75	
	Min	51	51	49	49	49	49	46	50	45	44	47	43	46	44	40	40	40	39	53	49	51	52	46	59	57	48	45	45	46	50	
Logan USU	Max	67	65	79	84	88	86	87	88	89	86	82	82	79	67	54	70	80	85	82	84	86	88	88	87	80	77	68	73	76	74	
Exp. Sta.	Min	52	52	45	45	46	50	50	61	47	53	58	52	52	42	39	38	40	42	48	50	47	47	48	55	51	44	45	40	41	44	

Table 30. Continued

Station		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
																													Oct. 1966			
Lewiston	Max	78	70	60	57	65	70	72	73	70	67	71	68	65	36	44	51	55	56	55	64	60	46	46	57	64	66	69	70	68	68	65
	Min	32	41	37	27	28	33	35	33	35	26	30	35	33	21	17	18	19	25	20	21	33	15	16	25	24	24	24	27	24	23	26
Logan USU	Max	66	71	62	54	62	69	71	72	69	63	67	68	62	33	42	49	54	56	53	61	61	45	46	56	61	64	69	68	62	66	65
	Min	42	46	38	35	39	42	46	43	40	40	41	44	31	25	25	27	29	29	34	34	32	24	26	36	37	40	41	42	40	38	38
Logan USU	Max	72	67	59	65	71	74	74	72	68	70	70	67	57	44	50	55	58	55	65	61	60	47	60	64	67	71	71	67	69	67	65
Exp. Sta.	Min	35	48	34	27	32	36	40	39	36	29	35	42	32	21	20	24	26	27	25	38	32	20	38	29	28	27	31	32	30	30	33
																													May 1967			
Lewiston	Max	36	42	46	53	58	55	62	59	71	73	54	47	52	56	56	65	72	76	77	73	76	81	84	86	83	71	75	75	75	61	60
	Min	23	25	30	30	34	33	41	39	41	38	35	32	30	35	36	37	39	46	49	39	42	44	45	50	51	39	43	45	49	44	37
Logan USU	Max	37	44	48	53	59	53	62	70	72	74	55	46	48	53	57	66	71	77	75	70	73	80	85	87	82	69	71	74	71	61	59
	Min	22	25	30	35	37	39	43	47	49	38	35	34	32	37	40	43	46	49	49	47	50	52	56	58	52	46	46	51	49	46	42
Logan USU	Max	42	47	53	60	55	62	69	73	75	72	51	50	53	58	65	72	77	77	76	76	81	86	87	86	79	73	75	75	73	61	65
Exp. Sta.	Min	19	29	30	30	39	37	45	42	45	38	33	35	31	34	37	39	41	56	46	41	45	46	50	60	51	41	54	50	47	54	41
																													May 1968			
Lewiston	Max	75	75	71	73	75	69	50	56	68	74	75	69	68	57	51	51	60	65	70	75	74	65	61	56	60	61	61	69	79	82	70
	Min	30	40	30	31	43	27	24	28	30	35	40	46	44	41	40	34	35	35	35	45	45	36	38	34	34	34	41	39	46	51	34
Logan USU	Max	74	74	69	72	75	67	47	56	66	72	72	68	67	57	50	53	57	64	67	72	75	66	60	55	57	63	61	68	79	83	67
	Min	46	49	41	44	48	29	31	38	41	45	46	45	44	41	39	33	38	44	45	48	50	41	42	39	40	40	47	47	54	54	44
Logan USU	Max	76	75	75	77	74	67	57	68	75	75	69	69	61	57	52	60	65	69	74	75	70	62	60	59	59	62	70	82	84	84	72
Exp. Sta.	Min	40	46	34	39	51	28	28	31	35	39	55	45	45	39	38	33	35	38	39	62	52	40	41	35	37	38	43	42	50	52	38
																													May 1969			
Lewiston	Max	60	68	68	66	70	76	77	79	76	79	79	77	78	78	78	61	73	78	81	79	72	73	78	83	83	86	86	84	77	83	78
	Min	28	35	32	39	40	44	46	40	38	39	39	36	41	41	45	35	38	42	42	39	36	38	39	45	48	47	48	40	38	43	40

Daily temperatures by day of month.

Table 30. Continued

Station		Daily temperatures — Day of month 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Logan USU	Max	59	68	69	66	67	75	76	77	74	77	78	75	78	75	76	60	73	78	79	78	69	71	76	81	82	84	84	83	75	83	78
	Min	30	41	35	40	46	50	56	50	48	46	48	48	47	47	48	41	45	52	50	44	42	44	46	52	56	59	59	47	49	53	47
Logan USU	Max	67	71	69	69	75	78	80	79	79	80	79	79	78	78	78	73	79	81	78	76	74	78	83	83	85	85	85	82	84	88	77
Exp. Sta.	Min	42	37	33	41	40	42	57	54	41	43	43	45	54	45	48	40	44	50	46	42	38	41	43	47	55	59	62	45	43	50	43
																													May 1970			
Lewiston	Max	48	51	62	70	74	77	76	57	60	61	47	52	56	50	58	69	76	82	82	81	77	59	70	65	73	77	79	72	69	72	64
	Min	28	29	31	32	37	42	38	41	42	38	30	33	33	34	31	35	38	42	47	41	44	41	45	45	42	43	48	43	42	40	32
Logan USU	Max	44	54	64	69	75	77	76	53	60	55	43	50	56	50	55	69	77	82	83	82	74	61	69	62	71	76	80	75	64	73	62
	Min	30	31	35	45	45	51	43	41	42	39	31	33	37	34	38	39	51	51	55	51	44	45	54	48	50	52	52	48	48	45	38
Logan USU	Max	56	63	70	76	78	77	76	60	61	50	52	56	57	58	69	78	83	83	84	81	70	72	70	72	78	80	76	70	73	73	68
Exp. Sta.	Min	29	32	34	36	46	54	38	40	42	38	30	36	35	31	32	39	43	44	56	44	44	40	49	46	45	41	54	45	43	42	33
																													May 1971			
Lewiston	Max	68	74	78	73	60	48	68	64	64	60	66	71	74	70	66	73	55	51	55	64	50	70	51	63	69	75	81	82	74	76	58
	Min	35	39	46	40	38	40	43	35	36	36	38	42	45	40	40	43	32	33	34	38	35	40	34	38	39	42	41	44	46	46	39
Logan USU	Max	68	73	77	74	60	49	65	62	64	62	66	71	74	69	66	73	53	49	53	62	57	70	70	62	68	75	81	79	72	70	58
	Min	44	51	52	47	40	40	49	42	43	41	45	52	51	44	45	45	32	33	39	42	42	43	40	43	46	54	52	53	51	48	44
Logan USU	Max	76	79	79	74	58	68	69	67	58	68	72	76	75	68	74	73	53	56	64	62	70	62	64	68	76	84	81	78	74	63	61
Exp. Sta.	Min	34	38	47	43	37	48	54	36	42	37	48	46	48	41	41	43	37	35	35	42	37	41	38	39	41	45	45	45	47	46	41
																													May 1972			
Lewiston	Max	46	58	63	72	77	75	71	67	60	58	62	63	67	75	71	80	82	80	75	74	71	62	71	66	75	70	74	78	80	81	84
	Min	19	24	28	31	36	39	39	45	41	32	31	33	33	39	34	39	39	44	44	41	33	34	36	36	40	37	35	40	39	44	44
Logan USU	Max	46	56	63	71	77	73	70	67	58	54	61	63	65	69	75	80	82	78	73	71	70	63	57	68	74	68	73	75	78	79	80
	Min	28	29	39	46	48	49	48	48	39	39	37	40	41	44	49	50	58	47	49	49	41	38	40	43	46	44	46	53	55	56	55

Table 30. Continued

Station		Daily temperatures																														
		Day of month																														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Logan USU	Max	58	65	74	78	78	75	68	68	58	63	65	68	70	76	83	85	83	78	75	75	64	60	70	76	75	75	78	80	82	83	87
Exp. Sta.	Min	23	30	33	39	43	45	50	45	35	35	33	34	36	38	45	46	45	45	55	49	48	35	37	41	42	37	39	46	48	53	47
																													May 1973			
Lewiston	Max	52	50	57	68	63	67	67	66	62	70	67	74	76	78	75	79	83	83	81	79	69	66	72	78	79	51	58	68	72	73	75
	Min	35	28	31	39	37	39	40	44	37	44	31	30	32	38	33	41	44	44	43	46	39	32	37	48	47	33	31	33	36	39	40
Logan USU	Max	49	48	58	70	64	64	65	65	61	69	68	69	75	77	75	77	81	81	81	79	65	65	71	79	77	51	56	63	70	72	73
	Min	36	32	37	43	40	42	44	50	43	44	39	43	52	52	48	48	53	55	54	55	46	41	42	51	48	37	38	42	44	46	50
Logan USU	Max	50	58	70	69	69	67	68	67	70	71	70	77	78	78	78	82	83	84	80	77	67	73	79	81	70	58	65	71	73	75	80
Exp. Sta.	Min	38	28	35	34	37	38	40	41	39	48	35	36	50	52	38	46	49	50	51	53	41	42	42	52	45	33	35	39	39	46	45
																													May 1974			
Lewiston	Max	67	76	59			76	78	78	79	75			71	56	61	56	61	69	65	63	50	61	69	74	78	74	82	86	77	77	71
	Min	33	43	34			34	38	43	42	48			36	33	32	36	34	34	43	38	34	37	40	43	39	43	46	51	50	40	39
Logan USU	Max	66	70	58	62	69	75	75	76	77	75	58	67	72	53	62	53	59	69	66	58	48	59	70	74	76	76	78	85	77	74	68
	Min	42	46	42	41	44	48	50	51	52	49	40	48	35	40	38	39	41	36	42	34	35	40	38	44	52	53	60	57	52	44	43
Logan USU	Max	75	73	65	70	76	76	77	79	78	76	70	73	74	64	65	62	70	70	63	46	58	70	75	78	78	82	82	79	78	72	72
Exp. Sta.	Min	38	47	39	38	37	39	47	46	60	55	36	42	33	41	35	37	37	33	42	34	36	34	41	42	47	48	59	55	53	38	37
																													June 1974			
Lewiston	Max	73	77	81	83	76	61	62			72	79	84	88	92	93	100	95	92	92	92	84	82	92	94	94	97	86	89			
	Min				34	50	38	40	32			41	44	43	44	44	53	55	52	55	55	53	47	51	46	47	49	54	45			
Logan USU	Max	72	75	80	80	76	58	61	52	62	69	78	82	88	90	93	93	94	92	91	91	83	79	89	91	93	91	82	87	88	87	
	Min	44	46	54	54	51	44	49	38	43	48	47	55	59	63	63	68	63	62	64	63	54	58	62	64	63	58	56	56	61	64	
Logan USU	Max	75	80	82	81	74		63	64	76	80	83	89	93	94	97	95	95	93	92	90	84	90	93	94	92	92	88	90	90	92	
Exp. Sta.	Min	40	43	49	51	50	42	45	35	39	42	46	49	51	55	57	54	60	55	62	63	50	51	55	53	57	53	49	49	58	51	

Table 30. Continued

		Daily temperatures Day of month																														
Station		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
																													May 1975			
Logan USU	Max.	58	62	72	70	48	45	45	54	64	70	73	70	70	80	82	82	79	75	72	43	51	55	53	70	68	64	65	66	69	72	76
Exp. Sta.	Min.	28	36	41	31	30	28	35	37	35	37	45	40	36	37	46	48	48	41	36	30	32	36	41	45	27	29	38	40	36	40	45

Source: U. S. Department of Commerce, Weather Bureau. Climatological Data, Utah—1952 1975.

Table 31. Growing Degree Days for selected growing season months from 1952 through 1975, calculated for Utah State University Experiment Station, (50°-86° F method).

Day of month	GDD							
	Month and year							
	May 1952	May 1953	June 1953	May 1954	May 1955	May 1956	May 1957	May 1958
1	11.5	0.0	12.0	0.0	10.5	6.5	11.5	6.5
2	15.0	1.5	7.0	2.5	2.0	9.0	12.5	10.0
3	16.0	1.5	8.0	7.0	0.5	10.5	12.5	10.5
4	12.0	6.5	10.5	11.0	7.0	11.5	7.5	12.0
5	12.5	10.5	9.5	12.0	13.5	7.5	12.5	13.5
6	12.0	12.5	8.5	12.0	13.0	10.0	13.5	13.5
7	14.5	11.5	8.5	13.0	13.0	12.5	16.5	13.0
8	11.0	4.0	8.0	15.5	12.0	10.5	10.0	8.0
9	6.0	0.0	14.5	17.5	6.5	10.5	8.5	9.5
10	9.0	0.0	19.0	18.0	10.5	7.5	9.0	13.0
11	13.5	2.5	17.5	11.5	12.5	2.5	5.0	12.5
12	15.0	3.0	22.5	14.0	14.0	0.0	3.0	4.0
13	12.0	5.5	15.5	14.0	12.5	1.0	4.5	5.5
14	12.5	8.5	14.5	13.5	12.0	5.0	5.0	5.5
15	4.5	7.5	11.5	13.5	3.0	9.5	5.5	7.5
16	2.0	9.0	18.0	16.5	3.5	12.0	5.5	12.0
17	7.5	9.0	17.5	15.5	6.5	14.5	8.0	13.5
18	10.0	7.5	17.5	16.5	10.0	15.0	9.0	16.0
19	11.0	6.5	17.5	17.0	13.5	17.5	9.0	18.0
20	8.5	3.0	12.0	17.0	15.5	15.5	0.5	18.5
21	1.5	4.0	14.5	13.5	16.0	16.5	0.5	21.5
22	0.5	5.0	17.0	3.5	11.5	16.5	4.0	17.0
23	10.0	5.0	17.5	9.0	12.0	15.5	6.0	16.0
24	7.5	2.0	17.0	12.5	12.0	16.0	2.5	16.5
25	14.0	9.0	12.0	12.5	4.0	14.0	8.5	18.0
26	10.0	9.5	13.0	5.5	6.5	14.5	11.5	17.5
27	12.0	11.0	11.0	5.0	5.0	9.5	13.5	17.5
28	15.0	11.5	18.0	6.0	8.0	7.0	14.5	21.0
29	15.5	7.5	18.0	8.0	14.0	10.0	13.0	15.5
30	11.0	7.5	25.0	8.0	13.0	15.5	13.0	13.0
31	15.5	12.5		7.0	11.0	18.0	15.0	12.0

Table 31. Continued

Day of month	GDD Month and year May 1959	June 1959	July 1959	Aug. 1959	Sept. 1959	Oct. 1959
1	12.5	11.0	15.0	24.0	12.5	1.0
2	12.5	13.0	14.0	21.5	14.0	3.0
3	0.0	16.0	19.0	20.5	17.5	5.5
4	4.0	15.0	14.5	19.5	17.5	8.5
5	4.0	18.0	18.0	17.5	16.5	10.0
6	3.0	21.5	19.0	19.5	16.5	9.0
7	7.0	18.0	19.5	20.0	18.0	7.5
8	8.0	13.0	10.5	18.0	22.0	0.0
9	8.0	20.5	17.0	22.0	15.5	0.5
10	3.0	16.5	18.0	19.5	18.0	3.0
11	9.0	17.0	18.0	22.0	20.0	8.0
12	14.0	18.0	20.0	20.0	20.0	8.0
13	16.5	22.5	24.0	28.5	21.0	5.5
14	16.5	25.0	23.0	15.0	16.5	6.5
15	12.5	20.0	22.0	16.5	12.0	8.0
16	11.5	18.0	20.5	18.0	16.0	8.0
17	3.0	18.5	21.0	18.0	16.0	6.0
18	3.0	18.0	22.5	24.0	15.5	5.5
19	1.5	22.5	21.5	13.0	15.5	5.0
20	0.0	20.0	20.5	15.0	17.5	6.0
21	4.0	21.5	22.0	14.5	17.5	5.0
22	4.0	22.5	21.5	14.5	5.0	3.0
23	5.5	21.0	19.5	16.0	5.0	7.5
24	9.5	22.0	22.5	16.5	5.5	10.0
25	9.5	21.5	22.5	17.5	5.5	10.0
26	5.0	18.5	22.0	16.5	4.0	4.0
27	1.5	8.5	22.0	16.5	2.0	3.5
28	5.5	4.0	21.0	19.0	0.0	3.5
29	5.0	5.0	18.0	15.0	1.0	0.0
30	4.0	9.5	19.5	14.0	0.5	0.0
31	8.0		28.5	14.0		0.0
Total	211.0	516.0	616.5	556.0	384.0	161.0

Table 31. Continued

Day of month	GDD					
	Month and year					
	May 1960	June 1960	July 1960	Aug. 1960	Sept. 1960	Oct. 1960
1	7.0	15.0	18.0	22.5	19.5	14.0
2	7.0	16.5	19.0	18.0	21.0	13.5
3	6.5	17.0	18.5	19.5	20.5	14.5
4	5.0	17.5	18.0	20.0	20.0	14.5
5	7.5	15.5	18.5	19.0	18.0	14.5
6	9.0	17.0	22.5	20.0	18.5	14.5
7	10.0	17.5	20.5	19.0	16.0	12.5
8	10.0	14.0	18.5	19.0	15.0	7.0
9	13.5	13.5	19.5	18.5	15.5	0.0
10	16.5	11.0	22.0	23.0	17.0	1.0
11	18.0	13.0	19.5	20.5	18.0	0.5
12	18.0	15.0	18.0	21.0	18.0	2.5
13	16.5	18.5	24.0	22.5	19.5	0.0
14	8.5	17.0	20.5	24.5	16.5	0.0
15	11.0	15.5	19.0	20.0	14.5	5.0
16	10.0	15.0	19.0	13.0	16.5	6.0
17	8.5	19.0	20.0	12.5	15.5	9.5
18	5.0	18.0	22.5	17.5	14.5	
19	3.5	20.0	22.0	18.0	17.0	
20	9.5	15.0	21.5	19.0	16.5	
21	9.5	10.0	22.0	20.5	14.5	
22	5.5	14.5	22.0	18.0	10.0	
23	6.5	15.0	26.0	7.5	11.5	
24	7.5	17.5	20.0	8.0	12.5	
25	8.0	18.0	21.0	10.5	16.0	
26	12.5	17.5	21.0	16.5	17.5	
27	11.0	18.5	25.5	15.5	17.5	
28	10.0	18.0	24.0	11.5	14.5	
29	15.0	18.0	24.5	17.0	16.0	
30	16.0	18.0	26.0	18.0	15.0	
31	16.0		24.5	21.0		
Total	318.0	485.5	657.5	551.0	492.5	129.5

Table 31. Continued

Day of month	GDD Month and year May 1961	June 1961	July 1961	Aug. 1961	Sept. 1961
1	12.0	18.0	17.5	20.0	20.0
2	11.0	8.5	18.0	23.0	14.0
3	8.5	8.0	19.5	22.0	8.5
4	7.5	8.5	19.5	22.0	12.5
5	1.0	10.0	18.5	24.5	15.0
6	5.0	15.0	22.0	23.5	17.5
7	5.0	17.5	24.0	21.5	17.5
8	7.5	18.0	20.0	23.0	15.5
9	10.5	17.5	20.5	20.5	13.5
10	15.0	18.5	20.0	21.5	12.0
11	8.5	17.5	18.5	21.0	14.5
12	5.0	14.0	18.5	23.0	14.0
13	8.5	14.5	19.5	20.5	11.0
14	7.5	15.0	23.0	19.0	13.5
15	4.0	16.0	20.5	18.5	17.0
16	3.5	18.0	21.5	19.0	18.0
17	10.5	19.0	22.5	18.0	14.0
18	9.5	18.0	20.0	19.0	9.5
19	13.0	18.0	21.0	21.5	4.5
20	15.5	19.5	22.5	27.5	4.0
21	11.5	19.5	20.5	21.5	4.0
22	15.0	19.5	19.0	19.5	1.5
23	16.5	20.5	18.0	20.0	4.0
24	17.5	20.5	18.5	22.5	1.5
25	18.0	20.0	18.0	20.0	7.5
26	18.5	20.0	22.5	18.5	9.5
27	14.5	24.5	24.0	19.0	10.0
28	17.0	20.0	21.0	20.0	8.5
29	19.5	19.5	25.0	27.0	8.5
30	12.0	18.0	24.5	16.0	5.0
31	14.5		23.0	16.5	
Total	343.0	511.0	641.0	639.0	326.0

Table 31. Continued

Day of month	GDD				
	Month and year				
	May 1962	June 1962	July 1962	Aug. 1962	Sept. 1962
1	7.5	12.0	23.0	17.0	16.0
2	9.5	11.5	18.0	18.0	18.0
3	12.0	11.5	16.5	20.5	17.5
4	13.0	4.0	16.0	23.5	17.5
5	14.0	7.0	18.0	15.5	18.0
6	14.5	7.5	20.5	16.5	17.5
7	15.0	6.5	19.0	18.5	16.5
8	15.5	10.0	19.5	21.5	14.5
9	17.0	14.0	18.5	27.5	8.5
10	13.5	17.5	19.0	18.0	14.0
11	11.5	21.5	18.5	17.5	16.5
12	9.0	16.5	27.0	18.0	17.5
13	6.0	17.5	18.5	18.5	15.5
14	6.0	19.5	12.5	18.5	16.5
15	3.0	13.0	16.0	19.0	17.0
16	7.0	9.5	16.5	21.5	17.5
17	6.5	11.5	19.0	21.5	17.5
18	9.0	16.5	18.0	21.0	18.0
19	12.0	18.0	17.0	19.0	19.0
20	11.5	19.5	19.0	18.0	20.5
21	2.5	17.0	18.0	21.0	12.0
22	5.0	18.5	22.5	18.5	14.5
23	10.0	20.0	22.0	12.5	16.0
24	8.0	20.0	25.0	15.0	15.5
25	5.0	19.0	20.0	18.0	15.5
26	7.0	19.0	18.5	18.0	16.0
27	6.5	22.0	15.5	16.5	12.5
28	4.0	19.5	17.5	13.5	10.5
29	7.0	18.0	18.0	12.5	8.5
30	11.5	20.0	18.5	10.0	7.0
31	10.0		19.0	12.5	
Total	289.5	457.5	584.5	557.0	461.5

Table 31. Continued

Day of month	GDD Month and year May 1963	June 1963	July 1963	Aug. 1963	Sept. 1963	Oct. 1963
1	8.5	11.0	18.0	20.5	13.5	17.0
2	7.0	12.5	24.5	18.5	15.5	16.5
3	9.0	8.5	19.5	23.0	18.0	17.0
4	11.0	5.5	24.5	23.5	18.0	15.5
5	13.5	7.0	19.0	19.0	18.0	15.5
6	15.0	7.5	18.5	23.0	20.0	14.0
7	15.0	8.5	20.5	25.0	19.5	15.0
8	11.0	9.0	18.0	22.5	19.0	15.0
9	10.0	9.0	19.0	25.5	19.5	16.0
10	10.5	6.5	21.5	23.5	19.0	14.0
11	7.5	13.0	17.0	20.5	18.0	15.0
12	6.5	15.5	17.5	21.0	18.5	12.5
13	9.0	22.0	17.5	21.0	20.0	1.5
14	12.0	10.0	19.5	21.5	10.5	8.0
15	10.5	8.0	18.0	21.5	11.5	10.0
16	10.0	15.0	18.5	19.0	9.0	11.5
17	12.5	15.0	18.0	21.5	10.5	11.5
18	14.0	15.0	19.0	20.0	8.0	12.0
19	13.5	17.0	18.0	21.0	13.0	9.5
20	14.0	18.0	19.5	18.5	13.0	14.0
21	15.0	18.5	21.0	18.5	8.5	8.5
22	16.0	12.5	24.0	15.5	13.5	10.0
23	12.5	16.5	23.5	16.0	12.0	7.0
24	10.5	17.5	21.5	17.0	12.5	4.0
25	8.5	15.0	20.5	22.0	15.0	9.0
26	12.0	15.5	18.0	17.5	16.0	7.5
27	13.5	18.0	20.5	18.0	16.5	4.5
28	15.5	18.0	18.0	17.5	16.5	3.0
29	14.5	17.0	18.5	18.0	16.5	7.0
30	14.5	14.5	19.0	21.5	17.5	0.0
31	14.0		18.0	15.5		0.0
Total	366.5	396.5	608.0	626.5	456.5	321.5

Table 31. Continued

Day of month	GDD Month and year May 1964	June 1964	July 1964	Aug. 1964	Sept. 1964
1	5.0	13.5	18.0	25.0	16.5
2	0.0	17.0	18.5	18.0	8.0
3	0.0	12.5	18.0	19.0	12.0
4	3.0	14.0	18.0	21.0	15.5
5	3.0	14.5	17.5	23.5	16.5
6	3.0	13.0	18.0	21.0	16.5
7	8.5	12.5	18.5	23.0	15.5
8	2.5	5.0	18.0	24.0	15.5
9	6.0	8.5	23.0	21.5	14.5
10	7.0	9.0	18.0	21.0	14.0
11	9.0	7.5	20.0	19.0	15.5
12	9.5	10.5	22.5	20.0	16.5
13	13.5	9.5	22.5	19.5	17.0
14	13.0	12.0	24.5	18.0	15.5
15	14.0	11.0	20.5	19.0	14.5
16	16.5	10.0	18.5	22.0	14.0
17	15.5	6.0	19.5	18.5	15.0
18	14.0	7.5	22.0	18.5	13.5
19	17.0	6.0	19.0	20.0	8.0
20	16.5	8.0	18.5	9.0	9.0
21	15.5	7.0	20.5	11.5	10.0
22	13.5	8.5	20.5	15.5	10.5
23	10.5	13.0	22.0	17.5	12.0
24	13.0	16.0	18.0	18.5	13.5
25	16.5	18.0	18.0	17.5	16.0
26	13.5	19.0	18.0	15.0	15.5
27	12.5	24.0	20.5	10.0	10.5
28	4.5	19.5	22.5	8.5	13.5
29	5.5	18.5	23.0	12.5	14.5
30	7.5	19.5	23.0	13.0	13.5
31	11.0		21.5	15.0	
Total	300.0	370.5	620.5	555.0	412.5

Table 31. Continued

Day of month	GDD				
	Month and year				
	May 1965	June 1965	July 1965	Aug. 1965	Sept. 1965
1	11.0	11.5	17.5	22.5	14.0
2	10.0	11.5	14.5	20.0	15.0
3	7.5	14.0	17.0	21.5	14.5
4	7.5	13.0	19.0	19.0	12.5
5	6.0	13.0	18.0	17.0	13.5
6	0.0	15.0	18.0	18.0	7.0
7	0.0	16.0	19.5	18.0	10.0
8	0.0	15.0	19.0	19.5	9.0
9	2.5	15.5	24.5	20.5	9.5
10	6.0	14.5	19.0	21.0	12.5
11	9.0	15.5	21.5	23.0	14.0
12	11.0	18.0	18.5	24.0	13.0
13	10.5	12.0	17.5	22.5	13.0
14	10.0	11.0	18.0	18.0	12.5
15	11.0	11.5	19.5	20.0	9.0
16	14.0	9.0	21.5	20.0	7.5
17	13.5	9.0	21.0	21.5	0.0
18	11.0	12.5	22.0	16.5	0.5
19	12.0	18.0	19.5	11.0	3.0
20	10.0	18.0	17.0	15.5	5.5
21	9.0	17.5	19.5	14.0	3.5
22	11.0	18.0	21.5	12.0	9.5
23	9.0	18.0	19.0	14.0	8.5
24	5.0	18.5	18.5	16.0	10.5
25	6.5	11.5	20.5	15.0	13.0
26	5.5	7.5	19.0	14.0	12.5
27	7.5	8.0	20.5	7.5	15.0
28	11.0	11.5	21.0	16.5	8.0
29	14.0	14.5	18.0	15.0	2.0
30	16.0	17.5	26.0	11.0	6.5
31	15.0		23.5	12.5	
Total	272.0	416.0	599.0	536.5	284.5

Table 31. Continued

Day of month	GDD					
	Month and year					
	May 1966	June 1966	July 1966	Aug. 1966	Sept. 1966	Oct. 1966
1	11.5	14.5	25.5	22.5	9.5	11.0
2	14.5	18.0	27.5	24.0	8.5	8.5
3	16.5	14.0	15.5	25.0	14.5	4.5
4	16.5	10.0	18.0	19.5	17.0	7.5
5	17.0	9.5	18.0	19.0	19.0	10.5
6	17.0	12.5	18.0	19.0	18.0	12.0
7	16.0	15.0	20.5	18.0	18.0	12.0
8	16.0	12.0	23.0	18.0	24.5	11.0
9	13.5	14.0	21.5	23.0	18.0	9.0
10	5.0	17.0	20.0	18.0	19.5	10.0
11	5.0	13.0	22.0	20.0	20.0	10.0
12	4.0	9.0	25.5	16.5	17.0	8.5
13	7.5	13.0	19.5	18.0	15.5	3.5
14	7.5	16.5	22.5	19.0	8.5	0.0
15	9.0	18.0	23.5	18.0	2.0	0.0
16	10.0	17.5	20.5	18.5	10.0	2.5
17	8.0	16.5	25.0	19.5	15.0	4.0
18	9.0	18.0	24.5	19.0	17.5	2.5
19	12.0	18.0	24.5	21.0	16.0	7.5
20	14.0	19.0	23.5	15.0	17.0	
21	20.0	27.0	26.0	13.5	18.0	
22	10.0	12.5	21.0	16.5	18.0	
23	5.0	13.0	19.5	18.0	18.0	
24	12.5	15.0	22.5	18.0	20.5	
25	15.5	12.5	24.0	18.0	15.5	
26	17.0	18.0	19.0	26.5	13.5	
27	18.5	18.0	20.5	14.0	9.0	
28	19.5	20.0	22.5	18.0	11.5	
29	18.5	21.5	19.0	22.0	13.0	
30	23.5	24.5	19.0	16.5	12.0	
31	19.0		26.5	14.5		
Total	408.5	477.0	678.0	586.0	454.0	134.5

Table 31. Continued

Day of month	GDD Month and year									
	May 1967	May 1968	May 1969	May 1970	May 1971	May 1972	May 1973	May 1974	June 1974	May 1975
1	0.0	13.0	8.5	3.0	13.0	4.0	0.0	12.5	12.5	4.0
2	0.0	12.5	10.5	6.5	14.5	7.5	4.0	11.5	15.0	6.0
3	1.5	12.5	9.5	10.0	14.5	12.0	10.0	7.5	16.0	11.0
4	5.0	13.5	9.5	13.0	12.0	14.0	9.5	10.0	16.0	10.0
5	2.5	12.5	12.5	14.0	4.0	14.0	9.5	13.0	12.0	0.0
6	6.0	8.5	14.0	15.0	9.0	12.5	8.5	13.0	4.0	0.0
7	9.5	3.5	18.5	13.0	11.5	9.0	9.0	13.5	6.5	0.0
8	11.5	9.0	16.5	5.0	8.5	9.0	8.5	14.5	7.0	2.0
9	12.5	12.5	14.5	5.5	4.0	4.0	10.0	19.0	13.0	7.0
10	11.0	12.5	15.0	0.0	9.0	6.5	10.5	15.5	15.0	10.0
11	0.5	12.0	14.5	1.0	11.0	7.5	10.0	10.0	16.5	11.5
12	0.0	9.5	14.5	3.0	13.0	9.0	13.5	11.5	18.0	10.0
13	1.5	5.5	16.0	3.5	12.5	10.0	14.0	12.0	18.5	10.0
14	4.0	3.5	14.0	4.0	9.0	13.0	15.0	7.0	20.5	15.0
15	7.5	1.0	14.0	9.5	12.0	16.5	14.0	7.5	21.5	16.0
16	11.0	5.0	11.5	14.0	11.5	17.5	16.0	6.0	25.0	16.0
17	13.5	7.5	14.5	16.5	1.5	16.5	16.5	10.0	23.0	14.5
18	16.5	9.5	15.5	16.5	3.0	14.0	17.0	10.0	20.5	12.5
19	13.0	12.0	14.0	20.0	7.0	15.0	15.5	6.5	24.0	11.0
20	13.0	18.5	13.0	15.5	6.0	12.5	15.0	0.0	24.5	0.0
21	15.5	11.0	12.0	10.0	10.0	7.0	8.5	4.0	14.0	0.5
22	18.0	6.0	14.0	11.0	6.0	5.0	11.5	10.0	18.5	2.5
23	18.0	5.0	16.5	10.0	7.0	10.0	14.5	12.5	20.5	1.5
24	23.0	4.5	16.5	11.0	9.0	13.0	16.5	14.0	19.5	10.0
25	15.0	4.5	20.0	14.0	13.0	12.5	10.0	14.0	21.5	9.0
26	11.5	6.0	22.0	15.0	17.0	12.5	4.0	16.0	19.5	7.0
27	14.5	10.0	23.5	15.0	15.5	14.0	7.5	20.5	18.0	7.5
28	12.5	16.0	16.0	10.0	14.0	15.0	10.5	17.0	18.0	8.0
29	11.5	17.0	17.0	11.5	12.0	16.0	11.5	15.5	22.0	9.5
30	7.5	18.0	19.0	11.5	6.5	18.0	12.5	11.0	18.5	11.0
31	7.5	11.0	13.5	9.0	5.5	18.0	15.0	11.0		13.0

Source: Drawn from Table 30.

Table 32. Mean growing degree days using the 50°-86° F method, for various time periods and stations in Utah

Growing Degree Days - Base 50° F									
				Day	Mean GDD 1959-1966				
Week	Lewiston	Logan USU	Richfield	of	USU Experiment Station				
begins	mean	mean	mean	month	May	June	July	Aug	Sept
Apr 5	26	25		1	9.4	13.3	19.1		
Apr 12	41	40		2	8.9	13.6	19.3		
Apr 19	44	44		3	7.5	12.7	20.3		
Apr 26	45	45		4	8.4	10.9	18.4		
May 3	58	59	74	5	8.3	11.8	18.2		
May 10	66	64	77	6	8.3	13.6	19.6		
May 17	69	67	84	7	9.6	13.9	20.3		
May 24	82	84	97	8	8.8	12.0	18.3		
May 31	77	80	97	9	10.1	14.1	20.4		
Jun 7	91	94	109	10	9.6	13.8	19.7		
Jun 14	101	107	116	11	9.7	14.8	19.4		
Jun 21	110	119	121	12	9.6	14.6	20.9		
Jun 28	118	128	128	13	11.0	16.2	20.4		
Jul 5	126	144	132	14	10.1	15.8	20.4		
Jul 12	130	152	134	15	9.4	14.1	18.9		
Jul 19	132	158	135	16	10.3	14.0	19.5		
Jul 26	136	159	138	17	9.8	14.3	20.8		
Aug 2	131	152	135	18	9.3	15.4	21.3		
Aug 9	129	148	132	19	10.8		20.3		
Aug 16	126	149	129	20	11.8		20.3		
Aug 23	119	134	125	21	10.9		21.2		
Aug 30	114	125	121	22	10.0		21.5		
Sep 6	107	114	115	23	8.9		21.2		
Sep 13	95	97	111	24	10.4		20.8		
Sep 20	81	79	97	25	10.9		20.6		
Sep 27	75	75	91	26	11.4		19.8		
Oct 4	65	60	80	27	10.7		21.1		
Oct 11	53	49	67	28	10.9		20.9		
Oct 18	40	36	62	29	12.4		20.5		
Oct 25	29	28	53	30	13.1		21.9		
				31	13.2		23.1		
				Monthly totals	314	454	626	575	409

Source: Drawn from Table 30.

Table 32. Continued

Growing Degree Days, 50°F Base - 86°F Maximum			
County	Community	Elevation	Silage corn May 3-Sept 13 22 weeks 133 days
Cache	Lewiston	4480	2059
	Logan	4785	2275
Sevier	Richfield	5270	2236

Source: E. Arlo Richardson, Utah State Climatologist, Department of Soil Science and Biometeorology, Utah State University. Personal interview, August, 1975.

Table 33. Prices for corn silage in Utah from 1953 through 1974

Year	$ Value/Ton
1953	7.00
1954	7.50
1955	7.50
1956	7.00
1957	6.50
1958	6.50
1959	7.00
1960	8.00
1961	8.00
1962	7.40
1963	7.60
1964	8.20
1965	8.40
1966	9.80
1967	8.60
1968	8.10
1969	8.30
1970	9.80
1971	10.00
1972	11.50
1973	14.50
1974	17.20

Source: Statistical Reporting Service, U.S. Department of Agriculture. Utah Agricultural Statistics—1973. Salt Lake City, Utah.

Table 34. Growing Degree Days to maturity for Utah hybrids with an attached comparison of several other brands and their growing degree days to maturity

	Growing Degree Days				
Utahybrid	2000 to 2100	2200 to 2300	2400 to 2500	2500 to 2600	2600 to 2700
216	x				
330		x			
544A			x		
680				x	
54-40					x
644				x	

Table 34. Continued

	Growing Degree Days											
Brand	2000 to 2100		2100 to 2200		2200 to 2300		2300 to 2400		2400 to 2500		2500 to 2600	2600 to 2700
Northrup King	KE408 KE410	KC3 PX417 PX418	KE435 PX420 PX13 HSE	PX442 N.King HS1	PX446 PX448 HS1	PX20 PX466 PX476 HS2	PX480 PX529 KE497 PX519 PX40 PX525 PX529 HS2	PX545 PX556 PX47E PX48 HS3 KM589	PX50A PX65 PX610 PX610A PX614 SP622	PX616 PX606 PX611 PX627 PX63 PX670	KT626 KT623A	KT680 PX72 PX661 PX675 PX77 PX79 PX677 PX76
DeKalb	007 29	DK22 XL301	XL11 XL302	45 XT138 XL311 XL10	XL14 XL304	XL12 XL15A XL16 XL21 XL306 XL307	XL19 XL22B XL24 XL316	XL22 XL23 XL322 XL325 XL38 XL338	XL42 XL43 XL54 XL45A XL44 XL49 XL343	XL347 XL64 XL66 XL363 XL364	XL361 442 XL415A	XL72A XL372 XL74 XL80 XL81 XL84 XL85
Pioneer	3894	3985 3990	3980 3981 3976	3965 3853	3935 3816 3959 3956A	3932A 3937 3740	3784 3785 3780 3764 3778	3773 3543 3724 3538 3570	3571 3588 3517 3520 3575	3381 3385 3388 3390 3505 3507 3366	3206 3291 3367 314	3369A 3368 3306 3195

Table 34. Continued

Brand	Growing Degree Days										
Funk's	G4082	G43 G4160 G4170 G5150	G4175 G5145	G4110 G4180 G4263 G4195	G10A G4252 G4240	G5207 G4222 G4292 G4343 G4404	G4360 G4366 G4444	G4384A G4445 G4455	G4465 G4567 G4505	G4595 G4599 G4641	G4646 G4697 G4628 G4757 G5757
PAG	SX42	SX47 22	SX48 7120	SX44 SX67	46 SX76	SX240 SX33 58 64	7316 SX69	SX53 SX71 272 7333	SX7 SX454 315 SX56 SX83	315 344	SX93 SX92 SX98 SX39 SX17A
Idahybrid		216			330	30-50		544A	45-90	680	
Utahybrid					30-30		45-70			54-40	

Source: Steve Regan Co., Salt Lake City, Utah.

Table 35. A 130 day frost free growing season frost probability table

May	Prob. of 32°	Prob. of 28°	June	Prob. of 32°	Prob. of 28°	Sept.	Prob. of 32°	Prob. of 28°	Oct.	Prob. of 32°	Prob. of 28°
1		.55	1			1			1		
2			2	.20		2			2	.65	.25
3		.50	3			3			3		
4	.85		4	.15		4			4	.70	.30
5		.45	5			5			5		
6			6			6	.05		6	.75	.35
7	.80	.40	7			7			7		
8			8			8			8	.80	.40
9	.75	.35	9	.10		9			9		
10			10			10			10	.85	.45
11		.30	11			11	.10		11		.50
12	.70		12			12			12		.55
13			13			13			13	.90	
14	.65	.25	14			14	.15		14		.60
15			15	.05		15			15		
16	.60	.20	16			16	.20		16		.65
17			17			17			17		
18	.55		18			18	.25		18	.95	.70
19		.15	19			19			19		
20	.50		20			20	.30	.05	20		.75
21			21			21			21		
22	.45		22			22	.35		22		.80
23		.10	23			23			23		
24	.40		24			24	.40		24		.85
25			25			25		.10	25		
26	.35		26			26	.45		26		
27			27			27	.50		27		.90
28	.30		28			28	.55	.15	28		
29		.05	29			29			29		
30			30			30	.60	.20	30		
31	.25								31		

Source: E. Arlo Richardson, and Gaylen L. Ashcroft. Freeze-Free Seasons of State of Utah—Map and Table. Published jointly by Utah Agricultural Experiment Station, Utah State University, Logan, Utah, and Department of Commerce, ESSA, Environmental Data Services.

Table 36. Growth stages of corn in GDD.

	Varieties				
	Basic	Utah Hybrids			
Stages	Model*	216	330	544	680
Plant					
	80	80	80	80	80
Emerge					
	850	800	838	916	955
Tassel					
	370	348	365	398	415
Silk					
	140	132	138	151	157
Milk					
	840	790	829	905	943
Mature					
Totals	2280	2150	2250	2450	2550

*Model and Program developed by Dr. R. J. Hanks, and P. V. Rasmussen, Utah State University.

Table 37. Silage yield data for Utah Hybrid corn trials in the years 1953 through 1966

Variety	Yield in tons per acre dry weight	Maturity*	Percent dry weight	Year
Utahybrid 680	7.8			1953
544	8.4			
330	6.8			
Utahybrid 680	9.1	1.3		1954
544	7.3	2.0		
330	7.0	1.0		
Utahybrid 680	7.4	1.3		1955
544	7.9	2.0		
330	7.6	1.3		
216	6.1	1.0		
Utahybrid 680	8.6	1.9		1956
544	7.8	1.8		
330	6.7	1.1		
216	5.7	1.0		
Utahybrid 680	7.8	1.6		1957
544	7.7	2.1		
330	6.8	1.1		
216	5.1	1.0		
Utahybrid 680	9.6	1.0		1958
544	8.2	1.0		
330	7.9	1.0		
216	4.8	1.0		
Utahybrid 680	5.8	2.8		1959
544	6.0	1.5		
330	6.2	1.0		
216	4.8	1.0		
Utahybrid 544	5.3	4.4	20	1960
330	5.6	3.9	22	
216	4.7	2.4	23	
Utahybrid 680	7.9	1.0	30	1961
544	8.3	1.0	30	
330	9.1	1.0	38	
216	7.9	1.0	41	

Table 37. Continued

Variety	Yield in tons per acre dry weight	Maturity*	Percent dry weight	Year
Utahvbrid 680	7.09	3.9	27	1962
544	6.57	2.9	30	
330	6.58	2.1	34	
216	4.85	1.0	38	
Utahybrid 680	9.40	1.2	29.4	1963
544	7.20	1.0	31.4	
330	7.10	1.0	37.6	
216	5.72	1.0	39.1	
Utahybrid 680	6.5	3.7	22.9	1964
544	5.9	3.0	22.5	
330	6.2	1.2	29.0	
216	5.5	1.0	32.0	
Utahybrid 680	8.3	2.1	29	1965
544	6.9	2.4	27	
330	7.0	1.0	36	
216	4.6	1.0	46	
Utahybrid 680	6.4	2.0	27	1966
544	5.5	1.0	29	
216	3.8	1.0	36	
216	4.4	1.4	26	
544	5.8	1.6	28	
680	6.7	2.0	25	

Source: Rex F. Nielson, Corn Trials, 1953-1966. Department of Soil Science and Biometeorology, Utah State University, Logan, Utah.

*Key: 1.0 Dent
2.0 Hard dough
3.0 Soft dough
4.0 Milk
5.0 Kernels not formed

Table 38. A comparison of several years data taking one Utah Hybrid at a time

Variety	Year	Tassel	Silk	maturity*	Yield tons/ac.	Planted	Harvest	GDD
Utahybrid 216	1959	7/18	7/22	1.0	4.8	5/8	9/17	2125.5
	1960			2.4	4.7	6/21	9/23	1735.5
	1961	7/14		1.0	7.9	5/4	9/14	2288.0
	1962	7/21	7/25	1.0	4.85	5/4	9/10	1990.5
	1963	7/24	7/28	1.0	5.72	5/8	10/2	2381.0
	1964	7/20	7/26	1.0	5.5	5/11	9/14	1992.5
	1965	7/18	7/23	1.0	4.6	5/3	9/20	1985.0
	1966			1.0	3.8	5/3	9/21	2412.0
	1966[a]			1.4	4.4	5/24	9/21	2177.5
Utahybrid 330	1959	7/25	7/28	1.0	6.2			
	1960			3.9	5.6	6/21		
	1961	7/21		1.0	9.1	5/4		
	1962	8/1	8/4	2.1	6.58	5/4		
	1963	7/27	7/29	1.0	7.10	5/8		
	1964	7/31	8/4	1.2	6.2	5/11		
	1965	7/26	7/29	1.0	7.0	5/3		
Utahybrid 544	1959	7/27	8/1	1.5	6.0			
	1960			4.4	5.3	6/21		
	1961	7/25		1.0	8.3	5/4		
	1962	8/1	8/5	2.9	6.57	5/4		
	1963	7/29	8/3	1.0	7.20	5/8		
	1964	8/1	8/6	3.0	5.9	5/11		
	1965	7/30	8/5	2.4	6.9	5/3		
	1966			1.0	5.5	5/3		
	1966			1.6	5.8	5/24		
Utahybrid 680	1959	8/1	8/5	2.8	5.8			
	1960							
	1961	7/26		1.0	7.9			
	1962	8/8	8/13	3.9	7.09			
	1963	8/8	8/10	1.2	9.40			
	1964	8/5	8/11	3.7	6.5			
	1965	8/1	8/5	2.1	8.3			
	1966			2.0	6.7			
	1966			2.0	6.4			

[a]Replant.

*See Table 37.

Source: Drawn from Tables 31, 32, and 37.

Table 39. Precipitation accumulated over the 14 day period ending with the dates listed, (in inches), at Utah State University Experiment Station

Dates	Precipitation in inches							
	Years							
	1959	1960	1961	1962	1963	1964	1965	1966
May 1	1.81	1.30	.41	1.63	2.10	1.26	.29	.82
2	1.03	1.30	.31	1.63	2.06	1.82	.21	.22
3	.73	1.07	.31	1.63	1.86	1.69	.21	.13
4	.71	1.28	.35	1.54	1.39	1.57	.21	.13
5	.71	1.28	.35	.82	.89	2.28	.51	.13
6	.71	1.28	.08	.82	.89	2.28	.41	.08
7	.71	1.01	.18	.82	.89	2.28	.41	.08
8	.71	.84	.18	.82	.92	1.97	.68	.08
9	.71	.84	.18	.82	.97	1.97	.81	.30
10	.21	.84	.18	.69	.68	1.77	.81	1.02
11	.00	.84	.18	.69	.26	1.98	.81	1.12
12	.00	.56	.18	.01	.30	1.98	.81	1.12
13	.00	.42	.18	.15	.30	1.98	.81	1.12
14	.00	.42	.21	.27	.30	1.98	1.07	1.12
15	.00	.42	.41	.44	.23	1.76	1.07	1.12
16	.26	.42	.53	.53	.23	1.15	1.07	1.12
17	.26	.22	.53	.53	.23	1.10	1.07	1.12
18	.30	.06	.52	.53	.23	1.10	1.07	1.12
19	.30	.06	.52	.53	.23	.21	.77	1.12
20	.30	.06	.52	.56	.23	.21	.88	1.12
21	.30	.06	.38	1.26	.23	.21	.88	1.12
22	.50	.05	.38	1.35	.20	.21	.55	1.17
23	.54	.05	.38	1.35	.15	.21	.42	.95
24	.54	.05	.38	1.42	.15	.21	.99	.15
25	.61	.05	.38	1.45	.14	.00	.99	.05
26	1.05	.05	.38	1.51	.10	.00	1.00	.05
27	1.78	.19	.38	2.04	.00	.30	1.00	.05
28	1.78	.19	.35	1.97	.00	.37	.74	.05
29	1.78	.19	.15	1.92	.00	.94	.74	.05
30	1.54	.19	.13	1.92	.00	.97	.74	.05
31	1.54	.19	.13	2.22	.00	.97	.74	.05

Table 39. Continued

Dates		Precipitation in inches							
		Years							
		1959	1960	1961	1962	1963	1964	1965	1966
Sept.	14	.00	.44	.04	.00	.47	.04	1.62	.79
	15	.51	.09	.04	.00	.47	.08	1.62	.64
	16	.56	.07	.06	.00	.47	.04	2.35	.59
	17	.56	.16	.18	.00	1.86	.04	2.35	.59
	18	.61	.16	1.08	.00	1.86	.10	2.35	.59
	19	.67	.12	1.75	.00	2.18	.10	2.27	.59
	20	.93	.12	1.80	.00	2.19	.10	1.01	.59
	21	1.07	.12	1.80	.02	2.30	.10	.98	.59
	22	1.07	.22	1.80	.02	2.34	.10	.80	.59
	23	1.07	.22	1.85	.02	2.34	.10	.73	.59
	24	1.09	.22	1.85	.02	2.34	.10	.73	.59
	25	1.45	.22	1.85	.02	2.34	.10	.73	.54
	26	1.62	.22	1.85	.02	2.34	.10	.73	.55
	27	1.74	.20	1.85	.08	2.04	.10	.73	.65
	28	2.02	.20	1.85	.25	2.04	.10	.73	.32
	29	1.59	.20	1.85	.31	2.04	.06	.86	.21
	30	1.54	.20	1.79	.31	.65	.06	.13	.21
Oct.	1	1.54	.10	1.67	.31	.65	.06	.13	.21
	2	1.49	.10	.77	.31	.33	.00	.13	.21
	3	1.43	.10	.10	.31	.32	.00	.13	.21
	4	1.17	.10	.05	.31	.15	.00	.13	.21
	5	1.03	.10	.05	.68	.00	.00	.13	.21
	6	1.03	.00	.05	.76	.00	.00	.13	.21
	7	1.19	.06	.14	.84	.00	.00	.13	.21
	8	.17	.58	.15	.84	.00	.00	.13	.21
	9	.95	1.07	.21	.84	.00	.00	.13	.19
	10	.78	1.14	.46	.78	.00	.00	.13	.10
	11	.66	1.26	.46	.61	.00	.00	.13	.00
	12	.38	1.28	.46	.55	.19	.00	.17	.00
	13	.30	1.64	.46	.55	.83	.00	.04	.41
	14	.30	1.64	.46	1.03	.83	.00	.04	.41
	15	.30	1.64	.46	1.04	.83	.00	.04	.41
	16	.30	1.64	.46	1.04	.83	.00	.04	.41
	17	.30	1.64	.46	1.04	.83	.00	.04	.41
	18	.30	1.64	.46	.65	.83	.00	.04	.41
	19	.30	1.64	.46	.57	.83	.00	.04	.41
	20	.30	1.64	.46	.49	.83	.00	.04	.41
	21	.14	1.58	.32	.49	.83	.00	.04	.41

Table 39. Continued

Dates		Precipitation in inches						
					Years			
		1952	1953	1954	1955	1956	1957	1958
Sept.	14	.15	.00	.26	.00	.06	.00	.50
	15	.15	.00	.26	.00	.06	.00	.50
	16	.15	.00	.14	.00	.06	.00	.50
	17	.15	.02	.14	.03	.06	.00	.50
	18	.15	.02	.14	.03	.06	.05	.50
	19	.15	.02	.14	.36	.06	.62	.50
	20	.15	.02	.14	.36	.06	.62	.50
	21	.13	.02	.14	.36	.06	.62	.50
	22	.13	.02	.14	.36	.06	.62	.50
	23	.13	.02	1.85	.36	.06	.62	.44
	24	.13	.02	1.85	.39	.05	.62	.49
	25	.05	.02	1.71	.69	.00	.62	.46
	26	.03	.02	1.71	1.22	.00	.62	.33
	27	.03	.02	1.71	1.22	.00	.62	.05
	28	.00	.02	1.71	1.22	.00	.62	.05
	29	.00	.02	1.71	1.22	.00	.62	.05
	30	.00	.02	1.71	1.22	.00	.62	.05
Oct.	1	.00	.00	1.71	1.19	.00	.62	.05
	2	.00	.00	1.71	1.19	.00	.66	.05
	3	.00	.00	1.71	.86	.00	.31	.05
	4	.00	.00	1.74	.86	.00	.57	.05
	5	.00	.00	1.79	.86	.00	.57	.05
	6	.00	.00	.08	.86	.00	.57	.05
	7	.00	.00	.08	.86	.00	.57	.05
	8	.00	.00	.08	.83	.00	.57	.00
	9	.00	.00	.08	.53	.00	.57	.00
	10	.00	.00	.08	.00	.00	.57	.00
	11	.00	.00	.08	.17	.00	.57	.00
	12	.00	.00	.08	.17	.30	.57	.00
	13	.00	.00	.34	.17	.31	.57	.00
	14	.00	.00	.34	.17	.31	.63	.00
	15	.00	.17	.34	.17	.31	.63	.00
	16	.00	.17	.34	.17	.31	.54	.00
	17	.00	.17	.34	.17	.31	.32	.00
	18	.00	.17	.31	.17	.31	.06	.00
	19	.00	.17	.26	.35	.31	.06	.00
	20	.00	.17	.26	.64	.31	.06	.03
	21	.00	.17	.26	.74	.31	.06	.03

Source: U.S. Department of Commerce, Weather Bureau. Climatological Data, Utah—1952-1975.

Table 40. Snow fall data, 1959-1974, at Utah State University Experiment Station

Dates	Snow total (inches)	Max. depth (inches)	Snow fall (inches)	On ground (inches)
1959 Sept.	0	0		
Oct.	0	0		
Nov.	0	0		
1960 Sept.	0	0		
Oct.	0	0		
Nov. 4			3.6	4.0
5			.5	
9			1.0	
1961 Sept.	0	0		
Oct.	19.0			
Oct. 22			4.5	5.0
28			6.2	6.0
29			5.3	9.0
Nov.	3.3			
1962 Sept.	0	0		
Oct.	0	0		
Nov.	0	0		
1963 Sept.	0	0		
Oct.	0	0		
Nov. 7	T	T	4.0	4.0
16			3.5	3.0
17				2.0
18				1.0
1964 Sept.	0	0		
Oct.	0	0		
Nov. 11	1.0	1.0	3.0	3.0
12			T	1.0
13			2.0	3.0
14				2.0
1965 Sept.	T	0		
Oct.	0	0		
Nov. 24	6.7	5.0	3.4	3.0
25			5.6	7.0
26			.8	6.0

Table 40. Continued

Dates	Snow total (inches)	Max. depth (inches)	Snow fall (inches)	On ground (inches)
1966 Sept.	0	0		
Oct.	0	0		
Oct. 13			.5	1.0
14			4.5	5.0
21			T	T
Nov.	3.0	3.0		
Nov. 8			8.5	9.0
9			.3	7.0
10			.3	5.0
11			T	3.0
1967 Sept.	0	0		
Oct.	0	0		
Nov.	.4	1.0		
1968 Sept.	0	0		
Oct.	0	0		
Oct. 17			T	
Nov.	12.8	6.0		
1969 Sept.	0	0		
Oct.	0	0		
Oct. 11			T	
13			T	
Nov.	T	0		
Nov. 16			T	
18			.5	1.0
1970 Sept.	0	0		
Oct.		2.0		
Oct. 7			T	
10			T	
11			T	
27			T	
Nov.		T		
1971 Sept.	0	0		
Oct.		4.0		
Oct. 1			2.0	2.0
18			5.0	5.0
19			T	3.0
27			T	T
28			6.0	6.0
29				2.0
31			3.0	3.0

Table 40. Continued

Dates	Snow total (inches)	Max. depth (inches)	Snow fall (inches)	On ground (inches)
1971 Nov.		3.0		
Nov. 1			2.0	3.0
2			T	1.0
3				1.0
1972 Sept.	0	0		
Oct.		T		
Oct. 29			1.2	2.0
30			T	1.0
31				T
Nov.	1.0	29.0		
Nov. 15			T	
27			.3	T
29			.8	
1973 Sept.	0	0		
Oct.	0	0		
Oct. 29			.1	
30			.2	
Nov.	3.0	26.0		
Nov. 5			1.4	
22			2.8	3.0
1974 Sept.	0	0		
Oct.	0	0		
Oct. 22			T	
Nov.	0	0		
Nov. 28			T	

Source: U.S. Department of Commerce, Weather Bureau. Climatological Data, Utah—1952-1975.

Table 41. Lewiston, Utah precipitation means and probabilities for one-week periods

	Probabilities			
	Inches precipitation			
Dates	.4	.6	.8	1.0
Sept. 6	.18	.11	.07	.04
Sept. 13	.24	.15	.09	.05
Sept. 20	.24	.16	.10	.07
Sept. 27	.21	.14	.09	.06
Oct. 4	.26	.16	.10	.06
Oct. 11	.33	.21	.13	.08
Oct. 18	.33	.22	.15	.10
Oct. 25	.35	.24	.17	.11

Source: E. Arlo Richardson, Utah State Climatologist, Department of Soil Science and Biometeorology, Utah State University. Personal interview, August, 1975.

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