In hotter areas, such as Utah’s Dixie, apples develop good size, shape, and eating quality but do not evolve the red coloring that is necessary for top grade apples. In a study conducted at St. George, Utah, Starkrimson Red Delicious apples were cooled during the last 20 days and nights before harvest by sprinkling with a mist of water. The cover shows the bright red color that developed on the treated apples and the pale pink blush on the untreated fruit.
Research helps Utah

As recently as 100 years ago, 75 percent of the human labor expended per day had to be devoted to the production of food and fiber. Up to that time significant changes in food production practices occurred only over centuries or even millennia. During the past 50 years, however, the application of science to food production has altered the pattern and the course of human living. Unfortunately, the increased capacity to produce food coincided with an explosion in population. Thus the world contains people who are still concerned about getting enough food to eat, while elsewhere attention has become centered on whether the food is pure and if the required nutrients are in balance.

In the U.S., foods must be free from disease organisms and insects or insect fragments. Furthermore, legal standards stipulate that no traces of pesticides or other chemicals that are necessary to produce the food crops are permitted in or on the final foods. These requirements can be met only after extensive research.

The large monoculture plantings that produce our tremendous quantities of essential food products at minimum cost introduce additional problems. Extensive acreages of corn, wheat or alfalfa present an ideal habitat for insects and diseases adapted to the particular plant. Insects and diseases are so supremely adaptable that it has not been possible to devise a pesticide, a new variety, or a management practice that has more than a temporary capacity for control. Those fighting the battles know that a new pesticide or a new plant variety resistant to a disease or insect will usually not be effective beyond 10 years. Only sustained, persistent efforts of plant breeders, entomologists and other concerned scientists, can hold off the very real threat of widespread, disastrous famines.

D. WYNNE THORNE

The Utah Agricultural Experiment Station is the agency designated in Utah to conduct scientific explorations designed to assure a continuing supply of quality food and fiber. Station personnel currently are pursuing some 150 different research projects. A few representatives are described here to illustrate the kinds of research going on and how these studies have helped each of us. More detailed reports of our research are presented in this and other issues of Utah Science as well as in more technical bulletins and professional articles.

IRRIGATION, THE BASIS FOR SCIENTIFIC FARMING

The first known field plot experiments in irrigation were conducted by J. W. Sanborn, the first President of USU, in the experimental fields east of Old Main where the USU quadrangle now serves as a general playing field. Since that time USU has maintained a leadership role in irrigation research.

Experiments over 8 years in the early 1950s compared sprinkler irrigation with traditional surface irrigation relative to five crops and a number of fertilizer treatments. These experiments provided some of the primary comprehensive data showing the potential for water economy and improved use of fertilizer and cropping systems with sprinkler irrigation. Such experimental data provided the important information base essential for the rapid adoption of sprinkler irrigation under uneven topographic conditions.

Currently, adaptations of trickle irrigation are being used by Dr. John Hanks for intensive studies of soil moisture-soil fertility relations in crop production. With trickle irrigation even further savings in water can be achieved, particularly with perennial, high value crops such as tree fruits.

Under traditional surface irrigation methods only about 40 percent of the water delivered to farms is used by growing crops. With sprinkler irrigation this has been increased to about 80 percent. Trickle irrigation might save an additional 10 percent of our irrigation water under moderately restricted conditions.

WHEAT BREEDERS AND DWARF BUNT SMUT

Since early in the 1920s the winter wheat crop of Utah and southern Idaho has been troubled by the dwarf bunt smut disease. These smut organisms live over in the soil, invade the wheat plant in the fall, cause a dwarving of the stems the next spring, and then invade and completely destroy the wheat seeds as they develop.
Utah Agricultural Experiment Station scientists produced the first wheat variety resistant to this smut in 1927. In that year over 70 percent of the winter wheat produced in Utah was graded smutty, and yields were reduced 50 percent or more in affected fields. The dwarf smut organisms have proved nearly as versatile as the scientists. Every 7 to 10 years the smut organisms produce a new race that attacks the resistant wheat varieties. As a result, there is a continuous race between the plant breeders developing resistant varieties and the smut evolving new strains that will attack the wheat.

Over the years, a succession of new wheat varieties has been released starting with Relief in 1927, and followed by Cache, Wasatch, Delmar, and Bridger. Now a new race of smut is attacking all of these. Fortunately, USU scientists have one or two new wheats ready to be placed in the hands of certified seed growers for multiplication this fall.

Through the continuing dedication of our wheat breeders, calamity is averted, but the battle is never over. They will soon begin searching the fields for any infected heads on the new wheats, and then seek out wheats resistant to these new races of smut. Often resistant wheats have few other desirable qualities, so the long process of crossing and selecting to combine all desirable traits within one plant goes painstakingly forward.

With increasing world demand for bread wheats, high prices, and the relaxing of acreage controls, the acreage of winter wheat will continue to increase from the present 200,000 acres toward the 350,000 acres achieved in the early 1950s. Also, the value of the wheat will likely soon far exceed the 11 to 12 million dollar level of the 1950s. USU's continued intensive breeding program carried on by Dr. Wade Dewey and Dr. Rulon Albrechtsen is an essential if this important industry is to keep viable.

It has been estimated that the benefits of this program alone to wheat growers of Utah amount to more than $2 million per year. This more than compensates for public support of the Agricultural Experiment Station.

CONTROL OF FORAGE CROP INSECTS

More than 40 percent of the cultivated land in Utah is planted to alfalfa. This is the most valuable of all forage crops, being the major source of protein for livestock. It is clearly the highest yielded of protein per acre of all crops and in today's feed and food market, protein is the most expensive and limiting of all nutrients.

One of the major problems in the production of alfalfa hay in this area is the control of alfalfa weevil. This voracious insect multiplies rapidly and unless controlled consumes large proportions of the nutritious leaves of the maturing crop. The annual cost of the alfalfa weevil to alfalfa producers in Utah exceeds $5 million. DDT and related insecticides provided satisfactory control for a number of years, but new weevil strains with high resistance to this group of pesticides were becoming common at about the time their use was banned. It was also found that extensive applications of all-purpose pesticides often favored development of weevils by indiscriminately killing many of their most effective predators.

Scientific advances in alfalfa weevil control have been slow because the insects could not be cultured under controlled synthetic conditions. During the past year, Dr. Hsiao and associates of Utah Agricultural Experiment Station have developed a synthetic medium and handling techniques that will sustain alfalfa weevil organisms through their complete life cycle, entirely apart from alfalfa or alfalfa preparations. Using these new techniques, the nutritional requirements and the biochemistry of the weevil are now being studied. Cultures of weevil organisms are being treated with viral preparations and are being exposed to other insects in search of effective predators. Among the candidates is a protozoan parasite (a microsporidian) that is restricted to the alfalfa weevil. Plans are being implemented to multiply this organism in sufficient quantities for limited field tests.

A third series of studies being conducted by Dr. Donald Davis involve combining insecticides at times and in ways that will least injure the weevil parasites. Present evidence indicates that effective insect control must come from integrated programs that encourage natural predators while applying pesticides at strategic times.

This multiple attack on the problem gives renewed hope of solving the alfalfa weevil problem that has plagued alfalfa production since shortly after the introduction of this crop to Utah more than 100 years ago.

VIRUS RESISTANT CHERRIES

Utah's environment favors the production of quality sweet cherries. Two problems, however, have plagued the industry and limited its healthy development. These problems are the rapid spread of virus diseases causing early death of trees, and the frequent killing of blossoms by spring frosts.

Research at Utah Agricultural Experiment Station is moving rapidly toward perfecting new varieties and practices that will minimize losses from these two major problems. The control of frost losses is reported separately.

Dr. Bryce Wadley, employed by the USDA Agricultural Research Service and supported in part by Utah Agricultural Experiment Station funds, has worked for years in identifying the various virus diseases and testing thousands of strains of cherries to find selections with resistance to these killer diseases. Two virus diseases known as Western X and Rusty Mottle cause the greatest losses and have received the most intensive study.
Success is now in sight. Some 10 to 20 strains of cherries have been found to have both resistance to the virus diseases and qualities attractive to consumers. Several of these new cherry varieties have been planted in private commercial orchards to test grower and public acceptance.

One strain that closely resembles the Bing variety is being considered for immediate release, and two or three other virus resistant strains will likely prove worthy of release in the next few years.

Dr. Wadley has retired from the U.S. Department of Agriculture but his work is being supported by the Agricultural Experiment Station until the cherries he has worked with for so long, can be evaluated and made available to the public.

Sweet cherry sales in favorable years exceed the million dollar level. Now the potential for a substantial increase in the crop is favorable if these new cherries prove popular.

**RESEARCH AND CHEESE**

During the past three years cheese production in Utah has undergone a phenomenal growth from 11 million pounds to 47 million. With cheese selling for more than 1 dollar per pound, the expansion of this industry is important to Utah's economy.

This growth has been strongly assisted by the research of Drs. Ernststrom and Richardson in the USU Department of Nutrition and Food Sciences. Among the distinctive recent research results that have been adopted by the industry are:

- New techniques for identifying and processing so-called "dead milk," which is resistant to usual cultures of organisms used in cheese making. New ways to adjust acidity and the use of special clotting enzymes now enable processors to make good cheese from batches of milk formerly wasted.

- Until recently, the calf gastric enzyme, rennin, was used almost exclusively for milk coagulation in cheese making. Few calves are slaughtered for veal today, and the supply of such rennin cannot satisfy more than half the requirements for cheese making in the United States. Substitute enzyme materials have given erratic results. Our studies have provided tests and guidelines whereby the use of these substitutes for "calf rennin" can be relied upon to produce quality products. The procedures involve adjusting the acidity and the calcium content of milk batches to the conditions that are optimum for each enzyme. Through these techniques cheese of uniformly high quality can be attained with benefit to the public and savings to the processors.

- Until recently cheese batches with slightly inferior flavors and scraps from cutting manufactured cheese into marketable packages have been wasted or sold at much lower prices. Utah State University researchers have devised new processed cheese products having special flavors such as smoked, pimento, etc. that have proved popular with consumers. These processed, flavored cheeses have created new markets and higher prices for previously unprofitable products.

USU research on the processing of milk products has attained national distinction. Numerous investigations here are now sponsored by many of the major national companies that produce milk products.

**A NEW FOWL CHOLERA VACCINE FOR TURKEYS**

Stimulated by the results of workers at Clemson University, South Carolina and the University of Minnesota, an avirulent oral fowl cholera vaccine has been prepared by Dr. Ross Smart and others of the Veterinary Science Department of Utah State University for use in Utah turkey flocks.

The vaccine, which is administered in the drinking water, has been tried in more than 15 commercial flocks in Utah that total more than 150,000 turkeys. Results indicate that immunity to virulent challenges is effective at least 5 to 6 times longer using this method than with the traditional bacterin treatment. Another advantage is the ease of administration, eliminating the stress and losses encountered when each bird receives an individual injection.

When cholera strikes, losses in turkey flocks often exceed 50 percent. One major turkey producer lost 50,000 turkeys last year out of a total production of 800,000 birds. Best estimates are that fowl cholera causes annual losses in excess of 1 million dollars per year to Utah turkey producers. This vaccine has the potential of reducing this loss by 75 percent.

The easily administered treatment is a major boon to the turkey industry. Production of the vaccine is booming and requiring increasing proportions of our veterinarians' time. The procedure and production of the vaccine should soon be standardized so that it can be taken over by industry.

**NEW HOPE FOR CALF SCOURS CONTROL**

At least 10 percent of newborn calves suffer from calf scours, resulting in an annual U.S. loss of $200 million and causing a major reduction in the nation's supply of beef. About 70 percent of this loss is caused by a special group of viruses. Dr. Rex Spendlove of the Agricultural Experiment Station staff and Professor of Bacteriology is one of the nation's best authorities on these particular viruses.

During the past year, the expertise of Dr. Spendlove and his associates and the calf scours problem have been brought together. Already pronounced progress has been made toward developing a rapid practical method to obtain an early identification of the causative agent.

The procedure being developed is...
The second area of research is concerned with the control of insects and diseases that affect both cows and calves. Reducing the present 30 percent level of embryonic death is one goal. Evidence indicates one cause of poor conception and possible fetal losses is a combined effect of para-influenza virus and phosphorus deficiency. These combined effects are being intensively studied. A protozoan infection of the reproductive system of cattle, termed coccidiosis, is being studied by Dr. Hammond in the Biology Department and new drugs are being found that provide increasingly effective control. The many diseases causing loss of the fetus are being studied and control measures investigated.

The third research effort is to increase the frequency of calving and the proportion of multiple births. Several factors become important. Hormones, or so-called fertility pills, can increase the probability of multiple conceptions. This must be accompanied, however, by good nutrition, sanitation, and management to lead to successful parturition and to enable the cow to successfully nurse more than one calf.

Present calf losses of 10 to 25 percent can, we believe, be substantially reduced. With about 300,000 calves per year in Utah worth $100 each, there would be a net value of $300,000 added to the livestock industry for each 1 percent increment saved.

The successful improvement of the nation's calf crop, we believe, is the most vital step that can be taken to beef up the nation's supply of beef. Utah's $80 million beef industry and its customers would be a prime beneficiary.

The diverse investigations essential to keeping abreast of nature and that must provide the improvements in the wide variety of crops and animals routinely demanded by modern society are far beyond the staff and financial resources of Utah Agricultural Experiment Station. Joint planning of research is therefore under-

AG NOTES

Tall corn cuts visibility at intersections and increases the hazard of accidents. Seed corners with a low growing grass or legume, and you will increase the visibility of approaching vehicles to a safe 400 foot or more.

- When repairing farm machinery, stop it before working on it!

- Match your fire extinguisher with the fire. Be sure to read the operating instructions on your extinguisher. "A" type on paper or wood, "B" type on gas or oil, "C" type on electrical fires.

- Respect the danger of electricity. Keep an eye peeled for power lines — above and below!

- Run a safety check around your farm. Replace worn wiring, destroy greasy rags, clean up oil spills. Stop trouble before it starts.

- When fire starts, get out of the house — and DON'T go back.

- Look, before backing!

- What's your Fire Department's phone number? If you don't know it — find out, and keep it handy!

- Around machinery, loose clothing means trouble!
COLOR BY COOLING

J. LAMAR ANDERSON, E. ARLO RICHARDSON,
GAYLEN L. ASHCROFT, RICHARD E. GRIFFIN,
GRANT HANSON, AND JOSE ALFARO

The color of red delicious apples can be enhanced in Utah by cooling the apples on the trees while the color is forming. The cooling is accomplished by spraying a mist of water to reduce the temperature of the fruit by evaporation (see article on "Reducing Freeze Damage to Fruit by Overhead Sprinkling").

As apples mature, an enzyme normally triggers production of the anthocyanin pigment, that gives the apples their red coloring. In hot temperatures, this enzyme breaks down prematurely and the apples do not become red. The apples may taste just as good, but without a bright red color they lack the necessary consumer appeal and are downgraded. Consequently, hotter areas such as Utah's Dixie, can grow apples of good size and eating quality but they don't grade up because of poor coloring.

In a study conducted at St. George, Utah State University researcher's installed equipment that put out a mist of water just above the apples on each tree. The amount of water was small enough that most of it evaporated from the apples and leaves and did not drip off and soak into the soil. The process brought the temperature of the apples down. This reduction in fruit temperature, which amounted to about 15 to 20 degrees in the hottest part of the day, reduced the break down of the "coloring" enzyme, and consequently resulted in redder apples.

MISTING MAKES RED

In the USU study, some of the trees were misted both day and night, some only at night, some only during the day and others were not sprinkled. Little or no advantage came from night-only misting. The day-only scheduling caused a marked increase in fruit color, but not quite so much as those misted 24 hours a day. The apples treated both day and night graded extra fancy, whereas the color of the untreated apples was so poor that they only made C grade (see front cover).

Overhead sprinkling to enhance fruit coloring involves different problems than does sprinkling in the spring for bud delay. In the early spring, there are no leaves and only the limbs and small buds must be moistened. Later in the year, the canopy of leaves makes it difficult to get water mist onto the apples themselves.

Our preliminary study showed that the coloring of red delicious apples can be enhanced through reducing the fruit temperature by overhead sprinkling with good quality water (salty water causes leaf burn and other plant damage problems). Much research is needed, however, before the technique becomes usable by growers. The most efficient type of sprinkler, the best timing arrangement, the optimum application rates, and other factors must be determined. We do not advise growers to purchase equipment for this treatment either to prevent freeze damage or to enhance fruit color until more refined answers are obtained as to what type of installation is most effective.

AG NOTES

If fire strikes, does your family know the best escape route? If not, plan one and practice using it!

• Equip all of your farm vehicles with a fire extinguisher. This small investment could save you the price of an expensive piece of machinery.

• When fire strikes, seconds count. Keep an extinguisher handy, and know your fire department's phone number.

• Electrical accidents need not occur. Plan your electrical system, plus keeping it up to date, can make it a safe product to use.

Make sure your farm machinery carries the orange and red bordered slow moving vehicle triangle: it could save your life.

• When fire strikes, get the family out first ... material things can be replaced.

• The assets of American agriculture equal about half the market value of all U.S. corporations listed in the New York Stock Exchange.

• American farmers raised 115.7 million turkeys last year. They were valued at $492.2 million.
Reducing freeze damage to fruit by overhead sprinkling

Delivering the blossoming of fruit trees by overhead sprinkling appears to hold great potential as a method of reducing the fruit damage caused by spring freezes. In a preliminary study conducted by USU researchers, the blossoming of apples was delayed by 17 days and sweet cherries blossoming was delayed by 15 days.

**FIRST IDEA**

The study was based on two scientific ideas. The first deals with the biology of fruit trees. In the fall, deciduous trees lose their leaves and enter a condition known as winter rest. The tree is incapable of growth during this rest period. After rest is completed, which occurs sometimes between mid-winter and early spring, depending on the climate, changes begin occurring in the buds that will eventually cause blossoming and leafing of the trees. The first changes are chemical in nature and do not modify the external appearance of the buds. The later changes, however, include swelling and eventually opening of the blossoms. The rate of bud development depends on the amount of heat that the buds are exposed to after completion of rest. When spring temperatures are considerably above normal, as in 1972, bud development accelerates and the trees blossom early. When the early spring is cool, as in 1973, blossoming is delayed. Thus, we concluded that if the buds could be artificially maintained at lower temperatures, bud development would be retarded, blossoming would be delayed, and spring freeze hazards would be reduced.

**SECOND IDEA**

The second idea was based on the principle of evaporative cooling and
the use of overhead sprinkling for reducing bud temperatures. Since the amount of evaporative cooling depends on the amount of water evaporated into the air, cooling is most effective when the air is dry, which it usually is in Utah's semi-arid climate. The feasibility of retarding blooming by overhead sprinkling to cool the trees by evaporation, was determined by an experiment in a commercial apple orchard in Logan, Utah.

Sprinklers extended about 1 foot above the tree tops were placed 40 feet apart in the orchard row. The system was programmed to turn on automatically when the temperature reached 45°F. It then remained on, with a cycle of 2 minutes sprinkling and 2 minutes not, until temperatures dropped below 45°F. Automatic foot valves were placed in the line to allow drainage and prevent damage to the sprinkler line during cold periods when temperatures dropped below freezing. The system was set up in the orchard to begin sprinkling as soon as the trees had completed their winter rest period (about March 1 in 1973) and sprinkling was continued through May 21. On this date, buds on the sprinkled trees were still tight, while the unsprinkled trees in the orchard were in full bloom. At this date the system was turned off and the trees developed without further overhead sprinkling. The sprinkled trees reached the full bloom stage on June 7, which was 17 days later than the unsprinkled trees in the same orchard. There was no apparent abnormality in fruit development and no apparent tree damage resulting from the sprinkler treatment.

However, analysis of fruit samples indicated that the delay in blooming subsequently resulted in delayed fruit maturity. On September 20 the apples from the unsprayed trees contained 10.3 percent soluble solids whereas those from the treated trees contained 9.6 percent soluble solids. Although no visual differences in fruit size or color were determined, the lower sugar content indicated that fruit maturity had been delayed at least 1 week by the sprinkling treatment.

**UNANSWERED QUESTIONS**

Many questions remain unanswered, however, and further research is needed before this technique is ready for commercial application. Future studies will have to determine, among other things, the optimum temperature for activating the sprinkling system, the best type of sprinkler heads to use, the most economical spacing of the sprinklers, the effect of the excess water on soil aeration, and the possible effects of excessive soil water on the trees. The length of time that blossoming can safely be delayed,

\[\text{June 9} \quad \text{May 30} \quad \text{May 20} \quad \text{May 10} \quad \text{Apr 30} \quad \text{Apr 20} \quad \text{Apr 10} \quad \text{Mar 31} \quad \text{Mar 21} \quad \text{Mar 11} \quad \text{1958} \quad \text{1959} \quad \text{1960} \quad \text{1961} \quad \text{1962} \quad \text{1963} \quad \text{1964} \quad \text{1965} \quad \text{1966} \quad \text{1967} \quad \text{1968} \quad \text{1969} \quad \text{1970} \quad \text{1971} \quad \text{1972} \]

**Figure 2.** Estimated dates on which peaches reached full bloom (colored bars) and dates on which the last temperatures of 32°F or lower occurred each spring (gray bars) at a Utah location for the years 1958-1972. In 10 of the 15 years (67 percent), a temperature of 32°F or lower occurred after full bloom.
Figure 3. Estimated dates on which peaches would have reached full bloom if blossoming had been delayed 15 days (colored bars) and dates on which the last spring temperatures of 32°F or lower occurred (gray bars). With this delay, a temperature of 32°F or lower would have occurred after the bloom date in only 6 of the 15 years (40 percent).

Figure 4. Gray bars show the dates of the last spring occurrences of temperatures 32°F or lower and colored bars show an assumed full bloom date of May 7. With this delay, the last spring temperatures of 32°F or lower would have occurred after full bloom only in 1971 (7 percent of the 15 years).
A MODEL CAN HELP SAVE UTAH'S FRUIT

E. ARLO RICHARDSON, GAYLEN L. ASHCROFT, J. LAMAR ANDERSON, SCHUYLER D. SEELEY, AND DAVID R. WALKER

The ideal model is not always of the 36-22-34 variety. Modeling by the numbers, however, has been an important tool of scientists for many years.

Recently a model* that describes the growth and dormancy cycle of apple trees has been developed at Utah State University. This model expresses the relationship between the atmospheric or climatic environment of an apple tree and its yearly phenological development. The mathematical model covers two periods in the life of the tree. Winter temperatures are related to the rest-dormancy requirements for a certain amount of chilling of the tree while springtime temperatures are related to the energy required by the bud for bud development. By defining these relationships, the model allows us to predict the likely bloom data for trees under specified conditions.

DORMANCY REQUIREMENTS

The most effective temperature in meeting the cold requirements of a tree is 43°F. Delicious apples require 1,234 hours at this temperature or equivalent conditions during the winter before growth can begin. By contrast, apricots require only 720 hours (table 1). "Cold" temperatures vary in their effectiveness in meeting the cold requirements of trees. We have equated temperatures with chill units, (table 2) which are related to the tree's need for exposure to a certain number of hours of cold temperatures.

WARM TEMPERATURES

Prior to the completion of winter rest, warm temperatures have very little effect on the development of the buds. Once rest is completed, any temperature above 40°F will induce some growth. The conditions necessary to produce budding have been related to the temperature of the tree in terms of the number of degrees above 40°F and the number of hours involved.

Dormancy Requirements

The time-temperature correlation equates with "growing degree hours." A growing degree hour has been defined as 1 hour at a temperature 1 degree above 40°F. In the USU model, the maximum accumulation within an hour is 37 growing degree hours, which is obtained at a temperature of 77°F. Temperatures above 77°F still contribute only 37 growing degree hours per hour. The number of growing degree hours accumulated after rest completion can be correlated with the various stages of development of the tree.

A Delicious apple tree annually experiences eight standard developmental stages. The usual energy requirements associated with each of these stages are shown in table 3.

Table 1. Chill units required to complete rest for various fruit trees

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Chill units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delicious apple</td>
<td>1,234</td>
</tr>
<tr>
<td>Apricot</td>
<td>720</td>
</tr>
<tr>
<td>Bing cherry</td>
<td>880</td>
</tr>
<tr>
<td>Elberta peach</td>
<td>800</td>
</tr>
<tr>
<td>Bartlett pear</td>
<td>1,210</td>
</tr>
<tr>
<td>Italian prune</td>
<td>818</td>
</tr>
</tbody>
</table>

Table 2. Conversion of selected temperatures to chill units

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Units contributed</th>
</tr>
</thead>
<tbody>
<tr>
<td>34°F or less</td>
<td>0</td>
</tr>
<tr>
<td>35-36°F</td>
<td>0.5</td>
</tr>
<tr>
<td>37-48°F</td>
<td>1</td>
</tr>
<tr>
<td>49-54°F</td>
<td>0.5</td>
</tr>
<tr>
<td>55-60°F</td>
<td>0</td>
</tr>
<tr>
<td>61-65°F</td>
<td>-0.5</td>
</tr>
<tr>
<td>Above 65°F</td>
<td>-1</td>
</tr>
</tbody>
</table>

Table 3. Energy requirements for Delicious apple bud development

<table>
<thead>
<tr>
<th>Stages of fruit bud development</th>
<th>Accumulated growing degree hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Silver tip stage</td>
<td>3710</td>
</tr>
<tr>
<td>2. Green tip stage</td>
<td>4580</td>
</tr>
<tr>
<td>3. Half-inch green stage</td>
<td>5580</td>
</tr>
<tr>
<td>4. Tighter cluster stage</td>
<td>7090</td>
</tr>
<tr>
<td>5. First pink stage</td>
<td>8740</td>
</tr>
<tr>
<td>6. Full pink stage</td>
<td>9710</td>
</tr>
<tr>
<td>7. First bloom stage</td>
<td>11,110</td>
</tr>
<tr>
<td>8. Full bloom stage</td>
<td>12,480</td>
</tr>
</tbody>
</table>

J. LAMAR ANDERSON is an Associate Professor in the Department of Plant Science.
E. ARLO RICHARDSON is the Utah State Climatologist stationed at Utah State University.
GAYLEN L. ASHCROFT is an Associate Professor in the Department of Soil Science and Biometeorology.
SCHUYLER D. SEELEY is an Assistant Professor in the Department of Plant Science.
DAVID R. WALKER is a Professor in the Department of Plant Science.
Full bloom requires near 12,480 growing degree hours. The past spring, following completion of winter, the growing degree hour accumulation for the various stages of development in 10 Utah orchards was compared with the actual dates of bud development. In all cases, the predicted date was not more than 1 to 3 days away from the observed date of occurrence.

**EVAPORATIVE COOLING**

In one test of our model, we used data from another experiment being conducted at the University. Evaporative cooling, as reported in another article in this issue, was used to delay bud development. By May 21, the unsprinkled trees were in full bloom; that is, the buds had accumulated 12,480 growing degree hours (see table 3). On the same date, the sprinkled trees were only in the 1/2-inch green stage of development. Thus, sprinkling had lowered temperatures enough that the sprinkled buds had only accumulated 5,580 growing degree hours — 6,900 less than the unsprinkled buds. Using the model, and assuming "normal" temperatures at Logan for the period after May 21, we calculated that it would require 16 days to accumulate the 6,900 growing degree hours necessary to bring the sprinkled trees into full bloom. The estimate was off by only 1 day; the trees actually required 17 days to reach the full bloom stage.

These results illustrate the practicality of using our mathematical model to predict any effects a cultural practice such as sprinkling may have on bud development and freeze susceptibility. The predicted development may be updated as the season progresses, using available climatological data. A grower can thus control the rate of bud development as he wishes.

**PUTTING A GOBBLE INTO THE DOG -- FURTHER PROCESSING OF TURKEY**

V. T. MENDENHALL

Recent innovations in the processing of Utah turkey have significantly changed the appearance of our broad-breasted friend in the marketplace. "All turkey" hot dogs which were unheard of a year ago are now a common sight in the processed meat sections of some supermarkets. It's not surprising to also find fresh turkey steak side by side with T-bone steak in the red meat counter. Quite a change from the frosty frozen fowl of yesteryear! Other products being introduced to the consumer include turkey ham, salami, pastrami, bologna, jerky and bacon, all from big tom himself!

**FURTHER PROCESSING**

Further processing of turkey, beyond slaughter, packaging and freezing, evolved from the cooperative contributions of innovative processing, advanced engineering concepts, imaginative food research and consumer demands. The result has been to rescue the turkey industry from its trau-

V. T. MENDENHALL is an Assistant Professor in the Department of Nutrition and Food Science.
ditional rigid marketing concept of "if it's turkey, it has to be frozen." Instead of a specialty item for Thanksgiving, Christmas and Easter dinners, turkey now has a chance of being consumed at other times, even at ball games and breakfast tables.

Breast meat, considered to be the prime cut of the turkey, has always commanded a premium price when compared to the remainder of the carcass. Removal of the breast cut thus left the processor with a carcass having less marketable value. Hand deboning was costly, and quite difficult due to the complex bone structure of the bird. Even after the dark meat was hand deboned, a ready market was not available to dispose of it at a reasonable price.

Engineering firms across the country began trying to develop an economical, mechanical device to replace the hand operation. One machine of superior quality and versatility was developed by Beehive Machinery Company of Salt Lake City. Whole or partial carcasses could be coarsely ground and then mechanically deboned (MD) by separating the edible tissue from the bone in a specially designed head. Although the mechanical removal of the edible turkey tissue was much more efficient than hand deboning, the texture and appearance of the MD meat was altered significantly. The semi-rigid turkey muscle tissue was converted into a homogenous, viscous paste. Consumer acceptance of MD meat, per se, was initially very limited due to its unfamiliar appearance and lack of the traditional meat qualities.

**NEW PRODUCTS**

Cooperative research between the Nutrition and Food Sciences Department of Utah State University and Ogden Poultry Company was initiated in 1967-68 to develop ways to use the MD meat. Turkeyburger (ground thigh meat with some fat added) gained in consumer popularity when red meat prices rose sharply. Hand deboning of thigh meat followed by coarse grinding provided the processor with a means of utilizing that portion of the carcass. Thigh meat was also the main ingredient in turkey ham or cured turkey loaf. Thighs were cured, combined with some MD meat, stuffed into casings and cooked. Turkey ham has smoked flavor, is pink in color, and has been readily accepted by the consumer. Mechanically deboned meat was found to be of exceptional quality for emulsified sausage products, mainly bologna and frankfurters.

**ECONOMIC ADVANTAGES**

Turkey products provide some distinct nutritional and economic advantages to the consumer. Some are naturally built into the bird while others have been incorporated by the processor and scientist. Turkey meat will always be more economical than beef, pork or lamb since turkeys have a more efficient system for converting plants into human food. Turkeys require fewer pounds of feed per pound of gain than do the other major animal meat protein sources. Current economic trends suggest that turkeys and other poultry, along with the domestic rabbit and some fish will assume importance as major sources of animal meat protein. Mixtures of plant and animal protein as well as pure plant proteins, may finally dominate the grocers' shelf as the major source of human protein about 2011.

Another economic advantage for turkey producers and users is in the recycling of turkey processing by-products into a future crop of birds. Feathers, viscera and blood, which have traditionally polluted the environment, now become part of the feed ration for other turkeys being raised for market, thereby reducing the cost of production.

**NUTRIENT VALUES**

Nutrient values of turkey meat are tailored for the modern consumer, being higher in protein and lower in fat and cholesterol. Processors have continued to produce additionally processed turkey products in a similar manner (table 1). Since the items listed are consumed as primarily sources of protein, the relative costs per pound of protein are important. Cost per pound of protein is lower for all items containing turkey (table 1).

Other nutrients including minerals and vitamins are also important to the well being of the consumer, however, in this age of mineral and vitamin supplementation, natural sources of the minor nutrients are not overly important. If the trend toward less

---

**Table 1.** Percent composition of raw and further-processed turkey products compared to red meat homologues.

<table>
<thead>
<tr>
<th>Item</th>
<th>Water</th>
<th>Fat</th>
<th>Protein</th>
<th>Retail² cost/lb</th>
<th>Calories/100 grams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turkey Frankfurters</td>
<td>59.06</td>
<td>20.24</td>
<td>17.26</td>
<td>$5.16</td>
<td>252</td>
</tr>
<tr>
<td>Beef Frankfurters</td>
<td>54.11</td>
<td>29.17</td>
<td>13.76</td>
<td>9.38</td>
<td>318</td>
</tr>
<tr>
<td>Turkey Bologna</td>
<td>60.71</td>
<td>21.45</td>
<td>14.81</td>
<td>5.74</td>
<td>252</td>
</tr>
<tr>
<td>Beef Bologna</td>
<td>52.87</td>
<td>30.12</td>
<td>13.96</td>
<td>11.46</td>
<td>327</td>
</tr>
<tr>
<td>Turkey Salami</td>
<td>61.23</td>
<td>13.96</td>
<td>21.46</td>
<td>5.03</td>
<td>212</td>
</tr>
<tr>
<td>Beef Salami</td>
<td>50.70</td>
<td>33.38</td>
<td>11.93</td>
<td>9.14</td>
<td>348</td>
</tr>
<tr>
<td>Turkey Bacon</td>
<td>60.03</td>
<td>3.60</td>
<td>28.90</td>
<td>5.53</td>
<td>148</td>
</tr>
<tr>
<td>Pork Bacon</td>
<td>19.31</td>
<td>68.71</td>
<td>12.06</td>
<td>18.26</td>
<td>653</td>
</tr>
<tr>
<td>Turkey Jerky</td>
<td>20.00</td>
<td>10.21</td>
<td>5.42</td>
<td>3.43</td>
<td>353</td>
</tr>
<tr>
<td>Turkey Thigh</td>
<td>73.00</td>
<td>4.10</td>
<td>21.00</td>
<td>5.14</td>
<td>121</td>
</tr>
<tr>
<td>Pork Ham</td>
<td>56.50</td>
<td>26.00</td>
<td>15.90</td>
<td>7.29</td>
<td>298</td>
</tr>
<tr>
<td>Beef Round</td>
<td>66.60</td>
<td>12.30</td>
<td>20.20</td>
<td>7.87</td>
<td>188</td>
</tr>
<tr>
<td>Turkey Breast</td>
<td>73.00</td>
<td>1.20</td>
<td>24.60</td>
<td>4.84</td>
<td>109</td>
</tr>
<tr>
<td>Pork Loin</td>
<td>57.20</td>
<td>24.90</td>
<td>17.10</td>
<td>9.30</td>
<td>284</td>
</tr>
<tr>
<td>Beef Loin</td>
<td>48.20</td>
<td>36.00</td>
<td>14.80</td>
<td>11.48</td>
<td>383</td>
</tr>
</tbody>
</table>

¹Data compiled from NSDA Handbook, No. 8.
²Calculated from retail prices of July 26, 1973.
³Calculated from production costs plus 27% price mark-up.
milk production continues, calcium may become limiting in the human diet since 76 percent of the calcium presently consumed comes from dairy products. The remaining 24 percent comes from fruits, vegetables, nuts and cereals, proving that "everybody doesn't need milk". Everyone does need calcium, however, and additionally processed turkey products may eventually provide an alternative source for the consumer.

During mechanical deboning, soluble portions of the bone are introduced into the edible tissue. Although bone had been previously classified as an adulterant in meat, the Federal Drug Administration now allows a maximum of 1 percent bone in MD meat. Bone contains about 18 percent calcium, which means that MD meat could contain as high as 0.18 percent calcium. Eight ounces of raw MDM would provide about one-half the recommended daily intake of 800 mg of calcium, making turkey a realistic source of another important essential nutrient.

From an economic standpoint, turkey, in its many forms, is one of the better buys for today's consumer. Tailor-made from the standpoint of protein, fat and calories, a higher quality meat protein is difficult to find. This is not to say the turkey is without its faults. He's probably the least knowledgeable domestic animal, sometimes an excessive drinker, plagued by disease and has a most unexciting sex life due to artificial insemination. Yet, because of research, he has the potential of being one of man's most economical sources of animal meat protein.

Cost analysis on cow and sheep prices relative to calf and lamb prices over the last 12 years indicate that cows bring close to 60 percent of the level of calves while ewes generally bring under 25 percent the level of lambs (see figure 1, taken from Wylie Goodsell of the Economic Research Service). Goodsell has further estimated that if cull ewes brought a price relative to lamb prices comparable to what cows bring relative to calves, ranch operators in the state of Utah would have increased their cash receipts by about $2,400 per ranch in 1970 and $2,700 in 1971. Returns to operator, labor and capital would have been increased by around 17 percent in 1970 and 24 percent in 1971.

![Figure 1. Cow and sheep prices relative to calf and lamb, northwest cattle and sheep ranches.](image-url)
content. This is a red pigmented protein in muscle similar to hemoglobin in blood, which gives meat its red coloring, much like blood is colored due to hemoglobin. In cured sausages myoglobin forms the typical color of a cured ham upon combining with nitrite cure products. Older animals are darker due to a higher myoglobin content. This gives a desirable pink color to a product like the frank. Younger animals are low in myoglobin and do not pigment as well.

2. Older animals’ tissue can bind large amounts of water. This makes their use more economical by the meat processor and also makes bologna, frankfurter and other luncheon meats more tender and desirable to the public.

3. Older animal meat has a high capacity to bind meat and fat into a stable product (like bologna and weiners). Bull meat is exceptionally good due to this emulsifying capacity.

4. Older animals are generally also more flavorful due to their chemical makeup.

Mutton, being mature, also has all these qualities which qualify it as a sausage ingredient, but it has not been widely accepted in this guise. Beef, being larger than mutton, has been more economical to bone. It takes a hand boner approximately the same time to bone a mutton carcass as it does a quarter of beef. The cow would yield 115 pounds of meat, while the ewe would give only about 38 pounds of meat.

**MECHANICAL DEBONING**

The advent of mechanical deboning erased this cost imbalance (figure 2). In fact, it should be cheaper to mechanically bone mutton than beef due to the larger bone size of cattle, which results in higher maintenance cost on machinery.

In terms of capacity, a hand boner might produce 50 pounds of boneless meat per hour while the mechanical deboner produces 2,200 pounds per hour. In manpower equivalents this is 44 times more than a hand boner. Put on a cost per pound basis, with 10¢ per pound and up on a hand boner and a .5 cent per pound on the mechanical deboner, and amortized over 5 years, the machine is 20 times more efficient. The idea of using a mechanical deboner to process turkey was tried years ago by USU researchers and has proved very successful. Only slight adaptations were needed to use the same process on sheep carcasses. Once the deboned meat is obtained, these USU scientists work out the methods to obtain flavorful products such as franks, bologna, meat loaf, sausage, etc.

**HOW IT’S DONE**

Mechanical deboning is a two step process requiring:

1. A bone cutter and, (2) a mechanical deboner.

<table>
<thead>
<tr>
<th>Item</th>
<th>Hand-boner</th>
<th>Mechanical-deboner</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Capacity (boneless)</td>
<td>50 lb/hr</td>
<td>2,200 lb/hr</td>
</tr>
<tr>
<td>2. Manpower equiv.</td>
<td>1</td>
<td>44</td>
</tr>
<tr>
<td>3. Cost/hour</td>
<td>$5.00/hr</td>
<td>$12.00/hr*</td>
</tr>
<tr>
<td>4. Cost/lb. meat</td>
<td>10¢</td>
<td>1/2¢</td>
</tr>
<tr>
<td>5. Efficiency (Rel.)</td>
<td>20 times less</td>
<td>20 times more</td>
</tr>
</tbody>
</table>

* Amortized over 5-year period

Figure 2. Hand deboning versus mechanical deboning of mutton.

**DECEMBER 1973**
Estimated Value Old Ewe
(55 lb Carcass)

- 70% deboner yield = 38.5 lb
- 38.5 lb x 75c/lb = $28.88
- Slaughter cost = 2.00
- Deboning cost = .28

Net Value = $26.60

**Figure 4.** Estimated value of old ewes if a mechanical deboner is used to process the carcass.

**THERE ARE PROBLEMS**

Mechanical deboning is not without its problems, however, since tolerance levels on bone content and standards of identity on the product have caused the Meat Inspection Service to curtail its use on other than poultry products in the U.S. Foreign countries, however, are using mechanically deboned mutton as one meat ingredient in processed meats. It is feasible that only parts of the carcass which are difficult to bone could be put through a deboner (breast, shoulder, neck and shank). Easily boned portions like the leg and back strips could be hand deboned. These larger pieces could then be used in processed mutton products similar to boiled ham, corned beef, salami and other products with larger particle sizes.

Products from mutton should be developed and test marketed prior to introduction on the market. The acceptable levels of mechanically deboned meats, mutton, and mutton fat, should be determined by taste panel analysis. Proper blends with other meats and spices should also be examined. Promotional marketing would then follow. The source of supply and availability will also be important considerations for the sausage manufacturer. Perhaps it could be integrated with other products of a seasonal nature (like turkey) to assure a constant supply of raw products.

**USE A RESOURCE**

With the rising cost of meat and a continual demand for more protein, we can’t afford to let ewes die from old age and not make effective use of their meat to feed a protein hungry world. The means to make processed mutton economical are now available with mechanical deboning. Technology is available to develop suitable products. The future should be bright for corned beef and *ewe*.  

**UTAH SCIENCE**
The energy crisis and the fate of strip mine lands

THADIS W. BOX

The energy crisis has special importance to Utah citizens. Not only do they suffer the same symptoms — closed gasoline stations, cold classrooms, higher energy costs — as the rest of the nation, but they sit on top of much of the nation’s energy reserves. Oil, natural gas, oil shale, water power, uranium, and natural geothermal areas are all found within the boundaries of the state. All these will have to be evaluated if the nation’s energy demands are to be met.

Even when the much publicized estimates of future energy “demands” are converted to more realistic “needs,” meeting those revised needs will require an unprecedented efficiency in utilizing fossil fuels and an objective pre-evaluation of the trade-offs between energy production, consumption of resources, and environmental quality. Public concern over unheated schools, oil-soaked cormorants, belching smoke stacks and the prospect of gasoline rationing have sandwiched policy makers between conflicting demands for more and cheaper energy and a cleaner, more livable environment.

No issue associated with the current energy debate is more central to this conflict between demand for immediate use and conservation of resources than is the surface mining of coal. Our most abundant domestic fossil fuel is coal, and much of it occurs at depths where it can be mined by surface methods. Surface mining destroys the existing natural communities completely and dramatically. The crude brutality of monster machines raping the landscape has caused great public outcry. Nevertheless, rising energy consumption coupled with increasing difficulty in securing adequate supplies of natural gas and low-sulfur crude oil inevitably focuses attention on coal.

Almost 18 percent of the land surface of Utah, about 15,000 square miles, is underlain by coal. Most of this is high grade, low sulfur coal that can be recovered only by deep mining. There are some 3,741 million tons of bituminous coal and 15 million tons of sub-bituminous coal in Utah’s reserves. Of these, only about 150 million tons, or less than 4 percent, can be recovered by surface mining using today’s technology. But almost 27 billion tons of coal can be surface mined in the other states west of the 100th meridian. The controversy over surface mining, which has been centered mainly in the eastern United States, is therefore shifting westward.

Unfortunately, the methods for reclaiming mined areas in Appalachia, Europe, and other humid areas are not directly transferable to the arid and semi-arid West. Because of the concern over strip mining, the uncertainty of technology transfer from humid regions, and the growing energy needs of the nation, the National Academy of Sciences (NAS) appointed a committee of 13 scientists familiar with rehabilitating arid lands to study the problem and report on the potential of western coal lands for rehabilitation. I served as chairman of the committee and this paper represents a condensation of the report related to Utah conditions.*

THADIS W. BOX is the Dean of the College of Natural Resources.

SURFACE MINING HAS BEGUN

Surface mining of large, low-sulfur coal beds, up to 50 feet thick, has begun in Montana, Wyoming, New Mexico, and South Dakota. Coal companies have leased large areas of land; power companies are acquiring water rights; elaborate schemes for water diversions have been proposed to meet projected industry requirements; unit trains are running to the Midwest; a coal slurry pipeline has been built; a number of mine-mouth generating plants are in operation and several more are planned; and the first coal gasification facilities have gone into pilot production. Public protest meetings are convened almost daily.

The extent and timing of future developments of western coal lands will depend to a large extent on policy decisions at the highest levels of federal and state governments relative to perceived energy needs. Many approaches have been suggested for meeting these needs, but for the immediate future, through at least 1990, no viable alternative has been suggested that relieves fossil fuels from supplying most of them. Nuclear fusion systems continue to be subject to extended delays due to a number of serious unresolved objections; geothermal sources are unlikely to satisfy more than a few percent of our total energy needs.


DECEMBER 1973
requirements by the end of the century; we do not yet know when or if research on solar and fusion energy systems will be successful. Man's only currently accessible large source of energy is fossil fuel. And coal represents the largest fossil fuel reserve in the U.S., with 57 percent of it in the arid West.

MEASURING THE RESERVE
Of the nearly 128 million acres in the western United States that are underlain by coal, approximately 1.5 million acres can be surface mined using current methods. This acreage holds about 27 billion tons of coal—a 45-year supply under today's conditions.

About 92,000 of the 128 million acres, or 140 square miles, will probably be mined by 1990 in order to meet the current projections of coal production. By the year 2000, projections indicate disturbance of about 300 square miles. Utah will have 4,680 acres disturbed by 1990 and 8,280 by the year 2000. (By comparison, approximately 1.3 million acres, nearly 2,000 square miles, have been disturbed by surface mining in the eastern coal fields during the complete history of strip mining in the eastern coal fields during the complete history of strip mining in the East.) These estimates are based on current conditions and do not consider large scale coal gasification plants or new technology for other coal energy processes.

REHABILITATION POTENTIALS
The NAS Committee found that areas receiving 10 inches or more of annual rainfall can usually be rehabilitated if the landscapes are properly shaped, and if techniques that have been demonstrated successful in rehabilitating disturbed rangeland are applied. This estimate is not based on long-term, extensive, controlled experiments in shaping and revegetating western lands disturbed by surface mining. It draws upon experience in revegetating western ranges, disturbed roadways, and other denuded areas in arid lands.

The drier areas, those receiving less than 10 inches (250 mm) of rainfall, pose a more difficult problem. Revegetation of these areas can probably be accomplished only with major, sustained inputs of water, fertilizer, and management. Range seeding experiments have had only limited success in such areas. Rehabilitation of these drier sites may occur naturally, but the time scale might be unacceptable to society since it could take decades, or even centuries, for natural succession to achieve stable conditions.

Satisfactory rehabilitation of mined land, however, requires more than just a stable growth of plants. If a mined area is to be restored to its former environmental status, the plants themselves should be a mixture of species capable of sustaining the area's previous inhabitants. Suitable habitats for the native fauna, which may have to be artificially reintroduced, can be formed by attempting to model the land into its former image. Such shaping can also help to satisfy aesthetic perceptions and may assist the control of erosion.

Environmental protection also implies finding the means of avoiding probable impacts of surface mining on surface water and ground water. In these aspects—wildlife, aesthetics, erosion control, and water quality—pertinent data for rehabilitating mined land in the arid west are virtually nonexistent. The necessary research had barely begun.
SPECIFIC SITE FACTORS

The potential for rehabilitation of any surface mined area in the West is critically site specific. The rehabilitation of any site will depend on its unique ecological and physical conditions, the land use projected for the site after mining, the available technology that is applied to the site, and the skill exercised in applying that technology. Rehabilitation may range from no treatment at all through the gamut of various reshaping and revegetation efforts, to a complete redesign of the landscape.

Existing natural ecosystems are good indicators of their associated climates and soils. Plant communities can thus identify the general potentials for growth of natural or induced revegetation. The coal regions of the West support four major vegetation types: Desert shrub, foothill shrub, Ponderosa pine and associated mountain brush, and prairie mixed grasses. Desert shrub areas are not easily revegetated and natural plant succession is extremely slow. In the foothill shrub areas, even the best methods may fail during drought years. The mixed-grass prairies and the areas of pine and mountain brush, on the other hand, have a high potential for successful revegetation. Utah's coal lands that can be strip mined occur in desert shrub and sagebrush foothills. About 72 acres will be disturbed per million tons of coal removed, meaning that over 11,000 acres could be disturbed in Utah.

THE WATER FACTOR

Water requirements for surface mining operations and rehabilitation practices are not large and should not seriously deplete aquifers or compete with existing uses. Disruption of natural drainage networks at mine sites, however, may interfere with downstream water rights, and groundwater aquifers that are intercepted by mining operations may be drained or changed in flow patterns causing problems for established users.

In the arid West, water consump-

NAS COMMITTEE RECOMMENDATIONS

Based on these findings the Committee made eight recommendations. They are quoted here directly from the report:

1. We recommend that surface mining for coal should not be permitted on either public or private lands without the prior development of rehabilitation plans designed to minimize environmental impacts, to meet on-and-off-site air and water pollution regulations, and to define a timetable for rehabilitation concurrent with the mining operation. The preplanning should be part of an original environmental impact analysis for the region and should clearly indicate the basis on which conditions at the proposed mine sites are evaluated. It is important that adequate provision for public participation be a part of the review of the preplans.

2. Responsibility for regulating surface coal mining and rehabilitation in the western states should be shared by the federal, state, and local governments. Methods for public participation at these several levels of government should be improved. Uniform state laws and regulations are unlikely and in some respects uniformity would be undesirable; however, we recommend that minimum regulations governing the surface mining of coal be promptly established by federal statute to provide for preplanning, monitoring, enforcement, and financing of rehabilitation. We further recommend that the costs of these activities be financed by mining operations. We also recommend that rehabilitation management plans be made and enforced for a period sufficiently long to assure vegetative stability.

3. Rehabilitation of surface mines on public lands should set the example of the best available planning and the most rigorous application of rehabilitation techniques. Permits and leases for mining coal on federal lands should be so written as to demand the
application of the most advanced rehabilitation technology.

4. Improvement of rehabilitation techniques and the reduction of environmental impacts depend critically upon monitoring and evaluation. Therefore, we recommend establishment of a comprehensive, non-industry program to monitor and evaluate the rehabilitation of all current and future coal surface mining operations. Through such experience, performance standards for rehabilitation can be based on technical knowledge. The evidence must include a complete baseline inventory of the existing ecology, geology, and hydrology prior to granting a permit and the establishment of a set of continuing observations to monitor the on-site and off-site effects of mining and its rehabilitation. Such studies must also include the determination of the chemical properties of the soils and overburden and the hydrologic effects of surface mining on groundwater, surface drainage, and water quality as affected both on-site and off-site. These data will be a necessary measure of what has been accomplished and serve as an essential guide for on-going and future operations. The observations would be verified by agencies independent of the mining operation because many years of objective observations are required and organizational continuity is essential.

5. Since mining and rehabilitation involve many diverse economic, ecological, engineering, hydrologic, and social factors in complex interactions and feedback loops, we recommend that federal research and development programs for coal include studies on total system approaches to energy resource mining, mined land rehabilitation, and energy conversion. Because rehabilitation depends upon qualified people, we recommend that the responsible governmental agencies develop interdisciplinary teams to assess the potential for rehabilitation of proposed mine sites and to conduct the research for rehabilitation.

6. Certain features of the landscape cannot be restored at any price. If irreplaceable historic, scenic, or archeological sites or endangered species occur in an area proposed for mineral exploration or surface mining, no mining should take place without an extensive review of the consequences. In some cases artifacts may be salvaged or moved with minimal loss of their value to society. In those instances the salvage operation should be considered part of the cost of rehabilitation and charged against the mining operation. If such irreplaceable artifacts cannot be moved or protected, or if the landscape and associated biota cannot be rehabilitated for social purposes, surface mining should be prohibited.

7. Modern technology provides opportunities for changed uses and the design of new landscapes in mined areas. Overburden is a resource for these activities, not a waste material. We recommend that regional planning for subsequent land uses, such as parks, recreational areas, and urban disposal centers, take advantage of these opportunities.

8. A shortage of water is the major limiting factor in planning for development of coal reserves in the American West. Although we conclude that enough water exists for large scale and rehabilitation at most sites, not enough water exists for large scale conversion of coal to other energy forms (e.g., gasification or steam electric power). The potential environmental and social impacts of the use of this water for large scale energy conversion projects would exceed by far the anticipated impact of mining alone. We recommend that alternate locations be considered for energy conversion facilities and that adequate evaluations be made of the options (including rehabilitation) for the various local uses of the available water.

**IMPLICATIONS FOR UTAH**

These findings and recommendations have several implications for Utah. Since Utah is one of the two states that have no state law covering surface mining, its mining industry will be governed only by federal statutes. Currently, there are three surface mining bills before Congress, and it is uncertain what the final outcome will be. The National Academy of Sciences Committee has reviewed all state laws in the West and could provide the groundwork for Utah legislation.

The Committee was charged only with looking at the rehabilitation potentials of mined lands. However, in an "extra mile" chapter, its report points out that water is really the limiting resource in the West and that, in many cases, water resources in entire river basins appear to already be over-committed. In discussing various agreements in the Colorado River Basin, they concluded "the cumulative effect of these factors is a substantial de facto over-commitment of the Colorado Basin." In a state as dependent on water as Utah, all mine-mouth conversion coal plants, whether in Utah or an adjoining state, should be evaluated on the basis of their effect on Utah's water supply.

The vast energy reserve in Utah's coal and oil shale poses a Jekyll/Hyde combination of economic blessing and environmental curse. Research before the land is disturbed should define the ways in which it can be rehabilitated, but as the National Academy of Sciences indicates, much technology is now available. However, little of this technology is being properly applied in already mined areas. State-specific statutes should demand that the best techniques be applied and that institutions monitor the results. Only in that way can we legitimately use our fossil fuels, while leaving land use options open for future generations.
Where did all the people go?

CALVIN HIIBNER

Every year a few people change their places of residence in every neighborhood. The effect on most neighborhoods, towns, and cities is not noticeable, and in any case, the right to move is acknowledged as a natural right in our society.

In the aggregate, however, this population movement is dramatic. In Utah the people are used to seeing considerable population migration. It is well known that Utah was founded by migrants and they have been joined every year by new families seeking a home in the state. Also, many born in the state have left Utah to make their homes elsewhere. In the aggregate, Utah has lost more population than it has gained in this exchange. In fact, the 1970 census reported that there were more people alive in the United States who were born in Utah than there were people living in Utah. This loss represented a net outmigration of 79,758 for the state or about 8 percent of the 1970 state population.1

NET LOSSES

In the decade 1960-1970, the state showed a net loss due to migration of 10,958 people or 1.2 percent of

---


---

Figure 1. Utah net migration from 1965 through 1970.

DECEMBER 1973
the 1960 population. Only four counties (Davis, Morgan, Utah, and Washington) experienced a net immigration in this decade. All other counties had a net migration loss as indicated in Table 1. The population gain in the state of 168,646 was due entirely to the high birth rate and not to people moving into Utah.

This general trend of population loss due to outmigration based on the 10-year census figures, appears to be continuing for all parts of the state. Evidence of this is given in the detailed migration reports of the Census Bureau on mobility status of the pop-

ulation between 1965 and 1970. In 1970, 164,385 people over 5 years of age were living in the state who did not reside here in 1965. On the other hand 178,010 people over 5 years of age who had lived in Utah in 1965 were found in other states in 1970. This represents a net loss due to migration of 13,625 for the state in this 5-year period.

NET GAINS

The net gains or losses from other states are shown in Table 1. This map shows that 29 states gained population from Utah and 20 states and the District of Columbia lost population to Utah. The state of Washington achieved a net gain of 4,787 people, California, 3,612, and Arizona gained 2,387 from Utah. The state showing the largest net loss to Utah was Idaho’s loss of 3,388 people.

Every geographic area of the state lost in this 1965-70 migrant exchange. The Wasatch Front (Salt Lake, Utah, Davis, and Weber Counties) had a net migration loss of 7,683. A total of 30 states gained population from the Wasatch Front and 20 states (including the District of Columbia) lost population to this area of the state. Those states receiving the largest number of net migrants for the period are Washington (3,398), California (3,284), and Arizona (2,146). Idaho, again, lost substantial numbers to Utah (3,054).

---

Table 1. Estimates of components of change for Utah by county, 1960-1970

<table>
<thead>
<tr>
<th>State and county</th>
<th>April 1, 1970 (census)</th>
<th>April 1, 1960 (census)</th>
<th>Number</th>
<th>Percent</th>
<th>Number</th>
<th>Percent</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTAH</td>
<td></td>
<td></td>
<td>168646</td>
<td>18.9</td>
<td>244926</td>
<td>65322</td>
<td>-10958</td>
<td>-1.2</td>
</tr>
<tr>
<td>Beaver</td>
<td>3800</td>
<td>4311</td>
<td>-531</td>
<td>-12.3</td>
<td>797</td>
<td>391</td>
<td>-937</td>
<td>-21.6</td>
</tr>
<tr>
<td>Box Elder</td>
<td>28129</td>
<td>25061</td>
<td>3068</td>
<td>12.2</td>
<td>7154</td>
<td>1782</td>
<td>-2304</td>
<td>-9.2</td>
</tr>
<tr>
<td>Cache</td>
<td>42331</td>
<td>35788</td>
<td>6543</td>
<td>18.3</td>
<td>10005</td>
<td>2604</td>
<td>-858</td>
<td>-2.4</td>
</tr>
<tr>
<td>Carbon</td>
<td>15647</td>
<td>21135</td>
<td>-5488</td>
<td>-26.0</td>
<td>3322</td>
<td>1572</td>
<td>-7238</td>
<td>-34.2</td>
</tr>
<tr>
<td>Daggett</td>
<td>666</td>
<td>1164</td>
<td>-498</td>
<td>-42.8</td>
<td>202</td>
<td>46</td>
<td>-654</td>
<td>-56.2</td>
</tr>
<tr>
<td>Davis</td>
<td>99028</td>
<td>64760</td>
<td>34268</td>
<td>52.9</td>
<td>21478</td>
<td>3065</td>
<td>15855</td>
<td>24.5</td>
</tr>
<tr>
<td>Duchesne</td>
<td>7299</td>
<td>7179</td>
<td>120</td>
<td>1.7</td>
<td>1722</td>
<td>517</td>
<td>-1085</td>
<td>-15.1</td>
</tr>
<tr>
<td>Emery</td>
<td>5137</td>
<td>5546</td>
<td>-409</td>
<td>-7.4</td>
<td>1096</td>
<td>505</td>
<td>-1000</td>
<td>-18.0</td>
</tr>
<tr>
<td>Garfield</td>
<td>3157</td>
<td>3577</td>
<td>-420</td>
<td>-11.7</td>
<td>673</td>
<td>298</td>
<td>-795</td>
<td>-22.2</td>
</tr>
<tr>
<td>Grand</td>
<td>6688</td>
<td>6345</td>
<td>343</td>
<td>5.4</td>
<td>1856</td>
<td>423</td>
<td>-1092</td>
<td>-17.2</td>
</tr>
<tr>
<td>Iron</td>
<td>12177</td>
<td>10795</td>
<td>1382</td>
<td>12.8</td>
<td>2560</td>
<td>794</td>
<td>-384</td>
<td>-3.5</td>
</tr>
<tr>
<td>Juab</td>
<td>4574</td>
<td>4597</td>
<td>-23</td>
<td>-0.5</td>
<td>868</td>
<td>516</td>
<td>-375</td>
<td>-8.2</td>
</tr>
<tr>
<td>Kane</td>
<td>2421</td>
<td>2667</td>
<td>-246</td>
<td>-9.2</td>
<td>635</td>
<td>187</td>
<td>-694</td>
<td>-26.0</td>
</tr>
<tr>
<td>Millard</td>
<td>6988</td>
<td>7866</td>
<td>-878</td>
<td>-11.2</td>
<td>1430</td>
<td>685</td>
<td>-1623</td>
<td>-20.6</td>
</tr>
<tr>
<td>Morgan</td>
<td>3983</td>
<td>2837</td>
<td>1146</td>
<td>40.4</td>
<td>691</td>
<td>223</td>
<td>678</td>
<td>23.9</td>
</tr>
<tr>
<td>Piute</td>
<td>1164</td>
<td>1436</td>
<td>-272</td>
<td>-18.9</td>
<td>283</td>
<td>95</td>
<td>-460</td>
<td>-32.0</td>
</tr>
<tr>
<td>Rich</td>
<td>1615</td>
<td>1685</td>
<td>-70</td>
<td>-4.2</td>
<td>351</td>
<td>150</td>
<td>-271</td>
<td>-16.1</td>
</tr>
<tr>
<td>Salt Lake</td>
<td>458607</td>
<td>383035</td>
<td>75572</td>
<td>19.7</td>
<td>108416</td>
<td>29254</td>
<td>-3590</td>
<td>-0.9</td>
</tr>
<tr>
<td>San Juan</td>
<td>9606</td>
<td>9040</td>
<td>566</td>
<td>6.3</td>
<td>3730</td>
<td>551</td>
<td>-2613</td>
<td>-28.9</td>
</tr>
<tr>
<td>Sanpete</td>
<td>10976</td>
<td>11053</td>
<td>-77</td>
<td>-0.7</td>
<td>2031</td>
<td>1275</td>
<td>-833</td>
<td>-7.5</td>
</tr>
<tr>
<td>Sevier</td>
<td>10103</td>
<td>10565</td>
<td>-462</td>
<td>-4.4</td>
<td>1723</td>
<td>979</td>
<td>-1206</td>
<td>-11.4</td>
</tr>
<tr>
<td>Summit</td>
<td>5879</td>
<td>5673</td>
<td>206</td>
<td>3.6</td>
<td>1306</td>
<td>531</td>
<td>-569</td>
<td>-10.0</td>
</tr>
<tr>
<td>Tooele</td>
<td>21545</td>
<td>17868</td>
<td>3677</td>
<td>20.6</td>
<td>5286</td>
<td>1313</td>
<td>-296</td>
<td>-1.7</td>
</tr>
<tr>
<td>Uintah</td>
<td>12684</td>
<td>11582</td>
<td>1102</td>
<td>9.5</td>
<td>3235</td>
<td>896</td>
<td>-1237</td>
<td>-10.7</td>
</tr>
<tr>
<td>Utah</td>
<td>137776</td>
<td>106991</td>
<td>30785</td>
<td>28.8</td>
<td>31379</td>
<td>6702</td>
<td>6108</td>
<td>5.7</td>
</tr>
<tr>
<td>Wasatch</td>
<td>5863</td>
<td>5308</td>
<td>555</td>
<td>10.5</td>
<td>1178</td>
<td>435</td>
<td>-188</td>
<td>-3.5</td>
</tr>
<tr>
<td>Washington</td>
<td>13669</td>
<td>10271</td>
<td>3398</td>
<td>33.1</td>
<td>2687</td>
<td>965</td>
<td>1675</td>
<td>16.3</td>
</tr>
<tr>
<td>Wayne</td>
<td>1483</td>
<td>1728</td>
<td>-245</td>
<td>-14.2</td>
<td>287</td>
<td>116</td>
<td>-416</td>
<td>-24.1</td>
</tr>
<tr>
<td>Weber</td>
<td>126278</td>
<td>110744</td>
<td>15534</td>
<td>14.0</td>
<td>28545</td>
<td>8422</td>
<td>-4559</td>
<td>-4.1</td>
</tr>
</tbody>
</table>


The counties surrounding these urban centers (Box Elder, Cache, Rich, Morgan, Sanpete, Sevier, Summit, and Wasatch) showed a net migration loss of 2,886. Net population losses from this area were distributed among a surprising total of 37 states with only 12 states and the District of Columbia gaining net population from Utah's urban fringe counties in the 5-year period. The states gaining the highest total of net migrants from these Utah counties are Washington (649), California (544), and Virginia (281). As was the case for the Wasatch front counties, Idaho contributed the highest net immigration total (539).

The remaining counties of the state (Beaver, Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Iron, Juab, Kane, Millard, Piute, San Juan, Tooele, Uintah, Washington, and Wayne) are classified as rural Utah. These 17 counties experienced a net migration loss of 3,056 people in the 5-year period. Those states seeing the largest net gain from the rural Utah counties were Washington (740), Texas (250), Wyoming (248) and Arizona (238). These states contributing the largest number to these counties were California (216) and New Mexico (210).

Striking similarities and differences are seen from the data presented above. First, all portions of the state saw substantial numbers of their residents move to the state of Washington. The net loss to Washington amounted to over 35 percent of Utah's net migration loss for the 1965-70 time period. Residents of Utah's more urban counties also continued to migrate to California in this 1965-70 time period with about 26.5 percent of the net migration loss accounted for by the Utah-California exchange. On the other hand, California had a net migration loss to rural Utah counties. The reverse was true for Idaho. The more urban Utah counties gained from Idaho and Idaho gained from rural Utah counties.

**INTRASTATE MIGRATION**

There was also a significant amount of population movement within the state in this 1965-70 time period. The magnitude of this is partially shown in table 1. A total of 58,988 migrants who did not leave the state moved across county lines in this time period. With all of this movement the urban fringe counties gained 176 in population because of the migration and the Wasatch front counties gained 1,347 people. Rural Utah then lost 1,523 to these other areas of the state.

<table>
<thead>
<tr>
<th>Area</th>
<th>Number of migrants from other areas of state</th>
<th>Number of migrants to other areas of state</th>
<th>Net migration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wasatch front counties</td>
<td>15,354</td>
<td>14,007</td>
<td>1,347</td>
</tr>
<tr>
<td>Urban fringe counties</td>
<td>9,150</td>
<td>8,974</td>
<td>176</td>
</tr>
<tr>
<td>Rural counties</td>
<td>8,039</td>
<td>9,562</td>
<td>-1,523</td>
</tr>
</tbody>
</table>


---

**PEELED PEARS MORE FLAVORFUL**

Food technologists are constantly seeking innovative ways to improve older methods of food processing and preservation. If these new processes preserve more nutrients, provide consumer appeal, are more economical, and are adaptable to the food processing industry, so much the better.

Last year, several Utah State University scientists tackled several particular processing problems — what to do with peelings, cores, and waste water as well as speed up the whole processing operation.

In the case of pears, the peeling operation is time consuming whether done at home or in a commercial cannery. The USU researchers — Dr. D. K. Salunkhe, Dr. R. L. LaBelle, and graduate students J. Y. Do and C. Sri-Sangnam — ran tests on unpeeled pear halves. They wanted to determine if the peels would influence the appearance or eating quality of canned pears.

Bartlett pears were obtained rather late in the season and ripened at 50 to 60°F in protected outdoor storage for several days until the desired softening and development of flavor and aroma were obtained. Pear halves, either peeled and cored, or cored only, were held in 1-percent brine until enough were accumulated for packing in 20 percent sucrose syrup in quart Mason jars. The filled jars were heated in an open kettle for 30 minutes to a center temperature of 185°F, then closed and air-cooled. The canned fruit was stored in the light and at room temperature for 2 months before evaluation by a taste panel.

Appearance of the unpeeled halves was quite satisfactory. However, to ensure that the panelists would judge the relative flavor of the peeled and unpeeled canned products without reference to the appearance or different texture of the peels, the peels were readily slipped off the unpeeled halves, and both lots were diced through a ⅜-inch square grid.

Members of two separate taste panels consistently chose the peeled pears as having the more fruity flavor. Leaving the peel on saves effort, reduces waste and saves time but at the expense of flavor.
Like most things — the answer in this case can be "It all depends." But research is showing that more often than not, in Utah at least, such development is more likely to be a long term bane with at best a short term boost effect.

Utah's economic problems have been well publicized, with the predominantly rural counties suffering the most. At the same time, much of the state is blessed with fantastic natural beauty and a potential for exploitation as a source of recreation. Combine these facts with Utah's reasonable proximity to the heavily populated cities of Los Angeles, Phoenix, Denver, and San Francisco — and recreational land is inevitable. Cap it all with the pervasive, ingrained conviction that an individual has a God-given right to do what he likes with his land — and problems can proliferate faster than rabbits without predators.

JOHN P. WORKMAN is an Assistant Professor in the Department of Range Science.
DONALD W. MACPHERSON, formerly a Research Assistant in the Department of Agricultural Economics.
DARWIN B. NIELSEN is an Associate Professor in the Department of Agricultural Economics.
JAMES J. KENNEDY is an Assistant Professor in the Department of Forest Science.

SOME WHERE AND WHO DATA
The USU study of the demand for recreational and second homesites covered 1962 through 1972 (table 1). As measured by the number of new lots created, Iron County experienced the greatest growth. But in terms of total acreage involved, Box Elder, Duchesne, Summit, and Wasatch were in the forefront of land development (table 2).

Based on limited information, it looks as if the original developers may be either in- or out-of-state residents. The buyer of a lot in a development,
however, is most likely an out-of-state resident looking for a vacation homesite or an investment. Certainly the number of actual lots and acres developed during the study period was not matched by increases in population (table 3). Box Elder County is an outstanding example of this inconsistency, being a major development area that nevertheless had a decrease in population.

THE ECONOMIC CRUNCH
It is this discrepancy between lots sold and people moving in that has so far saved many development areas from financial crises.

Incredible as it may seem, the developer or seller of lots has no legal responsibility to provide the buyer with water, sewage facilities, year round access roads, fire protection, or utilities. For example, between 1962 and 1972, only 50 percent of the recreational subdivisions that registered with the Utah Real Estate Division claimed availability of water (table 4). In 1972, the percentage was 42.

The potential costs to nearby incorporated towns if such subdivisions became fully inhabited, could boggle the mind. Residents of the subdivisions would inevitably turn to such communities for fire and police protection, for help in road construction and maintenance, for educational and medical facilities, etc. The strain that such increased demands would put upon a previously solvent community could be overwhelming. And there might also be relatively "hidden" costs such as occur with pollution of ground water or damage to watersheds.

But even if the recreational subdivisions remain vacant, they generally represent a cost to residents of the surrounding countryside. The prime arguments for fostering recreational subdivisions invariably cite an expanded tax base and higher tax revenues. Unfortunately, the research-documented facts don't support these generalized contentions. The special zoning - or variances allowed on existing zoning, seldom seem to anticipate by local interests. Instead, tax revenues are more likely to decrease - even as service demands go up. And at the same time, land is often taken out of livestock or other agricultural production at a time when food supplies are short.

TABLE 1. Number, size, and value of recreational subdivision in Utah, and subsequent sales through 1972

<table>
<thead>
<tr>
<th>Year</th>
<th>Total subdivisions</th>
<th>Total lots</th>
<th>Average size (acres)</th>
<th>Average price per acre ($)</th>
<th>Total value ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1962</td>
<td>14</td>
<td>7,650</td>
<td>1.6</td>
<td>12,127</td>
<td>899</td>
</tr>
<tr>
<td>1963</td>
<td>14</td>
<td>2,285</td>
<td>3.1</td>
<td>7,029</td>
<td>333</td>
</tr>
<tr>
<td>1964</td>
<td>17</td>
<td>2,801</td>
<td>12.0</td>
<td>34,314</td>
<td>138</td>
</tr>
<tr>
<td>1965</td>
<td>21</td>
<td>1,584</td>
<td>3.5</td>
<td>5,611</td>
<td>488</td>
</tr>
<tr>
<td>1966</td>
<td>20</td>
<td>3,356</td>
<td>4.0</td>
<td>13,544</td>
<td>424</td>
</tr>
<tr>
<td>1967</td>
<td>22</td>
<td>6,027</td>
<td>1.5</td>
<td>8,765</td>
<td>949</td>
</tr>
<tr>
<td>1968</td>
<td>21</td>
<td>3,983</td>
<td>.9</td>
<td>3,650</td>
<td>1,370</td>
</tr>
<tr>
<td>1969</td>
<td>39</td>
<td>4,262</td>
<td>1.8</td>
<td>7,769</td>
<td>1,738</td>
</tr>
<tr>
<td>1970</td>
<td>64</td>
<td>8,023</td>
<td>3.0</td>
<td>23,964</td>
<td>1,382</td>
</tr>
<tr>
<td>1971</td>
<td>39</td>
<td>8,637</td>
<td>8.1</td>
<td>69,557</td>
<td>289</td>
</tr>
<tr>
<td>1972</td>
<td>63</td>
<td>14,108</td>
<td>3.7</td>
<td>51,674</td>
<td>1,697</td>
</tr>
<tr>
<td></td>
<td></td>
<td>334</td>
<td>62,716</td>
<td>238,004</td>
<td>194,408,668</td>
</tr>
</tbody>
</table>

Table 2. Recreational subdivisions in Utah counties, 1962-1972

<table>
<thead>
<tr>
<th>County</th>
<th>Total subdivisions</th>
<th>Total lots</th>
<th>Average size (acres)</th>
<th>Total acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaver</td>
<td>13</td>
<td>618</td>
<td>1.7</td>
<td>1,068</td>
</tr>
<tr>
<td>Box Elder</td>
<td>9</td>
<td>3,709</td>
<td>15.7</td>
<td>58,242</td>
</tr>
<tr>
<td>Cache</td>
<td>2</td>
<td>1,425</td>
<td>3.6</td>
<td>5,100</td>
</tr>
<tr>
<td>Carbon</td>
<td>5</td>
<td>180</td>
<td>23.0</td>
<td>4,160</td>
</tr>
<tr>
<td>Daggett</td>
<td>5</td>
<td>3,157</td>
<td>.7</td>
<td>2,065</td>
</tr>
<tr>
<td>Davis</td>
<td>1</td>
<td>7</td>
<td>.7</td>
<td>5</td>
</tr>
<tr>
<td>Duchesne</td>
<td>8</td>
<td>6,194</td>
<td>5.6</td>
<td>34,381</td>
</tr>
<tr>
<td>Emery</td>
<td>1</td>
<td>101</td>
<td>.9</td>
<td>94</td>
</tr>
<tr>
<td>Garfield</td>
<td>13</td>
<td>1,122</td>
<td>.8</td>
<td>837</td>
</tr>
<tr>
<td>Iron</td>
<td>54</td>
<td>10,447</td>
<td>1.9</td>
<td>19,389</td>
</tr>
<tr>
<td>Juab</td>
<td>1</td>
<td>224</td>
<td>5.0</td>
<td>1,120</td>
</tr>
<tr>
<td>Kane</td>
<td>42</td>
<td>4,722</td>
<td>1.7</td>
<td>8,020</td>
</tr>
<tr>
<td>Millard</td>
<td>5</td>
<td>1,128</td>
<td>6.2</td>
<td>6,979</td>
</tr>
<tr>
<td>Morgan</td>
<td>3</td>
<td>394</td>
<td>7.5</td>
<td>2,950</td>
</tr>
<tr>
<td>Rich</td>
<td>6</td>
<td>475</td>
<td>1.4</td>
<td>648</td>
</tr>
<tr>
<td>Salt Lake</td>
<td>6</td>
<td>479</td>
<td>3.0</td>
<td>1,429</td>
</tr>
<tr>
<td>Sanpete</td>
<td>14</td>
<td>6,082</td>
<td>2.3</td>
<td>13,846</td>
</tr>
<tr>
<td>Sevier</td>
<td>1</td>
<td>528</td>
<td>1.1</td>
<td>76</td>
</tr>
<tr>
<td>Summit</td>
<td>36</td>
<td>3,217</td>
<td>8.6</td>
<td>27,773</td>
</tr>
<tr>
<td>Tooele</td>
<td>16</td>
<td>2,812</td>
<td>5.5</td>
<td>1,368</td>
</tr>
<tr>
<td>Utah</td>
<td>10</td>
<td>2,163</td>
<td>5.2</td>
<td>11,192</td>
</tr>
<tr>
<td>Wasatch</td>
<td>25</td>
<td>4,584</td>
<td>4.7</td>
<td>21,594</td>
</tr>
<tr>
<td>Washington</td>
<td>50</td>
<td>7,186</td>
<td>.8</td>
<td>5,608</td>
</tr>
<tr>
<td>Wayne</td>
<td>2</td>
<td>41</td>
<td>52.7</td>
<td>2,160</td>
</tr>
<tr>
<td>Weber</td>
<td>6</td>
<td>1,721</td>
<td>4.6</td>
<td>7,903</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>334</td>
<td>62,716</td>
<td>238,004</td>
</tr>
</tbody>
</table>

*No data available for Grand, Piute, San Juan, and Uintah counties.

DECEMBER 1973 125
Table 3. Comparison of amounts of recreational land subdivided with population change and 1972 population of Utah Counties

<table>
<thead>
<tr>
<th>County</th>
<th>1972 population (approximate)</th>
<th>1972 households (approximate)</th>
<th>1962-72 population change (approximate)</th>
<th>1962-72 household change (approximate)</th>
<th>1962-72 lots developed</th>
<th>1962-72 acres developed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaver</td>
<td>3,994</td>
<td>3.19</td>
<td>-306</td>
<td>-96</td>
<td>618</td>
<td>1,068</td>
</tr>
<tr>
<td>Box Elder</td>
<td>30,170</td>
<td>3.68</td>
<td>-930</td>
<td>-253</td>
<td>3,709</td>
<td>58,242</td>
</tr>
<tr>
<td>Cache</td>
<td>45,826</td>
<td>3.59</td>
<td>7,126</td>
<td>1,985</td>
<td>1,425</td>
<td>5,100</td>
</tr>
<tr>
<td>Carbon</td>
<td>16,439</td>
<td>3.16</td>
<td>-3,261</td>
<td>-1,032</td>
<td>180</td>
<td>4,160</td>
</tr>
<tr>
<td>Daggett</td>
<td>747</td>
<td>3.56</td>
<td>-753</td>
<td>-212</td>
<td>3,157</td>
<td>2,065</td>
</tr>
<tr>
<td>Davis</td>
<td>107,228</td>
<td>4.17</td>
<td>25,714</td>
<td>7,585</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Duchesne</td>
<td>9,700</td>
<td>3.76</td>
<td>2,580</td>
<td>691</td>
<td>6,194</td>
<td>34,381</td>
</tr>
<tr>
<td>Emery</td>
<td>5,231</td>
<td>3.34</td>
<td>1,572</td>
<td>-45</td>
<td>101</td>
<td>94</td>
</tr>
<tr>
<td>Garfield</td>
<td>3,126</td>
<td>3.42</td>
<td>-274</td>
<td>-80</td>
<td>1,122</td>
<td>837</td>
</tr>
<tr>
<td>Iron</td>
<td>13,198</td>
<td>3.60</td>
<td>3,666</td>
<td>555</td>
<td>10,447</td>
<td>19,384</td>
</tr>
<tr>
<td>Juab</td>
<td>4,774</td>
<td>3.29</td>
<td>1,451</td>
<td>83</td>
<td>224</td>
<td>1,120</td>
</tr>
<tr>
<td>Kane</td>
<td>2,707</td>
<td>3.37</td>
<td>803</td>
<td>7</td>
<td>4,722</td>
<td>8,020</td>
</tr>
<tr>
<td>Millard</td>
<td>7,668</td>
<td>3.35</td>
<td>2,289</td>
<td>-132</td>
<td>1,128</td>
<td>6,979</td>
</tr>
<tr>
<td>Morgan</td>
<td>4,179</td>
<td>3.78</td>
<td>1,106</td>
<td>-1,179</td>
<td>312</td>
<td>2,950</td>
</tr>
<tr>
<td>Rich</td>
<td>1,515</td>
<td>3.40</td>
<td>446</td>
<td>-185</td>
<td>475</td>
<td>648</td>
</tr>
<tr>
<td>Salt Lake</td>
<td>482,042</td>
<td>3.40</td>
<td>141,777</td>
<td>70,242</td>
<td>479</td>
<td>1,426</td>
</tr>
<tr>
<td>Sanpete</td>
<td>11,895</td>
<td>3.19</td>
<td>3,729</td>
<td>895</td>
<td>281</td>
<td>13,846</td>
</tr>
<tr>
<td>Sevier</td>
<td>10,823</td>
<td>3.20</td>
<td>3,382</td>
<td>423</td>
<td>132</td>
<td>528</td>
</tr>
<tr>
<td>Summit</td>
<td>6,071</td>
<td>3.40</td>
<td>1,786</td>
<td>471</td>
<td>139</td>
<td>2,776</td>
</tr>
<tr>
<td>Tooele</td>
<td>222,108</td>
<td>3.54</td>
<td>6,245</td>
<td>1,608</td>
<td>2,887</td>
<td>1,368</td>
</tr>
<tr>
<td>Utah</td>
<td>151,761</td>
<td>4.00</td>
<td>37,940</td>
<td>9,540</td>
<td>2,163</td>
<td>11,125</td>
</tr>
<tr>
<td>Wasatch</td>
<td>6,137</td>
<td>3.52</td>
<td>1,743</td>
<td>737</td>
<td>209</td>
<td>4,584</td>
</tr>
<tr>
<td>Washington</td>
<td>16,022</td>
<td>3.57</td>
<td>4,488</td>
<td>1,575</td>
<td>7,186</td>
<td>5,608</td>
</tr>
<tr>
<td>Wayne</td>
<td>1,517</td>
<td>3.25</td>
<td>467</td>
<td>-183</td>
<td>41</td>
<td>2,160</td>
</tr>
<tr>
<td>Weber</td>
<td>131,086</td>
<td>3.39</td>
<td>38,668</td>
<td>3,683</td>
<td>1,721</td>
<td>7,930</td>
</tr>
<tr>
<td>State</td>
<td>Total</td>
<td>1,965,984</td>
<td>3.58</td>
<td>308,393</td>
<td>62,716</td>
<td>238,004</td>
</tr>
<tr>
<td>Total</td>
<td>1,128,529</td>
<td>3.56</td>
<td>317,003</td>
<td></td>
<td>62,716</td>
<td>238,004</td>
</tr>
</tbody>
</table>

Table 4. Water availability of Utah recreational subdivisions, 1962-72

<table>
<thead>
<tr>
<th>Year</th>
<th># sub. and % of total</th>
<th># lots and % of total</th>
<th># acres and % of total</th>
<th>Water available</th>
<th># sub. and % of total</th>
<th># lots and % of total</th>
<th># acres and % of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1962</td>
<td>13</td>
<td>100%</td>
<td>13</td>
<td>7640</td>
<td>100%</td>
<td>13</td>
<td>12127</td>
</tr>
<tr>
<td>1963</td>
<td>13</td>
<td>100%</td>
<td>13</td>
<td>7640</td>
<td>100%</td>
<td>13</td>
<td>12127</td>
</tr>
<tr>
<td>1964</td>
<td>13</td>
<td>100%</td>
<td>13</td>
<td>7640</td>
<td>100%</td>
<td>13</td>
<td>12127</td>
</tr>
<tr>
<td>1965</td>
<td>13</td>
<td>100%</td>
<td>13</td>
<td>7640</td>
<td>100%</td>
<td>13</td>
<td>12127</td>
</tr>
<tr>
<td>1966</td>
<td>13</td>
<td>100%</td>
<td>13</td>
<td>7640</td>
<td>100%</td>
<td>13</td>
<td>12127</td>
</tr>
<tr>
<td>1967</td>
<td>13</td>
<td>100%</td>
<td>13</td>
<td>7640</td>
<td>100%</td>
<td>13</td>
<td>12127</td>
</tr>
<tr>
<td>1968</td>
<td>13</td>
<td>100%</td>
<td>13</td>
<td>7640</td>
<td>100%</td>
<td>13</td>
<td>12127</td>
</tr>
<tr>
<td>1969</td>
<td>13</td>
<td>100%</td>
<td>13</td>
<td>7640</td>
<td>100%</td>
<td>13</td>
<td>12127</td>
</tr>
<tr>
<td>1970</td>
<td>13</td>
<td>100%</td>
<td>13</td>
<td>7640</td>
<td>100%</td>
<td>13</td>
<td>12127</td>
</tr>
<tr>
<td>1971</td>
<td>13</td>
<td>100%</td>
<td>13</td>
<td>7640</td>
<td>100%</td>
<td>13</td>
<td>12127</td>
</tr>
<tr>
<td>1972</td>
<td>13</td>
<td>100%</td>
<td>13</td>
<td>7640</td>
<td>100%</td>
<td>13</td>
<td>12127</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>100%</td>
<td>13</td>
<td>7640</td>
<td>100%</td>
<td>13</td>
<td>12127</td>
</tr>
</tbody>
</table>

*These figures are based on data collected but not consolidated by Stephen J. Francis, UDRE. MacPherson consolidated the data by year in his thesis.

debt due from a solvent debtor. Thus, if speculation (such as buying a large parcel of land for $250 per acre, subdividing the selling 1/2 to 1 acre lots for up to $6,000 per acre) is obvious to the Commission — the tax rate is not figured on the sale price. Taxes thus remain unrealistically low, and land speculation flourishes.

THE IRON COUNTY PREDICAMENT

During the last 10 years, 86 percent of all lots sold in Iron County have gone to out-of-state residents. Most of this land activity has been associated with the Brian Head ski area — which includes 2,000 acres of privately owned land in the midst of Dixie National Forest.

One-third of the private land has been subdivided into mountain cabin communities (proximately) with populations ranging from 3,000 to 10,000. In the past 15 years, the population of Iron County has grown from 7,000 to 13,000, with a net increase of 6,000.

The iron county predicament is that the development of the ski area has led to a boom in population growth, and the resulting strain on services such as schools, hospitals, and roads has put a burden on local government. The predicament is exacerbated by the fact that most of the development is in unincorporated areas, where there is little oversight from the county government.

The predicament is that the development of the ski area has led to a boom in population growth, and the resulting strain on services such as schools, hospitals, and roads has put a burden on local government. The predicament is exacerbated by the fact that most of the development is in unincorporated areas, where there is little oversight from the county government.
sites comprising eight major subdivisions. The 840 lots within these subdivisions are assessed at $150 each. The selling price ranges between $4,000 and $6,000 per lot. Thus, if the average market value is $5,000 per lot, the land is assessed at only three percent of market value as compared to the Iron County average of 14 percent.

If these 840 lots were assessed at the county-wide average of 14 percent, Iron County would gain $462,000 in assessed value, resulting in $24,601 additional county revenue at the 1972 mill levy of 53.25 mills. Due to differential tax assessment, these eight subdivisions alone cost the residents of Iron County nearly $25,000 in forgone tax revenue. This amount may be viewed as the direct cost to Iron County residents of subsidizing out-of-state ownership of prime mountain property.

Utah property assessment rate is set by law at 30 percent of market value. Since, in practice, the assessment rates is nearer to 20 percent in most counties, the 1969 Utah Legislature passed legislation providing for a complete state audit and reassessment of all real property every 5 years. The new law should alleviate much of the inequity and loss of tax revenue resulting from mountain subdivisions such as the ones in Iron County.

CORRECTING INIQUITIES

The traditional tool of zoning has proved too readily susceptible to political pressures to be relied upon. Vested interests too often tend to profit from zoning manipulations — usually at the expense of the politically inept and weak members of society. Only an unusually well-informed, organized, and vocal group of tax payers is likely to realize the theoretically possible benefits of proper land use zoning at the county or more local levels.

The individual counties within Utah are therefore going to have to seek state-level action if they want to effectively better their current situation. Specific possibilities for improvement include a realistic land use plan for all of Utah, revision of tax assessment procedures for recreational subdivisions, and giving the Utah Real Estate Division authority to deny permits to obviously inadequate subdivision applications.

Table 5. Assessments on recreational subdivisions in Utah counties at the average rate of assessment for unimproved rural lot compared to the average county-wide rates

<table>
<thead>
<tr>
<th>County</th>
<th>Value of recreational subdivisions in 1972 dollars</th>
<th>Average assessment rates of unimproved rural lots (%)</th>
<th>Average assessment rates of entire county (%)</th>
<th>Assessment values of recreational subdivisions (dollars), 1972</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaver</td>
<td>2,914,240</td>
<td>5.67</td>
<td>12.38</td>
<td>165,237</td>
</tr>
<tr>
<td>Box Elder</td>
<td>4,656,177</td>
<td>8.10</td>
<td>14.13</td>
<td>377,150</td>
</tr>
<tr>
<td>Cache</td>
<td>2,813,210</td>
<td>4.13</td>
<td>13.62</td>
<td>198,903</td>
</tr>
<tr>
<td>Carbon</td>
<td>1,740,241</td>
<td>8.10</td>
<td>14.22</td>
<td>140,960</td>
</tr>
<tr>
<td>Daggett</td>
<td>1,832,610</td>
<td>20.77</td>
<td>18.70</td>
<td>380,633</td>
</tr>
<tr>
<td>Davis</td>
<td>73,780</td>
<td>5.66</td>
<td>13.37</td>
<td>4,176</td>
</tr>
<tr>
<td>Duchesne</td>
<td>11,593,079</td>
<td>18.00</td>
<td>18.70</td>
<td>2,086,754</td>
</tr>
<tr>
<td>Emery</td>
<td>165,690</td>
<td>19.28</td>
<td>20.71</td>
<td>31,926</td>
</tr>
<tr>
<td>Garfield</td>
<td>3,026,965</td>
<td>16.11</td>
<td>17.42</td>
<td>487,644</td>
</tr>
<tr>
<td>Grand</td>
<td>no data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>15,370,257</td>
<td>9.63</td>
<td>11.29</td>
<td>1,480,156</td>
</tr>
<tr>
<td>Juab</td>
<td>2,776,480</td>
<td>14.50</td>
<td>14.81</td>
<td>402,590</td>
</tr>
<tr>
<td>Kane</td>
<td>15,383,856</td>
<td>17.56</td>
<td>18.10</td>
<td>2,686,021</td>
</tr>
<tr>
<td>Millard</td>
<td>1,565,516</td>
<td>17.61</td>
<td>12.65</td>
<td>275,687</td>
</tr>
<tr>
<td>Morgan</td>
<td>1,942,079</td>
<td>16.67</td>
<td>17.64</td>
<td>323,745</td>
</tr>
<tr>
<td>Piute</td>
<td>no data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rich</td>
<td>2,612,764</td>
<td>18.76</td>
<td>17.65</td>
<td>490,155</td>
</tr>
<tr>
<td>Salt Lake</td>
<td>1,020,315</td>
<td>14.27</td>
<td>15.94</td>
<td>145,599</td>
</tr>
<tr>
<td>Sanpete</td>
<td>10,933,699</td>
<td>12.05</td>
<td>13.05</td>
<td>1,317,511</td>
</tr>
<tr>
<td>San Juan</td>
<td>no data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sevier</td>
<td>416,500</td>
<td>9.78</td>
<td>15.54</td>
<td>40,734</td>
</tr>
<tr>
<td>Summit</td>
<td>16,165,309</td>
<td>17.52</td>
<td>14.55</td>
<td>2,832,162</td>
</tr>
<tr>
<td>Tooele</td>
<td>19,074,267</td>
<td>5.10</td>
<td>11.87</td>
<td>972,788</td>
</tr>
<tr>
<td>Uintah</td>
<td>no data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utah</td>
<td>17,625,482</td>
<td>7.05</td>
<td>14.98</td>
<td>1,242,596</td>
</tr>
<tr>
<td>Wasatch</td>
<td>21,043,945</td>
<td>16.66</td>
<td>16.74</td>
<td>3,505,921</td>
</tr>
<tr>
<td>Washington</td>
<td>53,288,698</td>
<td>7.91</td>
<td>10.05</td>
<td>4,215,136</td>
</tr>
<tr>
<td>Wayne</td>
<td>156,528</td>
<td>18.00</td>
<td>18.74</td>
<td>28,175</td>
</tr>
<tr>
<td>Weber</td>
<td>5,826,873</td>
<td>4.91</td>
<td>12.53</td>
<td>286,099</td>
</tr>
<tr>
<td>Average</td>
<td>11.91</td>
<td>15.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>211,836,550</td>
<td></td>
<td></td>
<td>25,229,733</td>
</tr>
</tbody>
</table>

*Utah State Tax Commission (1972)*

DECEMBER 1973
RESEARCH MAY OPTIMIZE RANGE ANIMAL PRODUCTIVITY

JOHN C. MALECHEK, LORIN E. HARRIS, JOHN P. WORKMAN, AND MICHAEL WOLFE

One of Utah's prime resources is her rangeland (86 percent of the state's land area). Traditionally a source of feed for livestock and other animals, these lands are now of increasing interest to recreationists, ecologists (professionals and amateurs), and other diverse groups.

Utah State University's range research program has evolved with the changing times. With its existing national and international reputation built largely upon work in range livestock nutrition, the program has been broadened to include economists, ecologists, and entomologists.

Most of Utah's ranges are federally owned. This means that ranchers who run their cattle and sheep on this land during certain months of the year, are subject to various government restraints. Market demand for meat has historically had little effect on the numbers of animals allowed on a particular range. In the recent past, the main goal has been to avoid overgrazing. And the degree (over or under) of grazing has been pretty much defined in terms of the forage removed by cattle and/or sheep.

But today's world precludes simplistic analyses. For example, consumers want readily available meat—but does it have to be beef? Could other meat-type animals besides sheep be combined with cattle on the range and make better use of existing vegetation? Are there animals that would eat current under (or non-) used plants (greasewood, sagebrush, creosote brush, etc.)? And, for that matter, could other kinds of plants (that are palatable to cattle) be induced to thrive on Utah's ranges?

The USU range research program is currently geared to finding answers to such questions. The basic assumption is that more emphasis and a heavier degree of use will be placed on those lands having the highest potential for forage production (irrigated meadows and seeded ranges) while many of the less productive ranges are removed from livestock grazing and allocated to such uses as wildlife habitat and recreation. Unfortunately, management techniques that will accommodate this shift in land use patterns while increasing production, or at least maintaining the current level, are simply not available.

FERTILIZER

One of our current research approaches to intensifying management is through nitrogen fertilization of ranges that have previously been seeded to one of several species of introduced wheatgrasses (Agropyron spp.). These ranges have an inherently high level of productivity and they have a history of use devoted almost solely to grazing. In addition, they provide forage to the livestock industry during the early spring, a highly critical period when alternative forages are almost non-existent.

Work was initiated this summer at the Benmore Experimental Range, near Vernon, in Tooele County to test the effects of several levels of added nitrogen fertilizer on forage production, as well as beef production. The design of the experiment is such that results should be on a practical scale (each of the 30 experimental pastures is 50 acres in size) and, probably most importantly, the whole experiment will be evaluated from the standpoint of economic feasibility. Nutritional studies will play an integral part in the experiment of explaining livestock responses to the fertilization treatments.

GRAZING SYSTEMS

Another project, now in its second year, involves approaching intensified management through grazing systems. Grazing systems are strategies that combine timing and intensity of grazing use to achieve some management goal, whether range improvement, increasing livestock production, or in this case, optimizing use by both livestock and big game animals. This study is a cooperative effort between the Agricultural Experiment Station and personnel of the Utah Division of Wildlife Resources.1

Previous studies (Jensen and Smith, 1971) have indicated that if domestic animals such as sheep are properly managed while grazing on these ranges, competition with wintering deer forage is not only minimized, but in reality more winter deer can be produced. Division of Wildlife Resources personnel are pursuing this hypothesis in the present study by measuring sheep weight gains. They are then correlating this data with forage production and utilization on ranges grazed at two intensities during four time-periods in spring and early summer.

University personnel are studying 1Cooperating Division of Wildlife Resources scientists include Charles Jensen, Arthur Smith, and Philip Urness.
the nutritional implications of these grazing systems for the sheep that graze the area in spring as well as the deer that use such ranges in winter. A related study, even more basic in its orientation, is attempting to determine how the presence, location, and abundance of certain plant species (primarily shrubs) influence the behavior of the grazing animal with respect to the food plants he chooses, and consequently how his nutritional status is affected.

INSECT HAZARDS
The team of scientists associated with the integrated research on Range Animal Nutrition and Production are also committed to attacking problems of immediate consequence and need whenever they crop up. To this end, members of the Departments of Range Science and Animal Science are working with entomologist Austin Haws on the problem of the black grassbug (Labops spp.). This insect has recently infested thousands of acres of Utah's rangelands, principally the highly productive, seeded ranges. The insects have caused untold damage through reduction of forage production and forage quality. We are now attempting to quantify the degree of loss in forage quality through nutritional tests on several species of grasses where insects have been controlled, where there are different but known levels of infestation, and where fertilizer has been applied.

Results of this study should permit formulation of a more realistic estimate of damage from these insects, as well as some possible management alternatives to insecticides.

THE WILD HORSE FACTOR
One immediate problem is that of wild horses. Essentially a protected species since 1971 (Public Law 92-195), most of the populations have been growing steadily in response to good forage production. What are the carrying capacities of their ranges? Are they competitive with other wild and domestic range animals? What are their requirements for food if they are to survive and be preserved? All of these important questions need answers before crucial management decisions can be validly formulated.

COMPUTER MODELS
The potential for using ruminant creatures other than the traditional cattle and sheep as suppliers of dietary protein for humans is totally unknown. Some authorities feel that many thousands of acres of Utah's rangelands are well suited (if water can be made available) to some "new" browsing type of animal. Certainly, if the world's population continues to grow at its presently increasing rate, lands now used to produce forage for domestic livestock may, of necessity, be converted to production of cereal grain for direct human consumption. Under such conditions, an animal that could efficiently convert low quality range forage into protein for human use might be valued highly. Computer simulation models offer a promising way of pre-evaluating potential range manipulations.

Recently, a modeling effort has been initiated at Utah State University with the major objective of developing an ungulate-optimization system for the Cache National Forest. The research group comprises personnel from the International Biological Program (Desert Biome), Department of Wildlife Science (USU), Utah Division of Wildlife Resources and the U.S. Forest Service. Specific objectives of the study are to:

1. Construct conceptual models to simulate population dynamics of deer and elk on National Forest areas of the Intermountain West.
2. Synthesize life-history and demographic information for deer and elk on the Cache National Forest.
3. Explore the management implications of alternative ungulate combinations as obtained by integration of the data from Objective 2 with various stocking rates for cattle and sheep in the simulation model.
4. Develop an ungulate biomass optimization program for the Cache National Forest.

Obviously, the results of this simulation modeling will require some field validation, prior to any implementation of an optimization program.

The simulation approach also provides some indicators as to the most desirable direction for future research. Through sensitivity analysis, various biological parameters can be modified and the effects on the total system can then be evaluated. Those that produce the greatest response of the system are probably the most critical, and future field studies could then investigate these in depth.

The USU study group is now primarily concerned with the wildlife-biological aspects of the optimization system. Future efforts would, however, require inputs from other disciplines such as economics, sociology, recreation and watershed science. And once perfected, the modeling technique could be profitably applied to analyzing opportunities for incorporating other animal species.

INTRODUCING "NEW" SERIES
Various investigators have theorized that the climate and flora of the American Southwest was not appreciably different 12,000 years ago. Yet, at that time, the area was inhabited by several species of ground sloths, giant armadillos, horses, camels, four-horned pronghorns, shrub oxen, pecaries, tapirs and bison. This indicates that the present native American desert faunas are not exploiting all available niches. Nor do the introduced and currently cohabiting domestic cattle and sheep utilize desert shrubs such as greasewood (Sarcobatus sp.) and creosote bush (Larrea tridentata). Subject to important esthetic, economic, ethical, and biological considerations, the judicious introduction of some exotic herbivorous species might substantially increase animal biomass production on arid western rangelands.
For example, the creosote bush has been suggested as comprising a major portion of the now extinct Shasta ground sloth's diet. Utilization of creosote bush by other extinct herbivores seems probable, since the camels that were introduced by the military in the mid-1800s reportedly consumed the species. Some research data indicate that annual primary production may be greater in a creosote bush community than in an adjacent grassland. Presently, however, neither indigenous nor domestic livestock utilize this plant species to any degree, because of its high volatile oil content. Other vegetational types might be profitably used by appropriate browsing ungulates of African or Asian origin. A computer simulation approach as explained above could be advantageously employed to determine ideal stocking rates for a combination of ungulates in these areas.

Similarly, the "cold desert shrub" vegetation of the Great Basin area is largely untouched by native browsers. A species such as the saiga antelope (Saiga spp.), which utilizes sagebrush and several salt tolerant chenopod species such as might appreciably enhance protein production in this biome.

It has been estimated that the introduction of appropriate herbivores to utilize the desert shrub vegetation in the western United States and Mexico could increase the annual carrying capacity of these areas by 10-20 million animal units.

HAZARDS OF "NEW" SPECIES

The possible introduction of exotic herbivores, however, is subject to a number of important ecological, sociological, and esthetic considerations. Predeterminations would have to assure no disruption of the delicately balanced native ecosystems, and no dangers to the survival of indigenous ungulates. Haphazard introductions of exotic species could produce formidable competition for a native species. Or, perhaps even more of a hazard, is the possibility that an introduced species may serve as a vector of a disease, against which our native herbivores have little or no resistance.

A case in point is the concern for the welfare of the desert bighorn (Ovis canadensis nelsoni) in the American southwest with reference to recent introductions of the Barbary sheep or aoudad (Ammotragus lervia) from North Africa. The desert bighorn's numbers have already been drastically reduced from their pristine levels. Extensive competition from the aoudad, which shows considerable dietary overlap with the desert bighorn but enjoys a higher biotic potential, could cause further declines in bighorn numbers in areas where they coexist.

OTHER VETERINARY CONSIDERATIONS

To optimize rangeland productivity of all its potential products (meat, recreation, water, etc.) some long-standing veterinary problems also must be solved. In particular, current research into conception rates, abortions, neonatal diseases, and genetic factors must be successfully concluded.

If the animals on the range aren't reproducing efficiently, meat production can't be optimized. First the potential mother has to become pregnant — not as easy as it may sound when distance and timing considerations are realized. Then she has to carry the fetus term, give birth, and keep the youngster alive (despite potential diseases and predators) until it can be either harvested or bred.

Whatever the future may hold in terms of changes in our social, cultural, and economic institutions, the vast majority of the western United States will remain as rangeland, producing a surplus of plant material that is useful to man only after it is converted by grazing animals. The species, numbers, yield, and system of management used to regulate these animals, will depend largely upon research-enhanced understanding of the principles of range animal nutrition and production.

INCREASING THE Calf CROP

INCREASING CALF CROP

With the high price of beef, stockmen and beef producers more than ever are trying to increase the productivity of their herds. A number of management decisions are required for any livestock operation, but chief among them is animal reproduction.

Some agricultural research is aimed towards increasing twins in cattle. Another study is concerned with comprehensive crossbreeding in an effort to increase weaning weights. However, there is one problem that the stockmen must always face — how to manage his brood cows to increase the conception rate, birth rate, and number of calves at weaning. This is easy to talk about but extremely difficult to obtain in real life.

100 PERCENT

For instance, stockmen strive for a conception rate of 100 percent whether they use bulls or artificial insemination. Actually, 90 percent of the cows will conceive within a 21-day period. However, of this, 90 percent, only 60 percent will be pregnant at 90 days. That is the reason most ranchers keep bulls with the cows at least 90 days. By doing this, the cows affected by embryonic death have a chance to be rebred so that 95 percent of the cows will be pregnant at the end of 90 days. No one really knows why there is a 30 percent embryonic death rate among seemingly healthy cows. Geneticists suggest that this is nature's way of eliminating "trash."

DISEASES

Also involved in the picture is nutrition. When cows are not receiving balanced rations with adequate miner-
als, their ovulation and conception rates are influenced. Diseases such as vibriosis, trichomoniasis and PI 3 (pneumonia type germ) are also responsible for a number of embryonic deaths.

In normal operations there is also going to be another 5-percent death rate of fetuses (abortions) that result from abnormalities, injuries, or hormonal disturbances. Once disease enters the picture, however, these abortion rates skyrocket. Leptospirosis, brucellosis, ibreba and other as yet unidentified viruses can cause anywhere from 5 to 60 percent losses. In addition, there is the hazard of chemicals such as nitrates, heavy metals, and poisonous plants that can cause abortions. So it is a fortunate stockman that attains a 90 percent calf crop.

It isn’t hard to realize that beef production can be increased by any improvement in the above listed hazards. Immunizations and herd management practices designed to eliminate disease factors, proper nutrition, proper range use, being careful with diseases, and finding that the calves are so small hereford and angus females often results in death or injury to both the calf and the cow.

SCOURS

Once the calf is born, the scene is set for more trouble. One of the major diseases causing numerous deaths is scours. Approximately 15 million calves are born annually in the United States. About 1 in 10 (5 million) are affected by scours. This month, when the death rate amounts to about $36 million per year and the total losses resulting from death, medication, labor, weight loss, etc. exceeds $200 million. A number of researchers throughout the United States are trying to find ways for preventing scours. No single organism causes the disease. Instead there are several that work to cause the symptoms. One virus, a reovirus, generally responsible for diarrhea the first few hours or days causes the epithelial cells that line the calf gut to slough off. Once these cells are gone, the calves lose their resistance to a parapathetic bacteria called Eschericia coli and other bacteria that deliver the second punch from which few calves recover. Researchers are working trying to find vaccines that will stop the disease rather than spread it.

**By Computer . . .**

**BALANCING LIVESTOCK RATIONS**

**LORIN E. HARRIS AND LEONARD C. KEARL**

Today's average housewife knows that she should give her family a high quality, well balanced diet, hopefully at a low cost. If she fails to reach this goal, her family's general health and energy level will suffer.

Today's average livestockman also is in a comparable dilemma. He has to provide his animals with a high quality, well balanced ration at a minimal cost, or he is out of business. Fortunately for the livestockman, animal scientists saw the advantages of using computers to calculate rations as long ago as the 1940s.

A feed composition committee of the National Academy of Sciences including a representative from Utah State University was established in 1946 to provide precise information on the nutrient value of feedstuffs currently used, or available for use in livestock and poultry feeds. Changes and improvements were rapidly occurring in the processing of numerous feed ingredients, improved methods of chemical analysis were available, and ingredients were being

LORIN E. HARRIS is a Professor in the Department of Animal Science.

LEONARD C. KEARL is a Research Associate in the Department of Animal Science.
and is applicable on an international basis.

More than 7,600 feeds were named and qualitatively described in the USU Bulletin. The computer system that is used allows for the addition of new data to the existing “International Bank.” And all of the feed composition information that is stored in the USU computer is accessible to organizations and individuals who need it.

By the 1970s, the Food and Agriculture Organization (FAO) of the United Nations and the U.S. Agency for International Development (AID) were seeking ways to extend applications of the computerized feed data to some of the world’s less developed nations. In 1971, the National Academy of Science’s National Research Council published an Atlas of Nutritional Data on U.S. and Canadian Feeds containing chemical and/or biological data on 6152 different feedstuffs. Most recently, an International Network of Feed Information Centers (figure 1) was organized. This Network, to be correlated by scientists at USU, would allow feed data to be collected, computerized, and utilized on a world-wide basis.

At the same time, the existing USU storehouse of data is being adapted to better serve the needs of Utah livestockmen and feed dealers.

Computerized, most profitable diet programs are being prepared at USU to use the types of feeds available on a livestockman’s premises. The nutritional values of the feeds along with their current market prices will be processed through the computer. The results will give the amounts of each feed to mix in a diet for the maximum amount of gain (milk, eggs, etc.) at the least cost for the class of livestock being fed (cattle, sheep, dairy cows, etc.)

Before January 1974, it should be possible for an individual to phone a special number into USU and get a quick answer to virtually any question about ration formulation.

**COMPUTER TECHNIQUES APPLIED TO LIVESTOCK DIETS**

Computer time-sharing, a new concept in practical application of acquired knowledge, is the modern way to solve current problems and predict future developments. By effective use of time-sharing techniques, Utah State University will be able to do a better job in education, both in-residence and extension. This technology properly applied to the Utah livestock industry will make it more competitive with other areas of the country and the world.

USU’s time-share plan will permit extension specialists and ranchers in Monticello and Cedar City, for example, to dial a local telephone number and work directly with the computer on the USU campus.

It is anticipated the future will show more ranchers and feed dealers introducing these new techniques into their management and service programs. Advantage to the customer and to the University in providing these services on a relatively inexpensive basis is irrefutable.

The ability to assess advanced technology developed by various universities, government, and/or private industry through time-sharing programs greatly increases our productive capability. This is especially true in extension. This technique permits the use of programs and data banks costing millions of dollars to research, develop and introduce at a token of the original cost.

A time-sharing computer system consists of four major components: computer, programs, data banks, and communication facilities.

**COMPUTER**

The computer must be accessible, reliable, and have the capability of meeting the needs of the customer. For educational purposes, especially extension, accessibility to the computer is of primary importance. The computer at USU is accessible 24 hours a day, 7 days a week (except between the hours of 12:01 a.m. and 6:00 a.m. on Thursdays). This provides flexibility in serving a customer at almost any time.

Reliability is also important. To
avoid embarrassment to extension specialists performing “live” demonstrations, on-line communications and computer dependability are necessary — most facilities are available approximately 90 percent of the time.

PROGRAMS

The programs systems, and applications, are necessary to have an effective time-sharing operation. The applications of the program and the data provided are the heart of any good system. The language used must be oriented to that of the user. The language of the physicist, for example, would not be that of a cattle or dairy man.

DATA BANK

Data banks that contain reliable information are essential in preparing complex animal diets necessary to meet the nutrient requirements of all classes of livestock for all stages of growth and production. At USU the most comprehensive collection of feed composition data in the world is assembled. Also, the nutrient requirements for animals as established by the National Research Council are stored. The effective utilization of time-sharing capability can and is greatly improving our acquisition, organization, and dissemination of these data. Data banks for feed blend linear programming took nutritionists years to research and develop. Now, they are stored in a time-sharing computer system and are available to any Utah livestockman wishing access.

COMMUNICATIONS

Communications must be dependable, accessible, and at a relatively low cost. Communication cost, in using time-sharing computers, can often exceed the cost of the computer service. Therefore, maximum utilization and organization of data transmitted by remote terminals should be planned and embodied in the data transmittal procedures in order to reduce communication costs.

The telephone service offered in most areas is dependable and available when needed.

The service provided by a time-sharing program can be utilized by extension specialists giving group demonstrations or formulating rations for individual farmers. On-campus, the system is used for both teaching and research.

FUTURE PLANS

By accessing time-sharing technology to solving many of the complex problems facing agriculture today, greater efficiency can be achieved, and least-cost rations for all classes of livestock production can be provided.

As proficiency in operation improves, and demand warrants, improvement will be achieved in computer capabilities and communications.

To meet its responsibilities to agriculture, USU is contributing by sharing technology and data through time-sharing computer systems. These techniques and procedures will constantly be improved by our own program development and through cooperative efforts with other institutions.

Figure 2. Communication and data flow chart for computerized animal feed data.
Consumers have a stake in the Logan Central Milk Testing Laboratory

In July, 1973 the Utah State Dairy Herd Improvement Association (DHIA) unanimously recommended that all the state samples be forwarded to the Logan Central Laboratory testing program as soon as possible. This means that over 30,000 samples per month will be reaching the laboratory on the USU campus in the near future. In addition, samples from several herds in Wyoming are being tested in the laboratory and the number is increasing. The test results directly benefit dairymen and indirectly benefit consumers.

The Logan Central Laboratory is growing because it provides more services than dairymen can obtain elsewhere. One such service is the assurance of more accurate testing through new electronic methods. Another advantage is the faster turn-around-time for the records, which means the farmer gets his test information back before it is ancient history. So far the Logan laboratory has reduced turn-around-time by 1 day. Further improvements will depend upon whether dairymen decide they need additional tests, which could cause delays. Central laboratory data also has economic value for the farmer.

Through Wycoff-Postal Service, 1-ounce milk samples can be delivered to the central laboratory within 24 hours from any location in Utah, western Wyoming or southern Idaho. The samples are precooled by the tester-supervisor and shipped in special styrofoam containers which hold 50 samples each. Sometimes over 35 containers (1,750 samples) arrive at the laboratory per day.

One of the problems associated with establishing a laboratory relates to obtaining reliable, accurate instrumentation. The IRMA (Infra Red Milk Analyzer), reviewed in the December, 1971 issue of Utah Science, failed the course and has been deported! Capital investment and maintenance problems proved to be IRMA's downfall.

A Milko-Tester Mark III (for fat content) was then purchased to get the program started. This unit can test 180 samples per hour. Approximately 1,800 of these instruments are in use around the world, testing over 1 million samples per day.

PROTEIN

The Mark III in Logan has tested over 60,000 samples since it was installed and there have only been very minor maintenance problems. However, we have not been able to routinely test for protein since IRMA's rejection. The laboratory, therefore, lost protein customers. Drs. N. R. Gandhi and G. H. Richardson have applied for a patent to cover an economical method of protein testing based upon the absorbance of ultra-violet electromagnetic energy. The effluent from the Mark III, already tested for fat, can be successfully clarified through the addition of another reagent. This material can then be measured for protein. The protein tester can operate at the same speed as the Mark III and thus provide simultaneous protein data for a few pennies; much less than the cost for other methods of protein testing. The first research model of the protein tester looked very much like a Rube Goldberg assemblage (figure 1).

Figure 1. Experimental model of a milk protein testing device capable of preparing the effluent from the Milko-Tester for assay using ultra-violet energy absorbance.

GARY H. RICHARDSON is a Professor in the Department of Nutrition and Food Science.
This breadboard unit was assembled by Mr. Robert Pate, the 1973 Vale- dictorian of the Utah State University College of Engineering. The device can keep up with the Mark III in providing diluted milk samples to the ultra-violet detector.

This development did not go unnoticed. Foss Electric of Denmark, creator of the Milko-Tester, could not sell their protein tester in the United States due to instrument and per sample costs. When they learned of the USU development, they sent two engineers to evaluate this break through. Mr. Niels Brems, developer of the Milko-Tester Mark III, spent considerable time in Logan consulting about the possibility of Foss building protein units to interface with their fat test device. He agreed to have a prototype shipped to USU within 2 months for research purposes. If the work on the prototype proves successful, sales for the unit should mushroom because of the increased interest and concern over the protein content of dairy foods. Dr. Gandhi has demonstrated that the testers can be used to evaluate such foods as cheese, ice cream and sour cream in addition to milk. In fact, any product which can be prepared in a liquid form should be testable on the protein-fat testing instruments. The prototype will be assembled along side the Mark III and we will supply the DHIA members with protein and fat data on their computer print outs.

QUALITY

Another test which should be of great interest to farmer and consumer alike involves testing for milk quality or animal health. If the cow's udder is stressed or contains infectious bacteria, its output of leucocytes or somatic cells increases. Normal milk contains less than 500,000 cells per milliliter. Higher counts indicate abnormalities and a count of 1,500,000 is the maximum legally allowable. The Technicon Auto Analyzer II has been added to the battery of instruments in the central laboratory. It can be used for many tests, including the counting of somatic cells. Early results indicate that this instrument will rapidly pay for itself. A similar instrument in California, for example, detected a high somatic cell problem in one 250-cow herd. Within 1 year the same herd was lowered in average somatic count by 400,000 and the increased milk yield produced $19,000 more profit than before! Two herds in Utah have been compared using the new device (table 1). Herd #1 had 25 percent of all the animals over the allowable maximum. In other words, only 75 percent of the animals were producing legal milk! This explained why the animals were producing 2,500 pounds of milk per cow per year less than they had the previous year. This could have meant an annual loss to the farmer of over $14,000 for the 90-cow herd. The advantage of using the 120-samples per hour somatic cell counter becomes obvious.

Only one animal in herd number 2 (2 percent) was above the legal limit for somatic cell count. These dairies were using the same milking equipment but the first was using the equipment improperly. A milk sample can be processed through the somatic cell counter while protein and fat data are being generated. The savings achieved can be passed on to the consumer because the farmer will obtain higher volume yields with the same input when he has his herd carefully monitored and applies the management practices necessary to assure continued good animal health.

Projects funded by Dairy Research Incorporation (DRINC) have allowed USU researchers to develop assays for other constituents in milk. The laboratory can now test for casein, calcium, magnesium, manganese, potassium, sodium, and even trace minerals.

Logan's Central Milk Testing Laboratory can only have a positive effect upon the ability of the producer and processor to assure a safe, abundant milk supply for the Utah consumer. The data generated assists the farmer in choosing optimum breeding and management practices, which in turn assures Utah's dairy industry of a continued bright future.

Table 1. Distribution of somatic cell counts made upon individual animal milk samples from two herds. A Technicon AA II Somatic Cell Counter was used following formalin fixation of cells.

<table>
<thead>
<tr>
<th>Somatic Cell Count Range (millions)</th>
<th>Herd #1 (%)</th>
<th>Herd #2 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 0.1</td>
<td>3</td>
<td>57</td>
</tr>
<tr>
<td>0.1 - 0.25</td>
<td>15</td>
<td>32</td>
</tr>
<tr>
<td>0.25 - 0.5</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td>0.5 - 1.0</td>
<td>22</td>
<td>3</td>
</tr>
<tr>
<td>1.0 - 1.25</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>1.25 - 1.5</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>1.5 - 2.0</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Over 2.0</td>
<td>17</td>
<td>0</td>
</tr>
</tbody>
</table>

AG NOTES

More than 1,500 pounds of flour, cereal products, sugar, potatoes, fats, oils and eggs are consumed annually by the average American family of four.

American agriculture's assets now total more than $307 billion dollars.

About one-fifth of America's hay crop is sold. The remainder is fed to livestock on the farm where the hay is produced.

More than 40 percent of America's grass seed comes from Oregon.

Farming in the United States employs 4.6 million workers.

Farming in the United States employs as many people as the transportation, steel and auto industries combined.

The average family of four in the United States eats about 1,000 pounds of fruits and vegetables each year.
Behavior studies in farm livestock

B. O. BARKER, R. C. LAMB, AND C. W. ARAVE

Studies of animal behavioral patterns are extensive and have been conducted since before the time of Aristotle. However, the majority of studies of animal behavior have been made in the last hundred years, and most of these studies have dealt with wild animals. Very little research on the behavior of domestic animals has been reported.

Domestic animals, excepting cats, group together in herds, flocks or packs. With the formation of such groups; a social structure is established. Social dominance (certain individuals consistently bossing other individuals of the group) is exhibited in varying degrees by all classes of farm animals. A boss-follower relationship in dairy cattle was recognized as early as 1853 when it was noted that herds of Swiss cows always had a boss cow. A similar “peck” order has been shown in poultry flocks.

Social status has an important influence on the feeding patterns of cattle. One study showed that while grazing on good pasture, socially dominant dairy cows walked 8/10 mile per day to obtain necessary forage while the lower ranking cows walked 1 1/4 miles per day. In bunk feeding where adequate space was provided for all cows to eat simultaneously, the walking distance varied among cows from 1/4 to 3/4 mile per day. Social dominance accounted for the vast difference. The cow on the high end of the social scale walked only one third as far as the lowest ranking cow.

It was further observed that cows grazing or feeding in an area would protect it from cows lower in the social scale but would vacate for cows above them in the social order. Since social relationships can be very complex, butting and pushing often resulted.

EXPLORE PASTURE

Other researchers have observed that when cattle enter a new ungrazed pasture, they spend the first moments in a wild rush, circling the field with tails carried erect over their back, galloping in a strange awkward way. During the first 2 or 3 hours of the first day the herd spends very little time eating, but instead explores the environment.

After cattle have grazed for about 2 hours there seems to be a rest period in which practically all the cattle lie down, often closely bunched together. After the rest period, they resume feeding or leave the grazing area. A mass-psychology thus seems to lead them all to do the same thing at about the same time. As one cow leaves the grazing area and heads for the barn or water, the rest will follow within a few minutes in what has been described as a pilgrimage. The animals usually string out in single file, heads up, looking neither to the right nor left. They exhibit no foolishness and indulge in no eating or casual fighting, instead each animal walks briskly as if under orders. Some studies have shown that the dominant cows tend to be in the middle of such a pilgrimage with the mid-dominant cows leading and the most submissive cows trailing.

HERD ORGANIZATION

Other investigations have concluded that dairy cows organize themselves into a specific order for enter-

Figure 1. Domestic animal behavior studies are showing that some cows really are bossy. Cows, like chickens, have a definite social order.
ing the milking parlor. The pattern is relatively consistent, with the more aggressive cows usually entering the milking parlor first. When the cows were trained for 1 month to enter in a different order, they reverted to their original order as soon as they were permitted to enter the parlor without interference.

As concentrations of animals per farm increase, and management practices on livestock farms change, studies of animal behavior as a factor in increasing their efficiency of production become increasingly important.

The current trend in dairying is toward development of large herds with cows managed as groups rather than as individuals. Furthermore, animals are often confined to hard surfaced yards with limited space per animal. Many questions are being raised by dairymen regarding the practicability of group management of cows under total confinement systems. Many of the same questions are being asked by commercial beef feedlot operators.

In response, a new research thrust on group management of large animals has been initiated at Utah State University in a joint effort with the Agricultural Research Service of the USDA. Although the initial studies will involve dairy cattle, hopefully, applications to beef cattle management will also evolve. Scientists from several departments and with diverse backgrounds in several disciplines are working together on this research.

**MIXING GROUPS**

One of the first problems scheduled for study is how to best group cows to facilitate management for maximum milk yields. Questions about optimum group size, transfer of animals between groups, and amount of space needed per cow urgently need answers. Some dairymen, for example, group cows according to milk production. But others avoid this system because they feel that the associated transferring cows from one group to another stresses the animals and lowers production. In one recent trial at USU, putting a group of 12 cows in with another group of 20 cows started an involved chain reaction of conflicts among the cows as they interacted to establish a complete new social order. Fighting continued for at least 2 days and resulted in a fractured leg as one cow fell while losing a skirmish for social dominance.

Certain social changes have been observed to increase animal aggression. For example, the crowding of some species of animals into half the space they had been accustomed to has doubled the fighting. The opposite has been noted in dairy cattle. The amount of stress imposed on a cow low in the social order for constantly violating the space of higher ranking animals is not known, nor is the resulting loss in production.

USU and ARS scientists are studying the behavior of dairy animals subjected to various sociological stresses. Results should help dairymen manage their animals for more efficient milk production and growth.

**Wildlife Notes**

The skunk uses its potent scent sparingly. He can produce it at the rate of about one-third liquid ounce per week.

The pronghorn antelope buck has a dark patch on his face and neck, his horns are longer than his ears, and he runs with his nose pointed somewhat downward. The doe lacks most or all of the dark patch, seldom has horns longer than ear length and holds her nose more nearly horizontal when she runs.

The four-horned antelope of India and Burma is the only wild mammal in the world with four horns. Only the males have horns.

A large oak tree is capable of giving off as much as 40,000 gallons of water into the air during a single summer through the process of transpiration.

The bear moves with an awkward or shuffling gait because he has no clavicle to keep the shoulder bones steadily apart. Thus, as the forelegs are moved, the blade bones "work" much more on the side than is usual in animals.

Toads can live in places too dry for frogs, but they must return to water in the spring to lay their eggs.
Dairying, like most agricultural enterprises, is changing dynamically, which it must do to remain economically and technologically competitive. Projecting future changes and industry profiles is hazardous, but recent trends and current developments provide a basis for expectations.

LARGER HERDS

Utah once had dairy cows on more than 12,000 farms, but now there are fewer than 2,000 herds in the state. The number will likely stabilize at 1,000 to 1,500 herds within the next few years. Herd size has more than doubled in the past 20 years and may double again in the next 10. Several herds now have or soon will have more than 1,000 cows. Others will increase to this size within the next 5 years. Many family operated herds now exceed 100 cows and others will be increased to 100 to 300 cows. National trends are similar but less advanced in most states.

One of the major factors responsible for the increasing herd size is the need to generate an adequate family income, which must come either from more cows or from increased production per cow. Some dairymen seek part-time employment from other farm enterprises or from off-farm jobs. Others have sold their cows or combined them with those of other dairymen into larger more efficient herd operations. Dairymen who plan to retire often sell their herds to other dairymen and sub-divide their land. Younger dairymen who wish to continue must enhance their managerial ability, accept improved technology and make proper use of land, labor, capital and facilities. With these resources and abilities, one man with limited hired help can care for 100 or more cows as readily as he could care for 20-30 cows using more traditional facilities and procedures.

MILK INCREASE

Milk production per cow in Utah has increased by 64 percent since 1955 and will likely continue at a similar rate in the immediate future. This 3.5-percent annual increase is not likely to be sustained indefinitely despite methods of sire evaluation and selection that permit giant strides in genetic improvement of dairy cattle. Utah's dairymen have benefited substantially from USU research into sire evaluation. Other research-based advances in nutrition, herd health and other aspects of management are helping cows produce the greatest volumes of milk of which they are genetically capable. With increased production, there is an increased efficiency of feed utilization according to studies at Utah State University. Thus, fewer cows can produce more milk, consume less feed, and thereby excrete less total animal wastes.

Quality standards for milk have increased appreciably the past few years. They will continue to increase until all the milk that is marketed meets a single standard similar to that of Grade A milk. This improved quality will assure consumers of better milk and milk products.

IMPROVED TECHNOLOGY

An example of how improved technology is being developed to help the industry solve its problems is a study at Utah State University on whey utilization. Cheese plants have traditionally discarded whey into streams. Research has proved that nutrients in whey can be utilized by dairy cows when they become accus.
tomed to drinking it. Recycling of whey in this manner will avoid stream pollution as well as provide valuable nutrients to cows and reduce their feed costs. Preliminary results indicate that cows can drink considerable quantities of whey and maintain high levels of production.

The use of computers will continue to increase as dairymen utilize them in record keeping, sire selection and ration formulation. Individual matings based on computer pairings will soon be common. Computers will combine nutritious feeds at least cost, control electronic mixing, and direct the delivery to the mangers. Computerized cost account records are currently available and will be used by more herds in the years ahead.

Planned health programs for dairy herds will prevent most diseases and health impairments. Improvements in milking equipment will reduce udder injury and help maintain a high level of milk production. Studies in progress at Utah State University on calf health and reproduction efficiency should help dairymen reduce losses from these two costly problems.

Automated feeding, partially automated milking, and mechanization of waste removal will substantially reduce routine labor costs. Qualified dairy herd workers are difficult to find, and those who are available can command good wages.

Development of new dairy foods will continue to attract consumer demand as will the dairy farmer and processor financed promotion, advertising and professional education. The consumer attitude toward dairy foods is improving after a period of adverse publicity. Willingness of dairymen to jointly finance research will facilitate the solving of problems and the development of new products or new uses for old products.

MILK PRICING

Pricing of milk and other dairy foods is undergoing major changes. Traditionally, pricing systems have been based on fat content of milk, largely because of the ease of testing milk for fat. Laboratory procedures are now available for determining both protein and non-fat solids portions of milk. Since consumers want less fat and more protein, some dairy processing plants are now using protein as well as fat in their milk pricing systems. DHI testing programs include protein and solids-not-fat analyses as an aid to dairymen trying to develop herds that produce more of these nutrients. The Central Testing Laboratory at Utah State University (see article on page 134) is developing new and more efficient milk testing procedures.

Large herds with cows handled in groups present new challenges to managers. Studies of animal behavior at Utah State University should shed some light on cow responses to various managerial procedures (see article on page 136). Results from such studies will help provide guidelines, not currently available, for making successful decisions for future dairy herds.

New challenges will inevitably confront the dairy industry of Utah and other states. Currently profitable operations may be uneconomical within a few years. Dairymen must be alert to every new development and be able to distinguish the beneficial ones from those which will not help. Cows and their managers must be continually more productive and efficient to compete with other dairymen and with those industries producing competitive food products. Utah State University's resources will continue to help Utah's dairymen remain profitable and competitive.

Alfalfa - an ancient crop gone modern

JAMES H. THOMAS

To the casual observer the green patchwork patterns of Utah's valleys are just that — green patterns. Those who appreciate the significance of agriculture in our state, however, more often than not recognize the most brilliant greens as alfalfa fields. In fact 41 percent of the cultivated land in Utah is growing alfalfa and pumping more than $50 million annually into the economy in hay value alone. Another $250 million are realized in related sales such as livestock, machinery and supplies. Alfalfa is our most important crop because livestock and their products are our most important agricultural industry.

Alfalfa has been called "Queen of the forage crops" and this is certainly true in Utah. However, before we pay homage to this royal plant, let's take a new look at its attributes and problems.

Alfalfa has been around a long time. There is good evidence that it was one of the first crops domesticated by man and, under various identities, it has been intimately associated with progress and civilization. Reports of forage plants whose descriptions fit alfalfa are dated as early as 3300 B.C. Virgil mentioned alfalfa in his poems, and Varro, in 36 B.C., discussed the culture of alfalfa in knowledgeable terms. Aristotle (384-322 B.C.) described the usefulness of this plant, and Columella of Roman times warned of the bloat hazard and knew of its soil improvement capabilities. Alfalfa followed the Medes, Persians, Babylonians, Greeks, Romans and Huns in their world conquests because it fed the horses they
rode and the cattle they ate. In later times the Italians, Swiss and especially the Spaniards cultured alfalfa and took it with them throughout the world.

Alfalfa arrived on both the east and west coasts of America about the same time. In 1847-1850 “Chilean clover” was found growing in California, and by 1855 alfalfa was being used by California stockmen. “Lucerne,” another name for alfalfa, arrived in eastern U.S. and was taken to the midwest where Wendelin Grimm planted “Ewiger Klee” (everlasting clover) in 1858 and started the alfalfa variety that still bears his name.

Dr. John Carlson, long-time Utah researcher in alfalfa, referred nostalgically to the few pounds of alfalfa seed first brought here as the single most important introduction of our state, and undoubtedly the event heralded the beginning of an era of rapid expansion and realization of Utah’s agricultural potential.

Alfalfa has produced very well in Utah and has facilitated more intensive livestock and dairy industries than would have been possible using native ranges only. We have concentrated on alfalfa as feed and have made it into a gourmet food for livestock. We offer it to them in a variety of forms and flavors. Alfalfa is chopped, ensiled, baled, flaked, cubed, dehydrated or hammered into alfalfa meal. It is mixed in rations with corn, barley and oats and spiced up with salt, molasses and mineral additives. And all classes of livestock eat it with relish and thrive on it!

WHAT MAKES ALFALFA SO VALUABLE?

Alfalfa is bursting with much sought after nutrients. No fewer than nine vitamins are present in easily measurable quantities including large amounts of Vitamin A (122, 259 IU/lb.). It has phosphorus, calcium, magnesium, potassium, and iron in significant amounts. If we were to attempt to replace all the components found in alfalfa with similar ones from commercial sources, it is estimated that it would cost us nearly $150 to create a ton of alfalfa. Alfalfa hay at the current price of $40-$50 per ton is a real bargain.

U.G.F.?

Animal nutritionists speak of “unidentified growth factors” in feedstuffs, and as a forage feed, alfalfa is unsurpassed. Alfalfa has been thoroughly analyzed and yet there is “something” about the inclusion of alfalfa in one of two otherwise equal rations that promotes better yields of milk, meat and fiber. Animals are more fertile and in better health generally when high quality alfalfa is part of their diet. Perhaps the fabled “Elixir” will someday be isolated from an alfalfa plant.

THE PRESSURE FOR PROTEIN

With world protein sources in short supply, alfalfa doesn’t have to rely on an elusive U.G.F. for its claim to fame.

Approximately 15 percent of the dry weight of alfalfa is protein, with a variation of from 10 percent to 20 percent depending on the growth stage at which the plants are harvested, and on the manner and duration of subsequent storage. From 6.5 tons of alfalfa we can get up to 2,500 pounds of protein. Few other plants can produce this much protein per acre in 1 year. Unfortunately, this forage has to be fed to animals such as cattle, which convert it into a kind of protein that people can use as food. Small amounts of alfalfa have been used as food for horses, poultry and swine, but most of the crop has been fed to cattle.

Lately, however, U.S. scientists have found ways to separate out some forms of protein from alfalfa’s profuse supply that monogastric animals such as ourselves can utilize.

By fractionating one ton of freshly cut alfalfa into solids, water, and protein, we can produce the following:

349 pounds of dehydrated alfalfa having 19.6 percent protein (68.4 pounds.)

### Table 1. Value of components in a ton of dehydrated alfalfa.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Amount</th>
<th>Replacement material and price</th>
<th>Dollar value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>17.0%</td>
<td>46% protein soybean meal at $75 per ton</td>
<td>$27.71</td>
</tr>
<tr>
<td>Fat</td>
<td>3.0%</td>
<td>Animal fat at $0.04875 per lb</td>
<td>2.92</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>12.31 ppm</td>
<td>$0.0025 per gram supplied by a premix</td>
<td>0.25</td>
</tr>
<tr>
<td>Nicin</td>
<td>43.82 ppm</td>
<td>$0.0029 per gram supplied by a premix</td>
<td>0.12</td>
</tr>
<tr>
<td>Pantothenic acid</td>
<td>30.00 ppm</td>
<td>$0.0082 per gram supplied by a premix</td>
<td>0.23</td>
</tr>
<tr>
<td>Choline</td>
<td>1516.00 ppm</td>
<td>$0.1025 per lb. for 44% choline chloride</td>
<td>0.81</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>128.00 ppm</td>
<td>$27.0000 per million units</td>
<td>3.14</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>122239.0 IU/lb</td>
<td>$0.0210 per million units</td>
<td>5.13</td>
</tr>
<tr>
<td>Folic acid</td>
<td>2.10 ppm</td>
<td>$0.0650 per gram supplied by a premix</td>
<td>0.16</td>
</tr>
<tr>
<td>Thiamine</td>
<td>3.50 ppm</td>
<td>$0.0140 per gram</td>
<td>0.04</td>
</tr>
<tr>
<td>Pyridoxine</td>
<td>6.30 ppm</td>
<td>$0.0425 per gram</td>
<td>0.25</td>
</tr>
<tr>
<td>Xanthophyll1</td>
<td>257.00 ppm</td>
<td>$0.02100 per gram</td>
<td>49.10</td>
</tr>
<tr>
<td>Methionine plus</td>
<td>0.46%</td>
<td>$0.5500 per lb for MHA (90)</td>
<td>5.61</td>
</tr>
<tr>
<td>Cystine</td>
<td>0.73%</td>
<td>$0.6500 per lb for 50% material</td>
<td>18.98</td>
</tr>
<tr>
<td>Lysine</td>
<td>0.46%</td>
<td>$0.5500 per lb. for MHA (90)</td>
<td>5.61</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>2355.00 ppm</td>
<td>$85.0000 per ton for 18.5% Dical</td>
<td>1.06</td>
</tr>
<tr>
<td>Calcium</td>
<td>13300.00 ppm</td>
<td>$10.2600 per ton for limestone (38% Ca.)</td>
<td>0.33</td>
</tr>
<tr>
<td>Magnesium</td>
<td>2900.00 ppm</td>
<td>$0.0500 per lb. for 54% mg.</td>
<td>0.54</td>
</tr>
<tr>
<td>Potassium</td>
<td>24900.00 ppm</td>
<td>$0.0140 per lb. for potassium chloride</td>
<td>2.34</td>
</tr>
<tr>
<td>Iron</td>
<td>464.00 ppm</td>
<td>$33.4000 per ton for ferrous sulphate</td>
<td>0.08</td>
</tr>
</tbody>
</table>

The replacement shown above account for a ton of 511 lb, which means that 1,489 lb. of weight or bulk must be added into the total. This is figured at $40 per ton. Total value of a ton of 17% Dehy. $148.6C.

1No vitamin activity.

The values for methionine plus cystine and/or lysine were taken from new tables soon to be published. Cystine figured at the same price as methionine.

**Table 1. Value of components in a ton of dehydrated alfalfa.**
Plus the juice, from which we can make two protein products:

One weighing 17.8 pounds having 50 percent protein (8.9 pounds.) and one weighing 120 pounds having 7.4 percent (8.9 pounds.)

This gives us a total protein yield of 86.2 pounds of protein compared to 86 pounds from simple dehydration, or 75 pounds when the alfalfa is used directly as hay. More important, however, the 17.8 pounds (or 19.6 percent of original protein can now be fed in fairly large amounts to monogastric animals like swine and poultry. And, as protein becomes increasingly scarce, food scientists and nutritionists may be looking for ways to include alfalfa in our own diets.

ALFALFA FOR HUMANS

Some alfalfa is already being used as “people” food. Health food stores the world over sell alfalfa tablets, claiming they are an effective treatment for a wide variety of physical ailments. Alfalfa has been a component of baby foods and cereals, and recipes have been developed for “alfalfa” bread, cookies, casseroles, and for other dishes using alfalfa. Unfortunately, the human digestive tract can’t handle alfalfa in large amounts, and several alfalfa components such as the saponin compounds can be detrimental.

A PARAGON OF VIRTUES?

One might ask if there is anything bad about “the Queen.” Along with all of the good things that alfalfa is and does, we must acknowledge several significant problems. For some reason, still not fully understood, alfalfa can cause bloating in grazing cattle and sheep. We are making progress in solving this problem through dietary supplements that combat the bloating tendency, but many ruminate livestock are lost each year from bloat.

Alfalfa requires large amounts of water for best growth, but doesn’t like its roots wet. Under our Utah conditions it would be a blessing if it required less irrigation water and would tolerate more ground water.

Alfalfa is susceptible to many diseases and insects. We have to treat virtually every acre with insecticides to obtain economic yields and are continually fighting to keep ahead of diseases which develop on it.

Producing alfalfa seed has also been a chronic problem. The seed is small, 220,000 to 230,000 seeds per pound, about the size of a straight pin head. The weather, poor soils, damaging insects, pollinating insects and a Pandora’s box-full of other problems can harass the seed producer. Alfalfa seed production is not a game for the timid or the uninformed.

STILL THE BEST

Nevertheless, considering the pros and cons of alfalfa production, the pros carry far more tonnage than the cons. Therefore, scientists at Utah State University and elsewhere continue to try to solve the problems, because alfalfa, as a basic feed or food, could prove to be an important factor in the battle to keep the world’s food supply ahead of the population.

<table>
<thead>
<tr>
<th>Crop</th>
<th>1961 yield/acre</th>
<th>Lbs/TDN/acre</th>
<th>Lbs/protein/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn (grain)</td>
<td>100 bu</td>
<td>4,544</td>
<td>377</td>
</tr>
<tr>
<td>Corn (silage)</td>
<td>22 tons</td>
<td>7,920</td>
<td>528</td>
</tr>
<tr>
<td>Alfalfa (hay)</td>
<td>5 tons</td>
<td>5,040</td>
<td>1,048</td>
</tr>
<tr>
<td>Alfalfa (dehy.)</td>
<td>5 tons</td>
<td>7,195</td>
<td>1,898</td>
</tr>
</tbody>
</table>

Figure 1. As new alfalfas are bred for resistance to insects and disease, production will increase as will the importance of saving as much as possible of each cutting. Cubing saves nutrients otherwise lost as well as making these nutrients more available to cows.
Our potentially prodigious queen

JAMES H. THOMAS

Alfalfa hay in Utah costs $40-$45 per ton "and that ain’t hay." Pun or not, the rising price of alfalfa has brought into acutely sharp focus the important place alfalfa fills in the agricultural economy of our state. In 1973, Utah produced 1 1/2 million tons of this precious commodity, but still the demands of our livestock industry remained unmet. We import from neighboring states, especially Idaho, substantial quantities of alfalfa hay every year. This is good for Idaho and perhaps it is not bad for Utah. However, with the demand for livestock products spiralling upwards, Utah’s alfalfa producers could capitalize on a booming market by increasing production.

HIGHER YIELDS ESSENTIAL

Since alfalfa is already growing on 460,000 acres (41 percent) of our cultivated land, we only need to slightly raise the yield per acre a little to dramatically increase our total hay supply. If each acre yielded 1/2 ton more hay it would boost our supply by 230,000 tons and mean $9 to $10 million additional income for Utah’s farmers each year.

Average yields of alfalfa in Utah for 1971 and 1972 were 3.05 and 2.85 tons per acre, respectively. In 1973, a good year for hay producers, averages remained near 3.25 tons per acre. These figures are slightly higher than the national average but could be much better. Utah’s climate and soil conditions favor the growth of alfalfa. Our long days, low humidity, irrigation water, and calcareous soils make alfalfa a natural for Utah.

Through research, agricultural scientists have determined what is required to produce 5 tons of alfalfa. They have written the “recipe” in various forms, but a condensed version for Utah would include the following:

1. Level, well drained soil.
2. High plant population of an adapted variety.
3. Adequate water, applied optimally.
4. Adequate soil nutrients (as per soil test).
5. Control of insect pests, especially weevil.
6. Control of weeds.
7. Harvest first crop at first bloom to permit second and third crops to mature and insure high quality.
8. Pray, since weather control is yet out of our hands.

Careful mixing of each “ingredient” in proper amounts will increase yields, and conversely, the absence or insufficiency of one or more reduces yields. Unfortunately, many of our growers have not yet realized that they need to do more than plant when convenient and trust in providence.

On the other hand some of Utah’s alfalfa producers are already using the recipe and getting yields of 5 tons per acre. If average yields are going to be raised, those producers getting less than 5 tons per acre must utilize what we already know. At the same time we must find new and better ways to produce more so that we can write a recipe for 8 tons of alfalfa per acre for those now getting 5. USU alfalfa experts and scientists in many disciplines are seeking solutions to the alfalfa production problems which are presently limiting yields.

JAMES H. THOMAS is a Seed Specialist and Assistant Professor in the Department of Plant Science.

Figure 1. Weedy alfalfa fields produce yields far below their potential.

UTAH SCIENCE
RESEARCH IS THE KEY

Currently, researchers recognize problems — some relating to production techniques and some to the biological characteristics of the alfalfa plant. As your own good health is realized only by controlling many factors; e.g., nutrition, hygiene, diseases, physical activity and rest, so higher yields of alfalfa will be obtained only when we optimize all the factors influencing the growth of the plant. Most urgently needed, perhaps is research to increase the productivity of alfalfa itself by developing better varieties or hybrids, or to develop techniques that will take full advantage of the alfalfa plant and our natural conditions.

WHAT ABOUT HYBRIDS?

Between 1954 and 1965 the average yield of corn in the United States doubled and sorghum production per acre increased 2½ times. These dramatic increases were realized largely from the use of hybrids and fertilizer. During these same years alfalfa yields increased only 15 to 18 percent, largely due to improved varieties and better management. Why can’t we produce hybrids of alfalfa? We can! Some hybrid seed is being marketed in the midwest and there seems to be some promise for increased yields from hybrid alfalfa. However, production of alfalfa hybrids is much more difficult than producing hybrids of corn or sorghum.

Technically, alfalfa is already a hybrid — a natural hybrid. Presumably it is already expressing some or most of its hybrid vigor, so the usual dramatic increase in yield from creating a hybrid can not be realized. Hybrid seed production depends upon control of pollination. This control is simple in corn which is wind pollinated, and very difficult in alfalfa which depends upon bees for pollination. Hybrids of alfalfa could be produced economically only on plants having no pollen (male sterile), and most bees do not like to visit pollenless plants. Production of hybrid seed is consequently very low and therefore seed is expensive. A bee training program has been suggested but as yet it is impractical.

Finding the necessary parents to produce a valuable hybrid is much more difficult in alfalfa than in corn because of the tetraploid (4 sets of chromosomes per cell) nature of alfalfa (compared to 2 sets in corn). Plant breeders looking for a specific individual plant with 1, 2 or 3 desired characters would find it once in each 4, 16 or 64 plants in corn where they occur only once in 36; 1,296; or 46,656 plants in alfalfa. The search and research is magnified proportionately.

Alfalfa hybrids have potential, but much more research is needed in this area before it will be realized.

YIELD INCREASES FROM FERTILIZER!

Alfalfa is well known for its soil building capabilities. Because of this, farmers have been reluctant to apply fertilizers to alfalfa assuming it didn’t require any. This has been especially true in Utah where adequate yields were obtained for many years without fertilizer. Unfortunately, those days are gone except in a few very small areas. Now there is little doubt that alfalfa yields could be increased substantially by applying fertilizer.

The unknowns are, however, what kinds and amount should be used, and when should application be made to maximize production in Utah. At present scientists can make blanket recommendations for fertilizer application based on soil tests. These recommendations are easy to make, but often produce no tangible results because of local variations in soils, lack of water or some other factor.

With more than 50 types of soils in Utah, we could make more meaningful recommendations if we had more information on the alfalfa-soil-fertilizer interaction that occurs on each type. Such information, however, is obtained only through extensive, accurate investigations, which require the investment of considerable time and money. In the meantime, individual producers could increase their yields by taking advantage of USU’s soil testing services and applying recommended amounts of appropriate fertilizer.

MOST SERIOUS PROBLEM?

Ask any Utah farmer what the most serious problem in alfalfa production
is, and he'll likely say "the weevil" or "lack of water." Although the "most" serious problem is a matter of opinion, the weevil certainly must be considered a prime candidate. The alfalfa weevil has caused great losses annually since it was first discovered in America near Salt Lake City in 1904. We now can control it chemically with considerable success. Current concerns about the environment are making the use of chemicals more questionable, however, and several good control chemicals have been denied the alfalfa producers. As a result, different chemicals, which are more expensive and sometimes less effective, must be utilized.

Biological controls, through plant resistance or insect management, are the ideal solutions, but so far we have not discovered a practical way to do it. We continue to rely on chemicals. Unfortunately, the chemicals we have may eventually not do the job because of evolving insect resistance. Resistant weevils might then be happily eating their way through 5 to 50 percent of our alfalfa crop. The need for a solution to this problem is recognized as urgent, and USU scientists are now seeking new methods to control the weevil.

AND WHAT ELSE?
Perhaps less urgent, but no less serious if we really intend to continue increasing yields, are the problems associated with weeds, water application, diseases, nematodes, new varieties, stand establishment, plant population, seeding rates, rotations, and field renovation to name only a few. At the same time we need to look to the future. What can we do with more selective pesticides, stimulants, growth hormones, and other "treatments", and ultimately what is the interaction of all these factors and what will be their effect on our environment?

Research has provided many answers. With these answers, individual producers can raise yields right now. But neither growers or researchers can afford complacency. Alfalfa has great potential for the future — we need only find the keys to unlock that potential.

Forestry and watershed research - preparation for tomorrow's intensive management

RICHARD L. MEYN AND JAN A. HENDERSON

In contrast to some of its neighboring states, much of Utah's forested and high elevation lands are still unspoiled, aesthetically pleasing, and productive. Increasing populations, technological developments, and expanding recreational activities, however, promise serious pressures on these natural resources. Research in forest and watershed management at Utah State University at present is designed to provide an understanding of our forest ecosystems since understanding is prerequisite to intelligent manipulation. Practical tools, utilizing the latest computer technology, are being developed to facilitate the intensive management of the future and to help solve problems inherent in an increasingly complex society.

REFORESTATION AND STAND DEVELOPMENT

Regeneration and establishment of seedlings, litter accumulation, growth and productivity, cone production and climate of the spruce-fir forest in northern Utah have been studied in detail with the aim of providing management directions that will ensure optimum productivity of the type for timber, water, recreation and wildlife values. This forest type is the most valuable timber resource in the state. It covers about 1 million acres, accounts for about one third of the total commercial timber volume, and is second only to aspen in acreage.

The primary concern of managing and harvesting timber in this type is regeneration; second is soil disturbance and third accessibility. Regeneration of spruce and fir is sporadic and is influenced mostly by seed availability and summer moisture. A 26-year study of cone and seed production has shown that average or better cone crops of fir occur every 3 or 4 years. Average or better cone crops of spruce occur every 3 to 4 years. Over the same period, seed germination and seedling survival studies have shown that 86 percent of the spruce and 75 percent of the fir will die, mostly because of drought, during the first year. Most seedlings that survive are associated with decaying wood or mineral soil. Two factors are recognized for this: one, spruce litter is lethal to overwintering spruce seeds and two, the rotting wood and, to a less extent, the mineral soil provides more moisture to the germinating seeds. In northern Utah, the availability of water is more critical than elsewhere in the spruce-fir zone because this is an area of particularly low summer precipitation; moreover, the rate of establishment of spruce and fir seedlings is too small, under a mature stand, to eventually replace the dying trees if natural succession is allowed to proceed. It is also too little to assure a fully stocked residual stand if the overstory is harvested. After 10 years, the survival of a given
crop of seedlings will average 0.3 percent for spruce and 0.4 percent for fir. It takes 50 to 70 years for conifer seedlings in this area to reach breast height; whereas in more favorable climates such as along the west coast, endemic conifers take only 5 to 7 years. Regeneration after logging, either by seeding or planting in this zone has been a near failure because of summer drought. Therefore if the type is to be harvested the logging practice needs to make best use of advanced regeneration, site preparation and use pre-harvest planting to ensure establishment of the next generation. To enhance the chances of survival of the advanced regeneration and to favor post-harvest establishment, the silvicultural method which is most likely to be successful will be selection or patch cutting or some variation of the two.

If the proper silvicultural method is not employed, regeneration will likely not occur in sufficient quantity and the site will be occupied by grass, brush or aspen and the ecological cycle back to spruce-fir will take several hundred years, rather than less than 150 years.

**PRODUCTIVITY**

Another facet of the work on spruce-fir in the USU forest is concerned with the productivity of the type. Several studies are in progress to define rates of wood and total biomass production, decomposition and succession. A primary productivity model for forested ecosystems has been proposed by R. H. Waring of the Coniferous Forest Biome. This model is intended to provide an estimate of productivity of forested ecosystems with a minimum of required measurements. If the results of this study are favorable, comparable applications will be made relative to other forest vegetation of the Wasatch Front such as Douglas-fir and quaking aspen. From this work we will learn how our growth and decomposition rates compare with ecosystems throughout western North America.

**WATERSHED MANAGEMENT**

Utah's forested watersheds have long been valued for their water supply, timber resources, forage, wildlife habitat, and scenic beauty. At present these areas are performing well as a source of water, but population and industrial growth increases for the future indicate demand outrunning

---

**Figure 1.** Soil water depletion of a stand of Englemann spruce-subalpine fir at the U.S.U. Forest. Data are from M.S Thesis by F. D. Eaton.

**Figure 2.** Comparison of computed with observed discharge of a small forested watershed (Data are from computer simulation work by R. H. Hawkins.)
that supply. Trees, as well as other vegetation, transpire large amounts of water into the atmosphere during the course of their life cycle. Much additional water is lost directly from the soil surface. Collectively, the water transpired from vegetation and evaporated from the soil constitutes an evapotranspiration loss.

**INCREASING SUPPLIES**

Researchers at USU are studying possible ways to conserve water by modifying evapotranspiration. In one project timber will be completely removed from small (one-acre or less) area in conjunction with a timber harvest and reforestation in plant, and the magnitude of realized water savings will be evaluated. In the summer of 1969, aluminum tubes were installed in the ground at four, ½ acre plots of mature spruce-fir. At 2-week intervals during each summer season, soil water is sampled by a nuclear device which is lowered into the tubes. Water use by the forest has thus been recorded in 1970, 1971, and 1972. The 1973 sampling is in progress and several more seasons will be recorded before treatment begins. Treatment will consist of removing timber at three of the four plots. One plot will be left undisturbed as a control. The effect of timber removal on water savings will be estimated by using a predictive relationship between an uncut plot and each of three treated plots.

A comparison of soil water losses in the first 4 feet of soil between a forested plot and an adjacent herbaceous-grass meadow showed that the meadow retains, on the average, an additional 1.3 inches of water at the end of each summer. An additional contribution of 1.3 inches of water to subsurface water and streamflow on a watershed basis would be substantial.

The in progress study is expected to provide definitive values of the maximum savings of soil water that can be expected for spruce-fir harvest from areas in the Intermountain Region having similar soils and topography. The study should also help clarify how much manipulation can be used to increase snowpack accumulation and eventually point to ways of obtaining successful reforestation.

Despite the obvious importance of mountain watersheds in Utah and the Intermountain West, the nature and inner workings of these hydrologic systems are largely unknown. People and their technological innovations are bound to have increasing impacts in the future. The effects of air pollution, insecticides, heavy recreational use, and weather modification need to be defined now if undue ecological harm is to be prevented and the hydrologic systems controlled to benefit man. One road to such understanding utilizes computer simulation of techniques. One USU research team therefore is trying to mathematically model...
a specific small forested watershed or a series of associated watersheds. The resultant model will allow definition of the relative roles of evaporation, infiltration, snowmelt, and ground water movement.

**CONSERVING QUALITY**

Water quality is a many-faceted subject. Water emanating from mountain watersheds is commonly thought of as being clear, cold, and pristine — and often it is! Recent research in the northeast United States, however, has demonstrated that water from watersheds that have been harvested and burned in preparation for reforestation is markedly impaired in quality for a few years.

The Intermountain Region contains extensive stands of overmature lodgepole pine with large amounts of downed logs and woody debris. Various methods are being tried as ways to prepare the harvested areas for future crops and to remove or make the remaining debris more aesthetically pleasing. In cooperation with the Intermountain Forest and Range Experiment Station of the U.S. Forest Service, a USU investigator is trying to define the possible effects of these practices on soil microorganisms, soil chemistry, and quality of water leaving such areas. The study area is on the Teton National Forest in western Wyoming.

**SNOWMOBILES**

Snowmobile use in Utah is booming, but the physical effects of snowmobiling on the environment are, for the most part, unknown. A carefully controlled study near the USU Forestry Field Camp in Logan Canyon during the coming winter should help determine the effects of snowmobile use on the environment. The project is funded by the University's Environment and Man Program. One hypothesis to be investigated is whether heavy snowmobile use promotes a significant increase in snow density over non-use. Snowmelt rates between control and compacted areas will also be measured.

![Figure 5. A study plot in a cut-over area of Engelmann spruce-subalpine fir at the U.S.U. Forest. The stand was harvested in 1947 and natural reforestation has been generally poor.](image)

DECEMBER 1973
Publication: UTAH SCIENCE

EL 115 The face fly
EL 123 Aphid control
EL 127 Beet leafhopper control
EL 137 Fruit spray program for the home orchardist
EL 138 Pollen supplement for honeybees
ENL 20 Codling moth spray timing
ENL 32 Notes on the mosquitoes of Rich County, Utah
ENL 33 Notes on the mosquitoes of Cache County, Utah
ENL 39 Entomological supplies and equipment for county agents
ENL 49 The black widow spider
ENL 51 The oriental fruit moth
ENL 52 The pear psylla
ENL 53 Pesticide research at Utah State University
ENL 55 How to feed bees
ENL 56 Ants and termites
ENL 57 The honeybee, “Deseret,” and Utah
ENL 60 How to produce honey
ENL 62 Farmers and mosquitoes
ENL 64 Grass bugs
ENL 65 How to capture swarms
ENL 67 Range entomology
ENL 68 Beneficial insects
ENL 71 Vegetable garden pests
ENL 73 How to queen
ENL 75 Insect management
ENL 76 Instructions for preserving, labeling, packing, and shipping insects and mite specimens
ENL 77 Bees: how to winter colonies
ENL 78 Let’s control swarming
ENL 79 Common insect pests of shade trees
ENL 80 pH effect on pesticides
RB 340 Adult honey bee losses in Utah
RB 370 The superb plant bug
RB 379 Biology and control of the peach twig borer
RB 419 Insect pollinators of carrots in Utah
RC 145 Equipment for making nesting holes for the alfalfa leafcutting bee
R 717 New records of Hormia minitipennis Riley, with notes on its biology
R 750 Overwintering habits of the germinate leafhopper in Utah
R 758 Carrot seed yield and germination as affected by different levels of insect pollination
R 797 Biology of the McDaniel mite, Tetranychus medanieli McGregor in Utah
R 812 Laboratory tests with insecticides against Drosophilia melanogaster
R 857 Experimental control of the beet leafhopper on sugar beets grown for seed
R 929 Dieldrin residue on vegetation in an irrigated pasture
R 980 Some effects of aldrin, chlordane, dieldrin, and heptachlor on the European earwig, Forficula auricularia
R 1074 The biology of the rose stem girdler on raspberries in Utah
R 1118 DDT antagonism to dieldrin storage in adipose tissue of rats
R 1171 Drug effects of dieldrin storage in rat tissue
R 1186 Insecticide interactions affecting residue accumulation in animal tissues
R 1296 How different are the eastern and western forms of the alfalfa weevil
R 1315 Life history and behavior of the predatory mite Typhlodromus occidentalis in Utah
R 1336 Breeding bees to the crop
R 1374 Bioassay evaluation of heptachlor, isobenzan, and diazinon used against the alfalfa weevil in northern Utah
R 1435 Adenine and related substances as potent feeding stimulants for the alfalfa weevil, Hyperia postica
R 1440 Organochlorine insecticides and the stimulation of liver microsome enzymes
R 1441 Tests of eight rearing media for the mountain pine beetle Dendroctonus ponderosae (Coleoptera scolytidae), from lodgepole pine
R 1446 Insecticidal control of the alfalfa weevil in northern Utah and some resulting effects on the weevil parasite Bathyplectes curculionis
R 1464 Occurrence of refractile bodies in merozoites of Eimeria sp.
R 1469 Variations in the anatomy of Typhlodromus occidentalis (Ararina: Phytoseiidae)
R 1470 Chemical basis of host selection and plant resistance in oligophagous insects
R 1496 Organochlorine insecticide interactions affecting residue storage in rainbow trout

IRRIGATION AND DRAINAGE
EB 5 Measurement of irrigation water
EB 166 Measurement of irrigation water 10 cents
EC 331 Irrigation and canal companies in Utah 25 cents
EC 343 Plans for concrete slipforms $1.00
EL 83 Drought management of crops and irrigation water

UTAH SCIENCE