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Even if Utah is luckier than California, and we are into just a 1-year drought, our urgent need to conserve water in 1977 is undeniable. This article defines useful guidelines for urbanites as well as farmers.

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Utah's Drought—What Can We Do About It?

E. Arlo Richardson, Paul D. Christensen, Wade G. Dewey, Rex F. Nielsen, Gaylen L. Ashcroft and R. J. Hanks

Reliable indicators such as the width of tree rings, deposits of soil on river flood plains, and pollen in peat bogs point to recurring wide ranges in the earth's moisture and temperature conditions over the centuries. So drought, the dry end of the moisture range, is certainly no stranger to mankind. In the intermountain area, with its prevailing desert and semidesert environments, it is in fact a depressingly familiar visitor. But it still tends to take us unaware—or at least remain unrecognized until it is too late for precautionary action.

Today, drought conditions are being reported over most of the United States west of the Mississippi River. California, for example, is facing grim problems as it endures its second consecutive year of severe rainfall deficit. In San Rafael, 5-person households are already restricted to 108 gallons of water per day.

In Utah, when conditions over the entire state were averaged, 1976 was the driest year since record keeping began in 1892. The 7.71 inches of precipitation received in 1976 can be compared to the previous low of 8.10 inches in 1966 (Figure 1).

Averages for an entire state, however, can be misleading, especially when the state encompasses such varied topography as does Utah. In some years, for example, northern Utah can have above normal precipitation, while the south receives less than normal. For such a year, the state as a whole would have a near-average accumulation even though the southern part is undergoing serious drought conditions. Averages for Utah's seven climatic divisions are therefore more meaningful (Table 1).

Utahns in general did not know of the state's prospective drought danger until the last three months of 1976, when preliminary averages were calculated for the first quarter of the water year, which began October 1 (Table 2). That was the driest first quarter in all but the South Central (second driest) and Dixie divisions since division averages were begun (1931).

Based upon some 40 reporting stations, data for the 7 divisions are all much below normal for January. The early part of February followed a similar trend. The range was from 25 percent of normal in the Northern Mountains to 79 percent of normal in the South East division. The Northern Mountains are of particularly critical concern because they supply the major population centers of the state. On the morning of January 24, the weather station at Alta reported only 25 inches of snow on the ground. The previous low accumulation was 30 inches on January 15, 1963.

The water content of the snow on the ground in 1977 is even more indicative of the seriousness of the situation. As of January 20, the Brighton weather station had recorded 1.86 inches for the water year. A normal accumulation for that date would be 17.47 inches.

Utah undeniably confronts an alarming water shortage in 1977—with no guarantee of a reversal in 1978. The question
is—what can be done to minimize the effects of an existing and possibly persistent drought?

The remainder of this article presents research-based answers for farmers and urbanites.

**The Farm Scene***

Management alternatives that optimize effective use of irrigation water should be a perennial goal in Utah, but in a drought year, efficiency can mean the difference between success and failure in crop production.

In 1977, soil profile depths that would normally be wet by winter precipitation may contain little water and therefore require earlier than usual irrigation. At the same time, water supplies in streams may be hazardously low, even early in the season.

Solutions can be found in management alternatives that help minimize the effects of a drought. These include using late-winter or early-spring snow melt runoff waters for early irrigations, planting crops earlier than normal, exploiting to its fullest the soil's potential as a water reservoir, growing short-season varieties, and reducing the acreage irrigated. Choices among the possible alternatives should be geared to each farm’s soil moisture and irrigation water supplies.

**Evaluate Need Before Irrigating**

Normally, precipitation from October through March fills Utah's soil profiles along the Wasatch Front and in mountain valleys behind the Front. This water satisfies early-season water needs of crops and postpones the first irrigation. In other areas of the state, where winter moisture is normally more limited the first irrigation is needed as soon as water is available after the frost is out of the ground.

Under drought conditions,

### TABLE 1. Utah division precipitation totals 1976

<table>
<thead>
<tr>
<th>Climatic Division</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Western)</td>
<td>.25</td>
<td>.92</td>
<td>.48</td>
<td>.88</td>
<td>.57</td>
<td>.19</td>
<td>.74</td>
<td>.47</td>
<td>.67</td>
<td>.88</td>
<td>.13</td>
<td>.01</td>
<td>6.19</td>
</tr>
<tr>
<td>2 (Dixie)</td>
<td>.02</td>
<td>2.69</td>
<td>.46</td>
<td>1.14</td>
<td>.19</td>
<td>.01</td>
<td>.89</td>
<td>.23</td>
<td>.72</td>
<td>1.44</td>
<td>.25</td>
<td>.04</td>
<td>8.08</td>
</tr>
<tr>
<td>3 (North Central)</td>
<td>.73</td>
<td>2.20</td>
<td>1.36</td>
<td>2.12</td>
<td>.85</td>
<td>1.15</td>
<td>1.05</td>
<td>.83</td>
<td>.60</td>
<td>.91</td>
<td>.18</td>
<td>.08</td>
<td>12.06</td>
</tr>
<tr>
<td>4 (South Central)</td>
<td>.24</td>
<td>1.72</td>
<td>.88</td>
<td>1.27</td>
<td>.76</td>
<td>.09</td>
<td>1.17</td>
<td>.33</td>
<td>.88</td>
<td>.73</td>
<td>.26</td>
<td>.07</td>
<td>8.40</td>
</tr>
<tr>
<td>5 (Northern Mountains)</td>
<td>.90</td>
<td>2.20</td>
<td>1.20</td>
<td>1.52</td>
<td>1.42</td>
<td>.90</td>
<td>1.74</td>
<td>.58</td>
<td>.37</td>
<td>.79</td>
<td>.15</td>
<td>Tr.</td>
<td>5.28</td>
</tr>
<tr>
<td>6 (Uinta Basin)</td>
<td>.04</td>
<td>.65</td>
<td>.53</td>
<td>1.00</td>
<td>.91</td>
<td>.42</td>
<td>.33</td>
<td>.44</td>
<td>.79</td>
<td>.15</td>
<td>.22</td>
<td>.43</td>
<td>8.05</td>
</tr>
<tr>
<td>7 (South East)</td>
<td>.11</td>
<td>1.07</td>
<td>.48</td>
<td>.68</td>
<td>1.23</td>
<td>.11</td>
<td>.83</td>
<td>.48</td>
<td>1.11</td>
<td>.23</td>
<td>.04</td>
<td>.01</td>
<td>6.38</td>
</tr>
</tbody>
</table>

Average for all divisions in state 7.71 11.36

### TABLE 2. 1976-1977 division precipitation data

<table>
<thead>
<tr>
<th>Division</th>
<th>Oct-Dec Accumulation</th>
<th>Previous Record Dry Accumulation</th>
<th>* Jan 1977 Estimate</th>
<th>% of Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Western)</td>
<td>1.02</td>
<td>1.07 in 1958</td>
<td>.23</td>
<td>38</td>
</tr>
<tr>
<td>2 (Dixie)</td>
<td>1.73</td>
<td>10th Driest Year</td>
<td>.48</td>
<td>42</td>
</tr>
<tr>
<td>3 (North Central)</td>
<td>1.17</td>
<td>1.41 in 1962</td>
<td>.71</td>
<td>48</td>
</tr>
<tr>
<td>4 (South Central)</td>
<td>1.06</td>
<td>2nd Driest Year</td>
<td>.51</td>
<td>50</td>
</tr>
<tr>
<td>5 (Northern Mountains)</td>
<td>.70</td>
<td>1.81 in 1935</td>
<td>.55</td>
<td>25</td>
</tr>
<tr>
<td>6 (Uinta Basin)</td>
<td>.17</td>
<td>.39 in 1934</td>
<td>.22</td>
<td>43</td>
</tr>
<tr>
<td>7 (South East)</td>
<td>.28</td>
<td>.37 in 1950</td>
<td>.48</td>
<td>79</td>
</tr>
</tbody>
</table>

*Based on preliminary data from 50 stations and assuming that no additional moisture is accumulated after the 24th of January.
early spring irrigation is generally advisable, not only to wet the soil, but to make use of the early snowmelt water, which might otherwise be lost. But no irrigation should be undertaken until you know the moisture status of your soil to the depth occupied by crop roots.

Before irrigating, therefore, examine your soil to a depth of at least three feet or estimate whether water is needed based on measured crop use, evaporation, and precipitation since the last irrigation. Remember that water applied to already wet soils is wasted.

In other words, water according to crop need rather than by the calendar or "water turn."

1) Fields planted and irrigated in the fall may not need additional water until late spring.

2) Harvested fields not irrigated since late summer should be irrigated as soon as top-soil is thawed and water is available if they are to be used this year.

3) Alfalfa fields not watered in the fall should be irrigated as soon as the frost is out of the ground. The same is probably true for irrigated pastures.

4) The need to irrigate corn fields in early spring will depend on how much water was used by the crop following the final irrigation the previous season. Examine the soil to a depth of three feet, and apply water only if needed.

Know your soils and plants Try to adjust irrigation amounts and timing to match the water holding capacity of your soil and the root zone of the crop involved. Sandy soils may hold less than 1 inch of water per foot. Clay loams and silt loams can hold more than 2 inches per foot. Shallow, coarse, sandy or gravel-

Figure 1. Average annual precipitation for the state of Utah.

March 1977
Drought is . . .

the time when good range management pays dividends.

when expensive feed must be fed . . . yearlong.

the time when plant cover on upland areas is depleted so that more runoff and erosion occurs when finally rain does come.

when the Russian thistle dies.

when improved range does not produce much feed.

when plants don’t grow and maybe even die.

ly soils hold very little water and should never be given heavy irrigations. Alfalfa, in well-drained soils, will have roots extending below 6 feet. Grain and corn roots occupy 4 to 5 feet of soil. Potatoes are usually more shallow rooted.

Fertilizers Adequate soil fertility is always important. During a drought, good fertility is especially significant since it encourages efficient crop use of existing water. Efficient crop utilization of a heavy nitrogen application requires ample water. Therefore, adjust your nitrogen fertilization according to current water supply information.

Crops should receive their normal phosphate requirement during drought.

Cropping alternatives The anticipated availability of water after mid-summer should guide your crop plans in a drought season.

1) Early planting of small grains and other crops will help save water and increase yields. The criteria to consider are: potentials for seedbed preparation, possibility of frost damage, and the seedlings’ ability to withstand frost. With small grains and corn, each day of planting delay can cost 1 bushel of grain per acre. Small grains can perhaps be planted as early as late February or early March. Sugar beets this year might go into the ground the last week of March or the first two weeks of April. Corn could well be planted by late April or early May.

2) Select crop variety on the basis of early maturity since water supplies may be limited in late season.

Corn Many good early varieties are available.

Barley Gem, Steptoe, Steveland, and Deawn will get by on 1 or 2 fewer irrigations than varieties such as Bonneville or Vale.

Wheat The maturity differ-
ences for spring wheat varieties are less obvious than for the barleys; however, Moran, Fielder, and Twin tend to mature a little later than do Borah, Peak 72, and Fremont.

3) Limit your irrigated acreage. A small acreage correctly irrigated will usually give a greater total production than will skimpy irrigation of a large acreage. However, be sure you do not over-irrigate. Ideally, plan your irrigations to simply replace the moisture that has been removed by the crop.

Alternate Sources of Water Try to find sources not normally tapped. These can include wells and unappropriated drainage waters. Before any new well or drain source is developed, however, the water should be analyzed for salinity and sodium content. In addition, be sure to meet any legal constraints by first checking with the State Division of Water Rights.

Updating and Maintaining Irrigation Systems Since effective use of any early-season water is so important, be sure irrigation systems are cleaned and in working order well ahead of the time the water is diverted into the canals. Check, repair, and update diversion and control devices.

Repair sprinkler systems and consider whether additional equipment should be purchased to make it possible to sprinkle more acres at one setting during possibly brief periods of water availability. Sprinkler systems are generally more efficient in delivering the correct amount of irrigation water to the land than gravity systems.

Tillage and Weed Control You can conserve moisture if you:

1) Prepare seedbeds as early as possible so that planting isn't delayed beyond optimum dates.

2) Till early, shallowly, and only often enough to control weeds.

3) Use chemical sprays where appropriate—especially in

March 1977
nonrow crops like small grains.

**Long Term View** The above guidelines are designed primarily in terms of what to do during a one-season drought. Since a more prolonged drought is possible, other practices and measures should be seriously considered. Better control over available water can be achieved through land leveling, improvement of existing irrigation systems, or installing more efficient irrigation systems. Farm practices and field layouts can often be adjusted to increase irrigation efficiency. Corrugation of alfalfa, grain and improved pasture fields are examples. Tying your irrigation schedules to soil moisture monitoring will help you account for where your precious limited water goes. Irrigation scheduling to fit your particular situation can also improve water-use efficiency.

**The Urban Scene**

Of the huge amounts of water used each year to irrigate Utah's lawns, flower and vegetable gardens, shrubs, and home orchards, a surprisingly large percentage goes to waste. This year, if the drought conditions persist, we can't afford such wastage.

Making efficient use of limited water for outdoor purposes depends to a major extent on an understanding of and adherence to a few general rules:

1) **Avoid frequent light applications** (that is, apply larger amounts of water allowing longer intervals between applications).

2) **Do not apply more water than can be stored in the soil zone where plant roots are growing** (Table 3).

3) **When possible, irrigate in the late afternoon, early morning, at night, or on cloudy days to cut potential losses to evaporation.**

4) **Where practical, replace flood or furrow irrigation practices with a sprinkler method.**

5) **Keep your weed crop at a minimal level.**

**The Soil** The above rules are all based upon the concept of the soil being more than an anchor and source of nutrients for plants. Soil also acts as a water reservoir for plants. In many respects, it behaves like a sponge, holding just so much and letting any excess drain away.

Many plants commonly grown in vegetable and flower gardens have relatively deep roots. On the other hand, lawn grasses have relatively shallow root systems. Translated to the sponge example, the two types of root systems have access to thick or thin sponges. Additionally, just as sponges made of different materials have differing absorption potentials, the texture of a soil affects its water-holding capacity.

So—to use irrigation water efficiently, you must know your soil and your plants.

**Measuring the Water Applied**

How much water soaks into a soil and to what depth depends on the kind of sprinkler used, the water pressure, the duration of each sprinkling, and soil texture. When water is either expensive or in limited supply, it is to your advantage to know how much water you are getting into the soil that can be used by plants.

A simple way to measure water applied is to place three or four cans at varying distances from the center of your sprinkler (see Figure 1). In a way, the cans can be likened to your checking account. The water you apply is analogous to money deposited. And the processes of drainage, evaporation, and plant use are your withdrawals. With sprinklers that produce a fine spray, you can use shallow cans. With impact type (rainbird) sprinklers, you'll need taller (number 2½) cans to prevent the water from splashing back out. The tall cans should be stabilized by bending a small hook at the end of an 18-inch length of wire from a coat hanger and placing the hook over the edge of the can. The other end is pushed into the soil. Two stabilizers on opposite sides of each can may be required in loose soil. As an alternative to using the cans during each irrigation, you can determine how long it takes to collect a given amount of water in the cans. Then future applications can be timed to apply a predetermined amount of water, with the...
amount matched to soil and plants.

Only enough water should be applied during each irrigation to satisfy the needs of your plants and soil type (Table 3). The water collected in the cans will not only tell you when to turn off the sprinkler, it can also tell you when to turn it back on. If the cans are properly placed and maintained, they become evaporation meters.

In a lawn, the cans should be buried level with the soil, and the surrounding grass must be kept closely clipped. In a garden, the cans must be placed so they are not shaded by any of the plants.

When your water-catching cans are dry, the water applied in the last irrigation has evaporated. Plants exposed to the same weather conditions have transpired approximately the same amount. With sandy soils, irrigation can be delayed 1 day beyond the dry-can stage. With clayey soils, the “grace” period amounts to 2 or sometimes 3 days.

Orchards Trees require a special note because of their growth habits. A tree’s roots generally occupy a circular soil volume with a diameter similar to that of its branches. In addition, many tree roots extend deeply into the soil. The smaller roots, which are the most active in water uptake, are especially numerous directly beneath the branches having the most small limbs (the outer edge of the tree canopy). Water therefore can be conserved by eliminating weeds or grass between trees, by concentrating water applications within each tree’s effective root zone, and by making heavier but less frequent irrigations.

**TABLE 3. Tailoring irrigation water to soils and plants**

<table>
<thead>
<tr>
<th>Vegetation</th>
<th>Soil</th>
<th>Water Application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amount per Application</td>
<td>Frequency When The Weather is</td>
</tr>
<tr>
<td>Lawn</td>
<td>Cool (Spring and Fall)</td>
<td>Hot (Summer)</td>
</tr>
<tr>
<td>Coarse sand or gravelly soils</td>
<td>1 to 1 1/4 inches</td>
<td>6 to 8 days</td>
</tr>
<tr>
<td>Loam or sandy loam soils</td>
<td>1 1/2 inches</td>
<td>10 to 14 days</td>
</tr>
<tr>
<td>Clay loam or clayey soils</td>
<td>2 inches</td>
<td>14 to 20 days</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Orchard</th>
<th>Coarse sand, gravelly, or shallow soils</th>
<th>Water Application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amount per Application</td>
<td>Frequency When The Weather is</td>
</tr>
<tr>
<td></td>
<td>Cool (Spring and Fall)</td>
<td>Hot (Summer)</td>
</tr>
<tr>
<td></td>
<td>2 to 2 1/4 inches</td>
<td>8 to 12 days</td>
</tr>
<tr>
<td></td>
<td>Loam or sandy loam soils</td>
<td>3 to 4 inches</td>
</tr>
<tr>
<td></td>
<td>Silt or clay loam</td>
<td>4 to 5 inches</td>
</tr>
</tbody>
</table>

*These combinations of soil types, plants, and time intervals are designed to replenish the soil water to the depth penetrated by the plant roots. Applications of additional water are likely to simply drain away as wastage.

**Irrigation Methods** Furrow irrigation or flooding are effective ways to wet the soil when water is plentiful, but they are inefficient. With furrow irrigation in a sandy or gravelly soil, the root zone at the upper end of the furrows may be soaked long before the water gets to the lower end of the furrow. Then, while the lower end is wetting, considerable water goes to waste below the root zone at the upper end. When a lawn is flooded, substantial amounts of water soak below the root zone in low spots before the higher parts are adequately wetted. Occasional sprinkling that applies the needed amount gives a more uniform application and assures better use of a limited supply of water. But do try to resist any impulse to water by hand, since you’ll rarely provide a sufficient quantity.

**Other Factors** In many areas of Utah, winter storms normally wet the entire root depth in the soil profile so that the garden soil is moist at planting time. This year, unless we have a wet spring, many gardens will be dry when the soil thaws and should be irrigated with 2 to 6 inches (as measured in the cans) of water before planting. Shrubs, trees, and lawns will also need to be watered early in the spring.
Another factor to remember is that weeds use soil water just as do vegetables and flowers. Thus, keeping gardens free of weeds will allow more water for the cultivated plants.

And, should the drought not be content with a 1-year stand, water conservation efforts in 1978 will have to be even more vigorous than those recommended here.

*Management of range and range animals in a drought season will be discussed in the June issue of *Utah Science.*

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Cycles, Circles and Scythes—(Weather Through the Ages)

E. Arlo Richardson

Since man first began to observe the weather and its effects upon his crops and comfort, he has tried to classify it in terms of some predictable circle or cycle. He first noted the annually repeated seasonal changes in temperature and moisture that allowed him to plant and harvest his crops. He classified these recurring changes in terms of a yearly circle. Later he recognized that the intensity of the wet and dry cycles varied from year to year. That led him to superimpose on these annual circles, rhythmical cycles that he eventually tried to relate to the sun, the moon and the stars.

However, floods and drought were periodically remodeling the earth long before man was around to watch and wonder—to be devastated (Figure 1). The time scale and data on this graph can only be an approximation since authorities vary so greatly in their estimates. The Cambrian period, which began approximately 550 million years BP (before the present) according to Dorf (1957) started with a glacial epoch and ended with a climate considerably warmer than prevails today. The average temperature in the zone north of 40 degrees north latitude is estimated to have been in the low 50s.

The slight cooling trend (into the upper 40s) about 315 million years BP may have been caused by dust associated with increased volcanic activity. During those few million years, most of the seas that had been covering North America disappeared, leaving the continent quite arid. By 300 million years BP (the beginning of the Carboniferous period) the cycle had been reversed and the earth was warming rapidly. Temperatures north of 40 degrees latitude were averaging in the middle 50s. Most of the coal deposits in North America, Europe and Northern Asia were formed between 300 and 240 million years BP.

In the Permian period (240-200 million years BP) the direction of change again reversed. A series of glaciations were combined with temperatures in the northern hemisphere north of 40 degrees that dropped into the mid-30s. Some authors believe that the Appalachian Mountains were formed during this epoch.

Drought Cycles Trace From Antiquity

In that part of the world we know as southern Utah, southern Nevada and northern Arizona, a magnificently spectacular
drought began some 150 million years BP. That "dry spell" resulted in sand storms on a scale hopefully never to be equalled again. The dust bowl days of the 30s in the Great Plains area of the United States were a gentle picnic in comparison. Sand swirled for centuries, until it was piled in dunes 7000 feet high with their roots in an inland sea. Later, as the interior of the earth shifted restlessly, the land rose and mountains were pushed up to 12,000 feet or more. Eventually, another sea covered the area and endured for a hundred million years. When that sea gave way, the windblown sand was revealed as the multicolored mountains we see today.

The late Permian and early Mesozoic saw a rapid warming, with average temperatures again ranging in the low and middle 50s until about 65 million years BP when another minor cooling trend prevailed. Some authorities believe that it was this cooling that led to the extinction of dinosaurs.

During the early Cenozoic period, a peak in the mid-50s was followed by a drastic drop in temperatures. Glaciers became so abundant that the epoch is called the "ice age." Four different advances of the ice sheet in North America have been defined. Each of these advances was separated from its successor by a relatively warm interglacial period. Some authorities believe that we are living in one of these interglacial periods which will be followed by years of severe cold. Others believe that we may be in the beginning of a major warming trend. This winter’s east and midwest temperatures seem to belie a warming trend.

One thing we know for sure is that our American southwest was in a severe drought between 1276 and 1299 AD. That drought forced abandonment of many Pueblos that had depended on irrigation and a flood-plain watering of crops. These people responded to the prolonged drought in the only way they could. They gathered around permanent springs such as Nevada’s Little Red Rocks Red Springs where they could raise their corn, beans and squash. Their symbolic writing, the petroglyphs, indicates that they built 1,600 feet of diversion dams to funnel water to their gardens. Their weather bureau records were inscribed sandstone escarpments with cloud symbols that had lines, down for rain, up for drought. Deformed squash among the Indians squash fruit symbols presumably indicate weather effects.

Such short-term events are lost to sight when we consider climate on geologic scales. But if weather is averaged over 30 years, or 10 years or a single year, quite a different picture emerges. And both types of scales must be considered by today’s meteorologists as they try to find ways to accurately predict both short- and long-term.

Tree Rings Can Tell of Past Climates

One of the more accurate methods of estimating past changes in climate was developed by Dr. A. E. Douglas at the University of Arizona. He uses the width of tree rings as an index to past climates. Although plant development undeniably

![Graph showing climatic patterns through the ages](image)
Figure 2. Tree ring-based wet and dry periods calculated from the Colorado River basin.

reflects an interaction of several factors, including temperature, moisture, type of soil and its available nutrients, and topographic features such as elevation, slope and aspect, tree rings have proved reasonably reliable indicators of past climates.

In the arid environments of the western United States moisture is often the growth-defining climatic factor, especially at lower elevations. At higher elevations, temperature may be the more important element.

Let's consider climate variations (based on Douglas' tree ring index) in the Colorado River Basin since about 56 BC. The variations have been related to the 30-year basis that the National Weather Service considers indicative of normal. These 30-year normals are updated each 10 years (Figure 2) and can be calculated from tree rings. In 2000 years, the 30-year normals have been below the average 102 times and above on 94 occasions. A severe drought can be defined as the times when the 30-year average is below 90 percent of the 2000-year average, while excessively wet periods require that the 30-year average be greater than 110 percent of the 2,000-year average. On that basis, tree rings provide a good idea of the variability of the weather during the last 2,000 years in the Colorado River Basin. The rings tell us that severe drought conditions have occurred 18 times and so have excessively wet conditions.

The most intense period of drought prevailed during most of the 13th century. As described earlier, during this era the Indians in Mesa Verde and other southwestern areas of the United States were forced to move because of continuous crop failures. Tree rings as well as the Indians' petroglyphs verify that a succession of 30-year normals were below the 2000-year average. By contrast, the 30-year normal for the period 1291 through 1320 indicates this was the longest wet period during the last 2000 years. The 1931-1960 and 1941-1970 normals are both much below what would have been expected.

Weather History Can Suggest the Future

What do these 30-year normals and tree ring data imply for the way you and I should think about the future? Is today's weather technology a significant factor?

The answer to the last question is yes. Using the concept that the past is the key to the future scientists around the
world are reanalyzing all of the available records of the past. By means of modern computer technology, they hope to decipher the physical causes of past changes in the weather and use these keys to predict what the future may hold.

For the present, however, we must confront the challenges of today while preparing to meet the inevitably fluctuating cycles of the future. We must learn flexibility and how to modify cultural practices in response to weather extremes if we are to have adequate harvests ready for our scythes.

Science Short
Measuring Soil Water: Some Cautions

It seems reasonable to assume that accurately measuring available soil water with a hygrometer would simply require following the manufacturer’s directions. Instead, according to USU’s Professor of Botany, Herman H. Wiebe, the situation is generally complicated by temperature gradients.

Research completed by Professor Wiebe, Jerry Barker, and Ray W. Brown indicates that the universally present soil temperature gradients can significantly modify hygrometer behavior. Their work identified similar thermally-induced errors in: garden loam with peat moss, an agricultural loam, and a saline-desert sandy loam. The magnitude of the errors depended upon the design of the hygrometer.

Various alternatives were suggested for avoiding temperature-associated errors in measurement. Ideally, use a non-metal hygrometer with its measuring junction at the center of the cylindrical sample surface. Place the hygrometer horizontally, but also be alert to any temperature gradients longitudinal to the thermocouple and sample. If an error potential is suspected, a correction curve can be calculated, or readings can be taken only when temperature gradients are known to be acceptably close to zero. Such zero offset readings can provide invaluable checks on accuracy, even when a temperature-compensated hygrometer is used.

LITERATURE CITED

E. Arlo Richardson is Utah State Department of Agriculture Climatologist, Department of Soil Science and Biometeorology, USU.
Utah’s Geothermal Energy Resources: Their Potential Uses

Jerome V. DeGraff and Peter T. Kolesar

A geothermal resource is essentially heat energy from the deep interior of the earth. In most cases, this heat is too diffuse to collect and use in an economical manner (Muffler 1973). Occasionally, however, the hot rock material is near the surface of the earth and its heat is concentrated enough for extraction. In the western United States such areas of concentrated heat were created by the last 70 million years of geologic activity.

Ground water filters deep into the earth along rock fractures near these areas and is heated, producing very hot water or steam. Surface indications of these phenomena may be warm or hot springs, or geysers (Figure 1), which indicate potentially usable geothermal resources (Hammond 1972). The geysers and hot springs of Yellowstone National Park are a familiar example of ground water reaching a near-surface hot-rock mass (Figure 2).

There are two kinds of exploitable geothermal reservoirs. One type is dry or vapor-dominated. Most of the water in this reservoir type is available as steam. Geysers, fumaroles, and very hot springs may be surface evidence of this type of geothermal field. The other type is a wet steam or hot water reservoir (Figure 3), with hot or warm springs as its typical surface indicators (Robson 1974).

Depending on the type and conditions of the reservoir, the geothermal energy may be a high-temperature or low-temperature resource. High temperature resources are 160°C (320°F) or hotter. This resource is valuable primarily for electrical power generation. Low temperature resources are between 50°C (122°F) and 160°C (320°F). A wide variety of nonelectrical uses can be made of resources in this temperature range (Howard 1976, Reistad 1976).
Concern about national energy needs and policies is stimulating investigations of geothermal resources as a potential energy source. Currently, the major commercial use of geothermal energy is electrical power generation. Already, a significant amount of the electricity used in San Francisco is generated by geothermal steam at the Geysers, California. Electrical generation plants at the Geysers cost less to build and operate than similar fossil-fuel power plants in that region (Hammond 1972). The savings can be significant compared to conventional methods of power production. Additionally, the adverse environmental effects are reduced in relation to those of conventional generating methods.

Utah Specifics

A number of Utah geothermal resource areas have been identified as perhaps having sufficiently high temperatures and being in suitable locations for electrical power generation (Heylmun 1966, Mundorff 1970, Swanberg 1974).

Roosevelt (McKean) Hot Springs was designated as a promising exploration area in these early evaluations. This area, near Milford, Utah, was later identified as a Known Geothermal Resource Area (KGRA) for leasing purposes. Recently, two wells having temperatures high enough for power generation were successfully drilled in that area (Survey Notes 1976). At least ten more wells are to be drilled in the future.

Early evaluations of Utah's geothermal power potentials were based on either surface water temperatures or calculated temperatures. The calculations utilized the chemical relationships of sodium (Na), potassium (K), and calcium (Ca) in warm or hot water springs. Our own calculations (based on the silica content of the waters) indicated discrepancies with some temperatures calculated using the Na-K-Ca method. Even if detailed reevaluations reduce the previous estimations of Utah's geothermal power-generating ability, however, they would not negate the potential utility of the state's geothermal resources. The emphasis would merely have to shift to other applications.

Using Low-Temperature Resources

According to our calculations, some of Utah's geothermal resources are cooler than 160°C (320°F), putting them in the low-temperature category. But comparable low-temperature geothermal energy is already being used in the United States and other countries for heating, agricultural, industrial, and recreational purposes. (Hammond 1972, Lindval 1973, Lienan and Lind 1974, Hannah 1975, Ellis 1975, Reistad 1976).

Agriculture

Agricultural uses of low-
temperature geothermal water can be as simple as employing the available heat for drying crops, heating animal facilities, warming soil, and maintaining temperatures for aquaculture or greenhouse production (Lindval 1973, Linton 1974).

One potential use in Utah would be greenhouse heating by thermal waters. Commercially operated facilities in the United States, Japan, Hungary, Iceland, New Zealand, and other countries successfully grow tomatoes, cucumbers, melons, other fruits and vegetables, potted plants, roses, lilies, carnations, orchids, and chrysanthemums (Lindval 1973, Boldizsar 1974, Hannah 1975, Gutman 1976). It has been estimated that heating costs account for 15 to 20 percent of the product value in greenhouses heated with fossil fuels (Lindval 1973). Reducing this expense would be an economically sound basis for exploiting geothermal energy.

Greenhouse heating requires thermal water at 30°C (86°F) to 80°C (176°F). A majority of the thermal springs in Box Elder, Davis, Weber, Salt Lake, and Utah counties meet this criterion (Mundorff 1970).

Food processors have successfully used geothermal energy for canning, refrigeration, distillation, pasteurization, and sugar production (Lindval 1973, Wehlage 1974, Hannah 1975).

Sugar production from sugar beets is an energy intensive process. Heat energy is required for the initial production of raw sugar and also in its refining. Shreve (1956) estimated that 6,000 to 10,000 BTUs are consumed in the form of coal to produce the power and process
steam for one pound of sugar. Based on the average BTU values for Utah coal, a little less than a pound of coal is burned for each pound of sugar.

A major sugar beet processing center is located near Garland, Utah, in Box Elder County. Conservative estimates suggest that the county's thermal springs might provide waters at temperatures of 75°C (167°F) to 100°C (212°F). Sugar refining requires steam at approximately 130°C (266°F) (Lindval 1973). Box Elder County's geothermal water might be effectively used, especially if combined with technological systems such as heat pumps, to greatly reduce present steam production costs at the Garland plant.

Industry

Low-temperature geothermal energy has been applied in the United States and elsewhere to industrial uses such as paper pulp processing, drying lumber, and curing cement building slabs. Geothermal energy is also employed (in evaporative processing) to desalinate water and produce salts, soda ash, and other chemicals, and in ore refining (Lindval 1973). In areas adjacent to the Great Salt Lake, geothermal energy could be used in desalinating the lake water. Experimentation in the Imperial Valley and Salton Sea areas of California has demonstrated the technical feasibility of such a procedure (Lindval 1973, Fernelius 1976). Geothermal-powered desalinization could both produce fresh water for the Brigham City and Ogden areas and enhance the current production of chemical salts such as sodium chloride, potassium chloride and bromine. Desalinization by geothermal means would require water at temperatures of 120°C (248°F) or greater (Lindval 1973).

Community

Space heating is another possibility in Utah (Lindval 1973, Hannah 1975). Heating by geothermal waters has a well established technology. Most of the space heating requirements of Reykjavik, Iceland are met by geothermal energy (Zoega 1974). Houses and public buildings in Rotorua, New Zealand are heated by geothermal water from several wells (Ellis 1975).

Several locations in the United States, such as Klamath Falls, Oregon, have applied the technology. In 1974, eleven apartments and 468 residences in the Oregon city were being heated by geothermal energy. A number of institutions such as churches, schools, and a hospital were using geothermal water for heat (Lund, et al. 1974). The new Oregon Institute of Technology campus was designed to take advantage of the heating potential of geothermal waters at Klamath Falls. Current heating costs at that campus range between $12,000 and $14,000 per year to heat over 440,000 square feet of building floor space. At the Institute's older and smaller campus, heating costs ranged from $94,000 to $100,000 per year at preinflation fossil fuel prices (Purvine 1974). A similar program to heat public buildings in Boise, Idaho is presently under study (Kunze, et al. 1976).

Utah has a similar potential for space heating since a majority of the state's thermal springs occur along the populous Wasatch Front (Heylmun 1966, Mundorff 1970, Swanberg 1974) (Figure 4). Geothermal waters at temperatures as low as 60°C (140°F) have proved satisfactory for space heating (Lindval 1973, Hannah 1975). In Utah, institutions such as schools, churches, hospitals, and governmental buildings might advantageously consider the use...
of available geothermal energy. It may also prove economically feasible to heat residences in neighborhoods adjacent to a geothermal source.

Feasibility Studies

Implementation of any potential uses of Utah's geothermal resources should be preceded by thorough study. Economic and technological feasibility must be preevaluated in terms of specific projects. Use of low-temperature geothermal resources harnesses untapped energy and reduces demand on fossil fuel reserves. Clearly, the many applications of low-temperature geothermal energy in other areas illustrate that Utah would do well to consider how best to use this resource. Its potentials for other than electrical power production should not be neglected.

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Peter T. Kolesar is Assistant Professor, Department of Geology, USU.
The Changing Profile of Farmers and Farming in Utah

H. Reed Geertsen and Calvin W. Hiibner

What is happening to farm work as a full-time occupation in Utah? In the United States? We combined agricultural census data with information from a statewide survey (conducted in the fall of 1973) in an effort to answer those questions.

In 1790, when the first census of the United States was taken, over 94 percent of the nation's 3,929,214 persons were classified as rural residents. Most of those persons were gaining their livelihood through agricultural pursuits. By 1920, however, fewer than 30 percent of the nation's labor force were employed in agriculture. The magnitude of this continuing decline in recent years deserves attention and concern.

Changes in Agriculture

In 1935 over 32 million people lived on farms. By 1970, this figure had dropped to only 9.7 million. (US Bureau of the Census 1975) Utah trends in farm ownership and employment since 1935 reflect the same trend (Table 1). In 1935, Utah had 30,695 noncorporate farms. By 1974 this figure was 12,662, a decrease of about 60 percent. In the United States for the same period the number of farms declined by slightly over 58 percent. Thus, the declining rural population has been accompanied by a steady decrease in the number of noncorporate farms.

In Utah, as the number of farms and rural population have declined, acreage devoted to agriculture has increased (Table 1), with the average farm size increasing fivefold. In contrast, for the United States as a whole, acreage devoted to agriculture peaked in 1954, followed by a steady decrease. The average US farm has therefore only increased in size by 2.5 times.

Utah has consistently employed more of its employed labor force in agriculture than

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Figure 1. Agricultural employment in Utah and the United States, 1950-1974.

March 1977
has the nation as a whole (Figure 1). Nevertheless, similar trends of decline characterize both Utah and the United States. In 1950, 21.6 percent of all working persons over 16 years of age in Utah were employed in agriculture. In 1960, the figure was 14.4 percent, and in 1974 was only 6.8 percent. For the nation as a whole, 12.2 percent of the total employed labor force was involved in agriculture in 1950. By 1974 this figure had dropped to a mere 4.1 percent.

As US agriculture has shifted toward fewer, larger, and generally more productive farms, increasing numbers of non-corporate farmers have found it necessary to engage in off-farm work to supplement their farm income.

**Growing Importance of Part-Time Farming**

Working away from the farm has always been a noticeably more common practice among Utah farmers than other US farmers (Table 2). In 1935, for example, 56 percent of Utah's farmers reported working off the farm, compared with only 30.5 percent of farmers in the country as a whole. By 1969, the United States' figure had risen dramatically to 54.3 percent, with Utah at 64 percent. Although 1974 census data on off-farm work will not be available for another year, this trend seems likely to persist.

The importance of part-time farming in Utah is also attested to by the number of days farm operators devote to other types of work (Table 2). For example, in 1969, 51.4 percent of the Utah farmers who worked away from their farm said they did so for more than 100 days a year. In contrast, only 39.9 percent of farmers in the United States working off the farm reported doing so for more than 100 days per year. This difference might

**TABLE 1. Agriculture in Utah and the United States, 1935-1974**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>NUMBER OF NONCORPORATE FARMS</th>
<th>TOTAL ACRES IN AGRICULTURE (1,000s of acres)</th>
<th>AVERAGE FARM ACREAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Utah</td>
<td>US</td>
<td>Utah</td>
</tr>
<tr>
<td>1935</td>
<td>30,695</td>
<td>6,814,000</td>
<td>6,239</td>
</tr>
<tr>
<td>1940</td>
<td>25,411</td>
<td>6,350,000</td>
<td>7,302</td>
</tr>
<tr>
<td>1945</td>
<td>26,322</td>
<td>5,967,000</td>
<td>10,309</td>
</tr>
<tr>
<td>1950</td>
<td>24,176</td>
<td>5,648,000</td>
<td>10,865</td>
</tr>
<tr>
<td>1954</td>
<td>22,826</td>
<td>4,798,000</td>
<td>12,262</td>
</tr>
<tr>
<td>1959</td>
<td>17,811</td>
<td>4,105,000</td>
<td>12,689</td>
</tr>
<tr>
<td>1964</td>
<td>15,759</td>
<td>3,457,000</td>
<td>12,867</td>
</tr>
<tr>
<td>1969</td>
<td>13,045</td>
<td>2,999,000</td>
<td>11,313</td>
</tr>
<tr>
<td>1974</td>
<td>12,662**</td>
<td>2,415,938**</td>
<td>13,000*</td>
</tr>
</tbody>
</table>


*Estimates from Statistical Abstract of Utah, 1976
**Obtained through correspondence with US Bureau of the Census
be explained in part by the Utah farmers having access to more opportunities because of the high level of education characteristic of Utah’s population.

The age breakdowns of farm operators who work away from the farm (Table 3) indicate that for both Utah and the United States, the proportion is highest among younger farmers. In this regard, slightly over 65 percent of farm operators in Utah under age 45 indicated working off the farm during the year. This drops to only 23.1 percent for farmers over 65 years of age.

To relate the increasing number of days spent working away from the farm to income, a recent USU survey of randomly selected households across the state, asked if the chief wage earner of the household had any income from farming. Those responding “yes” were then asked if this was less than half of the chief wage earner’s total income. After adjusting responses to compensate for over-sampling in rural areas, 92 percent of the state’s households were found to have no income from farming. Of the remainder, 5.5 percent reported having less than half their income from farming. Only 2.5 percent indicated that most of their income was from farming. Thus, only 1 out of 3 persons engaged in farming in Utah reported that it provided more than half of their income.

The growing importance of farming as a part-time occupation, in Utah and elsewhere, can be explained to a degree by the combination of ingenious machinery, improved illuminating systems, and daylight savings time. Today’s farmers thus can accomplish more during non-standard hours. All-weather highway systems further facilitate part-time employment at long distances from the farm. As a result, many part-time farmers

**TABLE 2. Days spent working away from farm by farm operators in Utah and the United States, 1934-1969**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>NUMBER OF FARM OPERATORS</th>
<th>PERCENTAGE OF FARMERS WORKING OFF-FARM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Utah</td>
<td>US</td>
</tr>
<tr>
<td>1935</td>
<td>30,695</td>
<td>6,812,350</td>
</tr>
<tr>
<td>1940</td>
<td>25,411</td>
<td>6,096,799</td>
</tr>
<tr>
<td>1945</td>
<td>26,322</td>
<td>5,858,889</td>
</tr>
<tr>
<td>1950</td>
<td>24,176</td>
<td>5,388,437</td>
</tr>
<tr>
<td>1954</td>
<td>22,992</td>
<td>4,782,416</td>
</tr>
<tr>
<td>1959</td>
<td>17,811</td>
<td>3,710,503</td>
</tr>
<tr>
<td>1964</td>
<td>15,759</td>
<td>3,157,857</td>
</tr>
<tr>
<td>1969</td>
<td>13,045</td>
<td>2,730,250</td>
</tr>
<tr>
<td>1974</td>
<td>12,662</td>
<td>2,415,938</td>
</tr>
</tbody>
</table>


*1974 data not available until 1978.
currently view their farming as a voluntary "healthy hobby" that "provides a good place for the kids to grow up," or as a way to "keep the place in the family." Thus, off-farm employment can no longer be automatically equated with an adaptation to hardships.

The increase in part-time farming in Utah also holds special interest because a number of past studies* have closely associated part-time farming and rural-to-urban migration. The traditional pattern has the young farmer becoming disillusioned with his low farm income and finding part-time employment in a small community near his home. The training he acquired thereby, facilitated subsequent movement to an urban area in search of higher paying full-time employment. Historical evidence indicates this pattern existed in Utah. For example, the number of Utah farmers working off the farm over 100 days per year increased significantly in the 1940-1945 period when large numbers of defense-related industries located in Utah as a result of World War II. The same trend, which was repeated in the Korean War and the missile buildup period of the 1950s, apparently allowed Utah farmers to eventually sell their farms as their off-farm employment became secure while prices paid for farm products remained inadequate.

**Conclusions**

Farms in Utah, as well as in the US as a whole, are becoming fewer and larger. Increasing numbers of farm operators are at least occasionally working away from their farms. In Utah, over two-thirds of all individuals engaged in some kind of farming earn less than half of their income from farming activities. The foregoing trends suggest that a number of the traditional relationships among farmers and others involved in farm production such as farm suppliers might benefit from reexamination. For

**TABLE 3. Farm operators working away from their farm in 1969 by age of operator**

<table>
<thead>
<tr>
<th>AGE</th>
<th>% Of Total Farm Workers Doing Some Work Off the Farm</th>
<th>% Of Off-Farm Working Operators</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Working 1-99 Days Off the Farm</td>
</tr>
<tr>
<td></td>
<td>Utah</td>
<td>US</td>
</tr>
<tr>
<td>Under 35</td>
<td>65.4</td>
<td>57.4</td>
</tr>
<tr>
<td>35 - 44</td>
<td>65.6</td>
<td>53.8</td>
</tr>
<tr>
<td>45 - 54</td>
<td>59.4</td>
<td>47.5</td>
</tr>
<tr>
<td>55 - 64</td>
<td>47.8</td>
<td>36.4</td>
</tr>
<tr>
<td>Over 65</td>
<td>23.1</td>
<td>18.3</td>
</tr>
<tr>
<td>OVERALL AVERAGE</td>
<td>53.1</td>
<td>43.3</td>
</tr>
</tbody>
</table>


*1974 data not available until 1978.
example, do agricultural-support businesses adequately accommodate the time schedules of part-time farmers? Likewise, the implications of part-time farming for migration, land ownership, crop planning, risk-taking and overall farm production merit closer examination as to efficiency potentials. If current trends continue, part-time farming will surely be a significant factor in Utah's future agricultural production and organization.

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Sheep and Goats—
an Evolutionary Jackpot

Lois M. Cox

Sheep—goats—who needs them? Believe it or not, you and I and all the rest of the world's people.

The fact is, sheep and goats represent one of evolution's more remarkable success stories. Whether still wild, or already modified into domestic types, sheep and goats are uniquely well adapted to surviving in bleakly forbidding habitats. Without them, much of the forage from billions of acres of deserts and mountains throughout the world would never be converted into meat, milk and fiber useable by people.

Scientists (Thomas D. Bunch, Warren C. Foote, and J. Juan Spillett) at USU's International Sheep and Goat Institute are therefore devoting a lot of time and thought to finding ways to optimize that conversion potential. In a way, they are substituting science for evolution. And they do it by identifying superior animals that are adapted to specific ecological conditions and making sure they reproduce themselves.

Recently the scientists have been concentrating on wild sheep. One immediate aim is to preserve endangered species, especially those that have evolved such characteristics as substantial size coupled with efficient feed conversion ability, good reproductive rates, and high quality meat and/or wool or fiber. As they seek that goal, they are perfecting techniques that can also be used to enhance the productivity of domestic breeds of sheep and goats.

The limited past efforts to control the breeding of wild sheep and goats have had little success. The problems have included susceptibility of captive animals to disease and stress-induced malfunctions associated with confinement rearing, low reproduction rates, and poor survival of offspring. To avoid or minimize such difficulties, the USU researchers have been working with two approaches. One involves making artificial insemination as practical a tool for wild sheep propagation as it has become for the cattle industry. The other centers on modifying the ability of individual ewes to produce a given number of lambs in a lifetime.
On the Male Side

A successful artificial insemination (AI) program requires two keystones: repeatable semen collection techniques (Figures 1 and 2) and storage procedures that insure long-term sperm viability.

By satisfying these requirements, the USU scientists are opening many previously inaccessible doors. For example, superior rams that have been raised in captivity, or that have adjusted to such conditions, can sire offspring in distant locations. Through AI, zoological gardens can avoid the hazards of excessive inbreeding. In addition, AI provides the possibility of keeping endangered genotypes (species) from extinction. Size and behavioral differences that inhibit breeding potentials also can be overcome by AI.

As collection techniques become more sophisticated, free-roaming rams can perhaps be tranquilized and their semen collected for use at distant locations. The scientists have already successfully collected semen in conjunction with the field capture and release of some species of wild sheep (Figure 3).

On the Female Side

If the semen (once collected and frozen) is to be most effectively utilized, then the recipient ewes have to be in the “right” stage of estrus. Toward that end, the considerable work already done with hormone modification of domestic ewes’ reproductive cycles can be readily translated to their wild counterparts. The USU scientists thus have used progesterone and progesterone-like substances to inhibit hypothalamic function in domestic

Figure 1. Semen can be collected from this hand-reared wild aoudad ram utilizing an artificial vagina. This method is preferred yet it necessitates the ram be specifically trained.

Figure 2. A second method of semen collection employs the electroejaculator which is frequently used on untrained, free-roaming or captive rams.
Figure 3. Crossing a mouflon sheep with a desert bighorn sheep produced these hybrid lambs. The cross was accomplished using frozen desert bighorn semen surgically inseminated in the uterus of the mouflon ewe. This is the only recorded instance of this crossing and probably would not have been possible without the artificial breeding technique. Hopefully, this technology will enable preservation of endangered species and propagation of wild sheep in zoological parks.

Figure 4. This mouflon embryo transfer lamb was born to the domestic ewe. The wild hair sheep is especially adapted to keen hearing; note the ears held in an erect position. Originating in Europe, the mouflon averages one-half the size of the US western range sheep.
interspecies embryo transfers from especially hard-to-maintain-in-captivity species such as the North American Bighorn to domestic ewes might solve some perplexing problems for wildlife specialists.

It is also possible that embryos of wild sheep can more readily survive and adjust to disease challenges presented in utero when they are in a domestic ewe than when being carried by their natural mothers. After they are born, embryo-transferred lambs may also derive an as yet unmeasured benefit by having access to the passive immunity conferred by a domestic ewe’s colostrum.

What Next?

Obviously the problems are not all solved. For one thing, pregnant mare serum gonadotropin (PMSG), which is the more commonly used inducer of superovulation, often provokes unpredictable ovarian responses and effects on fertility. In their search for better alternatives, the scientists are investigating anterior pituitary extracts from sheep, cattle and horses.

Other research is designed to develop tissue culture techniques whereby the free-living embryo can be grown (2-3 days) to a more optimal stage for transfer. Embryos of 6 or fewer cells are relatively easy to surgically retrieve from the oviducts, but they have a low probability of surviving to full-term after transfer. In contrast, unattached embryos in the uterus (from the 8-cell to blastocyst stage) can be difficult to collect but have a much higher chance of going full-term.

In a project soon to be undertaken, the scientists will be looking into the possibility of freezing embryos for long-term storage purposes. The advantages of perfecting practical techniques would include being able to transfer the frozen embryos at one’s convenience. Also, with frozen embryos, time would no longer be a limiting factor in synchronizing recipient animals, and the recipients could be geographically remote from the donors. Successful long-term storage of embryos could very well safeguard against the possible extinction of threatened or endangered genotypes.

Ultimately, of course, the goal is to produce superbly efficient sheep and goats that will help satisfy the world’s need for animal protein.

Lois M. Cox is Science Writer, Agricultural Experiment Station Publications, USU.

Pinyon—Juniper Proceedings to be Reprinted

Due to many requests, the Utah Agricultural Experiment Station is reprinting The Pinyon-Juniper Ecosystem: A Symposium. This 194-page publication contains 18 papers discussing all aspects of the pinyon-juniper ecosystem. If you would like to order a copy, please write Frank E. (Fee) Busby, Department of Range Science, UMC 52, Utah State University, Logan, Utah, 84322. Cost of the Symposium Proceedings is $10.00.
Detailed population projections for Utah have been prepared by Dr. Yun Kim, Professor and Head, Department of Sociology, Social Work and Anthropology, in collaboration with Michael MacFarlane, Graduate Assistant, Department of Sociology, Social Work and Anthropology, and Katsuaki Oki, Graduate Assistant, Department of Sociology, Social Work and Anthropology, in the latest Agricultural Experiment Station Research Report. Projections have been carried out by age and sex from 1970 to the year 2000 for each of the Utah counties. Such details in population projections are important for future economic and social planning. The primary needs of the people, such as education, health, housing, recreation, and other social and cultural amenities cannot be rationally gauged without regard to the expected size, composition, and distribution of the population. The future size of the labor force which will be available for economic production and distribution, the size and structure of the school population in different age groups, the aged, and other special groups must also be considered in proposed planning.

The population projections which the researchers have prepared are based on the so-called component method which involves projecting males and females separately for each age group, and deals with the population changes by components; that is, birth, death, and migration, assuming that population changes are the result of all social, economic, and other cultural factors. The study is based on the results of the 1970 United States Census, the vital registration statistics, and other demographic information available, including the school census results.

A major improvement made in this study over the other Utah studies is that age-specific fertility rates by State Planning Regions are used instead of a single fertility index or set of fertility rates for the state.

According to these projections, the total population of Utah, which was 1,059,000 in 1970, will increase to between 1,578,000 and 1,929,000 by the year 2000, the most likely figures being in the range of 1,653,000-1,836,000, depending upon the future trend of fertility and migration. Thus, the population of Utah will increase by about 56 to 73 percent by the year 2000. According to the medium projections, which the researchers consider most likely, Utah's birth rate would decline from the present level of about 24 births per 1000 population to about 18 by the year 2000, while the death rate will remain more or less the same at the present level of 6-7 deaths per 1000 population. According to these projections, the proportion aged 15 and younger will decrease considerably from the present level of 33 percent to around 26 percent, while the proportion of the population aged 65 years and over will increase slightly from 7 percent to about 8 percent of the total population. During the next 25 years, from 1975 to 2000, there will be some increase in absolute numbers of children of school age, while there will be a great increase in number of people 65 years of age and over. The population aged 65 years or older will increase at least 74 to 81 percent.

This Report (Experiment Station Research Report 28) is in two volumes. Volume I includes a mixture of text and illustrating tables and Volume II contains tables only. They can be purchased for $2.00 and $5.00 respectively through the Agricultural Experiment Station Publications Office.
Projects in Progress

In this regular feature of *Utah Science* we briefly describe some of the research in progress across the USU campus. Each installment is a scant sampling of the remarkably diverse research scene.

Plants for Pleasure

You believe in a do-it-yourself approach to landscaping and gardening—but you’re having trouble deciding what to plant where. How big will the cute little tree be after 10 years’ growth? That shrub is lovely in its nursery setting, but will it survive a vicious winter? How much attention do those fantastic flowers in a yard two blocks from your house demand? The answers you need can probably be found at the Agricultural Experiment Station’s Farmington Unit.

In operation since 1954, the Farmington display gardens represent a perpetually in-progress effort to combine research with public service. The responsibility for their current design and management lies with USU’s Professor Alvin R. Hamson and Research Associate William A. Varga. Under their direction, the Farmington acreage has been split among varietal test plots and four evolving garden types. The four gardens are designed to give visitors (through self-guided or pre-arranged, accompanied tours and clearly-labeled plant materials) opportunities to see how specific plants look in yard-sized settings.

The display gardens are designated as: mostly annuals, mostly perennials, ground covers, and naturally-occurring Utah plants in a dry riverbed atmosphere. Because the gardens have been a continuing project, visitors can now see trees and shrubs at (or approaching) their mature size. In combination with the Unit’s varietal trials, the gardens have also defined the long-term adaptability of various grasses and other perennial ground covers to Utah’s climate.

Recently, in response to visitor interest, food crops have been given special attention. One development has been table and raisin grapes that do well in Utah.

A few miles north of the Farmington gardens, the Agricultural Experiment Station has devoted about 50 acres to fruit tree trials and weed control experiments. This area, too, is open to visitors, but the plantings are less readily understandable without a guide. Even at Farmington, groups of people do well to call ahead to make sure someone knowledgeable will be available to answer questions. The telephone number is (801) 867-2492.

Perhaps this is the year you should check out the Farmington unit. Your yard and garden (and maybe even your neighbors) might consider it a favor if you did.

Shortcutting Mother Nature

Will plant breeders ever substitute several small (approximately 2½ in x 1½ in x 1 in) glass flasks and a few months in a laboratory for 100 acres and 5 years in the field?

Professors J. T. Bowman (geneticist), J. R. Simmons (biochemist), and R. Lynn (algologist) have reason to think they may. If these 3 men are right, plant breeders will soon shortcut their way to crop plants with resistance to diseases, tolerance for herbicides—perhaps even a specific nutrient content.

The USU scientists start with a piece of leaf. (They are currently working primarily with alfalfa, hoping to create, identify, and multiply plants that are resistant to the popular herbicide, atrazine). They use enzymes (naturally occurring, reactive chemicals) to separate the section of leaf into individual cells.

...
called a callus. These calli are then transferred to larger containers that hold a different kind of nourishing media. Then comes the tough part—trying to convince each callus to shift into a growth pattern that will produce a viable plant.

The scientists accomplish this with a blend of hormones and various nutrients that induces an alfalfa callus to begin shoot production. After applying these techniques, the scientists are now producing plantlets that have atrazine resistance. If all goes well, seed produced by these or comparable plantlets will be available to plant breeders in approximately one-fourth the time it would have taken to produce atrazine-resistant alfalfa starting with seed.

In another series of related experiments, the scientists are investigating bindweed. That’s right—bindweed—the bane of so many farmers and gardeners. Believe it or not, bindweed could be the rainbow’s pot of gold for those seeking a plant to grow on and convert strip-mined land and mine tailings back into fertile soil. The USU group is presently pretesting bindweed plantlets to see whether any of them have the growth qualities needed for the mine tailings job.

The plant callus technique may well soon be providing answers to more and more plant breeding puzzles. Not only does it constitute a shortcut, but its application could free thousands of test-plot acres for actual crop production.

Defining Deadly

Nobody disputes that larkspur (Delphinium barbeyi Huth) kills cattle. In fact, it is second only to locoweed as a poisoner of western range-state livestock.

But debates do arise about the relative culpability of the numerous larkspur species, and how they can differ in toxicity (deadliness) among years or within one growing season. Even a single species may fluctuate in its poisoning potential depending on where the plants grow.

John D. Olsen, a researcher with the USDA’s Agricultural Research Service in Logan has finally gotten a start on unraveling some of the riddles. His newly developed bioassay procedure permits a reasonably accurate, quick assessment of larkspur toxicity. According to Dr. Olsen, his method of extraction is “relatively simple to use and duplicate, and can provide a screening procedure for studying variations in larkspur toxicity. But it doesn’t solve the problems inherent in the diversity of alkaloids contained in each larkspur plant. Since toxicity has been correlated with alkaloid content, it is essential that we learn more about the alkaloids.”

To check the validity of his technique, Dr. Olsen did an experiment with 3 larkspur species from different locales. His results indicated that D. barbeyi was more toxic than either D. glaucescens, or D. occidentale—even though all the plants were collected when at similar stages of growth. So several questions remained unanswered.

As Dr. Olsen puts it:

The variations in toxicity could be due to differences in types, chemical forms, or general proportions of alkaloids in the tested larkspur species. Or maybe these species differ in their total alkaloid contents, even when at the same growth stage. Then too, soil or climate or some other environmental factor could be the crucial variable.

What we are hoping, of course, is that our continued application of the bioassay technique and chemical analyses will give us the insights we need. Then we’ll be able to give livestockmen fact-based recommendations about how best to manage larkspur-contaminated ranges.

Does Pure Equal Safe?

When it comes to water, these days the answer is not necessarily “yes!” A major problem is that the standardly accepted measure of pure, safe-to-drink water has been the presence or absence of certain bacteria. Today, however, pervasive viruses are as (or more) likely than the indicator-organism bacteria to pose health hazards, often in the shape of gastrointestinal malfunctionings. And these pathogenic viruses strenuously resist laboratory cultivation, which, in turn, has made it virtually impossible to find ways to detect and inactivate them.

This is becoming critical now that current trends favor early reuse of only partially cleansed waste waters. Waters that have been brought to a level of organic content deemed inadequate for household use, are considered fit for industrial cooling towers, spray irrigation, and similar purposes. Part of the rationale is that land applications (filtration) of wastewaters or treated effluents are known to effectively reduce their populations of pathogens.

Unfortunately, viruses thus filtered out may eventually find their way into ground waters tapped by wells or contaminate plants destined for human consumption. Specifically, certain intestine-inhabiting viruses have survived 188 days in river water...
and up to 175 days in soil. They have also been recovered from wells 20 feet below the soil surface in areas subjected to sewage spray irrigation.

Several USU scientists are combining their talents to try to solve some of these water-borne, viral-contamination problems. Led by Rex S. Spendlove, Professor of Microbiology, and Dr. Dennis George of the Utah Water Research Laboratory, the group is initially concentrating on perfecting badly needed methodology.

Since reoviruses are among the viruses most often found in sewage, they will be one of the first types investigated intensively by the USU team. The reoviruses rarely cause gastroenteritis and/or respiratory ailments and are superbly equipped by nature to resist inactivation. They are therefore prime candidates for the category of indicator-organism virus. The scientists must first learn how to accurately identify and quantify the water-borne reoviruses. The next goal would be to consistently reduce their activity to an innocuous level. The assumption is that effective inactivation of the reoviruses would also adequately control their more menacing associates.

The team’s immediate objective is to see whether their recently perfected fluorescent virus precipitin test will work with water-borne viruses. If it does, they’ll have solved the identification problem. That would put them within 1 or 2 years of achieving potentially field-applicable results.
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March 1977
Before 1977, Utahns have relied on the familiar ample snowpack for winter recreation and summer moisture.

Photo by Rex F. Nielson