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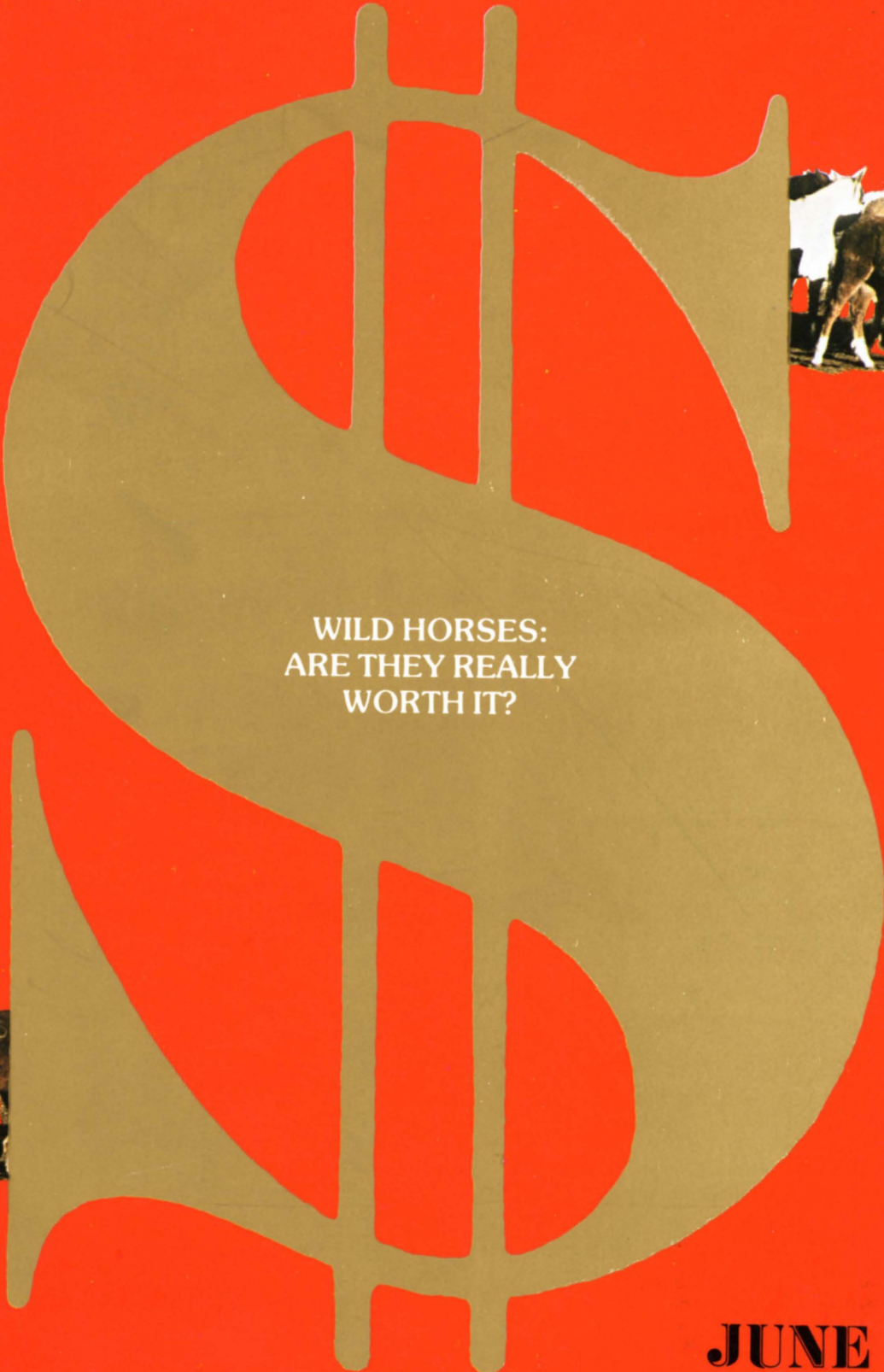
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WILD HORSES:  
ARE THEY REALLY  
WORTH IT?

JUNE 1979

# UTAH SCIENCE

UTAH AGRICULTURAL EXPERIMENT STATION VOLUME 40 NUMBER 2



# UTAH SCIENCE

UTAH AGRICULTURAL EXPERIMENT STATION

## ABOUT THE COVER

The cover of June UTAH SCIENCE seeks to symbolize the enormous expense borne by the public for the execution (i.e. the "animal processing" by federal agencies) of wild horse laws which were passed in an environment of emotional persuasion rather than from creative and pragmatic analysis of the basic problems and how best to deal with them. USU's E. Bruce Godfrey offers us an economic report of the current situation beginning on page 44.

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# ANALYZING INVESTMENT ALTERNATIVES

LARRY K. BOND

## INTRODUCTION

The ability to make rational decisions under all kinds of circumstances is what makes some farmers successful while others just barely make a living. Reliance on past experience can be very helpful in making decisions. Yet, there are some decisions that require a basic knowledge of economic principles. Such is the case with decisions relative to capital expenditures.

How does one go about determining the "best" of several alternative capital investments in terms of their effect on the long-run profitability of the farm? For example, suppose that a

farmer has determined that it would be a good investment to build a granary. This will allow him to hold onto his grain and market it when prices are not as depressed as at harvest time. He has looked into costs of materials and construction. A granary that will last 30 years will cost \$1,800. One of lesser quality can be constructed for \$1,250, but its useful life is only 15 years.

Assuming the farmer will need a granary for 30 years, which of the two granaries is the best investment? A clear-cut answer cannot be given since many factors are involved. Yet, with a

few simple assumptions and a little knowledge of economics, one can easily determine which of the two granaries is the best investment.

Without a knowledge of basic economics, one might say that the choice is an easy one, arguing that it is cheaper to build one \$1,800 granary than to build two \$1,250 granaries; but is this really true?

In order to analyze this situation, let it be assumed that: (1) Money invested off the farm will earn 12%; and (2) construction costs of a replacement for the cheaper granary will likely be \$1,750 in 15 years.

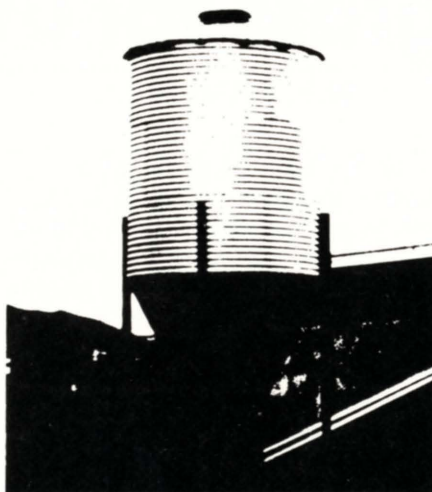
**Alternative No. 1.** If the less durable granary is built, it will require a cash outlay of \$1,250 right now. The farmer knows he will have to spend \$1,750 in 15 years for another granary. How much money would he have to invest today at 12% in order to have \$1,750 in 15 years? This can be calculated using the formula:

$$PV = \frac{FV}{(1 + i)^n}$$

where PV (Present Value) is the amount of money that must be invested today, FV (Future Value) is the amount of money needed at some specified time in the future, *i* is the interest rate, and *n* is the time period. In this case:

$$PV = \frac{\$1,750}{(1.12)^{15}}$$

or PV = \$320. That is, \$320 invested today at 12%, and compounded annually, would grow to \$1,750 in 15 years. The total cost of having two granaries with a total useful life of 30 years, in terms of the investment required now, is \$1,570 (\$1,250 + 320).



**Alternative No. 2.** If a single granary is built to last 30 years, the cost is \$1,800. It is \$230 (\$1,800 - \$1,570) more costly than building two less durable granaries.

Although the farmer would be spending \$230 more than he needed to in order to have a granary for the full 30-year period, the actual loss for building the more durable granary is much greater. The question that must be asked is, "What would this amount of money be worth in 30 years if invested today?" Rearranging formula (1) and using the known values we have:

$$FV = \$230 (1.12)^{30}$$

or, the Future Value of \$230 invested today at 12% would be \$6,891. This represents the total loss, over a 30-year period, of constructing the more expensive granary. Therefore, Alternative No. 1, of the cheaper granaries, would be a better investment.

### ABOUT THE AUTHOR

Larry K. Bond is the Davis County Extension Agent with Utah State University's Extension Service.

## SUMMARY

Many farmers can work 12-14 hours a day and some have greater technical knowledge than others. However, it is the farmer with managerial ability who will still be in business years from now. A knowledge of simple economic principles such as this one does not guarantee financial success, but it is certainly helpful.





# a new turfgrass for Utah's Dixie

W.F. CAMPBELL

Grasses aren't all the same. They can be as individualistic as you and I. In fact, if grasses weren't that way, scientists would be hard pressed to solve certain kinds of problems. Consider, for instance, Washington County, Utah. Temperatures there can vary from 116° F (47° C) to -11° F (-24° C). Such fluctuations make it difficult to grow good turf, and thick, healthy turf is what homeowners, golf course superintendents, industrial groundkeepers, and athletic groundkeepers are seeking. Most turf grasses are adapted either to cool humid conditions, or to warm humid conditions. They have a disturbing tendency toward dormancy or even death, if expected to endure a climate that encompasses both heat and cold.

FuTurf, *Paspalum vaginatum* Swartz., a perennial grass that spreads by creeping stolons and rhizomes, may be suitable for Utah's Dixie. It has been tested at Phoenix, Arizona and Indio, California. FuTurf has been exposed to overnight minimums of 22

to 24° F (-5.6 to -4.4° C) and a daytime maximum of 126° F (52° C) with no adverse effects. Following the cool night-time temperatures, recovery of complete color was evident within 10 to 14 days. FuTurf appears to be adapted to all turfgrass areas of Washington County, i.e., home lawns, landscaping commercial buildings, golf courses, greens, fairways and tees, sports fields such as football, baseball, tennis courts, and bowling greens, and all areas where a dense hard wearing beautifully colored grass cover is desired. We have studied FuTurf's responses to day:night temperatures of 30:25° C (86:77° F); 30:5° C (86:41° F); 16:0° C (61:32° F); and 12:-5° C (54:23° F). The plants were exposed to 12 hr day:night cycle and light intensities (400-700 nm) of 1,200  $\mu\text{m}^2 \text{sec}^{-1}$  (high-light treatment) or 300  $\mu\text{m}^2 \text{sec}^{-1}$  (low-light treatment).

FuTurf produced its greatest leaf and shoot growth at 30° C (86° F) day and 25° C (77° F) night temperature (Table 1). These temperatures are not

too dissimilar to mean daily maximum (26° C; 78° F) and mean daily minimum (9° C; 45° F) observed in Washington County. There were, however, no differences between dry weights of plants subjected to night temperatures of 5, 0, and -5° C after days 1 and 2. At the 5° C night temperature, no differences were seen during the first 3 days, but dry weights were significantly reduced after the 4th day. At the 16° C day and 0° C night temperatures, significant reduction in weights occurred on days 3, 6, and 7. With a 12° C day and -5° C night regime, significant reductions occurred on days 3, 4, and 5. Significant reduction in dry weights was observed between temperature 0 and -5° C after day 5 and thereafter.

When temperature and light intensity interaction experiments were conducted, a significant reduction in dry weights with increased time was observed (Table 2). There was, however, no significant difference between the different light intensities.



**Table 1. Effect of low night temperatures on dry weights (expressed as percent of control) of *Paspalum vaginatum***

No. of Nights Treated	Night temperatures			
	30:25	30:5	16:0	12:-5 C
1	100 a x	68 a y	77 a y	77 a y
2	100 a x	75 a y	77 a y	73 a y
3	100 a x	69 a y	47 b z	52 b z
4	100 a x	48 b y	42 b y	33 c z
5	100 a x	42 b y	35 b y	7 d z
6	100 a w	48 b x	22 c y	4 d z
7	100 a w	54 b x	13 d y	4 d z

Those values within a column (a, b, c, d) or row (w, x, y, z) followed by the same letter are not significantly different at P 0.05.

**Table 2. Effect of low night temperature (5°C) and light intensity on dry weights (gms) expressed as percent of control in *Paspalum vaginatum* Swartz**

Time in Weeks	Treatment Temperature	Light Intensity	
		Low	High
1	30-25°C	100 a	100 a
	30- 5°C	76 b x	81 b x
2	30-25°C	100 a	100 a
	30- 5°C	25 c y	33 c y
3	30-25°C	100 a	100 a
	30- 5°C	22 c z	17 d z
4	30-25°C	100 a	
	30- 5°C	3 d	

Those values within a column (a, b, c, d) or row (x, y, z) followed by the same letter are not significantly different at P 0.05.

Except for the plants exposed for 5 days at 12° C day/-5° C night temperatures, all plants exposed to cool night temperature had fully recovered after being returned to 30° C day/25° C night for 7 to 14 days.

To gain a better understanding of this plant's response to these cool night temperatures, we examined cells from the leaves with the light and electron microscopes. Examination of cells from the leaves of the plants exposed to the various night temperatures with the light microscope revealed no significant findings. However, examination of the mesophyll cells with the electron microscope indicated little if any structural changes in the chloroplasts that could be attributed to light intensity at the various temperatures. By contrast, there were changes that could be assigned as an effect of growth temperature on chloroplast structure. At the end of the day, chloroplasts in leaves from plants grown at 30:25° C were slightly

swollen because of the abundance of starch grains (Figure 1) though within a leaf cell there was considerable variation in starch content between chloroplasts. Chloroplasts in leaf cells of plants grown at 30:25° C exhibited normal digestion of starch grains in cells sampled at the end of the night (Figure 2). In plants exposed to the cooler night temperatures, the chloroplasts contained varying amounts of starch at the beginning of the day, the amount of starch per chloroplast being greater at the lower temperatures. After 5 days of the 12:-5° C regime, senescence of the leaf cells is well underway (Figure 3).

Characteristically, the photosynthates produced by chloroplasts may be utilized in three ways: directly in metabolism for new growth, converted to sucrose for translocation to other areas where needed in the plant, or converted to starch, which accumulates in the chloroplasts during light hours. Normally, starch is converted to sucrose and translocated

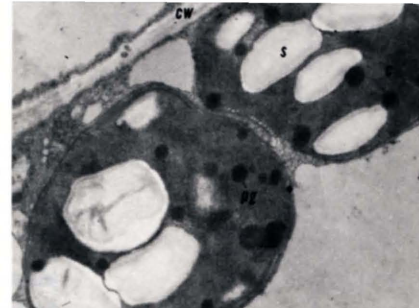


Figure 1. Electron micrograph of leaf cell from plant exposed to 30:25°C, high light, end of day, showing numerous starch grains per chloroplasts. CW = Cell Wall, PG = Plastoglobuli, S = Starch grains.



Figure 2. Electron micrograph of leaf cell from plant exposed to 30:25°C, high light, end of night. Note the absence of starch grains in the chloroplasts. C = Chloroplast, M = Mitochondrion.

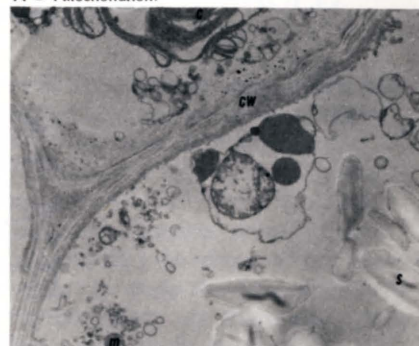


Figure 3. Electron micrograph of leaf cell from plant exposed to a 5-day 12:5°C regime. Note the general breakdown of the chloroplasts, swollen mitochondrion and general senescence of the cell.

to the root tissue for storage during the dark hours, and from here it is recalled as needed by the plant. The cool night temperatures are inhibiting to the normal conversion of starch to sucrose. This apparently results in the eventual starvation of the plant cells which results in an enhancement of senescence. After several nights at these cool temperatures the plants reach a point from which they do not recover when returned to normal night temperatures (25° C). There is much scientific evidence that indicates that the leaf assimilate level (starch) is a controlling factor in the rate of photosynthesis and the capacity of chloroplasts to release oxygen upon exposure to light. Further, photosynthesis is drastically reduced when the internal membrane structure of the chloroplasts is destroyed.

#### ABOUT THE AUTHOR

William F. Campbell is Professor of Agronomy with the Plant Science Department, Utah State University.



# THE INTERMOUNTAIN HERBARIUM



Mat-forming shadscale is common to clays and shales of eastern Utah (same family as sugarbeets and spinach).



Bindweed is a common weed in the gardens of Cache Valley.



Milkweed is poisonous and commonly lives along roadsides.



This milkweed is extremely toxic, making it responsible for many animal deaths.



The sego lily is a starchy sweet bulb which was food for Indians and early settlers in this area.



This columbine is the same species as the Colorado blue columbine. Its long nectar spur attracts hummingbirds.





*Primula maguirei* (photo by L. Shultz)

This primrose occurs only in Logan Canyon on moist cliff faces. The populations are confined to a small area of the canyon and transplant efforts have not been successful. The species has been proposed for inclusion on the list of threatened species.



*Cycladenia humilis* var. *jonesii* (photo by John Shultz)

This photograph shows the entire known population of this plant. It is found on the edge of a wash in San Juan County, Utah, and reproduces from a spreading root system. A study made in 1977 showed that no seeds are produced.



*Haplopappus* (photo by L. Shultz)

This is a plant recently discovered in the Toiyabes Mountain Range of Nevada. We know it is in the genus *Haplopappus* of the Sunflower family, but the species has not yet been described.

## MARY E. BARKWORTH AND LEILA M. SHULTZ

*My child just ate some bright red berries: are they poisonous? Some cattle have died and we suspect poisoning: are any of these plants in the pasture toxic? There is a new weed in my garden: what is it and what should I do about it? We have a contract to study the revegetation of strip-mine sites: are there any native species that might do well? We are going to visit our relatives this summer: are there any books which would tell us about the plants in their part of the world?*

These are the questions that might lead you to the Intermountain Herbarium for the staff there are specialists in *plant taxonomy*, the science concerned with the recognition of different types or species of plants and their inter relationships. In responding to a question, they draw not only on their own training and experience, but also on the collection of plants in the herbarium and the technical literature and manuals that are housed there.

The collection of the Intermountain Herbarium consists of over 160,000 carefully pressed specimens, each of which has been mounted on stiff white paper, together with a label that says what it is, where it was collected, and what grew around it.

People sometimes wander into the herbarium just out of curiosity, wondering why herbs are being grown on the fourth floor of a building or what dried herbs are available there.



To their astonishment, there is not a plant to be seen. Instead there is row upon row of large cases with tightly latched doors. Their sense of dismay increases when they are shown the inside of a case with its folder upon folder of pressed plants. But these mounted specimens are the heart of the herbarium.

Before anyone can find out anything about a plant, such as whether or not it is poisonous, one first has to know the plant's name. That is where the collection comes in. If someone brings a plant into the herbarium for identification, the staff first examines it closely to see what it is most likely to be. Then to make sure that they are correct, they go to the identified specimens in the herbarium and compare the new plant to them. If the plants match, even when examined under the microscope, the tentative identification is correct. If they do not match, the staff can consult the technical manuals and other literature and try other possibilities.

The collection of the Intermountain Herbarium consists mainly of native plants from the intermountain region, an area which includes all of Utah and Nevada and large parts of Idaho, Oregon, and Arizona. It is the only herbarium which specializes in the plants of this region. Some specimens in the herbarium were collected in the 1700s and there is a large collection made in the 1800s by Marcus E. Jones, one of the early collectors in the region. Important historical collections and specimens from throughout the world are acquired through exchanges with other institutions. We send duplicates of collections from our fieldwork to researchers throughout the world, then receive their specimens in return. The herbarium thus serves as a historical record of vegetation patterns as well as documentation for changing plant distributions.

Dr. Barkworth guides the development of the herbarium as a research and teaching facility. Here she is working on the revision of the genus *Stipa*, a grass.

published and the other four are in varying stages of preparation.

Judging by the number of inquiries received, the importance of the collection in the Intermountain Herbarium is becoming more and more widely appreciated. During the last five years the number of requests for identifications has increased from around 1,500 per year to nearly 5,000. Many people think that once one knows the plants of a region they can be identified on sight but this is not so. Many species are distinguished by features that can only be seen under the microscope. For instance, there are over 100 species of milk vetch (*Astragalus* sp.) in Utah, some of which are toxic to cattle, some of which are not. To identify these species it is often necessary to determine a number of microscopic features, such as whether the plant's hairs are attached at the base (like human hair) or in the middle (like a pick).

Curator Leila Shultz does floristic research and is responsible for preservation and development of the collection.



If nothing matches, the excitement mounts. Perhaps the plant is a previously undiscovered species? Or a weed that has only just begun to spread into the intermountain region? Before answering these questions, it may be necessary to borrow specimens from other herbaria. Fortunately, almost all the identification requests that come in can be answered without going to these lengths. But the thought that one may find a new species, or a plant that has only recently arrived in a particular region adds excitement.

The Intermountain Herbarium was founded in 1931 by Bassett Maguire. When he left to work with the New York Botanical Garden in 1943, he insisted that the herbarium be left in the care of one of his students, an enthusiastic field botanist, Arthur Holmgren. Under Art's care and direction, the collection continued to grow, until now it is serving as one of the main sources of information for the preparation of a definitive work on the plants of the intermountain region. Two volumes of this work, *The Intermountain Flora*, have already been



It is sometimes difficult to persuade contracting agencies and others of the importance of such careful identification. The result is that, in some cases, plant lists include species that are apparently growing a long distance from any other members of their species, but which, on close examination, prove to belong to another species altogether, one that is quite common in the region. Unfortunately, only the plants that would appear to be far from their normal range are likely to be noticed as having been misidentified.



Misidentifications are more likely to occur if a person relies on knowing plants by sight. In many ways, Utah is a particularly difficult region in this respect because its geological history has led to the development of a flora which contains many very similar species with extremely localized distributions. Utah has more than 3,000 different species of plants, and the intermountain region has about 5,000 different species.

But identification is not the sole function of the Intermountain Herbarium; it is also an important research facility. It nearly always has some specimens on loan from other institutions for study by individual students and faculty members at Utah State University.

This lending arrangement, which extends throughout the world, enables the scientists at one institution to examine a far wider range of specimens than would be possible if they had to rely on the resources of

The herbarium offers spacious facilities for graduate student studies of plant taxonomy.



their own institution. It also saves considerable time and money by cutting down on the amount of field-work required. Very often it enables a scientist to pinpoint certain areas which would be particularly valuable to explore; sometimes it makes fieldwork unnecessary.

Why do scientists want to look at specimens from a wide area? If they are writing an identification guide, it is important to know what the variation is within a particular species. Sometimes the plants of a species growing in one particular region are

hairy whereas elsewhere they are not at all hairy. This is a simple example of the kind of information that can be found from herbarium specimens. This information can then be included in the description. Many new species have first been found by looking carefully at the specimens in several herbaria; in other instances, examination of herbarium specimens has enabled us to recognize differences between weedy and non-weedy races of a species. This is helpful in determining whether or not a control program is warranted in a particular region.

Other research programs that make use of the herbarium's facilities include vegetation studies, pollination studies, and investigations of the possible medicinal value of certain species. All such programs rely, however, on the work of taxonomists to distinguish between the myriad of species that exist.

What does the future hold for the Intermountain Herbarium? The increasing interest in Utah's coal and

mineral reserves means there will be increasing demands on the staff for assistance in identification. There will also be large numbers of specimens to mount and record: specimens collected in connection with environmental impact vegetative studies as well as those collected by the herbarium staff as they explore those parts of Utah that are still poorly known.

We would like to expand the collection of photographic slides for use in university teaching as well as in talks to interested non-university

groups. We would also like to develop a display side to the herbarium, drawing on the slides in the teaching collection to provide displays of the plants growing at a particular season or in a particular locality.

Another hope is to include the collection of the Intermountain Herbarium in the Plant Information Network. The members of this computer network are able to find out how many specimens of a particular species are located at the other herbaria included in the network and where those specimens were collected. This would, in many instances, enable us to be more selective in asking for loans, asking only those institutions that have particularly interesting collections.

Yet another area we would like to develop is the bryophyte collection. The present collection, which was started by Leila Shultz, contains around 1,300 specimens. We would like to build this up so it could serve as a useful collection in teaching a taxonomy course on bryophytes.



These goals, when realized, will complement and encourage the continued growth and development of the vascular plant collection, and assist us in fulfilling the herbarium's service obligations to the public, government agencies, and the research community.

#### ABOUT THE AUTHORS

Dr. Barkworth and Leila Shultz are, respectively, Director and Curator of the Intermountain Herbarium. Dr. Barkworth succeeded Professor Holmgren who retired earlier this year and is now Professor Emeritus of Plant Taxonomy.





# Pruning Curleaf Mountain Mahogany in Northern Utah

DENNIS D. AUSTIN  
PHILIP J. URNESS





The rangelands are slowly shrinking because people and their machines are changing winter wildlands into backyards and highways. The result is predictable—a gradual and parallel reduction in potential big game numbers. Utah wildlife managers have been aware of this trend, most noticeable along the Wasatch front, and have instigated three programs designed to offset this encroachment: (1) acquisition of important winter rangelands; (2) supplemental feeding (currently restricted to Hardware Ranch); and (3) range improvement through vegetative treatments and other land management procedures.

Curlleaf mountain mahogany (*Cercocarpus ledifolius*) grows throughout most of the intermountain area on winter game ranges. It is highly palatable<sup>1</sup>, nutritious<sup>2</sup>, digestible<sup>3</sup>, and is preferred<sup>4</sup> by deer. Unfortunately, its characteristic tree-like growth form puts most of its branches beyond the grazing reach of big game. This leaves only a small portion of the forage produced actually available to the animals.

Pruning treatments, however, have stimulated vegetative growth in many shrubby species<sup>5,6</sup> including curl leaf mountain mahogany.<sup>7,8</sup> The objective of the study described here was to determine how various intensities of pruning would modify the available forage production of curlleaf mountain mahogany plants.

During the winter of 1975-76, four study sites were selected in northern Utah: two were on lower winter ranges (elevation 5400-6000 feet), one was on an upper winter range (6600 feet), and one was on summer range (8000 feet). At each site, 25 groups of 6-8 individual trees were randomly selected and tagged. The weights of total forage production and of that portion available to big game were visually estimated. Plants were pruned once, during late winter at 2 m (6.6 feet) height and at intensities ranging from 20-100 percent foliage removal. Following treatment, the weights of the remaining foliage volumes were obtained. Subsequent available production was determined on all plants following the growing seasons in 1976 and 1977. All

estimates were converted to an oven-dry basis.

Results from the three winter range sites were similar and showed a positive response to treatment when compared to control trees at the same locations. Production increased 300-700 percent in the first two growing seasons under the 90-99 percent canopy removal with lesser increases at lower pruning intensities. However, all trees pruned at the 100 percent level died, as did 32 percent of those pruned to a 99 percent level. Mortality was 3 percent when pruning intensities were between 80 and 99 percent. No plants died at intensities below 80 percent. Thus removal of 90-99 percent of the canopy produced the best response.

Although response to treatment was positive, actual increases in forage volume were meager. Since all study plants on the winter ranges averaged less than 2 gm (.07 oz) of available forage before treatment, even the several-fold increase in production amounted to very little usable forage. Furthermore, increased growth occurred only from the live shoots present before treatment; adventitious sprouting did not occur. This leads to the unfortunate conclusion that unless a plant has appreciable available forage before treatment, the practical benefit to big game from pruning would be negligible.

The summer range site had been producing more forage (64 grams (2.26 oz) before treatment) than the winter sites and the pruned plants on this site showed an even stronger response to pruning, which again decreased with intensity. Plants pruned of 90-99 percent of their canopies showed a mean increase in available production of 600 percent in the first growing season following pruning and 1300 percent the second year when compared to control plants. Assuming a sustained increased production of this magnitude, pruning treatments could be considered worthwhile in such cases. However, responses of other browse species have generally declined sharply within 3-5 years following treatment<sup>9</sup>.

Our results indicate that forage production by curlleaf mahogany

could be increased by pruning, on ranges where at least a moderate amount of forage is currently being produced. These areas generally would be above the normal winter range and used mostly in the fall by deer and elk. The additional high quality forage would be important in maintaining the body condition of these animals further into the wintering period. Pruning of curlleaf mahogany at lower elevations, however, would not induce a useful increase in production. During harsh winter periods of deep snow, however, pruning of these stands could provide an emergency source of high quality forage.

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# A VERY UNUSUAL VETCH

M. D. RUMBAUGH

Most plants, when mature, bear flowers and produce seeds to propagate their species. In fact, most people like to think of attractive flowers with a bee or two buzzing around them as typical of all plants. This pleasant but erroneous concept is enhanced by floral displays and garden catalogs. All flowers are not large and showy. Indeed, some plant species have tiny, inconspicuous flowers that do not require pollination by insects or wind before seed is set. Often these miniature flowers are fertilized in the bud without the petals even opening. Such floral structures are described by botanists as "cleistogamous."

Like the other species of vetch, *Vicia sativa* spp. *amphicarpa* has quite large, attractive flowers. Some vetches have white, yellow, or blue flowers. Those of *amphicarpa* are typically a deep lavender or purple (Figure 1). But some *amphicarpa* plants have only cleistogamous flowers whereas others possess both types. The cleistogamous flowers are borne in the leaf axils, and quite often do not even have petals. When petals are present, they are rudimentary and whitish in color (Figure 2). The larger flowers result in fruit with as many as nine seeds per pod. Pods from cleistogamous flowers are smaller and usually contain one or two seeds. The word "amphicarpous" means "producing two kinds of fruit" and this is the origin of the subspecies name, *amphicarpa*.

But it is not cleistogamy that makes *Vicia sativa* spp. *amphicarpa* unique. A number of plant species have cleistogamous flowers. This vetch, however, not only flowers aboveground in the usual manner but also flowers underground! Several cultivated crop species such as peanut, *Arachis hypogea*, and subterranean

clover, *Trifolium subterraneum*, produce flowers aboveground but after pollination the developing fruits and seeds are buried in the soil by their elongating peduncles or primary flower stalks. In contrast, *Vicia sativa* spp. *amphicarpa* produces underground cleistogamous flowers that are never exposed to light. These flowers are sessile in the axils of minute, lobed leaves on subterranean rhizomes or stems. The flower-bearing rhizomes develop from cotyledonary buds and buds situated at the basal nodes just above the root collar. They are chlorotic, rather delicate, rarely branched, and consist of a few long internodes. The apex is recurved to protect the apical bud as it infiltrates the soil. Subterranean and aerial flowers normally flower simultaneously, although the subterranean flowers sometimes develop after those above ground are completely mature.

The underground flowers are more fertile than their exposed counterparts. About half the subterranean flowers result in seeds, whereas less than 53 percent of the aboveground flowers produce fruit. The location of the subterranean flowers probably protects them from environmental factors harmful to pollen formation and fertility. The belowground pods are white, in contrast to the chlorophyll-containing green pods found above ground (Figure 3). Subterranean seeds are generally fewer in number, larger and heavier than those produced aboveground but are the same deep purple color (Figure 4).

Plants of subterranean vetch (*Vicia sativa* spp. *amphicarpa*) are grazed readily by sheep and cattle as well as by wild herbivores. The subterranean rhizomes and fruit are less exposed to damage by mammals and insects than comparable aboveground structures.

Underground flowering may be an adaptation to habitats where a dry period follows the flowering season, as it is reproductively advantageous for a plant to have some of its seeds already buried in a drying soil. It obviously is a mechanism by which an annual species can secure for its progeny the favorable sites previously occupied by the parental plants.

*Vicia sativa* spp. *amphicarpa* is a Mediterranean species found in Europe, western Asia, and northern Africa. It grows wild mainly in the hilly and mountainous parts of that region and prefers soil mixed with sufficient stones or gravel to provide good aeration and drainage. Subterranean vetch does best in microhabitats that are relatively humid but still too dry for other vetches. Like other legumes, subterranean vetch is valued for its nitrogen fixation ability in addition to its nutritious forage. The nodules are large, numerous, and effective. The possibility of using subterranean vetch as a reseeding annual legume in certain pastures and rangelands is intriguing. Its ability to produce both aerial and subterranean seeds should enhance drought resistance and persistence under grazing. At the present time we (USDA Crops Research Laboratory personnel) are increasing seed stock of several strains and familiarizing ourselves with the habits and requirements of the species, prior to more extensive testing and evaluation.

#### ABOUT THE AUTHOR

Melvin D. Rumbaugh, a research geneticist with USDA, is part of a team of five scientists working on improved plant germ plasm for rangeland use in the intermountain area. His particular project deals with breeding of forbs. Their breeding program includes both native and introduced species and emphasizes the improvement of alfalfa and the native lupines for the range environment.





Figure 1. Aboveground flowers of *Vicia sativa* ssp. *amphioxys* which are similar to those of other vetch species.



Figure 2. Rudimentary aboveground cleistogamous flowers of subterranean vetch.



Figure 4. Aboveground parts of subterranean vetch.



Figure 3. Belowground part of subterranean vetch.



Figure 5. Excavated vetch showing entire plant.



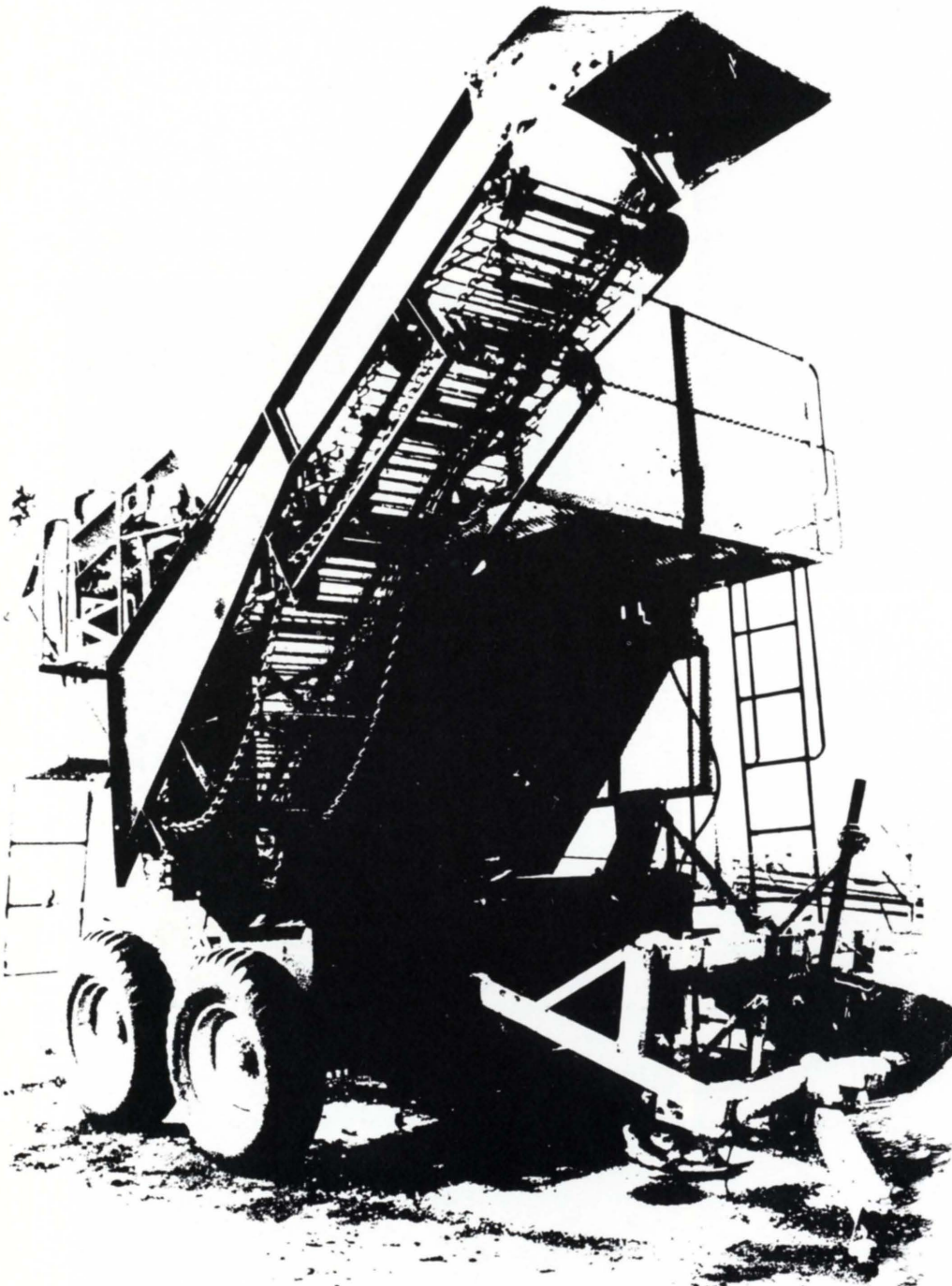
# SUGARBEETS:

ROGER WYSE

**T**he amount of sucrose (table sugar) that can be recovered from sugarbeet roots after storage depends on the extent of the injuries they sustained during harvesting and handling as well as on storage conditions. The respiration of the roots, which is a major cause of sucrose loss during storage, increases in direct relationship to the severity of any injury (Wyse et al. 1978; Cole 1977; Akeson 1974). Since respiration rates govern the ultimate sucrose extraction potentials, and injuries govern respiration rates, one way to increase sugar production is to decrease injuries to the sugarbeet roots.

Breaking the surface of a root makes that root vulnerable to botrytis and penicillium, the two fungi that are prevalent during storage (Mumford and Wyse 1976). The subsequent degree of rotting caused by these organisms is related to storage temperature and duration. But it doesn't take much rotting to greatly increase the non-sucrose impurities in a sugarbeet root. These non-sucrose impurities (with invert sugars being a prime example) reduce the recovery of sucrose and increase that of the less economically attractive molasses. The invert sugars (difficult to manage forms of the sugar molecule) normally do accumulate during storage but very slowly. They become a problem when mold (fungal) growth occurs and enhances their production (Wyse and Dexter 1971; McCready and Goodwin 1966). Invert sugar contents are, in fact, a good index of mold growth (Mumford and Wyse 1976).

Many of the effects of injury (including mold growth) can be minimized by maintaining cool (3° to 5° C) storage temperatures and using fungicides (Mumford and Wyse 1976;





# Not as Tough as They Look

Miles et al. 1977). These procedures, however, are only part of the solution. Our 1976-77 study (detailed in *J. Am. Soc. Sugarbeet Technologists*, vol. 19) clearly showed that machine harvesting is much harder on sugarbeet roots than is hand harvesting. Machine harvesting thus greatly increased the loss of potentially recoverable sucrose during storage.

Sugarbeet harvesting and handling equipment has been designed for volume capacity and cleaning ability, with no regard for its potential to injure the root. A study that would define machine-induced sources of injury, if followed by a redesigning of equipment to minimize those injuries, could be highly beneficial to sugar production.

Among the most severe harvest-time injuries, are those that occur during crown removal. Our data and those from other studies (Akeson 1974; Cole 1977; Dexter et al. 1970) indicate the importance of crown removal, or non-removal, on the storage life of sugarbeets. If the crown is *not* removed, extreme care must be taken to remove all petiole material, or the result would be a trash-filled pile and costly "hot spot" development.

The practice of crown removal has been perpetuated on the premise that the crown is a source of high levels of impurities. And it is true that impurities are reduced somewhat by crown removal. Any such advantage is quickly lost, however, during the storage of the de-crowned beets (Akeson 1974; Cole 1977; Dexter et al. 1970). Since most sugarbeets grown in the United States are stored for at least 30 days prior to processing, it may be time to consider the relative values of crown versus petiole removal.

Figure 1: Machine harvested and topped

Figure 2: Machine harvested and flailed

Figure 3: Hand harvested and flailed

Figure 4: Hand harvested and topped

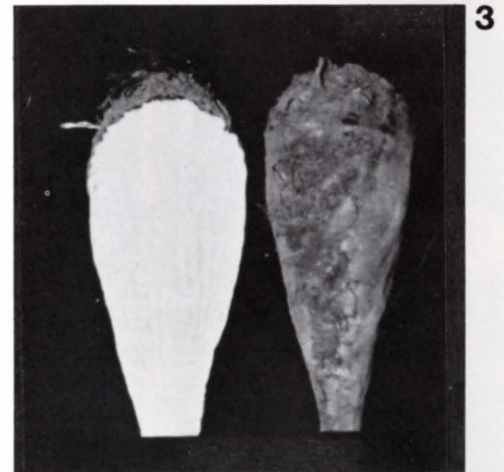
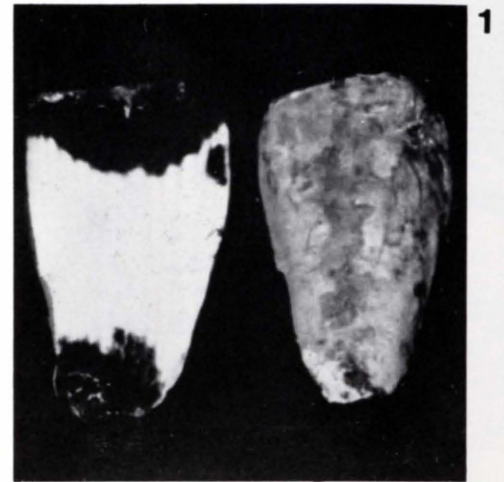
The dark areas indicate rotten tissue.

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## ABOUT THE AUTHOR

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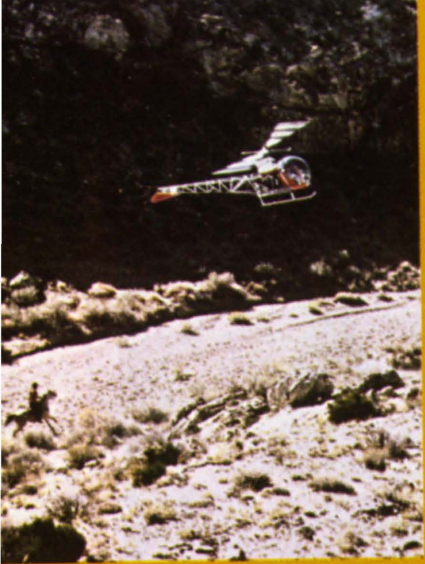
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# THE WILD HORSE LAWS\*

E. BRUCE GODFREY

Thunderhead, My Friend Flicka, and Wild Horse Annie represent popular symbols associated with wild horses and their role in the West. Few other animals have captured the heart of so many Americans to the same degree. As a result, stories which indicate that any wild horse has been abused or mistreated invoke strong emotions from some people. Historically, however, individuals have abused wild horses or burros in any way they saw fit. The animals were used as "war ponies" by the American Indian and the U.S. Cavalry and later as plow ponies. As a result, their value was tied to what they did toward the discovery and development of the West.

\* This represents a summary of a study conducted for and supported by the Forest Service, which was designed to evaluate the economic problems with Wild and Free-roaming Horse and Burro management.



# HAS THE SOLUTION BECOME THE PROBLEM ?

Later, as agriculture mechanized, the numbers of domestic and wild horses decreased drastically and many were slaughtered for various uses. Eventually, the romantic aura spun around wild horses led to two major wild horse acts, Public laws 86-234 and 92-195. These laws, passed in 1959 and 1971, respectively, were supposed to "save" the wild horse from destruction. Provisions of the laws included:

- 1) No motorized vehicles or planes could be used to round up or harass any Wild or Free-roaming Horse or Burro (WFHB).
- 2) All WFHB that use public lands are to be administered by the Forest Service (FS) and Bureau of Land Management (BLM).
- 3) Excess numbers can be destroyed in a "humane manner" or "captured and removed for private maintenance under humane conditions and care."
- 4) No WFHB nor any part thereof can be sold for any consideration.
- 5) WFHB using privately owned lands can be removed by personnel of the responsible agency if requested by the private landowner.
- 6) Private citizens may not:
  - a. remove or attempt to remove WFHB from public lands.
  - b. convert WFHB to private use without authority.
  - c. maliciously cause the death or harassment of any WFHB.
  - d. process or permit any WFHB to be processed into any commercial product.

e. sell any WFHB that are held under private maintenance.

7) No WFHB are to be relocated to areas where they did not exist when the law was passed in 1971.

These laws had a dramatic impact on populations of WFHB. For example, the BLM estimated that only 17,000 wild horses or burros were using federal lands when public law 92-195 was passed in 1971. By 1974, however, the BLM and FS estimated that 44,000 wild horses and 14,000 wild burros were using western public lands. By 1976 there were an estimated 50,000 wild horses using BLM lands in the West.<sup>1</sup> Such numbers presented a difficult problem for land managers who were also charged to "...achieve and maintain a thriving natural ecological balance on the public lands...in an effort to...protect the natural ecological balance of all wildlife species..." These managers had the following options available: (1) continue to let the populations grow and "let nature take its course" or (2) reduce populations in some way.<sup>2</sup> The first alternative is generally not viable for several reasons. First, WFHB have the ability, like all biological species, to reproduce beyond the capability of the resources upon which they depend. This results in starvation and overgrazing.<sup>3</sup> Secondly, many herds expanded and began to compete with other species such as domestic livestock and wildlife. Then state fish and game departments and livestock

producers pressed for reductions in WFHB populations. Thirdly, these animals began to take approximately 12 percent of their feed from private lands (Figures 1 and 2), although more than 75 percent still comes from lands administered by the BLM.<sup>4</sup>

As a result of the preceding conflicts, BLM and FS personnel started to conduct roundups in 1976 and 1977.<sup>5</sup> This decision was popular with groups such as livestock organizations and state fish and game departments,<sup>6</sup> but presented agency personnel with new problems. For example, agency personnel have often been criticized for and stopped from reducing the size of a particular population. For example, the Park Service personnel have recently proposed to shoot most of the burros using Grand Canyon National Park. This proposal has generated considerable controversy but few alternatives exist as the costs of removal are nearly prohibitive.

Even after approval for conducting a roundup is obtained, agency personnel may find that their problems have only begun. The wild horse laws have severely limited the actions that can be undertaken. For example, when most of the early roundups proved to be extremely expensive,<sup>7</sup> congress amended the laws in 1978 and allowed the use of motor vehicles for capturing and transporting WFHB. This change allowed more animals to be captured but left disposal mechanisms undefined. The resultant "adopt-a-

<sup>1</sup> These population estimates are commonly questioned by groups favoring WFHB management. Recent population estimates, however, are generally felt to be fairly accurate. If they are acceptable estimates, it is likely that the number of WFHB that existed prior to 1971 were probably much larger than most people suspected and it is generally conceded, except by the most ardent WFHB advocates, that WFHB populations have increased dramatically since 1971.

<sup>2</sup> More than 28,000 horses and burros were claimed as being feral and were subsequently captured by private owners between 1971 and 1976.

<sup>3</sup> One roundup which the author observed in southwestern Utah involved horses that were generally in very poor condition (pictures). This herd was traveling approximately 10 miles to water each day. As a result, many were weak and would probably have not survived this past winter. The poor condition of these animals caused most observers (e.g. potential adopters and the author's teenage daughter) to see the need for action which would reduce the suffering of these animals.

<sup>4</sup> This utilization pattern raises several interesting questions. The Dugway Proving Grounds, for example, rounded up 95 and sold 90 head of horses in 1977 as "army surplus" property. The remaining animals in the area were judged to use neighboring BLM lands and therefore had to be administered by other federal agencies. There is therefore a strong incentive to shift WFHB problems to another federal agency for solution. Furthermore, WFHB that use private lands are being supported by individuals, primarily ranchers, who receive little if any benefit from their existence and may eliminate other uses on these lands.



horse/burro" program has been plagued by its own set of problems.

First, most prospective adopters want female horses, but the capture ratio of males to females is nearly even. For example, of the 13,650 people interested in wild horses in September 1978, nearly 75 percent requested females.<sup>8</sup> Further, most applicants prefer relatively young animals (Tables 1 and 2) while a high proportion of captured animals is much older. While the provisions found in the Rangeland Improvement Act of 1978 could change these trends (WFHB can become private property after a year) disposing of older male animals will probably continue to be difficult.<sup>9</sup>

Second, only about 10 percent of the applicants actually come to pick up a horse or burro, and each adopter normally is allowed no more than four animals.<sup>10</sup>

What happens to the animals that are adopted is cause for concern among agency personnel as well as other individuals. The news media, when publicizing abuses of the law (ABC news, 20/20, January 8, 1979) have generally not explained that agency personnel have limited ability to enforce the laws.

Some have questioned whether the adoption program can place all of WFHB that are being captured. However, as of 26 February 1979; 7,469 applications were being held by the BLM for 2,219 burros and 18,990 horses. While many (90%?) may not

pick up an animal, a new possibility of private ownership after a year may lessen this percentage. Adoption can not be viewed, however, as a never-ending way to place WFHB. Furthermore, it is not known whether adopters have been satisfied with their WFHB once they obtained possession.

Perhaps the most obvious economic impact of WFHB management is on the budgets of the federal land management agencies. While some would argue that WFHB management is a relatively inexpensive program, the data provided by the BLM and FS indicate otherwise. For example, 45 BLM districts and FS forests indicated that they spent \$470,000 in 1976, \$719,000 in 1977, and \$612,000 in 1978 on WFHB programs. These figures exclude all roundup and adoption costs and expenditures for the supervision of WFHB programs. Additionally, more than 1,000 man months of time were invested nationally by BLM employees in solving WFHB problems. This cost nearly 1.7 million dollars during fiscal year 1978, exceeded the 1.4 million dollars spent on rounding up and adopting out the approximately 6,500 head of WFHB captured in 1978.<sup>11</sup>

These overall costs, however, can be misleading since the numbers of WFHB vary widely among states (Figure 3). For example, nearly 79 percent of the burros managed by the BLM are located in Arizona, California, and southern Nevada.

Differences also exist between the agencies involved. For example, the BLM administers nearly 18 times as many horses and nearly 22 times as many burros as does the FS. While wild horses exist in other places, the problems are particularly acute for BLM districts within the Great Basin and western Wyoming.

Large differences also exist in the roundup and adoption costs of the agencies that collected wild horses and burros. The roundup plus branding, vaccinations, identification, feed and care, transportation, veterinary expenses, and adoption procedures may result in expenditures of \$150 or more per animal captured.<sup>12</sup> Thus, it could easily cost the American taxpayer \$200 or more per animal just to place a WFHB with an acceptable adopter if all overhead (like supervision and maintenance) costs were ignored. Insuring that adopters treated the animals in a lawful manner would further add to the total. While complete data are not available, BLM personnel indicated that they spent about \$450 per animal adopted in 1978. This probably represents a reasonable estimate of the direct cost borne by taxpayers to place a WFHB under private maintenance. This also represents a major budgetary expense that can be questioned during a period when taxes needed to support government are being limited and evaluated.

As large as the above costs may seem to some people, they do not really represent the *total* costs of

<sup>5</sup> Very few agency roundups were conducted before 1977.

<sup>6</sup> Livestock organizations and state fish and game departments were the most commonly listed organizations by agency personnel as favoring reductions in WFHB while some organizations oppose any roundups in favor of letting "nature take its course."

<sup>7</sup> Capture costs of over \$1,000 per animal were not uncommon.

<sup>8</sup> As of 13 September 1978; 9,794 horses and 943 burros had been adopted through the BLM program by 3,900 individuals (3,384 people adopted horses).

<sup>9</sup> Most of these animals are mature jacks or stallions which cannot be broken or domesticated. Data from several districts indicate that a large portion of the animals destroyed or killed by agency personnel are a result of their being undesirable.

<sup>10</sup> The maximum number has changed over time. An unknown number of adopters have obtained more animals than the maximum number specified. For example, one adopter obtained 160 head and another took 104 head from the Rock Springs district and shipped them to Missouri in 1977.

<sup>11</sup> Similar costs are not available for the FS but it is likely that they did not spend as much as did the BLM as they did not roundup or manage as many WFHB.

<sup>12</sup> These costs would increase if supervisory costs borne by the agencies were also included.



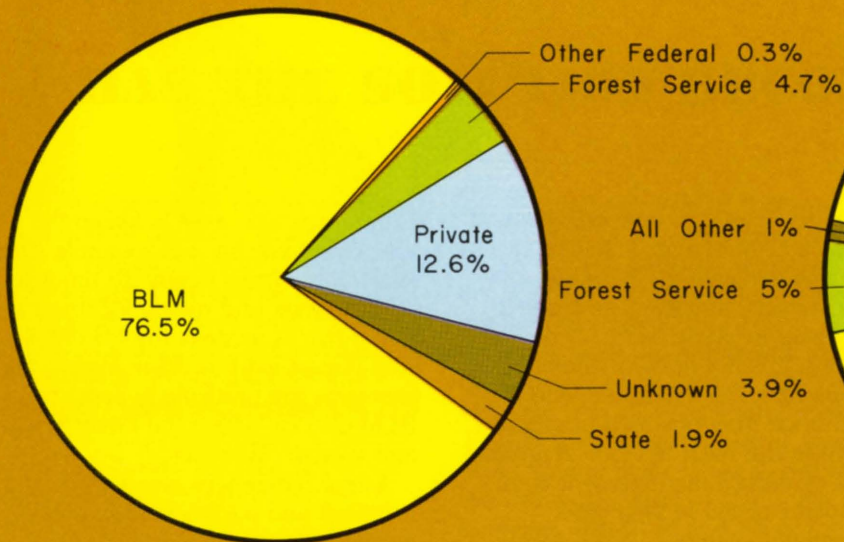


Figure 1. Percentage of feed obtained by wild & free-roaming horses by ownership class, 1978.

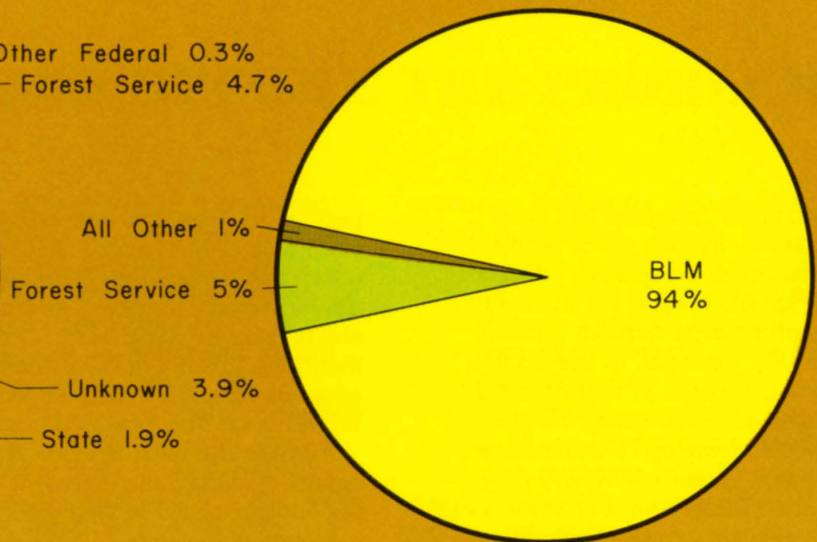
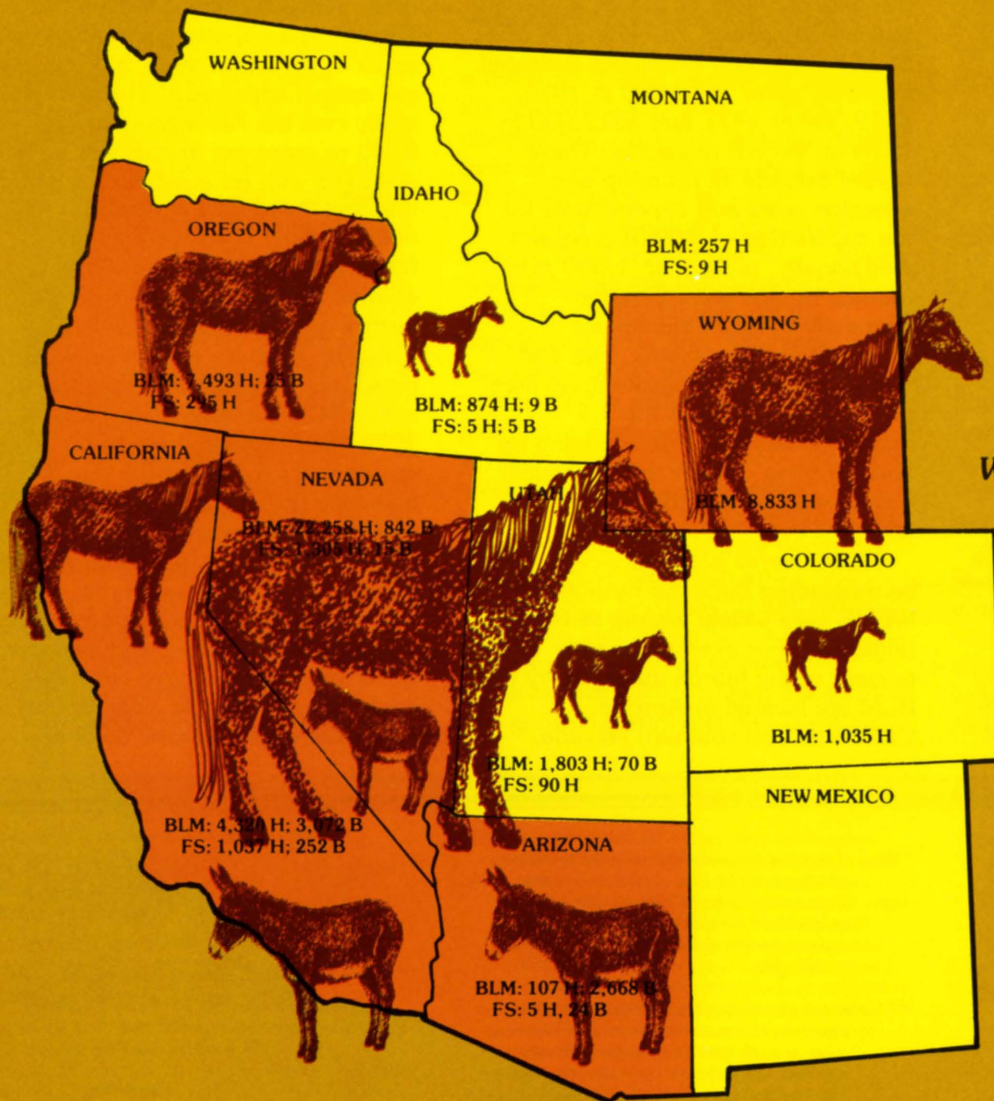


Figure 2. Percentage of feed obtained by wild & free-roaming burros by ownership class, 1978.



*Wild oats from Congress;  
an expensive harvest  
for all.*

Figure 3. Number of Wild and Free-roaming Horses(H) and Burros(B) located in each state by agency, 1976. Source: second FS/BLM report to Congress.



WFHB management. Of perhaps as great importance, are the costs borne by other uses or user groups that result from maintaining WFHB populations. Some of these include decreased grazing by domestic livestock and wildlife; increased siltation of streams; increased maintenance of springs, fences, and other improvements; and manure in camping areas.

Some people would question the preceding costs as money spent on lives of little or no value. Others will claim that WFHB have high value. *So what is a wild horse or burro really worth?* Some values possibly associated with WFHB include: sightseeing; photography; objects of scientific research; domestication for riding, showing, or breeding. Furthermore, they could, if the law were changed, be used as rodeo stock, pack animals, or be made into various

products for pet or human consumption. In addition, they have value as part of western folklore. The information (Table 3) gathered from agencies that have auctioned wild horses or burros to the highest bidder should not be viewed as representing the total value of a WFHB, but the receipts obtained by these agencies from the sale of excess wild horses or burros have rarely covered capture costs.<sup>13</sup> The data further indicate that people who adopt WFHB probably receive a large subsidy. At the current demand for horsemeat, the potential thus exists for substantial profits to be made. For example, horses weighing 1,000 pounds or more currently bring 40 to 50 cents per pound, when sold for conversion to commercial products. Illegal roundups could be attractive, therefore, as capture and transportation costs would probably be less than \$200 per animal, which could

mean a net return per animal of \$200 or more. Animals obtained from the BLM or FS by adopters could, however, yield net returns of \$300 or more as the federal taxpayer pays capture costs. These net return figures also indicate that if the laws and regulations governing the management of WFHB were changed, the government may be able to offer permits to capture WFHB at competitive bids and realize return to the federal treasury. Such action, however, would change the distribution (who benefits and who pays) of the benefits and costs of WFHB management, a distribution about which much remains unknown.

These unknown factors suggest that research is needed to assist federal land managers and the American people to better evaluate the role of WFHB as users of America's public lands.

**Table 1. Number of horses desired for adoption by sex and age class, 29 September 1978, BLM adopt-a-horse program.**

Age	Males		Females	
	Minimum	Maximum	Minimum	Maximum
0	1150	27	2759	55
1	943	267	2564	601
2	737	544	2487	1148
3	223	470	1338	1280
4	346	441	694	945
5	30	402	138	1285
6	102	190	130	765
7	3	54	2	449
8	2	241	0	845
9	1	33	1	266
10		324		901
11		3		44
12		85		288
Over 12		456		1240
Total	3537	3537	10113	10113

**Table 2. Number of burros desired for adoption by sex and age class, 29 September, 1978, BLM adopt-a-burro program.**

Age	Males		Females	
	Minimum	Maximum	Minimum	Maximum
0	467	19	1095	50
1	197	123	370	260
2	84	133	140	281
3	39	84	77	200
4	12	85	26	134
5	3	89	8	170
6	6	39	9	92
7 and over	6	242	13	551
Total	814	814	1738	1738

**Table 3. Sales of Wild horses or burros by agencies not subject to the WFHB Acts.**

Animal	Agency	Average selling price	date/location	
Horses	Defense Depart.	\$ 87.77	Utah	1977
Horses	Fish & Wildlife Ser.	132.20	Calif.	1978
Horses	Fish & Wildlife Ser.	172.42	Calif.	1978
Horses	Fish & Wildlife Ser.	207.00	Calif.	1979
Burros	Park Service	11.00	Ariz.	1977

<sup>13</sup> For example, the Park Service spent more than \$1,200 per animal rounding up burros which were subsequently sold to the highest bidder. These burros were sold for \$11 per head, which represented less than one percent of the costs of their capture.

<sup>14</sup> This response will probably vary by age, sex, and type of animal adopted.



# IS THERE A REAL SOLUTION ?

Most of the research that has been advocated by others (e.g. see Artz 1977) is ecological, and must precede any economic evaluation of the WFHB problem. However, a large portion of the work advocated by others will not answer the two basic questions faced by agency personnel: *How many WFHB can be justifiably maintained and how can these numbers be most efficiently managed?* The following presents some of the major socio-economic questions that need to be answered before such issues can be resolved.

## Demands for WFHB

Opinions vary widely as to the value of and demand for WFHB. Research could define their values as:

domesticated animals (riding, breeding stock, rodeo, etc.), for use in commercial products, and part of the natural ecosystem (option, research, and aesthetic values). There is also need to evaluate the uses of horse-meat for which the original acts were passed—i.e. What portion of the horses killed are actually used in pet foods, for human consumption, etc.? Were the WFHB acts passed to eliminate practices which do not, in fact, occur?

## Adoption procedures and success

The current regulations and laws governing the use of adopted WFHB place stringent restrictions on potential adopters. Furthermore, existing economic incentives could lead some people to break the law. It is known that some people have ignored these restrictions. The adoption procedures, therefore, need to be objectively evaluated. How many of the animals that have been adopted to date are currently retained<sup>14</sup> by original adopters and how many have been given away, sold, or destroyed? What is the potential for increased use of the adoption procedures under existing or altered laws and regulations? What subsidies, if any, do adopters obtain?

## Control techniques

As the data in the cost section above indicate, WFHB roundups differ largely in costs. Research could identify how these costs might be minimized. There is also a need to evaluate the cost, effectiveness, and impact of techniques that can be used to control populations of WFHB.

## Maintenance of populations

Any of several methods could be used to identify the optimum number of WFHB. These alternatives include:

the establishment of WFHB reserves and management areas, creation of new WFHB ranges, eliminating populations in some areas and various other combinations. Each of these would have differing impacts and costs that need to be economically evaluated. For example, given the capture costs incurred and other values such as livestock grazing which may be foregone in some areas it may be better to eliminate WFHB populations in some areas while fostering herds in other areas.

## Legal restrictions

Investigation and evaluation of the costs of the existing restrictions are sorely needed. Questions that might be addressed include:

1) Does the legal restriction which does not allow WFHB to be used for "commercial" purposes result in the killing or use of animals such as domestic horses, cattle, or other animals that are more valuable? Need all WFHB be eliminated from being used for commercial products? Why? What are the consequences of these restrictions on the use of other animals?

2) What is the potential for selling wrangling permits in lieu of government conducted roundups?

3) What would be the demand for WFHB if restrictions concerning commercial uses were lifted?

4) What will be the impact of allowing "private ownership" on the demand for and use of adopted WFHB? Is the net effect the same as if no restrictions were in existence?

5) What is the potential for selling excess animals by the government or by licensed wranglers to possible adopters?

Research on these topics would probably have substantial impact on WFHB management. There are reasons why the capture and use of WFHB need to be controlled but it is not obvious that the present laws result in efficient or equitable solutions.

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## ABOUT THE AUTHOR

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# MUNICIPAL WATER USE

ROGER D. HANSEN

HERBERT H. FULLERTON

TREVOR C. HUGHES

Utah's population is currently increasing at the sixth fastest rate among states in the U.S. The state's oil shale, tar sands, and coal deposits are increasingly exploited and as steam-powered electrical generation facilities continue to be constructed, competition for Utah's limited water supply will intensify. Such competition would be important to all classes of users, including municipalities.

Over 450 public and private systems supply water to residential customers in Utah. The Utah Water Research Laboratory, in a cooperative effort with the Utah League of Cities and Towns and the Utah State Bureau of Environmental Health and the Utah Divisions of Water Rights and Water Resources, and funded by the Bureau of Reclamation, recently inventoried

the water usage patterns of Utah's major municipal water systems.<sup>1,2</sup> This is the first such inventory since 1960.<sup>3</sup>

The data collected provide insights into both cross-sectional variations in municipal water use and historic trends. This article will discuss water usage in 50 of Utah's largest municipal systems (Figure 1). It includes estimates of per capita use rates, and a discussion of water use determinants and future water use rates. The 50 systems serve a combined population of 877,000 (75 percent of Utah's total population).

## Per capita use rates

Municipal, defined for the purposes of this article, includes water supplied by public systems for residential,

commercial, and industrial customers. The water may be used for fire protection, street flushing, irrigation of lawns and gardens, public institutions, domestic purposes, or may be lost through leakage in the distribution system.

The common unit for reporting municipal water usage is gallons per capita per day (gcd). This unit is arrived at by dividing the total quantity of water withdrawn by a municipal system for a given time period by the population served and by the length of the time period in days. The metric unit is cubic meters per capita per day (m<sup>3</sup>cd).

Municipal water usage in Utah amounts to 115 billion gallons per year (average of 1974, 1975, and 1976), which reflects a statewide



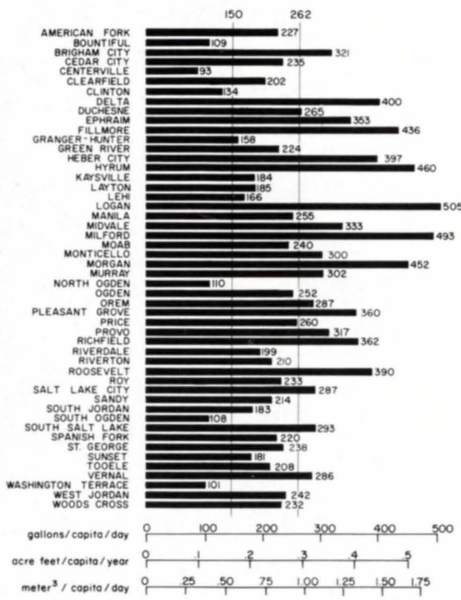


Figure 1. Per capita water use (gcd) for 50 Utah municipal systems (average of 1974, 1975, and 1976); the vertical lines represent the national (150) and state (262) per capita use rates

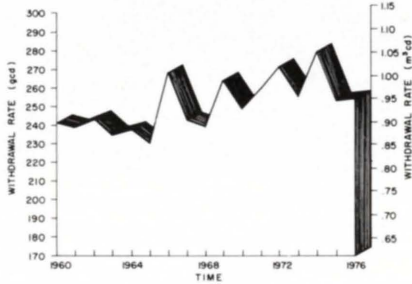


Figure 2. Yearly per capita water use rates for Utah

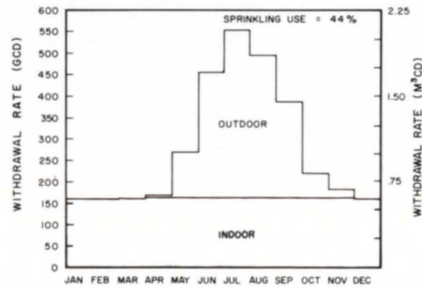


Figure 3. Monthly per capita water use rates for Salt Lake City (average of 1974, 1975, and 1976)

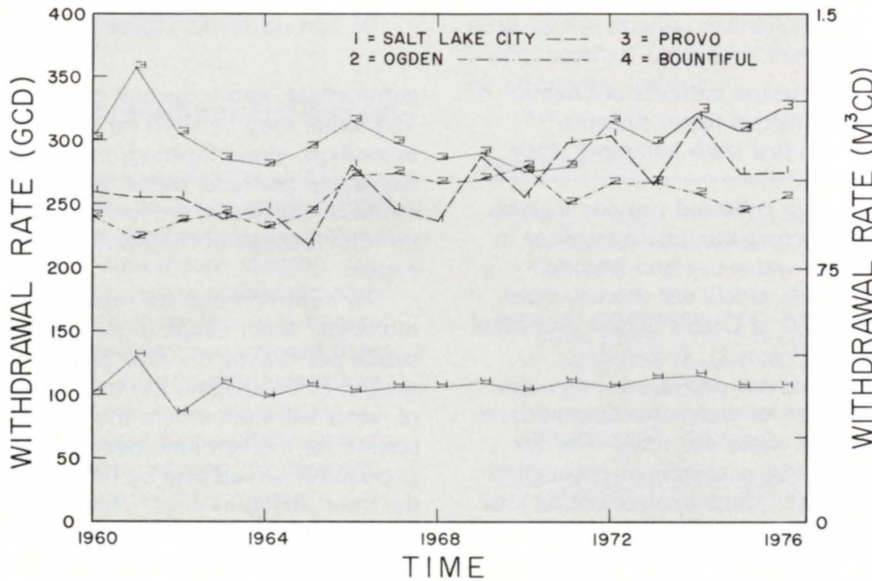


Figure 4. Yearly per capita water use rates for four Utah municipal systems  
Charts and graphs done by Susan Bissland of the Utah Water Research Laboratory

average use rate of 262 gcd or 1.0 m<sup>3</sup>cd. Per capita usage since 1960 has increased 1.5 gallons per year (see Figure 2). Utah has a considerably higher use rate than the national average of 150 gcd (0.6 m<sup>3</sup>cd). One of the principal reasons for this high-use rate in Utah is summer lawn and garden watering, as illustrated in Figure 3. If one ignores the small increase in indoor use during the summer (as in Figure 3), Salt Lake City is estimated to use 44 percent of its municipal water for lawn sprinkling and garden watering on an annual basis. However, this figure increases to 71 percent during the month of July.

As the data in Figure 1 indicate, Delta, Fillmore, Hyrum, Logan, Milford, and Morgan all have comparatively high (over 400 gcd or 1.5m<sup>3</sup>cd) use rates, while Bountiful, Centerville, North Ogden, South Ogden, and Washington Terrace have low per capita rates. The people who draw upon the latter systems are also served by separate pressure irrigation systems. Thus outdoor usage is not reflected in per capita use rates.

The per capita use rates for small municipal systems can be misleading, however. As an example, consider our data for Amalga, a small rural community in Cache County with a population of 210. Amalga's average per capita water use rate of 1680 gcd (6.3 m<sup>3</sup>cd) appears extremely large. The town, however, contains a large cheese manufacturing plant, which uses approximately 70 percent of the municipal water. Also, several of Amalga's residents operate large dairy herds. Cows, in fact, far outnumber the town's human inhabitants. The Holsteins drink culinary water and the milking facilities are cleaned with town water. In general, the dairy operations use 57 gallons (.2 m<sup>3</sup>) of water per cow per day. Amalga's unique characteristics make its apparently excessive water use rate understandable. Obviously, care must be taken in interpreting per capita use rates.

### Determinants of water use

Among the factors that affect per capita use rates are: size of residential lots,<sup>4</sup> the amount and type of fees paid by customers,<sup>5</sup> and availability of a separate source of irrigation water.<sup>6</sup>



The type of industrial firms and agricultural establishments using municipal water are also relevant.

An important, noneconomic determinant of municipal water use is population density. For example, three people living in a house situated on a one-acre lot (4000 m<sup>2</sup>) use more water than three living in a house on one-half acre (2000 m<sup>2</sup>). In the house on either lot each person uses a given amount indoors plus one-third the water used outdoors, which will be less on the one-half acre lot (assuming similar landscaping).

Just how vitally the cost of water to the residential customer affects usage has been a matter for much discussion in the literature. Indoor water use is generally regarded as less sensitive to price than is outdoor use.<sup>7</sup> Our results indicate that a 10.0 percent increase in the cost of water can result in a 5.2 percent decrease in water use. Thus, price can be used to encourage conservation as well as to generate revenue.

### Future water use rates

When projecting future municipal water needs, a growth trend is commonly assumed for per capita demands. Figure 2 indicates that use rates in the state as a whole have increased between 1960 and 1976. It seems unlikely, however, that this increasing trend will continue. Per capita water usage in Utah's urban areas has stabilized at between 250 gcd (.9 m<sup>3</sup>cd) and 300 gcd (1.1 m<sup>3</sup>cd) for areas without separate pressure irrigation systems (Salt Lake City, Ogden, and Provo) and at 110 gcd (0.4 m<sup>3</sup>cd) for areas with separate outdoor irrigation systems (see Figure 4).

Water costs to individual customers in Utah are currently increasing and will continue to increase. Previously "free" quantities of water from springs are no longer adequate for many communities and their supplementary water, which must be pumped, transported, and/or treated, will cost more. It is definitely inappropriate to project future water usage using per capita figures (current or past) based on less expensive water. Future per capita water use rates will be lower because the cost of water will be higher.

The same higher costs will also make it impractical for municipalities to permit the large amounts of leakage that are common today. In the future, economic realities will dictate that leakage losses be drastically restricted.

Lot sizes in Utah, on the average, decrease as more residents inhabit multiple-family dwelling units and mobile homes. This trend (and its associated lowering of per capita water use) will be encouraged by rapid increases in the value of land and inflating construction costs.

While it is impossible to predict future national, regional, and state policies, the emphasis on conservation is likely to increase. The Carter administration, for example, has proposed legislation that could encourage municipalities to cut their current water use by 15 percent. In light of Utah's experience during the recent drought, the 15 percent figure does not seem unrealistic. In fact, as is shown in Figure 1, many communities are using remarkably large quantities of water, perhaps more than is actually needed.

Some long-term per capita reductions in indoor water use can be realized through improvements in internal plumbing. The California Department of Water Resources concluded that the replacement of inefficient toilets, washing machines, and showerheads can reduce indoor water usage by 6 to 12 percent.<sup>8</sup> However, it is the outdoor component of water use which can most easily be reduced. As was demonstrated during the 1977 drought, lawns and gardens can thrive with less water. The drought-induced restrictions on outdoor lawn watering resulted in substantial reductions in per capita water usage.

### Summary and conclusions

Utahns use considerably more water, on a per capita basis, than the national average. This is explained to some extent by Utah's semi-arid climate and the watering requirements of lawns and gardens. If the price of water increases and the average size of residential lots decreases, per capita water usage in Utah can be expected to decline. Municipal systems which now accept excessive losses in their distribution systems will probably

choose to reduce leakage rather than develop new supplies. It seems inappropriate, therefore, for planners to include a growth rate in per capita demands.

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# TRACTOR UPDATE

Be prepared for  
future fuel shortages  
with more efficient  
farm machinery.





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There is a man at Utah State University earning national acclaim as a traveling tractor doctor. Using his trailer mounted dynamometer, Von H. Jarrett, Associate Professor of Agricultural and Irrigation Engineering, estimates that he has upgraded the performance of approximately 1,000 Utah tractors in the past several years. Just as (or perhaps more) important, however, has been his upgrading of each tractor owner's ability to care for his intricate machine.

If you become exasperated when the complexity of your \$7,000 car defeats your ambition to save a little money by fixing it yourself, and you can't find anyone else who'll do a competent job—consider the plight of a farmer or rancher contemplating an ailing tractor. His machine cost a minimum of between \$15,000 and \$30,000, and skilled, reliable tractor mechanics are harder to find in Utah than their auto-specializing counterparts. Because each of the 87 types of U.S. tractors has its own peculiarities, a mechanic who uses a rule-of-thumb approach, even to maintenance servicing, can be a hazard.

With the Utah State Energy Office picking up part of the expense of his unique program, Jarrett works largely through county Extension agents. Each agent schedules presentations for key community areas in his county. Jarrett and his dynamometer then arrive on the scene prepared for a two-installment session.

The first meeting, generally in the evening, is devoted to helping class participants achieve a better un-

derstanding of the idiosyncracies of diesel engines. During that 3- to 4-hour class period, Jarrett says he covers such topics as, "What the operator can and should do to keep his tractor in optimum running condition; importance of selecting, storing, and maintaining diesel fuel; lubrication needs; servicing of filters; and the fuel system. The goal, of course, is increased efficiency and subsequent energy and dollar savings. In the class, I rely on slides and other visual aids to demonstrate the principles of diesel engine operation and how to keep the various kinds of tractor units in optimum working order."

When asked about the dollar value of his tractor-testing efforts as an Extension Agricultural Engineer, Jarrett answered, "Every tractor horsepower I can gain for a farmer is worth about \$230 these days. When he buys a tractor in the first place, the farmer is buying horsepower. But, over time, the machine inevitably declines in efficiency. The cause can range from inadequate servicing to fuel that hasn't been maintained at peak quality. As the available horsepower falls off, so do fuel economy and general performance."

It is during the second installment of his two-session program that Jarrett actually salvages horsepower for individual tractor owners. In his words, "The dynamometer I'm using is essential to modern troubleshooting techniques in diagnosing engine malfunctions. It is a remarkable instrument for measuring mechanical force. Besides allowing me to put a stationary tractor under a heavy load,

it gives me absolutely precise rpm readings. The dynamometer is a major reason why I've been able to average an improvement of over 20 horsepower per tractor."

But despite his dynamometer, Jarrett's work on each tractor seems, to the casual observer, to have elements of art as well as science, coupled with old-fashioned, indispensable experience. (No one can so consistently interpret a diesel's exhaust system with reliable accuracy unless they've had years of practice.) Nor has the dynamometer been of use in the classroom, where the tractor owners get the information they need for the months when Jarrett is elsewhere.

Farmer interest in the tractor clinics has been high ever since they began in 1977, perhaps catalyzed by steadily inflating prices for fuel and for tractors. The individual farmer obviously can't have access to a dynamometer every time he finds himself having to shift down a gear more than usual to get a job done. But he can postpone that day of power drop-off. All he needs is to apply the up-keep techniques that Jarrett teaches.

In February of this year, Allis Chalmers (A. C.) honored Von Jarrett for his unique work as a traveling tractor doctor. The company had made a film of his program in 1978. That film was designed to show A. C. dealers an example of how to optimize long-term satisfaction among their tractor buyers. So Jarrett's approach to helping farmers save energy and overall tractor costs will soon be moving beyond Utah's borders.



# PROJECTS IN PROGRESS

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## A ROOT-ROT RIDDLE

### The Target:

A fungus that attacks the roots of bean plants and is a suspected cause of drastic yield reductions.

### The Problem:

Defining precisely what the fungus does to its victims, its life requirements, and potential ways to control it.

### The Solution Seekers:

In Colorado, researchers are trying to breed fungus-resistant bean plants. At USU, Neal Van Alfen (Associate Professor of Biology), George Welkie (Associate Professor of Biology), and Paul Dryden (graduate student) are working with farmers in southeastern Utah who rotate pinto beans with their dryland wheat crops. Their first goal is to learn as much as possible about how the fungus operates.

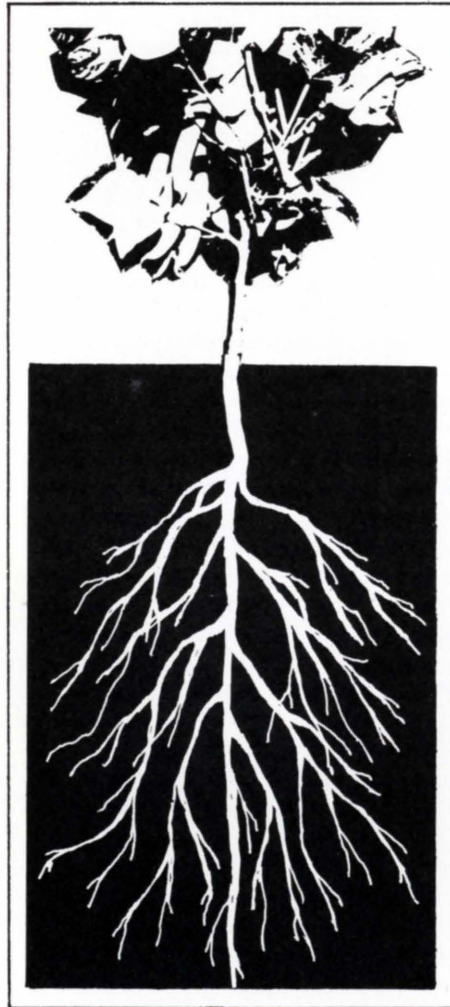
As Van Alfen pointed out, "The information we have about bean root rot contains about equal amounts of folklore and data-based details. To better that ratio, Welkie and Dryden are initially doing some basic studies."

When asked for specifics, Van Alfen replied, "We are trying to identify exactly what variety of *Fusarium* fungus is the culprit. Then we plan to evaluate its virulence.

"At the same time, we're checking on whether fungus populations vary with soil types and depths. If they do, that could affect what management procedures might be used as controls.

"But before we can hope to develop practical control recommendations, we have to know where and how the fungus damages bean plants. There is a chance," he continued, "that lowered yields are due as much to stresses inherent in dryland farming as to the fungus."

For now, the researchers are combining field and laboratory efforts with surveys of Utah's pinto bean growers to try to decide whether cropping patterns and rotations seem to limit or enhance the fungus. The final results, although based on Utah conditions, could be useful to growers in Washington, Idaho, New Mexico, Colorado, and California, whose bean crops are also host to the root rot fungus.



## WHICH END IS UP?

If you were an *Osmia lignaria* bee, the answer to that question, and how fast you figured it out, could mean life or death. To a scientist such as Philip F. Torchio, a USDA collaborator, however, the intriguing question is why do these bees have that problem.

Torchio, who has been working with *O. lignaria* bees for several years, began his investigation because he had a hunch they could be persuaded to work as productive pollinators of orchard crops (apples, prunes, almonds). It was only as he gained familiarity with their private lives that he recognized the directional confusion that was killing some *O. lignaria* bees before they could emerge from their nests.

On the pollinating front, the bees perform exceedingly well. It has been possible to time their brief (2 to 4 weeks) life span to match tree bloom periods and thus avoid insecticide applications, which have decimated so many colonies of honey bees. But even as his field surveys were confirming their likely value as orchard pollinators, Torchio's laboratory work was showing him that the *O. lignaria* bees had some perplexing biological habits.

"For example," Torchio said, "as I first glanced at the data I'd gathered about their nesting patterns, it looked as if they were promoting their own extinction as a species."

As Torchio explained it, the *O. lignaria* are among those bees who nest opportunistically in nature. In other words, the females will nest wherever they find ready-made holes of acceptably small diameters (7/32 to 9/32 inch). (Their need for pre-formed holes as nest sites makes them amenable to accepting man-made nesting facilities, and thus to management as pollinators.) Under natural conditions, the bees favor dead



trees with beetle-bored holes. Lacking that ideal, the female may construct her nest cells in cracks or holes in rocks or exposed vertical soil embankments.

In either case, individual cells are normally built in a linear series. Each cell is provisioned with pollen that has an egg deposited on its surface. Within a week of being laid, the egg produces a larva that develops (over several months) through several stages, ending with transformation into a male or female *O. lignaria*. Each "new born" adult must then make its way into the world by breaking out of its larva-spun cocoon, with male-occupied cells characteristically positioned so that the males emerge one to three days before the females.

"And that", said Torchio, "is when life for the bee can become elusive. From the start of the study, I saw numbers of cocoons with their naturally defined point of egress turned away from the nest entrance. After a while, I was able to see that

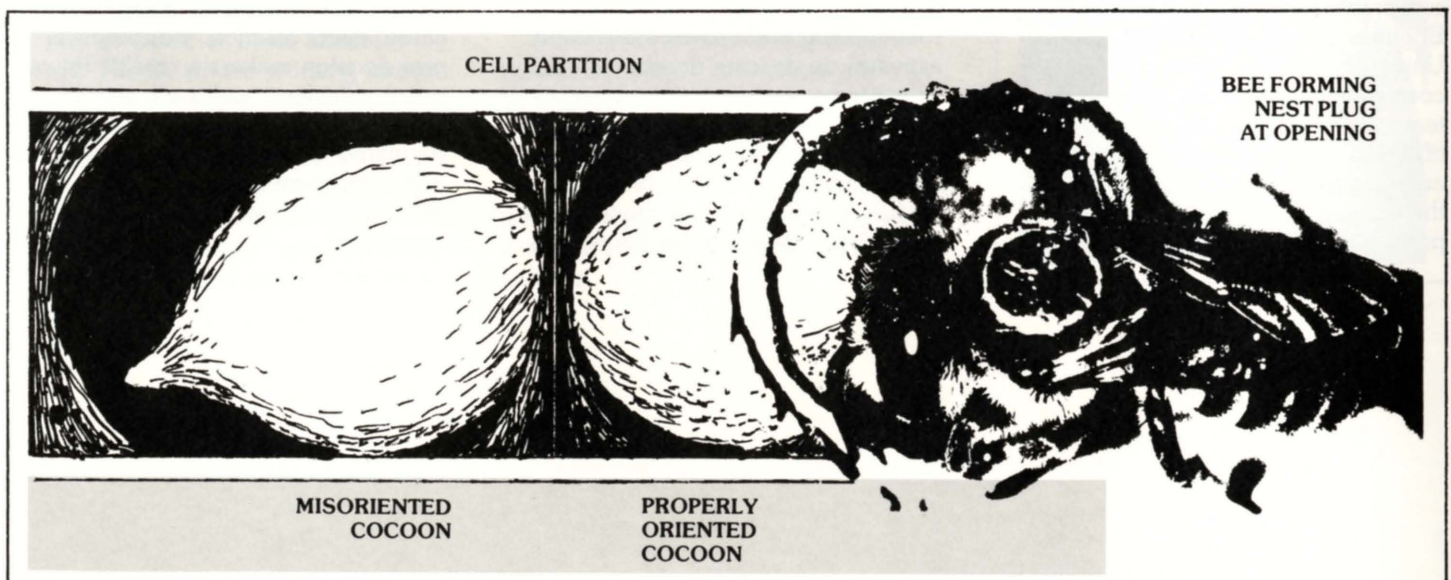
several factors were relevant to such misdirection: the orientation of the nests relative to gravity, the diameter of the nesting holes, and the sex of the trying-to-emerge bee.

"A couple of the most interesting—and problematical—points," continued Torchio, "were that, the smaller the diameter of the nesting hole, the fewer the misdirected cells, and the more preponderant were the males. Conversely, the larger (9/32 vs 7/32 inch) diameter holes contained both more females and more misdirected cocoons. Overall, though, the misdirected cocoons most often contained male bees."

In further conversation, Torchio indicated that females who nested early in the season were associated with proportionally more emerging females per nest and fewer misdirected cocoons than were late-season nesters. The relationship between numbers of misdirected cocoons and male vs female occupancy thereof proved to be relevant because male *O. lignaria*

are considerably smaller than females. So, the male that happens to find itself headed the wrong way has at least a fair chance of being able to turn around and make his entrance into the world. It also seems that *O. lignaria* larvae are specifically programmed to direct the spinning of their cocoon's normal exit point opposite to gravity's pull, which would be advantageous with many naturally occurring holes.

Research into the biology and pollinator potentials of *Osmia lignaria* is far from concluded. But Torchio obviously found it reassuring to be able to say, "Now that I've had time to translate the nesting data I accumulated with man-made nest boxes to the bees' natural lifestyle, their nesting habits no longer cause me concern. They aren't, as I'd first feared, working against their own survival. Which, along with all their other attributes, should give them tremendous long-term value for orchardists."





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## SOOTHSAYING—THE SCIENTIFIC WAY

Finding the “just right” location for a home can be a problem for anyone. But when you are shopping with a power plant in mind, difficulties multiply faster than the proverbial rabbits. There are simply too many people to satisfy, along with a mass of economic/social/environmental trade-offs to consider. And the whole has to be done with an eye toward “iffy” future contingencies.

Then, too, it has happened, on occasion, that when emergency-generated time pressures are overlaid on such a complex situation, the public interest is neglected in the name of expediency. Logic implies that one way to lessen that risk is to indulge in pre-emergency investigations and thought. To some extent, an Energy Facility Siting Study being led by T.F. Glover (Professor of Economics) is dedicated to that proposition.

The study (which involves—besides Glover—W.C. Lewis, J.E. Keith, and H.H. Fullerton of the Economics Department, and G. Wooldridge of the Soils and Biometeorology Department) is part of a more comprehensive project in which Brigham Young University and University of Utah personnel are also cooperating. In essence, the USU team is doing a preliminary identification and evaluation of potential energy facility sites in Utah’s part of the Great Basin. Virtually all projections of demands for energy

forecast a spurring consumption in the western states. Since it is economically impractical to try to satisfy such demands on anything but a relatively local basis, Utah’s share of the Great Basin is a serious contender. Beyond that undisputed fact, however, lie far more questions than answers.

As Glover stated, “The USU team is looking at four general topics as we begin to either discard or retain particular sites on our list of possibles. One is the environmental implications, another involves the alternative energy technologies that might be best under certain circumstances. The third is an overall economic feasibility evaluation, in which we consider sources of, and transportation facilities for, the fuel needed by a plant. Along with those variables, we determine how its product would be delivered to points of consumption. Our fourth concern is with the availability of sufficient water, whether on a direct basis or through diversion from some existing use such as agriculture.”

The environmental implications being analyzed go beyond the usually thought of air quality, to the effects of roadbuilding and other construction activities on delicate desert ecosystems, and how the increased numbers of people living in a power plant area would modify its social/cultural as well as physical profile. Where and how much coal of a specified quality (sulfur content) is

located in Utah is another prime consideration when coal-fired power plants and their environmental impacts are in question.

“Obviously,” said Glover, “whether Utah ends up exporting power or coal, the major market will be the west coast, mostly California. The alternatives we are evaluating therefore have had to include shipping coal to any plants that might be built in California. In such a case, a choice would have to be made between Utah’s coal and what is being produced in Wyoming and New Mexico.

“In the geothermal (hot and/or exceptionally deep aquifers) field, one of Utah’s most promising locations is around Roosevelt Springs. Results of our work and of studies by engineers were so encouraging that plans are being made for the production of exportable amounts of electricity from that area’s geothermal resource.”

But as Glover hastened to make clear, the Roosevelt Springs situation is an exception. Few (if any) of the on-going site investigations are likely to produce an equally quick cause/effect reaction. But they will give decision makers a reliable list of practicable sites, with each one’s outstanding plus and minus features stipulated. And such a list could be an invaluable time saver as energy demands outpace existing production capacities.



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## HOW MUCH—FROM WHAT?

"We know we need it, we even know why we need it. The unanswered questions center around how much is enough, and what are our main sources?"

The "it" referred to by Joan Howe, a graduate student in the Department of Nutrition and Food Science, is pantothenic acid (p.a.). Nutritionists classify p.a. as a vitamin, and therefore essential to human health. One reason it is so essential is its work as a component of coenzyme A, a substance that helps give cells access to energy.

So why aren't more data available about pantothenic acid? Mostly for the practical reason that it has been inordinately difficult to measure. The complex, microbiological method that has been used since the 1940s, requires two enzymes, special growth media for the bacteria, and lots of patient, tedious pipeting and can take two days to produce results.

But in 1977, Bonita Wyse (Associate Professor of Nutrition and Food Science) perfected a radioimmunoassay that quickly (4 or 5 hours) and accurately determines the p.a. content of blood or other animal tissues. Howe, who is working under the direction of Wyse, began her research by checking whether the radioimmunoassay could be used with confidence to measure the p.a. in foods common to most American diets.

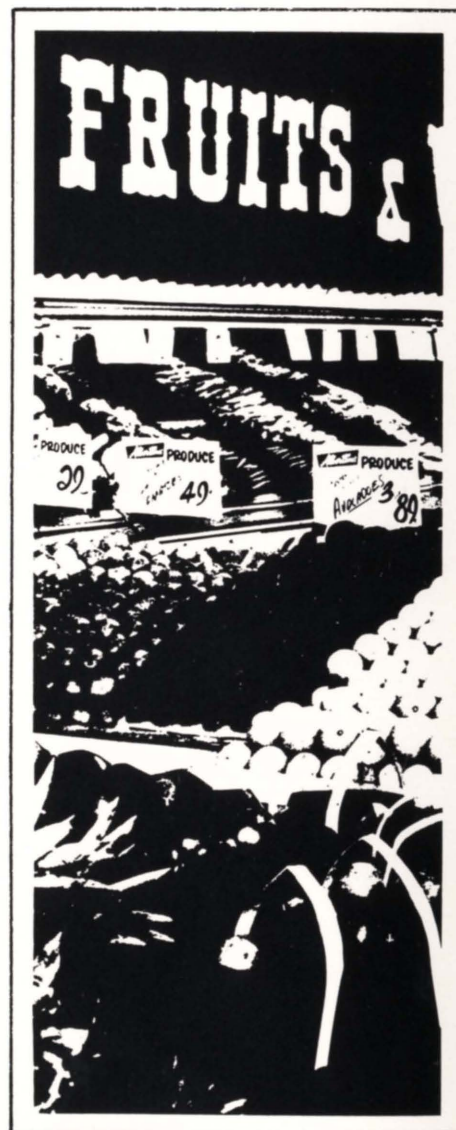
"Our ultimate goal," said Wyse, "is to contribute to the basis for stating a

pantothenic acid RDA (Recommended Dietary Allowance). To publish a meaningful RDA, however, the Food and Nutrition Board of the National Academy of Sciences has to have data on how much of the vitamin apparently healthy people obtain in their diets and store in their tissues. We are currently looking at the diet side of the problem."

When asked about the progress she had made so far, Howe replied, "Meals being served at Sunshine Terrace were analyzed using both of the assay methods. The results were in such remarkably close agreement that we believe the relatively simple radioimmune process definitely produces reliable p.a. values when applied to foods.

"With that question settled, I can concentrate on assaying my way through more than 100 foods—from cereals to mayonnaise and including frozen dinners and canned foods. Unless I run into unforeseeable problems with particular food items, we should have the data we want before this year is over."

Publication of the Howe/Wyse results, which will prove that p.a. can be assayed with relative ease, will probably encourage further research at other laboratories. For the consumer, that means access in the near future to an RDA statement about pantothenic acid and information about its likely sources.





# UTAH SCIENCE

Agricultural Experiment Station

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DIRECTOR

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