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Is It Meat?

D. G. Hendricks,
A. W. Mahoney, and
V. T. Mendenhall

The mechanical separation of flesh from bone was adopted years ago by the poultry industry as an efficient tool in producing turkey franks, turkey bologna, and similar meat-counter items, with a legal limit of 1 percent bone content in the finished product.

Then in 1975, the red meat (beef, pork, lamb) industry tried to obtain government approval for including mechanically deboned meat in diverse items. Their proposal called for a legal limit of .8 percent bone content in the finished product. Consumer groups moved to obstruct federal approval. They contended that such products would be (at best) adulterated and (at worst) dangerous.

The problem seems to be one of definition. Bone, to most consumers, means a hard, obviously indigestible substance. Those calculating percent bone in products made with mechanically deboned meats, however, are concerned with something very different. They work with the minerals, water, fat, and other materials that are squeezed out of the solid bones during deboning — not with bone fragments, chips, or slivers.

The bone components are in the paste that is produced by the

Figure 1. The coarsely ground bone-meat material is fed through the deboner sieve by a conical auger;

the edible portion is extruded through the sieve and the unedible portion is discarded through the apex of the sieve;

unedible deboned meat is on the left; the edible on the right is ready to be processed into turkey products.
deboning machine. And since meat itself contains virtually no calcium, while bone is 20 percent calcium, chemically analyzing a sample of the paste gives a valid indication of how much material extracted from bone is in the paste. Thus, both percent figures quoted above are actually based on the amount of calcium (rather than bone per se) that is in the finished product (Figure 1).

In both poultry and red meat processing, mechanical deboning constitutes an exceptionally efficient way to safely conserve high quality protein that is otherwise unavailable for human consumption. It also can be viewed as an alternative natural source of calcium for the many people who dislike or can't digest milk and milk products. Specifically, 58 g (3 oz) of mechanically deboned poultry (prior to incorporation into a consumer item) contains about as much calcium as 160 g (2/3 cup) of milk.

**What Does a Deboner Do?**

Before a mechanical deboner can be put to work, the whole or partial carcass(es) must be coarsely ground. The deboning machine then separates out the edible tissue (Figure 1). In so doing, the machine converts bone and semirigid tissue into bone and viscous paste. The bone portion can be used in animal feeds, fertilizers, soup stocks, and gelatin. The paste, unappetizing on its own, is believed by representatives of the red meat industry to have potential as an ingredient of further-processed products.


---

**Figure 2. Compositional comparisons of mechanically and hand-deboned meats.**

To provide comparative data on the nutritional qualities of mechanically deboned poultry, beef, and fish, personnel of the Nutrition and Food Science Department at Utah State University conducted a series of studies. Alternate samples were taken from a commercial processing line, one to be mechanically deboned and the other to be hand deboned. The analyses were done on composite samples involving at least 25 carcasses or carcass parts. All beef was from utility grade carcasses, turkey was from C-grade toms, and fish were carp obtained from a commercial supplier.

Mechanical deboning was accomplished with a Beehive mechanical deboner at Beehive.
Machinery Company, Salt Lake City. The hand deboning was completed by personnel at the USU Nutrition and Food Science Meat Laboratory. The meat from the hand deboning was put through a meat grinder twice to obtain textural characteristics resembling those of the mechanically deboned product.

**What Does Deboning Produce?**

Total starting weights, discard weights, and edible meat weights were recorded to permit yield comparisons (Figure 2). The yields of edible product were greater with mechanical deboning, because the mechanical procedure removes 40 to 50 percent of the nonedible connective tissue, and it crushes most bones thus allowing their juices to be extracted. Poultry, additionally, is very difficult to get clean by hand deboning.

Mechanical deboning resulted in lower water and protein contents than hand-deboning, and in higher lipid and ash (mineral) levels (Figure 3). When the meat had a high connective tissue content (for instance, the beef shank), mechanical deboning materially improved protein quality (Table 1 and Figure 3). Calorie yields were higher with mechanical deboning because of the relative fat contents of the edible portions.

These yield values have significant implications for efficient utilization of meats as sources of protein. The relatively low protein yield from the mechanically deboned shank is due to the mechanical deboner's having removed 40 to 50 percent of the connective tissue (along with the bone). Thus, in a cut of meat heavy in connective tissue, mechanical deboning may lower quantity; but, at the same time, it can significantly improve the amino acid pattern. Specifically, the mechanical deboning of the beef shank reduced the protein yield by 10.3 percent, but enhanced protein quality (as measured by percent essential amino acids) by 14.6 percent.

---

**Figure 3. Yield comparisons of mechanically and hand-deboned meats.**
Table 1. Comparison of mechanically and hand-deboned meats in some mineral nutrients.

<table>
<thead>
<tr>
<th>Nutrient Element</th>
<th>Mechanical Deboned</th>
<th>Hand Deboned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium, mg/kg</td>
<td>Beef/shank 217</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Beef/plate 391</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Turkey/frame 57</td>
<td>5</td>
</tr>
<tr>
<td>Phosphorus, mg/kg</td>
<td>Beef/shank 231</td>
<td>170</td>
</tr>
<tr>
<td></td>
<td>Beef/plate 284</td>
<td>135</td>
</tr>
<tr>
<td>Iron, mg/kg</td>
<td>Beef/shank 38</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Beef/plate 24</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Turkey/frame 20</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Carp/whole eviscerated 14</td>
<td>17</td>
</tr>
<tr>
<td>Metabolizable iron, mg/kg*</td>
<td>Beef shank 18</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Beef plate 13</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Turkey frame 8</td>
<td>4</td>
</tr>
</tbody>
</table>

*Iron efficiency for hemoglobin regeneration x iron concentration.

(Figure 3). Such enhancement is substantial, however, only in cuts with a heavy concentration of connective tissue.

Biological evaluations of protein quality indicated no differences between hand and mechanically deboned turkey meat products when they were incorporated into the diets of rats as their sole source of protein.

The calcium and iron contents were higher in mechanically deboned beef and turkey products than in the hand-deboned (Table 1). The fish probably failed to show comparable mineral differences because hand deboning inadvertently leaves many small bones. Calcium and iron are of special interest because dietary surveys of people in the US indicate that these minerals are invariably the ones most often in short supply. Calcium was increased by 10-fold in the 2 meats (beef shank and beef plate) that appear to be influenced by mechanical deboning. An adult human being requires about 1 to 2 mg of metabolizable iron per day. It would therefore take only 59 to 113 g (2 to 4 oz) of mechanically deboned shank meat but 90 to 180 g (3.2 to 6.4 oz) of hand-deboned shank meat to meet that requirement.

Would Consumers Gain?

The data reported here certainly indicate that, in terms of resource (animal protein) conservation and nutritional value, the mechanical deboning of low-return meat animal cuts has distinct advantages over hand deboning. Labor costs (detailed in *Utah Science* (34:114-115) by Gillett) also favor mechanical over hand-deboned.

In answer to the question posed by the title of this article—the available nutritional and chemical data make it obvious that we are indeed dealing with a safe-to-eat "meat" product of considerable nutritional worth. We are also looking at a procedure that can shift approximately 6.5 kg (15 lb) of a beef carcass from nonhuman to human consumption. Admittedly, more data need to be obtained about ultimate product worth to the consumer relative to various cuts, animal age, effects of pore sizes used in the deboner, temperature of the flesh when deboned, and the total composition of the product into which the deboned flesh is incorporated. Nevertheless, perhaps those who have opposed government approval of mechanically deboned meat in processed meat consumer products should reevaluate the situation.

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Utah Science
Asking Questions of Desert Shrubs

Lois M. Cox

Time was, when even erudite scientists believed that one photosynthesis formula \((\text{CO}_2 + \text{H}_2\text{O} \xrightarrow{\text{sunlight}, \text{chlorophyll}} \text{O}_2 + \text{carbohydrate})\) was accurate for all higher green plants. Although the formula is still true, it has been realized that various plant species impose individual variations upon the theme. And apparently the variations (differences in how a plant's cells manipulate the carbon dioxide and water) have evolved in response to particular environments.

The first-recognized photosynthetic pathway prevails among plants that do their most vigorous growing under moderate to cool conditions, preferring neither total sun nor total shade, and needing access to reasonable amounts of moisture. This route is called the C\textsubscript{3} because the plant's initial combination of carbon dioxide and water produces a 3-carbon compound along with oxygen.

Another major pathway (called C\textsubscript{4}) is favored by plants that grow especially well in relatively sunny, warm, dry climates. C\textsubscript{4} plants differ from the C\textsubscript{3} plants in initially producing a 4-carbon compound and in being able to do their photosynthesizing efficiently even when water is in short supply. The C\textsubscript{4} approach to carbon fixation has been identified in so many unrelated families of plants (ranging from tropical grasses to certain chenopods such as shadscale and halogeton) living in such diverse environments, that scientists have begun to wonder if it is a relatively recent evolutionary experiment of nature.

These plants are paying little if any attention to scientific theories about the C\textsubscript{3} and C\textsubscript{4} photosynthesizing pathways

That kind of hypothesis is tough to prove or disprove, however, no matter how many data are accumulated, unless they include results of experiments with C\textsubscript{3} and C\textsubscript{4} plants living in close proximity within a particular environment. Curlew Valley, in northwestern Utah, is one of the rare places where such field work is possible. In that part of the Great Basin's cold-winter desert, several C\textsubscript{3} and C\textsubscript{4} species coexist in productive harmony. Winterfat (Ceratoïdes lanata) a C\textsubscript{3} shrub, and shadscale (Atriplex confertifolia), a C\textsubscript{4} shrub, offer representative examples of the way these types live in mixed and relatively monospecific communities.

Posing the Questions

And so, over a period of 6 years, Martyn Caldwell (Professor of Range Science) and several graduate students have asked questions of these C\textsubscript{3} and C\textsubscript{4} shrubs. Their general goal was to evaluate how effective the C\textsubscript{4} pathway is under temperate conditions. Specifically, the researchers wanted to test several ideas that logic indicated should hold true for the C\textsubscript{4} Atriplex in the Great Basin:

1) It would photosynthesize at a higher rate and fix (convert) more carbon into tissue than the C\textsubscript{3} Ceratoïdes.
2) It would do most of its growing in the valley’s warmest, sunniest months.
3) It would curtail potential water losses by closing the stomatal openings (intake valves for CO₂) in its leaves more than the C₃ plant.

4) It would photosynthesize more, while transpiring (losing) less water than would Ceratoides under comparable conditions.

The scientists were also concerned with assessing potential differences between the 2 types of shrubs relative to how much energy each one invested in producing and maintaining an effective root system. Their "guesstimate" was that the extra efficiency of the Atriplex photosynthesis/water conservation procedures would allow it to put more of its energy into producing aboveground parts and less into roots than Ceratoides.

Methods and Measures

The work began in 1970, with measurements being taken on 3 kinds of sites: strongly dominated by Atriplex, strongly dominated by Ceratoides, and virtually 50-50 communities.

The procedures used by the researchers have been detailed in an article to appear in a 1977 issue of Oecologia. In general terms, photosynthesis, transpiration, and respiration were gauged with gas exchange gadgets and recording techniques along with an in-the-plant tracking of radioactive CO₂. The resultant data were then correlated with measurements of solar radiation and of soil and air temperatures.

Biomass (roots, shoots, and foliage) production was mostly assessed by physically collecting, drying, and weighing materials. Productivity was measured in several ways including use of a

Figure 1. Carbon balance of the Atriplex and Ceratoides communities for the 2-year period of 1973 and 1974. All values designate annual carbon flow rates in terms of average grams of carbon per square meter of ground area per year.
new radioisotope technique. To minimize the effects of inevitable seasonal and yearly variations, the definitive analysis was done on an average of two years' data: one relatively dry, the other relatively wet.

Another normally accepted methodology was used to determine the plants' soil moisture extraction patterns at various soil depths throughout each year's growing season.

**Pondering the Peculiar Replies**

After 6 years, sufficient data were in hand from all phases of the investigation to allow the researchers to enter their pay-off stage: that of analyzing and drawing conclusions. Out of this stage came the almost immediate realization that, apparently, these plants were paying little if any attention to scientific theories about the C₃ and C₄ photosynthesizing pathways.

In rates of photosynthesis, for example, the C₄ *Atriplex* did not notably outstrip the C₃ *Ceratoides*. Actually, *Ceratoides* plants often showed higher rates when both species were operating under what were assumed to be optimum conditions for each. And both species hit their maximum rates in April and May. Rates for both decreased through the summer until, in August, some C₃ individuals had completely stopped photosynthesizing. Most C₄s were still persisting at that time, though at low levels. And, contrary to all expectations, both kinds of plants could conduct photosynthesis when leaf temperatures were below freezing in the early spring.

Interestingly, as aboveground
activity went through its cycle, belowground activity (root respiration, extraction of water and nutrients, and growth) was also cycling, but in a downward shifting pattern. In other words, the roots (of both species) in the top 30 cm of soil were well into their moderate → maximum → minimum activity cycle before the deeper roots had begun operating. This sequential root search for water and nutrients optimized the photosynthesizing potentials of the aboveground foliage (Figure 1).

Clarification of the carbon balance profiles for monospecific communities indicated that *Atriplex* was investing more carbon in annual renewing of roots (up to 24 percent) than was *Ceratoïdes*. The C₄ plants also seemed to be incorporating more carbon overall into their tissues. But the amounts were relatively insignificant considering how much more foliage the average C₄ plant has per unit ground area than does the average C₃ plant (Figures 2 and 3).

The photosynthesis/transpiration (P/T) relationships also provided some surprises. For one thing, only about half the annual precipitation (averaged for the 6 years of the study) was processed through the vegetation (perhaps because so much evaporates in the desert before the plants can get at it). Then too, the P/T ratios of both species were virtually identical until late in the season, when that of the C₃s declined more abruptly. For a still unknown reason, the C₄ plants did not seem to make special use of their stomatal openings as regulators of water loss at any time. Overall, despite what human logic predicted, the two types of plants were about equal in their annual water use.

Possible Rationales— and Implications

The similarities in timing and levels of photosynthesis peaks, leaf and shoot development, and root growth could indicate that the C₄ species has simply adapted to cooler temperatures than those normally preferred by such plants. The genetics of such adaptation are so far undefined. In any case, the existing growth responses of *Atriplex confertifolia* allow it to make the most of the desert's ephemeral period of reasonably reliable moisture. As a comparison, C₄ grasses that thrive in temperate climates (the Great Plains) seem to "come on" later than their C₃ counterparts. This strategy works for them because they average better access to moisture in hot months than does *Atriplex* in Curlew Valley.

Some of the differences the researchers noted in energy expenditures (as measured by carbon fixation) and in transpiration could involve the two species' ways of processing salt. In the Great Basin's notoriously saline soils, *Ceratoïdes* apparently restricts salt uptake at its roots. *Atriplex*, however, allows salt to enter its roots and then excretes excesses through the bladder hairs on its leaves.

Although the USU research obviously had to leave unanswered many questions about C₄ photosynthesis in temperate climates, its results did include a superbly practical, unexpected bonus. Past studies of range utilization have generally evaluated the impact of grazing by measuring one (or at most two) characteristic of the plants involved. The catch has been that no one could be positive whether the item measured was an unequivocally valid indicator of grazing effects. With the techniques perfected by the Caldwell-led group, however, future investigators can consider the response to grazing of entire plants, in terms of their below- as well as aboveground anatomy.

Lois Cox is Science Writer, Agricultural Experiment Station Publications, USU.
Shrubs Plus Grass for Livestock Forage: A Possibility

Gordon A. Van Epps and C. M. (Cy) McKell

Vast areas of tillable range land in the arid Great Basin have been planted to crested wheatgrass (Agropyron desertorum or A. cristatum) as a replacement for sagebrush or pinyon-juniper. This practice is still being continued, having proved to be an economically feasible way to increase forage production where precipitation is adequate.

The interplanting of selected palatable native shrubs with the grass may provide a means for improving the quality of livestock forage. The shrubs could actually enhance the nutritional balance of the range feed available for livestock consumption. This would be especially true during the fall when the crude protein value of crested wheatgrass is low. An overall increase in forage production as well as in the availability of forage during drought years or deep snows are other potential advantages.

Besides investigating the above possibilities, we were interested in studying the practicality of using shrub-grass combinations for livestock grazing as an alternate crop for wheat on marginal dry-farm lands. In many years wheat and, more especially, grass proved not economical as monoculture crops on these lands.

A successful planting of shrubs in permanent dry-land grass, however, requires spacing that limits or avoids competition from the grass during the shrub establishment period. Optimum growth of the shrub seedling also must be achieved to assure increased forage and adequate seed production. Management practices that balance grass and shrub maintenance and use are obviously essential.

Methods

We initiated two studies in 1974 at the Nephi Field Station to identify the space requirements for successful establishment and optimum seedling growth. One study involved direct seeding of 5 important shrub species. In the other, fourwing saltbush (Atriplex canescens), rubber rabbitbrush (Chrysothamnus nauseosus albicaulis), winterfat (Ceratoides lanata), big sagebrush (Artemisia tridentata), and antelope bitterbrush (Purshia tridentata).

Five different spacings of 53, 105, 158, 210, and 263 cm (21, 42, 63, 84, and 105 in) were cleared between rows of established crested wheatgrass. The grass had been originally seeded November 1962, in east-west rows 63 cm (21 in) apart. This east-west orientation was expected to help protect the shrub seedlings from north-south winds and frost.

Precipitation during the calendar year of 1975 was 23.8 cm (9.52 in) and for 1976 only 12.75 cm (5.10 in). The long-term average at the station is 21.15 cm (8.35 in).

The exceptionally unfavorable climatic conditions combined with the usual high variability among plants caused our data to be unsuitable for statistical analysis. They are, however, indicative of what might be expected from field plantings under similar conditions.

Direct Seeding of Shrubs

The seeding experiment consisted of 5 species, 5 spacings, 2 seeding times, and 8 replications. The 5 species were: fourwing saltbush (Atriplex canescens), rubber rabbitbrush (Chrysothamnus nauseosus albicaulis), winterfat (Ceratoides lanata), big sagebrush (Artemisia tridentata), and antelope bitterbrush (Purshia tridentata).

September 1977
between grass rows. Two rows of crested wheatgrass were left between shrub plots for competition.

All shrub species were seeded at a high rate to ensure a good stand. Seeding depths were: bitterbrush, 1.25 to 1.875 cm (1/2 to 3/4 in); fourwing saltbush, .625 to 1.25 cm (1/4 to 1/2 in). The other 3 shrub species were barely covered.

Results of Direct Seeding

By mid-March 1974 seedling emergence in all the fall plantings was excellent except for bitterbrush, which showed good emergence.

Below freezing temperatures of -13 to -12° C (9 to 10°F) in late March destroyed the initially excellent to good stands except for rabbitbrush and sagebrush, and some seedlings of these species appeared to be injured. Later in the spring, drought and within-row seedling competition took most of the remaining sagebrush seedlings. A few belated seedlings of fourwing saltbush, winterfat, and bitterbrush emerged after the late March cold spell. Except in areas (such as central Utah) where there is danger of late frost, all of these species can be successfully planted in the fall.

Table 1. Seedling survival of 5 shrub species comparing the first and second growing seasons when subjected to 5 spacings, 2 seasons of planting and when seeded in competition with established crested wheatgrass. Data are the sum of 8 replications and 2 rows per replication.

<table>
<thead>
<tr>
<th>Species</th>
<th>Time of Planting</th>
<th>53 cm (21&quot;)</th>
<th>105 cm (42&quot;)</th>
<th>158 cm (63&quot;)</th>
<th>210 cm (84&quot;)</th>
<th>263 cm (105&quot;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975 Growing Season</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Fourwing saltbush</td>
<td>Fall</td>
<td>6</td>
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<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>18</td>
<td>8</td>
<td>40</td>
<td>66</td>
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<tr>
<td>Rubber rabbitbrush</td>
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<td>644</td>
<td>1322+</td>
<td>2462+</td>
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<td></td>
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<td>336</td>
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<td>866</td>
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<td>Winterfat</td>
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<td>70</td>
<td>184</td>
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<td></td>
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<td>282</td>
<td>502</td>
<td>726</td>
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<td>Big sagebrush</td>
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<td>1</td>
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</table>
which is the preferred time. Even rabbitbrush, which showed good survival from both spring and fall plantings (Table 1) does best when started in the fall.

Results from our March seeding and previous unpublished studies show, however, that all of these species, other than sagebrush, can be successfully planted in the spring (Table 1). The requisites are early seeding and adequate precipitation. Stratification of bitterbrush seeds with a cold moist thiourea treatment prior to a spring planting helps to insure against seed dormancy. Rodent damage is also a major hazard for spring-planted bitterbrush.

Some spring-planted seedlings lived through the first growing season, but died during the second. This was especially true for the 53-cm to 158-cm (21-in to 63-in) spacing. Most of the winterfat and big sagebrush seedlings that survived their first year showed little growth and died during their second growing season. These were growing on the protected north side of the grass rows in close proximity to the grass. In most cases, the first- and second-year seedling deaths can probably be attributed to drought conditions.

Seedling survival appeared to increase with the distance between rows of crested wheatgrass. Rabbitbrush, however, will survive relatively close to the grass rows, but its growth is limited, at least during the first 2 years. Shrub growth followed the same trend as seedling survival.

Our preliminary data indicate that spacing between rows of grass should be at least 100 cm (40 in) if the shrub species tested are to survive and grow. Optimum spacing would be over 150 cm (60 in) (Figure 1). In general, shrubs can survive between rows of grass that are less than 100 cm (40 in) apart, but growth is poor under the precipitation at the Nephi Station.

Transplanting of Fourwing Saltbush as Bare-root Seedlings

We used the same 5 spacings (53, 105, 158, 210, and 263 cm) for our transplanting studies between grass rows, with 3 being duplicated for a total of 8 plots. Those that were duplicated (158, 210, 263 cm) contained 2 rows of transplants as compared to 1 row in each of the other 5 plots. There were 5 plants spaced 60 cm (2 ft) apart in the single row plots. The plants in those plots containing 2 rows were spaced 60 cm (2 ft) apart within the row and 53 cm (21 in) between rows for a total of 10 plants. The rows were located in the center portion of the cleared area. There were 5 replications. The initial planting was made in spring 1974.

Results of Transplanting

Survival of the fourwing saltbush transplants was affected by competition between grass rows having intervals of 53 cm (21 in). Spacings between grass rows of 105 cm (42 in) or greater had no apparent adverse affect on plant survival (Table 2).

In considering both survival and growth, spacings of at least 158 cm (63 in) proved desirable (Table 2). Optimum growth requires a grass row spacing of approximately 210 cm (84 in) or more. Plots containing 2 rows of

Figure 1. Shrubs of rubber rabbitbrush and fourwing saltbush at the end of the second growing season. Seeded in a spacing of 262 cm between rows of crested wheatgrass.
Table 2. Average plant size of fourwing saltbush bare-rooted transplants comparing 8 planting intervals from 5 replications in an established planting of crested wheatgrass. Included is a percent comparison of live plants at the end of the second growing season in 1975 and the third in 1976.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Distance between rows of crested wheatgrass</th>
<th>Soil area per plant</th>
<th>Percent Live Plants 1975</th>
<th>Percent Live Plants 1976</th>
<th>Average of 2 largest plants per row in plots**</th>
<th>Height</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cm (In)</td>
<td>M² (Sq ft)</td>
<td>%</td>
<td>%</td>
<td>Cm (In)</td>
<td>Cm (In)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>53 (21)</td>
<td>.315 (3.5)</td>
<td>84</td>
<td>60</td>
<td>4.8 (1.9)</td>
<td>3.6 (1.4)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>105 (42)</td>
<td>.63 (7.0)</td>
<td>96</td>
<td>84</td>
<td>12.2 (4.8)</td>
<td>11.4 (4.5)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>158 (63)</td>
<td>.945 (10.5)</td>
<td>96</td>
<td>84</td>
<td>51.8 (20.4)</td>
<td>53. (20.9)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>158 (63)</td>
<td>.468 (5.2)</td>
<td>92</td>
<td>84</td>
<td>39.9 (15.7)</td>
<td>33. (13.0)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>210 (84)</td>
<td>1.26 (14.0)</td>
<td>100</td>
<td>92</td>
<td>75. (29.6)</td>
<td>28.3 (38.3)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>210 (84)</td>
<td>.63 (7.0)</td>
<td>92</td>
<td>80</td>
<td>65.8 (25.9)</td>
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<td></td>
</tr>
<tr>
<td>7</td>
<td>263 (105)</td>
<td>1.575 (17.5)</td>
<td>96</td>
<td>92</td>
<td>82. (32.4)</td>
<td>109.2 (43.0)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>263 (105)</td>
<td>.783 (8.7)</td>
<td>94</td>
<td>94</td>
<td>79.5 (31.3)</td>
<td>84.8 (33.4)</td>
<td></td>
</tr>
</tbody>
</table>

*The approximate spacing between fourwing saltbush and established grass per treatment were:

1. 25.4 cm (10 in)
2. 53. (21 in)
3. 78.7 cm (31 in)
4. 53.36 m (21 in) with 53. cm (21 in) between the 2 rows of saltbush
5. 105 cm (42 in)
6. 78.7 cm (31 in) with 53. cm (21 in) between the 2 rows of saltbush
7. 132 cm (52 in)
8. 105 cm (42 in) with 53 cm (21 in) between the 2 rows of saltbush

**End of third growing season

shrubs rather than 1 produced intermediate to good growth relative to single-row planting.

Conclusion

The width of the area cleared between grass rows definitely affects plant survival as well as growth, at least during the first 2 years. Optimum spacing for direct seeding is 100 cm (40 in) or more. For transplanted shrub seedlings, spacing should exceed 158 cm (63 in).

Despite possible frost hazards the following spring, fall seeding is preferred most years over spring seeding at this site. Some species will establish well from a spring planting if the seeding is done sufficiently early and subsequent moisture is adequate.

Utilizing the experience gained in these studies can help to establish fodder shrubs in existing stands of crested wheatgrass and thus improve the production of late fall livestock forage on foothill ranges of the Great Basin.

Gordon A. Van Epps is Associate Professor, Department of Plant Science and Institute for Land Rehabilitation, USU.

C. M. (Cy) McKell is Professor, Department of Range Science, and Director, Institute for Land Rehabilitation, USU.

Utah Science
Repopulating Bryce Canyon

Steve Elmore and Gar Workman

No, Bryce Canyon National Park hasn’t lost its attraction for visitors. It has, however, lost all of its colonies of Utah prairie dogs (Cynomys parvidens). These squirrel-related rodents, which average about 1 k (2 lb) in weight as adults, are now classified as a rare and endangered species.

Because of that classification, and because this mammal used to be common in the Bryce Canyon area, Park Service personnel want to help them reestablish residence.

Toward that end, the Department of Wildlife Science at USU agreed to fill a 1975 Park Service request for research into prairie dog transplant potentials. A 1974 attempt to establish a colony within the Park boundaries had apparently failed, and Park administrators wanted to know two things: Why had the colony failed and how could failures be avoided in the future?

We began our 3-year project in the spring of 1975. Our immediate objectives for that year were:

1) To inventory meadow environments and evaluate potential Utah prairie dog habitats in Bryce Canyon National Park relative to colonies of Utah prairie dogs established outside the park.
2) To document past Utah prairie dog colony sites within Bryce Canyon National Park.
3) To capture and transplant Utah prairie dogs into sites in the Park preidentified as favorable.

What Is a Utah Prairie Dog?

Before we could start the study, however, we had to know what makes a prairie dog happy.

We already knew the situation was urgent since a 1972 investigation by Collier and Spillet (1974) had identified a drastically declining population trend.

Prairie dog “towns” consist of a labyrinth of burrows. Mounds surround the burrow entrances to keep surface water out of the system and to provide lookout points. Many burrows have at least two exits, which are believed to be insurance against dig-
ging predators. Bulbous excavations, known as nesting chambers, are dotted throughout the burrow system. The lateral passageways are from 0.6 to 4.5 m (2 to 15 ft) below the surface, depending on a number of variables including soil composition, depth to bedrock, and climate. Good drainage is vital to avoid flooding.

Outside their burrows, prairie dogs rely on constant communal vigilance as their prime survival mechanism. The prairie dog is the natural prey of raptors such as the golden eagle and the red-tailed hawk. Their land-bound enemies include badgers, coyotes, and bobcats. Prairie dogs therefore use tactile, visual, and vocal interactions to keep a colony viable.

Out of the burrows, dogtown social life revolves around vigorously defended territories. Each territory houses an average of 1 adult male and 3 adult females together with about 5 offspring. Territorial boundaries are maintained by frequent contacts with other members of the dogtown. A territory usually covers about 0.2 ha (1/2 ac), though it may vary, particularly at the edge of a town, where the animals may move in to adjacent uninhabited regions (King 1971).

Dogtowns must be located near areas that will support moist, nutritious herbage, even during a severe drought. In fact, in years of early drought, reproduction is probably substantially reduced because moist herbage is not nearby. Utah prairie dogs rarely range over 60 m (200 ft) from their burrows in the spring but may range much farther in the summer looking for food. In June and July of 1974, quality forage around dogtowns near Bryce Canyon became so scarce that prairie dogs traveled daily up to 400 m (1320 ft) from their home burrows to forage (Crocker-Bedford 1975).

At the same time, prairie dogs try to avoid vegetation over 4.7 cm (12 in) high. Taller vegetation disrupts their social communications and their ability to guard against predators. Then too, shorter vegetation tends to have a relatively low fiber content and may be more palatable.

Prairie dog breeding activity near Bryce Canyon occurs in early May, and gestation requires about 30 days. The females are thus lactating in late June or early July, which allows weaning of the young before the forage scarcities of summer. The mean litter size is approximately 5.5, but varies from 3 to 8. One litter is produced annually. Winters are spent in “hibernation.”

Why Are the “Dogs” In Trouble?

The prairie dog simply has not
fit into human value schemes. As white settlers began making intensive use of the Great Plains and Intermountain grasslands, both the prairie dogs and their natural predators were categorized as competitors, pests, and/or threats. The next step was vigorous campaigns designed to eliminate such animals.

Prairie dogs have also been victims of more or less accidental habitat destruction. Changes in adjacent vegetation, whether through conversion to farms or because of heavy grazing, have made dogtowns uninhabitable by their builders. Diseases and guns have also taken their tolls.

**Transplant Efforts**

Sites for possible transplants were chosen on the basis of on-site and nearby vegetation, soil, slope, and aspect suitabilities. One area is in a ponderosa pine clearing, the other is in a more open, range-like situation. Both had apparently served as natural dogtowns sometime in the past. Nevertheless, we augered special holes, hoping to encourage the prairie dogs we planned to introduce.

### Table 1. Total number and percent composition of Utah prairie dogs captured at the “Y-dogtown” near Panguitch and transplanted to the visitors’ center site, Bryce Canyon National Park

<table>
<thead>
<tr>
<th>Sex</th>
<th>Age</th>
<th>Total Number</th>
<th>Percent Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>immature</td>
<td>11</td>
<td>20.2</td>
</tr>
<tr>
<td>Female</td>
<td>immature</td>
<td>18</td>
<td>33.4</td>
</tr>
<tr>
<td>Male</td>
<td>mature</td>
<td>7</td>
<td>13.0</td>
</tr>
<tr>
<td>Female</td>
<td>mature</td>
<td>18</td>
<td>33.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>54</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

### Table 2. Total number and percent composition of Utah prairie dogs captured at Churchwell, Cedar City and transplanted at East Creek, Bryce Canyon National Park

<table>
<thead>
<tr>
<th>Sex</th>
<th>Age</th>
<th>Total Number</th>
<th>Percent Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>immature</td>
<td>38</td>
<td>23.8</td>
</tr>
<tr>
<td>Female</td>
<td>immature</td>
<td>73</td>
<td>45.6</td>
</tr>
<tr>
<td>Male</td>
<td>mature</td>
<td>26</td>
<td>16.2</td>
</tr>
<tr>
<td>Female</td>
<td>mature</td>
<td>23</td>
<td>14.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>160</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Potential transplant animals were captured and moved to the two designated areas in July 1975 (Tables 1 and 2). Although the artificially introduced dogs uniformly abandoned the augered holes shortly after they arrived, at least a few did relocate into the old mounds.

Transplanting highly social animals (whether predators or prey) is necessarily hazardous because the process inevitably disrupts established relationships. (Also, in our project, even though we tried to more or less match old and new environments, some differences were drastic). Transplanted animals therefore tend to be heavily stressed in several ways.

In our animals the stress effects were most obviously evidenced by atypical daily behavior patterns, including a marked degradation of vocal communications. Such changes, in turn, made the prairie dogs especially susceptible to predation.

Early (almost immediate) disappearance of approximately 80 percent of our introduced animals from the transplant sites told us that several years of transplants may be necessary to establish a self-sustaining colony. The effort seems warranted, however, since the result could be not only the rescue of an endangered species—but the definition of general principles applicable to many species living in diverse areas of the state, nation, and world.

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Gar Workman is Associate Professor, Department of Wildlife Science, and Fish and Wildlife Specialist, University Extension, USU.
High/Low Predation—Some Why Factors

Darwin B. Nielsen

In 1974, personnel of the US Statistical Reporting and Economic Research Services studied sheep industry predation. The data they gathered allowed us to identify a sample of high-loss sheep ranches (8 percent or more of tail-docked lambs) and low-loss producers (0 to 3 percent of docked lambs). These high- and low-loss ranches are located in Oregon, Idaho, Wyoming, Utah, and Colorado.

Initially, about 40 ranchers constituted each sample group. Later, however, we discovered that some low-loss ranchers were not range operators, others had entered the high-loss category, and others simply did not choose to cooperate in our study. Ultimately, we could legitimately analyze 37 high-loss questionnaires and 29 low-loss questionnaires. We also drew upon some management data acquired by the Economic Research Service personnel in their 1974 Sheep Industry Structure Survey.

Lamb Crops

Percent lamb crop is an important measure of the economic efficiency on any sheep ranch operation. We computed lamb crop percentages from the total number of lambs docked and total number of yearling and older ewes in the flock. High-loss ranches averaged a 90 percent lamb crop. Low-loss ranches averaged 113 percent. The ranges were: high-loss—152 to 41 percent, low-loss—200 to 67 percent. This is probably the most significant difference that we identified between the two groups of ranches.

Part of that difference can be explained by the number of ranchers in each group who lambed in sheds. About 59 percent of the low-loss ranches, but only about 35 percent of the high-loss ranches, shed-larmed. The alternative was some type of range lambing. After the lambs' tails were docked (at approximately 30 days of age) and before they were marketed (at 5-6 months of age), 84 percent of the high-loss ranchers and 93 percent of the low-loss ranchers ran their sheep on open ranges. The others ran their sheep in some form of fenced pasture system.

Loss Trends

In 1974, high-loss ranches lost an average of 14 percent of their docked lambs. From 1971-1974 the losses were 7, 10, 12.5, and 14 percent, respectively. Stock (adult) sheep losses averaged 3.7 percent in 1974.

In 1974, low-loss ranches lost an average of 3.8 percent of their docked lambs. From 1971-1974, the losses were 2.2, 4.0, 4.7, 3.8 percent, respectively. Stock sheep losses were under 2 percent in 1974.

Most of the high-loss ranchers reported generally increasing losses through the 5 years, 1970-1974. Three reported losses holding about steady over those 5 years, while one rancher reported high yearly variations.

Most of the high-loss ranchers reported generally increasing losses through the 5 years, 1970-1974. Three reported losses holding about steady over those 5 years, while one rancher reported high yearly variations.

Sixty-two percent of the low-loss ranchers reported generally increasing losses over the 1970-1974 5-year period. Two ranchers reported variable losses from year to year while 21 percent (6 ranches) indicated losses holding steady. Three ranchers in this group said their losses had increased through 1973 then decreased in 1974.

In comparing 1975 with 1974 losses, high-loss ranchers reported as follows: higher—16 percent; lower—62 percent; no change—22 percent. The factor cited as most important in accounting for loss reductions was more effective flying for coyote control. Other factors mentioned were: fewer coyotes, increase in
MAN: (Homo sapiens) person.
By definition a uniquely intelligent animal.

COYOTE: CO-yo-TE,
often abbreviated orally into KYOHT (Canis latrans).
Member of the dog family.

PREDATION:
1 the act of preying or contriving (see man).
2 a mode of life in which food is primarily obtained by the killing and consuming of animals (see coyote).

PREY: 1 something taken or got by violence: spoil.
2 an animal that is or may be seized by another to be devoured: see VICTIM.

VICTIM
alternative prey species, shed lambing. Of those reporting higher losses, the most important reason noted was increased number of coyotes. Low-loss ranchers responded as follows: 10 percent—no losses; higher—19 percent; lower—35 percent; no change—36 percent. More effective flying for coyote control was again ranked as the most significant factor when losses had decreased. Fewer coyotes were reported by 2 of the low-loss ranchers. Of the low-loss ranchers reporting higher losses, the most important reason was again increased number of coyotes.

**Hypothesized Reasons**

Ranchers were asked to rank nine factors that might affect lamb losses to coyotes. The possible rankings were: little or no effect = 0; some effect = 1; major effect = 2; don’t know = 3 (Table 1).

The most often reported "other" causes were the proximity of other sheep herds in the area or low sheep density, with restrictions on tools for coyote control also mentioned.

When asked whether some herders are more effective than others in preventing sheep and lamb losses to coyotes, 89 percent and 93 percent of the high- and low-loss groups, respectively, answered yes. Four factors were mentioned most often as distinguishing the effective herder: 1) the amount of time spent with the herd (cited by 85 percent of the high-loss ranchers and 63 percent of the low-loss ranchers); 2) the effort made to kill coyotes by shooting or trapping (30 percent of the high-loss ranchers and 22 percent of the low-loss ranchers); 3) human presence and noise as a deterrent (15 percent of both groups); and 4) close herding—keeping sheep close together while grazing (10-15 percent of the low-loss ranchers but none of the high-loss ranchers). About 56-67 percent of the ranchers in both groups used an incentive, bonus, or reward system for herders who killed coyotes and/or otherwise reduced lamb losses.

**Loss Cutting Factors**

About 85 percent of both groups of ranchers used federal or state trappers for coyote control work. In general, they thought the agencies were doing their best with the tools available. However, a few complained that the agency trappers were not available when needed, that they had too large an area to travel, and that "red tape" sometimes hindered control efforts. Aerial hunting was believed the most effective control method.

It has been hypothesized that having more sheep in an area of a given coyote population would lower the percentage of lambs lost to predation. The rationale included more intensive and economical coyote control efforts because of pressures from sheepmen. To test this idea, we asked ranchers in both groups to report numbers of other sheep and sheep producers within 10 miles of their herds. These data were difficult to define because flocks are moved considerable distances during a year. Flocks are split in the summer and combined into larger units in the winter. Information about other herds in each 10 mile area was gathered on the basis of 3 time periods: 1) lambing to docking; 2) docking to marketing of lambs; and 3) marketing to lambing. Some individual ranch data were combined in the interest of consistency (Table 2).

In addition to the tabulated information, more high-loss than low-loss ranchers had no producers or sheep within 10 miles. The high-loss group averaged 11 ranchers alone in a 10-mile area, and the low-loss group averaged 5.5.

Low-loss ranchers consistently tended to operate in areas of relatively high concentrations of sheep producers and sheep. The data, however, did not allow us to measure the exact effect this had on predation losses.

Information about how intensively coyote control was practiced on each ranch was either not available or not known by enough ranchers to make it meaningful. The ranchers themselves have coyote control programs; the state often supports other control efforts; the federal government has control programs; and "sport" hunters and trappers also destroy coyotes. Much of the state and federal control work (such as aerial hunting) is done over broad areas. The rancher could not show how much effort was made on his land, and the agency could rarely stipulate actual time allocated to a given rancher. The activities of "sport" hunters and
Table 1.  Rancher ratings of the importance of certain factors relative to lamb losses to coyote predation

<table>
<thead>
<tr>
<th>Factor</th>
<th>Major % of Ranchers</th>
<th>Some % of Ranchers</th>
<th>No Effect % of Ranchers</th>
<th>Don't Know % of Ranchers</th>
<th>Relative Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Number of herders:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>High loss ranches</td>
<td>3</td>
<td>30</td>
<td>67</td>
<td>—</td>
<td>8th</td>
</tr>
<tr>
<td>Low loss ranches</td>
<td>3</td>
<td>10</td>
<td>87</td>
<td>—</td>
<td>8th</td>
</tr>
<tr>
<td>2) Competence of herders:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High loss ranches</td>
<td>34</td>
<td>65</td>
<td>22</td>
<td>5</td>
<td>6th</td>
</tr>
<tr>
<td>Low loss ranches</td>
<td>3</td>
<td>55</td>
<td>7</td>
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<td>3) Range condition (type):</td>
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<tr>
<td>High loss ranches</td>
<td>43</td>
<td>30</td>
<td>22</td>
<td>5</td>
<td>4th</td>
</tr>
<tr>
<td>Low loss ranches</td>
<td>3</td>
<td>31</td>
<td>31</td>
<td>3</td>
<td>4th</td>
</tr>
<tr>
<td>4) Level or effectiveness of coyote control:</td>
<td></td>
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<td>83</td>
<td>7</td>
<td>3</td>
<td>0</td>
<td>1st</td>
</tr>
<tr>
<td>5) Number of coyotes:</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High loss ranches</td>
<td>97</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>2nd</td>
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<td>Low loss ranches</td>
<td>52</td>
<td>21</td>
<td>14</td>
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<tr>
<td>6) Number of rabbits or other prey species for coyotes:</td>
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<tr>
<td>High loss ranches</td>
<td>38</td>
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<td>8</td>
<td>0</td>
<td>3rd</td>
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<td>Low loss ranches</td>
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<td>59</td>
<td>17</td>
<td>7</td>
<td>5th</td>
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<td>7) Sheep management practices:</td>
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<td>43</td>
<td>51</td>
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<td>5th</td>
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<td>31</td>
<td>24</td>
<td>41</td>
<td>3</td>
<td>6th</td>
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<td>8) Government grazing regulations:</td>
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<td>High loss ranches</td>
<td>0</td>
<td>5</td>
<td>89</td>
<td>5</td>
<td>9th</td>
</tr>
<tr>
<td>Low loss ranches</td>
<td>0</td>
<td>7</td>
<td>93</td>
<td>0</td>
<td>9th</td>
</tr>
<tr>
<td>9) Other:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High loss ranches</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Low loss ranches</td>
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</tbody>
</table>

Table 2.  Average numbers of other sheep producers and sheep within a ten-mile area of a rancher's herd

<table>
<thead>
<tr>
<th>Rancher Group</th>
<th>Producers</th>
<th>Sheep</th>
<th>Producers</th>
<th>Sheep</th>
<th>Producers</th>
<th>Sheep</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-loss</td>
<td>2.0</td>
<td>4,414</td>
<td>2.2</td>
<td>3,481</td>
<td>1.6</td>
<td>3,992</td>
</tr>
<tr>
<td>Low-loss</td>
<td>3.5</td>
<td>4,559</td>
<td>4.2</td>
<td>5,359</td>
<td>3.4</td>
<td>4,814</td>
</tr>
</tbody>
</table>

September 1977
trappers are too diverse and variable to tie to a given area or ranch.

These data do not clearly identify alternative management systems that could be used to effectively reduce predation. Some of the differences between the high-loss and the low-loss groups, however, have implications for management. First, the percentage lamb crop. Suppose a single rancher was running 1,000 ewes in the high-loss group and 1,000 ewes in the low-loss group. On the average he could expect crops of 900 lambs and 1,130 lambs at docking in his high- and low-loss herds, respectively. Suppose these herds were exposed to the same level of predation and that coyotes took 75 lambs in each herd. The percentage loss would be 8.3 percent for the high-loss and 6.6 percent for the low-loss herd. The absolute value of lambs lost is the same for both herds, despite the percentage loss being lower for the low-loss herd.

Concentration of sheep and/or sheeplemen in a given area is an important factor in explaining some of the differences in losses. Unfortunately, it is not a factor that can be easily manipulated by managers seeking to lower their losses.

Coyote concentrations and availability of alternate prey species were two highly significant variables that we were not able to measure. They could very well be the most important differentials between the two groups relative to predation losses.

Since this study was initiated, another economic consideration has become relevant to coyote predation in the West. The value of coyote pelts reached an all time high last winter (1976-1977). It is becoming profitable to hunt coyotes for their pelts, and salvaged pelts help pay for the cost of control programs.

This project was funded by a grant from Economic Research Service, USDA.

Darwin B. Nielsen is Professor, Department of Agricultural Economics, USU.

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### Science Short

**Group Living Among Animals—Lessons for Human Society?**

David F. Balph and Martha H. Balph

Group living must confer benefits, or it would not be practiced by so many animals. For instance, the collective decision of a group may be better than the decision of a single animal, and groups may be more efficient than individuals in locating and exploiting resources or in detecting and avoiding danger. However, group living also may impose costs that can include energetically expensive disputes between individuals over resources such as food, shelter, mates, and space itself.

**Species Differences**

The relative importance of various benefits and costs of group living may differ from one species to another, or within a species under different environmental conditions. Animals that have to solve complex navigational problems (as do many migratory birds), or that depend upon food sources that are locally abundant but unpredictable in space and time, or that must rely upon numbers to combat predation, tend to form large groups and to tolerate neighbors at close range. Animals with less stringent needs, but that still derive benefits from group living, may form smaller groups, tolerate group members at moderate distances, and respond with hostility to outsiders attempting to join the group.
Moderately gregarious animals often reduce the problem of aggression within the group through social relationships that space individuals and order priorities at resources. Sometimes these relationships are hierarchical in that one animal is dominant to all others in the group, a second animal is dominant to all but the first, and so forth.

Within a species, animals may vary in gregariousness according to environmental circumstances (such as season or habitat type), but only within limits that have been established by natural selection. Species differ from one another in gregariousness, and these differences have been shaped by broad differences in their lifestyles and evolutionary histories.

Research conducted by the junior author on moderately gregarious sparrows has shown that when members of a flock are familiar with one another and when resources are adequate, subordinate individuals voluntarily maintain a distance from dominants. However, if flock members do not know one another or if the birds become crowded at an essential resource, flock members no longer defer peacefully to one another, and fights may occur. Social conditions can sometimes deteriorate to a point at which the costs of flock membership exceed the benefits for some low-ranking individuals, and the subordinates leave the group. Under extreme conditions, social organization may break down altogether. Conversely, our ongoing research on some highly gregarious finches suggests that these birds are better able to tolerate changes in group membership and close proximity to neighbors. The differences in gregariousness that
we have observed in these and other species of birds appear to be related in part to the birds' normal feeding habits, the highly gregarious species being those which most often have to cope with "feast or famine" situations.

Relevance To Domestication

Is there any practical value in knowing about the comparative gregariousness of animals or the social systems of animals living in groups? We believe that there is. For example, there appears to be a relationship between the species people have chosen to domesticate and the gregariousness of those species in the wild. Sheep, horses, chickens, and dogs are descendants of wild stock that lived in groups. Some wild species that live in very large groups, such as caribou (reindeer), bison, and ducks, have characteristics that blur distinctions between wild and domestic varieties. Certain of the more solitary animals, such as cats, have been domesticated but tend to retain behavioral traits not always compatible with management.

Obviously, in choosing a wild species for domestication, one should focus upon species that normally live in groups and should attempt to match behavioral predispositions with intended management practices. Today, game ranchers in Africa and elsewhere are having success in domesticating some highly gregarious species such as wildebeest.

Although today's domestic animals generally are well suited for husbandry, certain management techniques may go beyond what some of the moderately gregarious forms are able to cope with. Sheep are a case in point.

Sheep in flocks of 10 or 20 know one another, exhibit stable social relationships, defer to one another in an organized way, and play roles as leaders or followers. But when they are associated in flocks of hundreds, Ernest Gluesing, a graduate student of the senior author, has discovered that the animals exhibit little of this behavior. Such flocks appear to be an amorphous mass, with little social behavior other than some propensity to stay together. One could hypothesize that the recognized difficulties sheep in large flocks have in coping with certain social and environmental stresses (such as those that occur on lambing grounds) may be associated with the breakdown in their social organization.

Human Implications

Are there parallels in group living between animals and people? Does the stability that is seen in small, homogeneous human communities and in tradition-oriented families have a biological basis? Does the hierarchical structure and unit sizes seen in military and business organizations fit behavioral predispositions that have been selected for during evolution?

One could hypothesize that in a biological sense we are a "moderately gregarious" species that derives benefits from group living, tolerates group members at moderate distances, responds with hostility to outsiders attempting to join the group, and has complex social relationships that tend to mediate conflict. One could further speculate that current trends in human population mobility, population density, and availability of resources (including space) may go beyond what people can deal with successfully.

Some ethologists (biologists who study the behavior of wild animals) and sociobiologists (biologists who study the evolution of social behavior in animals) might find such hypotheses attractive. These biologists strongly emphasize the role of natural selection in the evolution of behavior and do not hesitate to include human beings in their emphasis. However, many psychologists, sociologists, and geneticists would disagree. They believe that human behavior is solely a product of experience. Recently, the two groups have been hotly debating the merits of their respective positions. The debates are an extension of nature-nurture arguments that have gone on for years.

Our own view (and that of some other animal behaviorists) falls between the two extremes. We believe the evidence indicates that any behavior involves the interaction of both genetic and environmental factors. In general, evolutionary processes define behavioral potentials and set behavioral limits. Experience operates within these potentials and limits. We think that the social behavior of human beings, like that of other animals, is subject to constraints set during the evolutionary history of the species. Unfortunately, neither we nor anyone really knows the nature or extent of biological constraints on human sociality. We believe it would be fascinating to discover what these constraints are and to find out whether people can accept their implications.

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Martha H. Balph is Research Assistant Professor, Department of Wildlife Science, USU.
To Market—To Market

It is hardly news that many western cattle ranchers are in serious financial trouble these days. Even before the drought hit, several years of low calf prices had been forcing ranchers to rethink their operational procedures.

Weaner (7-month-old) calves were bringing abnormally low prices, because feedlot operators couldn't afford the grain they needed to take the youngsters to market weights. In contrast, feeder (18-month-old) cattle were selling at fairly high rates because less grain was required to make them marketable. As a result, it was beginning to look as if the cow/calf herds that had prevailed in the West since the end of World War II should be converted to a cow/yearling base.

To help ranchers realistically evaluate all their practicable alternatives, John P. Workman (Associate Professor of Range Science) and David B. Hewlett (Range Science graduate student) decided to enlist the capabilities of the USU computer. Only with the computer's help could they simultaneously consider enough variables to produce validly useful results.

The researchers did their calculations for 2 hypothetical ranches—one having 300 cows, the other 150. After their cost/price data had been fed into the computer, they defined 3 possible situations and asked the computer to identify sensible ways to maximize each ranch's income in each situation. In essence, the 3 possibilities centered around an average of Utah cattle prices for 1970-1975, the 1973 outstandingly high prices, and the 1975 depressed prices.

"The cattle ranchers," says Dr. Workman, "are having to make decisions today that will affect their economic well being for years to come. You can't build up a herd of high-producing, quality cows overnight. So we wanted to be sure that any recommendations we might make would leave the ranchers with viable alternatives even if the market did a complete turnaround this year."

After the computer had done
its work, the researchers evaluated its conclusions about the 2 ranches under the 3 pricing regimes. For their projections, they relied on the data generated when they used the 1970-1975 average price. On that basis, the computer was adamant: the ranchers could maximize their cattle incomes by cutting their cow herds by about 25 percent, selling all steer calves as yearlings, and selling all heifer calves (except those destined to be replacements) as weaners.

According to Dr. Workman, "If we had another 1973, following such recommendations would mean something less than maximum income. But if we had another 1975, the outfit that had cut back its base herd and sold its animals as indicated would be well ahead of the one that stuck with the traditional cow/calf pattern. If most of the western ranchers converted to a cow/yearling basis, and decreased their cow herds, they would soon see prices going up in response to fewer numbers of feeder cattle being marketed."

Now that the cattle/marketing computer model has been created, it will be routinely updated with current pricing data. Utah ranchers thus have access (through Dr. Workman) to a data-based rationale for the crucial decisions they confront.

How Much Is Too Much?

Some USU researchers (led by Martyn Caldwell, Professor of Range Science) have been trying for years to persuade plants to answer the above question relative to a particular waveband of solar ultraviolet radiation. This so-called UV-B radiation warrants special concern because it is readily absorbed by nucleic acids and proteins, components of both plants and animals. Amounts beyond "normal" can disrupt cellular processes.

The Earth's stratospheric ozone layer characteristically transmits only minimal amounts of the UV-B. The total transmission varies, however, with prevailing solar angle, land elevation, proximity to polar or equatorial regions, and turbidity of the atmosphere as well as ozone concentration. The problem is that lately some of our technology's inventions (SST aircraft and certain spray-can propellants) have been tampering with the ozone layer. Such inadvertent meddling and its potential effects helped to motivate the USU research program.

"To date," says Dr. Caldwell, "we've learned that artificially confronting plants with 1.3 to 2 times more UV-B than they'd normally receive decreases their total vegetation and their photosynthetic effectiveness. Very low dosages (30 percent of average) produced comparable effects if maintained for about 60 days."
"Our present effort, which is cooperative with W. D. Billings of Duke University, is taking advantage of nature's own gradients in UV-B radiation. Instead of imposing measured quantities of the radiation on plants around here, we are looking at plants growing in places that routinely receive relatively large or small amounts."

The field observations, which are being made in the high Andes, at the equator, and in the Arctic, will be supported by additional laboratory tests. But in 1977, the emphasis is on in-place checks of closely related plants as they occur from Peru to northern Alaska.

The basic questions being asked are: Do plants from different latitudes vary in their sensitivity to UV-B radiation, and if so, why? What (if any) unique physiological or anatomical adaptations are displayed by plants growing in areas subject to naturally high UV-B irradiance? And do plants in those global areas differ from close relatives growing under low UV-B radiation conditions in their ability to repair UV-B damage?

Eventually, the investigators hope to accumulate enough information to insure a secure understanding of the potential implications of ozone reduction for natural and agricultural vegetation. Only then will it be possible to validly preevaluate how much additional UV-B would indeed be too much—for plants and/or animals.

**Food: The Storage Scene**

Few would question that, sooner or later, stored food begins to deteriorate. But unequivocal data about the long-term nutritional value, functionality, and palatability of particular foods is virtually nonexistent. That makes it almost impossible to predict for sure whether a given food will be usable (and/or worth eating) after a year or two, or even after just a few months.

A team of USU researchers has therefore begun what will be a 5-year effort to produce that information about dried milk, wheat, dried eggs, and dehydrated vegetables. The group, led by Deloy Hendricks, Associate Professor of Nutrition and Food Science, will be checking the storage effects of plastic and metal containers and various temperatures, as well as atmospheres of air, carbon dioxide (from dry ice), and nitrogen (used by commercial processors).

Wheat will be tested over time and under various storage conditions for its nutrient content, palatability, and performance as a constituent of baked goods. Ways to limit or avoid insect infestations are also scheduled for investigation.

Working with commercially dried milk and eggs, the researchers want to know how storage time and conditions will affect such characteristics as flavor, nutrient levels, solubility, and compatibility with other ingredients used in cooking and baking.

Plans call for dehydrated vegetables to be checked during the storage period for effects of different original moisture contents and storage conditions on reconstituted appearance, edibility, and nutritional value.

In all cases, the ultimate verdict (about palatability) will come from trained taste panels.

**Some Feedlot Ins and Outs**

"Even if I could afford to, it wouldn't make sense for me to install the kinds of pollution controls the big feedlots are using. I only feed 30 to 40 head at a time—not several hundred. Sure they put out wastes, but not enough to affect the river!"

Virtually all of Utah's feedlot operators and many dairymen truthfully claim the above. The trouble is, while each one does run relatively few animals, they had tended to cluster in river basins that assure them a year-round water supply. And the clustering can mean substantial surface runoffs of waste materials during snowmelt or rainstorm periods.

But do those runoffs really have a dangerously cumulative pollution effect on river basin streams? Precisely how much nitrogen, phosphorus, organic matter, and other substances do feedlots in a given area load into local streams? And if the cumulative amounts are large, how can they be controlled in an economically practical manner?

Dennis George and Dan Filip (Research Assistant Professor and Research Biologist, respectively, of the Utah Water Research Laboratory), in conjunction with William Grenney and James Reynolds, have just completed the first year of research designed to answer those questions. Thanks to the
help of an exceptionally dedicated graduate student, Steve Wieneke, and well qualified technicians, the researchers have gotten a fairly good handle on the essential baseline data. But that handle didn't come easily. Slogging through a knee-deep combination of mud and manure or taking late-night stream samples at the height of a cold rain are enough to make any sensible person question the choice of research as a career.

Now, however, after simultaneously monitoring a network of small streams that drains into the Little Bear River, and several feedlots in a different part of the Little Bear River Basin, the team is ready to start inserting data into a computer model of the limited network of streams. Later they'll shift to a model of the Basin's entire stream system.

Ultimately, the models should allow for valid projections of future water-pollution events, and be readily applicable to comparable river basins. The models will also indicate the pollution-processing capabilities of specific streams in wet, dry, and those rare "normal" years.

At the same time, the research group will be perfecting inexpensive, low-maintenance waste-treatment schemes. In some cases these may require regional or local cooperation among feedlot operators and dairymen. In other instances, individuals may be able to avoid or limit their surface runoff potentials by modifying their operations in minor ways.

One such possibility is being evaluated this year in Cache Valley. A minimum of 2 feedlots will be used as test sites.

In each case, the animals will be fed in an area removed from the stream and will have no direct access to that water. (Their drinking water will be provided in other ways.) Grass will be established as ground cover between where the animals are held and the stream. The expanse of grass is expected to effectively pre-filter any potential pollutants.

This "greenbelt" or overland-flow approach to the waste-treatment problem should require little or no maintenance as it physically and biologically screens feedlot wastes. Additionally, the grass will create an esthetically acceptable buffer zone around the livestock operation.

**Self Defense—Inside Out**

Your body has two major defense systems (circulating antibodies and tissue mechanisms) that it can use against invaders such as bacteria, viruses, or other alien substances. But in these days of proliferating chemicals, the systems are sometimes challenged in ways evolution couldn't foresee. As a result, many scientists have wondered whether prior or post confrontation with certain chemicals modifies the ability of your defense systems to respond to traditional invaders.

Joseph C. Street (Professor of Animal, Dairy and Veterinary Science), R. P. Sharma (Associate Professor of Animal, Dairy and Veterinary Science), several graduate students, and Rita Nelson, a research associate, are among those trying to find ways to answer that question. Their search for reliable procedures has already extended over several years, with progress being slowed by a confusion of biological variables.

Along with the frustrations, however, have come a fair share of useful insights. In fact, according to Dr. Street, "There is no doubt that chemicals artificially introduced into the environment (such as pesticides and industrial wastes) do affect the body's immunological processes. But the specifics of how an animal's thymus, spleen, lymph and blood cells, endocrine glands, and other components interact to produce the effects we see—these remain elusive."

Their experiments have involved animal species ranging from rabbits to guinea pigs, and chemicals such as DDT, carbaryl, PCBs, and ions of heavy metals. Their results have confirmed that responses will vary with the chemical and its dose level as well as with animal species, strains within species, individual animals, and sex.

Those same experiments also demonstrated unequivocally that exposure to foreign chemicals prior to a challenge by bacteria suppressed an animal's ability to defend itself by producing antibodies. In other words, the encounter with the chemical had lowered the animal's resistance (level of the appropriate antibody) to the bacteria. This phenomenon was apparent even in animals whose resistance to the bacteria had been boosted above average by a vaccination.

The USU research group is currently investigating mechanisms of the tissue defense system. This is the system that is commonly activated against abnormal (tumor) cells. Vigorous tumor growth equates with
(among other things) an inadequate or nonfunctioning cellular defense system.

The general question the researchers are trying to answer, says Dr. Street, is, "Does an animal's exposure to foreign chemicals modify its immunological surveillance system? At this stage, we are primarily trying to accumulate baseline data by defining the effects of specified dosages of chemicals, different kinds of introduced abnormal cells, variations in injection sites, and strains and sex of the experimental mice.

"Some of our preliminary work seemed to indicate that low doses of DDT enhanced a mouse's ability to combat certain tumor cells, while high doses had the opposite effect. The catch is, the dosages we used and the general circumstances of the experiments had little or no correlation with situations in the real worlds of either mice or men. Translation of such results to practical medical applications can't come until huge amounts of data have been gathered. And such a collection has to involve dozens of laboratories around the world, with each of us concentrating on a relatively limited problem."

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**Drought Update for the Week Ending August 5, 1977**

E. Arlo Richardson

As the drought decreases available culinary and irrigation water supplies, it is very interesting to note the reactions of various residents of the state. A vast majority of the population accept the situation and are unitedly working to cope with it. But there are a minority who feel that the problem is none of their doing and they are going to get their share regardless of who else may suffer.

At a recent church social, a woman working in the kitchen turned the water on full force at the sink to rinse dishes. When a friend reminded her of the gallons of water she was wasting she replied, "Oh! That's okay, I don't have to pay for it." When the friend added that it was not the money as much as the need to conserve water, she retorted heatedly, "This isn't my water, quit bugging me!" She failed to realize that the water at her home and that at the church came from the same spring whose flow was already at less than half the normal flow for this season of the year.

Another man who was caught with an open hose running full blast to irrigate his garden was very insulted and openly cursed the watermaster of the system when he was reprimanded. He had purposely turned off his sprinklers because he knew that they could be seen, but felt that it was perfectly okay to use the open ended hose at a time when the water should have been used elsewhere, by others.

**Energy Conservation**

Another aspect of the drought situation that many citizens might overlook is the fact that water conservation and energy conservation are very closely interrelated. There have been public statements recently to the effect that there is plenty of water underground. All that is needed to relieve the situation, they say, is to drill more wells. In some areas of the state there is vast underground water storage which may be made available for use. However, to pump this water from several hundred feet underground requires energy. Moreover, the more water pumped the lower the water table becomes.
and the more energy per unit of water is required. This turns into a vicious cycle: Lower water table, more energy, lower water table, more energy. And as the water table is lowered, residents who are dependent on shallow wells find their wells going dry as the water table drops.

As the underground water table is harvested, springs dependent on a particular aquifer will also dry up. In a recent court case in a valley near Salt Lake City, a rancher spent several thousand dollars drilling a deep well and installing a pump to irrigate his fields. But when the well was pumped, a spring which supplied water to his neighbors ceased to flow. The court ordered that he discontinue pumping from the well because the pump was really stealing water from his neighbors.

**Rights of the Individual**

While the underground reservoir is an excellent source of water in areas that are not being overharvested, it, like the surface flow, is dependent upon recharge from rain or snow. A drought eventually affects the underground water storage; the only difference is in the time lag of a few months or a few years, depending upon the recharge source for that particular aquifer.

There is water available for Utah’s growing population, but we must all learn to manage our portion of the supply efficiently. To paraphrase Benjamin Franklin, “We must all conserve together, or assuredly we shall all thirst separately.”

With this sage advice, let’s take a look at present conditions and what the future may hold. Table 1 shows the drought picture as of the week ending August 5, 1977 for the state’s seven climatic divisions. To a certain extent, however, these figures are misleading. Most of the rainfall this year took place in months other than the three winter months of January, February, and March. Summer rainfall is subject to much greater evaporation stress than the same amount of winter snowfall. Only about 4 percent of the annual evaporation from free water surfaces occurs during the winter season, but nearly half the annual evaporation occurs during the summer season.

These evaporative losses have a marked influence on the effectiveness of rainfall. If most of the rainfall occurs during the summer months, its effectiveness in meeting the water needs of

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**Table 1. Water year accumulation as of the week ending August 5, 1977 in each of the 7 climate divisions**

<table>
<thead>
<tr>
<th>Division</th>
<th>Current Week</th>
<th>Water Year Accumulation</th>
<th>Departure From Normal</th>
<th>Percentage of Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western</td>
<td>.23</td>
<td>6.46</td>
<td>-0.89</td>
<td>88%</td>
</tr>
<tr>
<td>Dixie</td>
<td>.03</td>
<td>7.44</td>
<td>-2.04</td>
<td>78%</td>
</tr>
<tr>
<td>North Central</td>
<td>.16</td>
<td>10.44</td>
<td>-4.25</td>
<td>71%</td>
</tr>
<tr>
<td>South Central</td>
<td>.05</td>
<td>5.97</td>
<td>-4.21</td>
<td>59%</td>
</tr>
<tr>
<td>Northern Mountains</td>
<td>.00</td>
<td>9.52</td>
<td>-8.22</td>
<td>54%</td>
</tr>
<tr>
<td>Uinta Basin</td>
<td>.04</td>
<td>4.23</td>
<td>-2.37</td>
<td>64%</td>
</tr>
<tr>
<td>South East</td>
<td>.06</td>
<td>3.93</td>
<td>-3.02</td>
<td>57%</td>
</tr>
<tr>
<td>State Average</td>
<td>.10</td>
<td>6.30</td>
<td>-3.38</td>
<td>67%</td>
</tr>
</tbody>
</table>

*Values are based upon preliminary reports from about 50 reporting stations scattered about the state.
Table 2. Lowest percent of normal winter precipitation in each of the 7 climate divisions

<table>
<thead>
<tr>
<th>Division</th>
<th>Normal Winter</th>
<th>Percent</th>
<th>Minimum Percentage</th>
<th>Potential Precipitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western</td>
<td>1.99</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dixie</td>
<td>3.66</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Central</td>
<td>4.39</td>
<td>41%</td>
<td>at least 92%</td>
<td>1.50 or more</td>
</tr>
<tr>
<td>South Central</td>
<td>3.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northern Mountains</td>
<td>5.98</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uinta Basin</td>
<td>1.55</td>
<td>41%</td>
<td>at least 92%</td>
<td>1.50 or more</td>
</tr>
<tr>
<td>South East</td>
<td>1.95</td>
<td>50%</td>
<td>at least 58%</td>
<td>1.50 or more</td>
</tr>
</tbody>
</table>

plants, recharging the soil and underground aquifers, and filling reservoirs will be much less than the same amount falling during the winter season. Thus, since the portion of the precipitation which fell during last winter was much less than normal while that falling during the spring was much above, the percentages in Table 1 do not indicate the true severity of the drought we are now experiencing.

The Future

In analyzing the past 46 years of weather records for Utah, we find that no two winters in succession have occurred which have accumulated less than 50 percent of normal winter moisture. In Table 2, Column 2 lists the normal winter precipitation in each climate division, Column 3 lists the percentage of normal precipitation accumulated during the winter of 1976-1977, Column 4 lists the minimum percentage of normal precipitation which has followed years accumulating less than 50 percent of normal precipitation, and Column 5 lists an estimate of the potential precipitation for the winter of 1977-1978.

There is nothing in the books that will ensure that the weather will follow this same pattern, but this is the best estimate we have at the present time.

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