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Cover photo by James Fain

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**UTAH SCIENCE**

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Lynne Paolletti, Assistant Editor
Lois M. Cox, Science Writer
Susan Truxes, Editorial Assistant
Utah's Horses, an Economic Asset

J'Wayne McArthur

Prehistoric horses used ice bridges to migrate from North America, where they originated, to all other continents except Australia. Then they became extinct in North and South America until the Spanish conquistadores brought them back.*

For three hundred years after that reintroduction it was the donkey, horse and mule that transported men and goods in the new world. They provided power for farmers and for soldiers; they helped build the railroads, telegraph lines and roads for their nemesis, the automobile. But even with the coming of tractors and other gas-driven machinery, horses persisted and in 1976 remain important to the economy of almost every state in the union. In estimating the value of horses today, however, money oriented criteria are inadequate. Money can't measure the love and closeness that a child has for his or her pony, nor the satisfaction and self-esteem a teenager gains from competing in 4-H shows. No more can the businessman or housewife put a price on the relaxation and mental peace that they derive from riding a good horse. But at the same time, rodeos, horse shows, races, farm and ranch work, and pleasure riding do cause money to change hands and thus exert an economic impact. To define this impact in Utah, a horse and pony survey was completed (results detailed in Utah Science, June 1975).

The survey indicated that Utah was home for 132,743 horses and 37,367 horse owners. From the original survey, other samples were drawn, and these people were questioned about their horse-connected expenditures and incomes. Arabian, Appaloosa, and Quarter Horse owners who were members of their breed associations were also queried in this regard.

Annual Costs to Horse Owners

The number of horses in the State was far larger than anticipated but the total money expended per horse was even more surprising. Predictably, some owners spent large sums on their animals while others provided a minimum care at a very low cost. The average animal expenditure per horse was $342.21 (Table 1). A horse in a stable, located on expensive real estate, provided with fine tack and equipment hauled many miles to shows or other competitive activities cost its owner over $1,000 annually. By contrast, the ranch horse that never saw the inside of a barn and ate the leavings of the cattle, or was on

* Horsemanship's Handbook California State Horseman's Assoc., p. 106.
pasture 12 months of the year noted an annual expenditure of less than $100.

In any case, owners concerned with the welfare of their horses know that proper feeding was a major item. Unless a horse is fed properly, its maximum potential in growth, body form, speed, reproduction, endurance, and attractiveness cannot be achieved. Feed, which included hay, grain, feed supplements, pellets, pasture, boarding costs, vitamins, and minerals averaged 43.6 percent of the total cost associated with owning a horse. Hay accounted for 23.1 percent of the total annual expenditure even though not all horse owners fed hay. Some used complete pelleted feeds, while other pastured their horses year around.

The over 300,000 tons of hay fed to horses represents about 20 percent of the State's average total hay production. Utah horse owners also fed about 25,000 tons of grain and 5,350 tons of pellets and protein supplements. They utilized over 400,000 animal unit months of pasture. In all, $19.8 million was spent to feed Utah's horses.

Shoeing costs averaged about $12 per horse. Over half of the owners preferred to hire the shoeing done while 37 percent tried the do-it-yourself route. The shoeing cost amounted to 3.5 percent of the total.

Thirty-eight percent of those questioned reported no cost for veterinarian services. A few had very high vet bills. The average for those that reported any such costs was $21.49 per horse. This would amount to about a $13.30 average for all the state's horses.

Stallion service fees amounted to 4.8 percent of the total cost of owning a horse. This is a distorted figure because only about 30 percent of the owners reported paying a fee. Most of these breeders used Utah stallions. Some, however, did pay high fees (over $1,000). Others obtained free or low-cost breedings whether in or out-of state.

Training costs amounted to 9.5 percent of all reported costs, with large amounts being spent on some horses to train them for special activities such as racing. Such training can cost upwards of $9 a day plus extras. Show horse trainers charge $200 a month and more. Training, shoeing, and trading activities provide full employment for many individuals and part-time employment for many more.

Tack purchases and repairs accounted for over three million dollars, or 6.8 percent of the total.

<table>
<thead>
<tr>
<th>Table 1. Annual Costs to Horse Owners</th>
<th>Percent of Owners Reporting</th>
<th>Average Expenditure Per Horse</th>
<th>Percent of Total Expenditure</th>
<th>Total Expenditure Dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hay</td>
<td>86</td>
<td>91.82</td>
<td>23.1</td>
<td>10,482,079</td>
</tr>
<tr>
<td>Grain</td>
<td>63</td>
<td>37.65</td>
<td>6.9</td>
<td>3,148,594</td>
</tr>
<tr>
<td>Supplement</td>
<td>16</td>
<td>14.12</td>
<td>.7</td>
<td>299,895</td>
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<tr>
<td>Pellets</td>
<td>10</td>
<td>58.00</td>
<td>1.7</td>
<td>769,892</td>
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<tr>
<td>Pasture</td>
<td>57</td>
<td>41.31</td>
<td>6.9</td>
<td>3,125,680</td>
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<td>Boarding Cost</td>
<td>12</td>
<td>75.89</td>
<td>2.7</td>
<td>1,209,342</td>
</tr>
<tr>
<td>Vitamins &amp; Minerals</td>
<td>44</td>
<td>12.49</td>
<td>1.6</td>
<td>729,503</td>
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<td>Shoeing: Hired</td>
<td>64</td>
<td>14.39</td>
<td>2.8</td>
<td>1,222,509</td>
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<tr>
<td>Shoeing: Self</td>
<td>37</td>
<td>7.08</td>
<td>.7</td>
<td>347,734</td>
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<tr>
<td>Vet Services &amp; Supplies</td>
<td>62</td>
<td>21.49</td>
<td>6.3</td>
<td>2,852,647</td>
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<tr>
<td>Stud Fees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In State</td>
<td>26</td>
<td>42.04</td>
<td>3.2</td>
<td>1,450,926</td>
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<tr>
<td>Out of Utah</td>
<td>4</td>
<td>138.37</td>
<td>1.6</td>
<td>734,745</td>
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<tr>
<td>Training Costs</td>
<td>18</td>
<td>180.41</td>
<td>9.5</td>
<td>4,310,670</td>
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<tr>
<td>Facility Rental</td>
<td>7</td>
<td>50.65</td>
<td>1.0</td>
<td>470,640</td>
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<tr>
<td>Tack Cost</td>
<td>62</td>
<td>28.06</td>
<td>5.1</td>
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<td>Tack Repair</td>
<td>61</td>
<td>9.28</td>
<td>1.7</td>
<td>751,432</td>
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<td>Entrance Fees</td>
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<td></td>
<td></td>
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<tr>
<td>In State</td>
<td>40</td>
<td>49.40</td>
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<td>Out of Utah</td>
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<td>71.35</td>
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<td>Lodging &amp; Food</td>
<td>37</td>
<td>55.78</td>
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<td>Transportation</td>
<td>70</td>
<td>30.60</td>
<td>6.3</td>
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<tr>
<td>Other Expenses</td>
<td>19</td>
<td>66.51</td>
<td>3.7</td>
<td>1,677,460</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>$45,425,607</td>
</tr>
<tr>
<td>Per Horse</td>
<td></td>
<td></td>
<td></td>
<td>$342.21</td>
</tr>
</tbody>
</table>
Transportation was another important cost reported by 70 percent of the owners. This cost amounted to 6.3 percent of the total cost.

In 1974 Utah's horsemen spent $45,425,607, or $342.21 per horse. As this money entered the State's economy, it generated a secondary impact almost as great as the primary. Horses obviously affect many different industries in the State advantageously, thereby enhancing the State's overall economy.

**Horse-oriented Income**

The horse industry is not usually visualized as a money-making business. And indeed, only about one-fourth of the horse owners reported receiving income from their horse programs, with horse sales involving just 22 percent of the owners reporting. Nevertheless, income derived from horses or horse-oriented activities by Utah horse owners in 1974 was approximately $23.4 million (Figure 1).

Winnings out-of-state was the next largest source of income (12.2 percent of the total) although it affected only 4 percent of the owners. These same owners probably had high feed, training, and transportation costs.

Many stallions are standing at stud in Utah. Possibly some of the best in the west are in the State. Horse owners from all over the west bring their mares to these stallions for service. Eight percent of the owners reported income from this source. This amounted to 9.6 percent of the total income figure.

Income was also produced by winnings in Utah, boarding and training services, and stock and facility rentals.

**Capital investment**

The dollar investment in the horse and pony industry in Utah during 1974 was approximately $329.3 million (Figure 2). Horse facilities, horses, tack, trucks, trailers, and pick-ups were the major items included in this category.

Many businesses in the State depend on and are built around the horse industry. Hundreds of retail and wholesale store owners derive a major portion of their income from the sales of horse equipment, feed, or western apparel. Trailer, truck and pick-up dealers rely on horse owners for a considerable share of their business (47 percent of the horse owners owned a horse or stock trailer and 82 percent owned a pickup).

In evaluating horse-owner investments in trucks and pickups, however, it was determined that not all the use of these vehicles could be assigned to horse-related activities. Therefore only the identifiable portion of the investment was charged against the horse enterprise.

The major investment reported was in facilities, which accounted for 67.1 percent or $221 million of the total investment. This real estate

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**Figure 1**

**ANNUAL INCOME FROM HORSES OR HORSE ORIENTED ACTIVITIES**

<table>
<thead>
<tr>
<th>Description</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Horse Sales</td>
<td>56.5%</td>
</tr>
<tr>
<td>B. Winnings out of Utah</td>
<td>12.2%</td>
</tr>
<tr>
<td>C. Breeding Fees</td>
<td>9.6%</td>
</tr>
<tr>
<td>D. Winnings in Utah</td>
<td>7.9%</td>
</tr>
<tr>
<td>E. Boarding Fees</td>
<td>6.4%</td>
</tr>
<tr>
<td>F. Training Fees</td>
<td>6.0%</td>
</tr>
<tr>
<td>G. Other Horse-oriented Income</td>
<td>1.3%</td>
</tr>
<tr>
<td>H. Stock and Facility Rental</td>
<td>0.3%</td>
</tr>
</tbody>
</table>

March 1976
Figure 2
CAPITAL INVESTMENT PER HORSE IN FACILITIES AND EQUIPMENT

COMPONENTS OF CAPITAL INVESTMENT

Horse Tack
Trucks
Horse Trailers
Pickups
Horses
Horse Facility

7.4%
4.2%
4.1%
3.7%
13.4%
67.1%

$221.0 million
$44.2 million
$24.6 million
$13.8 million
$13.4 million
12.2 million

TOTAL CAPITAL INVESTMENT $329.3 million

Horse Facilities $221.0 million
Horses $44.2 million
Horse Tack $24.6 million
Trucks $13.8 million
Horse Trailers $13.4 million
Pickups $12.2 million

is on tax rolls and adds to the city, county and state taxes collected.

The horses themselves represented the second largest investment, 13.4 percent or $44.2 million. Many of these horses are also on tax rolls and add to the public income.

People invest in horses for many reasons. Some do it to make money, but most are actually foregoing potential income from alternative investments. Apparently, the satisfaction and enjoyment derived from their horses are sufficient to offset such financial “losses” and to make them invest and reinvest their money in Utah’s horse and pony industry.

Conclusions
Whatever it is that draws individuals to horses, whether it be pleasure riding, racing, jumping, deer hunting, breeding, training, or combinations of these, horses and horse-oriented events are one of our most popular outdoor recreation activities.

As the horse population continues to increase, the strain on present facilities will become greater. More boarding stalls, arenas, club facilities, and equestrian trails are already needed. Many counties are planning future facilities with which they hope to accommodate expanding activities and events.
The remaining counties might want to review their current and projected involvement in the State's horse industry.

Zoning problems are associated with the desire of city dwellers to have a horse. Zoning for ranchette communities, where people with similar interests can keep horses and yet have nice homes and access to community service, may be one solution. Wider awareness of the horse industry's economic effects on the State can help promote such changes. All individual owners, breed associations, horse organizations, and county, state and local agencies must work together to help meet the needs of the industry and identify its priorities and alternatives.

J'Wayne McArthur is Lecturer, Department of Animal Science, USU.
Increasing Yields on Recently Graded Land Through Proper Phosphate Fertilization

Charles M. Burt, Glen E. Stringham, and David W. James

Land grading (leveling), a common practice in western irrigated agriculture, is a major land development expense. The cost is usually justified on the basis of a more uniform water application, improved land tillage efficiency, better surface water drainage, and an anticipated yield increase which should net a larger profit for the farmer.

After land has been graded, patches of stunted crop growth often appear. Some patches may disappear after a few years, while other persist. Such spots can be due to soil compaction by the earth-moving equipment, or exposure of very sandy or clayey subsoil. In many cases, however, poor phosphorus and/or nitrogen fertility on cut and fill spots very often causes the spotty growth. A technique to be used in avoiding a phosphorus fertility deficiency on leveled fields is presented in this article.

To evaluate the phosphorus fertility problem, 12 leveled fields in Cache Valley were selected, representing several different soils. A 4 or 5 acre plot within each field was staked to match the grid from the original SCS land grading records, and soil samples were taken at each stake. The samples were analyzed in the USU soil testing laboratory for soil phosphorus availability.

From results of the laboratory analysis, available soil phosphorus was plotted against the depth of cut or fill for each field. Average soil test results showed that the phosphorus content decrease in all 12 fields was almost linear as the depth of cut increased. This linearity is illustrated in Figure 1 drawn from field data for one of the sampled Cache Valley fields, (it should be noted that this linearity is applicable only to cut depth of about 1.5 ft).

Predicting Phosphorus Needs

Because of the relationship illustrated in Figure 1, phosphorus needs in potential cut areas can be predicted before land is graded. By using the simple method explained below, a farmer can predetermine how much phosphorus fertilizer he will need for different depths of cut, and thus estimate his true cost of reclamation. Then after his land is graded, he can spot fertilize and thus optimize the efficiency of his reclamation investment. Comparable predictability cannot be extended to fill areas, however, because they contain both topsoil and subsoil.

To predict phosphorus needs of land to be graded the following procedure should be used:

1) Before the grading begins, obtain a copy of the engineer’s cut-and-fill calculation sheet for the field, and note the maximum depth of cut.

After land has been graded, patches of stunted crop growth often appear.
2) Go into the field and take a 10-inch deep soil sample (usually a core about 1 inch in diameter) starting at the depth of the deepest cut. For example, if the deepest cut will be 12 inches, the soil sample will include soil from the 12-22 inch zone of the undisturbed soil.

3) Repeat step 2 at five other locations in the field.

4) Combine the samples into two bags (3 samples/bag), being certain to mix the samples thoroughly. The mixing reduces the number of samples to be analyzed to 2 and provides samples that represent “average” conditions at the cut depth.

5) Repeat steps 2, 3, and 4, but this time take the 10-inch deep soil samples from the 0-10 inch zone (from the undisturbed topsoil).

(Accurate results can be assured only if the above sampling procedures are strictly followed.)

6) Send the 4 labeled samples (two from the topsoil and two from the cut depth) to Utah State University soil testing laboratory, or a commercial laboratory, to be analyzed for available phosphorus.

7) When you receive the results, calculate the average phosphorus concentration at the cut depth \( \frac{P_1 + P_2}{2} \), and the average phosphorus concentration at the topsoil level \( \frac{P_3 + P_4}{2} \), where \( P_1 \) and \( P_2 \) are the two phosphorus readings at the cut depth, and \( P_3 \) and \( P_4 \) are the two topsoil phosphorus readings. For the field described on Figure 1, these two values would correspond to 4.1 ppm of P at 1.2 feet of cut and 8.0 ppm of P at the zero cut.

8) Construct a graph similar to that in Figure 1 by plotting the average P of samples 3 and 4 against the zero cut, and the average P of samples 1 and 2 against the appropriate cut depth. Then draw a straight line between the two points.

9) Using this graph and Table 1, you can estimate optimum phosphorus fertilization rates for any depth of cut. For example, using the data of Figure 1, the average phosphorus concentration at a cut of .8 feet is about 5.3 ppm. Since Table 1 indicates that a soil test phosphorus concentration of 5.3 ppm corresponds to a fertilization rate of slightly less than 222 lbs. of triple super phosphate (TSP)/acre, you would apply TSP on .8-foot-cut areas at a rate of about 210 lbs./acre.

10) After your land is graded, while the stakes are still in the field, use the land grading map to locate cut areas and fertilize according to the rates calculated in step 9.

11) Fertilize the light (5 inches or less) fill areas at the same rate indicated for areas of zero cut. Fertilize heavier fill areas at about the same rate as used for slight (3-4 inch) cuts.

**Dollar Value**

To illustrate the dollar value of predicting specific phosphorus needs, let’s consider again the data graphed in Figure 1.
Table 1. Relationship between soil test phosphorus and phosphorus fertilizer recommendations (based on data from the Northwest Soil and Plant Test Group).*

<table>
<thead>
<tr>
<th>Soil Test Phosphorus (ppm)</th>
<th>Elemental Phos. (P)</th>
<th>Phos. Oxide (P₂O₅)</th>
<th>Triple Super Phosphate (0-45-0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>87</td>
<td>200</td>
<td>444</td>
</tr>
<tr>
<td>1</td>
<td>78</td>
<td>180</td>
<td>400</td>
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<td>2</td>
<td>70</td>
<td>160</td>
<td>356</td>
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<tr>
<td>3</td>
<td>61</td>
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<td>5</td>
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<td>110</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*These rates are recommended for most field crops except potatoes, dryland grass, or pasture. The terms Elemental Phosphorus (P), Phosphorus Oxide (P₂O₅) and Triple Super Phosphate (0-45-0) are common expressions for phosphorus fertilizer analysis.

Using a phosphorus-yield relationship developed by Dow and James (1973), decreases in yield due to phosphorus deficiencies in the cut areas of this field (assuming no other fertilizer deficiencies) would average 9 percent. If the field were planted to field corn, in Cache Valley the loss in tonnage would be:

\((.09) \times (26 \text{ tons/acre max}) = 2.34 \text{ tons/acre}\).

The loss in income due to decreased yield would be:

\((2.34 \text{ tons/acre}) \times ($16/\text{ton}) = $37.44/\text{acre}\).

On the cost side, we would include taking the soil samples, having them analyzed, and applying the fertilizer, which might average $5/\text{acre}$. We’d then calculate the cost of fertilizer actually needed in the cut zones:

\[
\begin{align*}
183 \text{ lbs. TSP (0-45-0)/acre} & \times 2,000 \text{ lb/ton} \\
& \times $165/\text{ton of TSP} = $15/\text{acre} \\
& \text{and add to it the $5 per acre for the testing and application to give a total cost of $20/acre.}
\end{align*}
\]

In this example, by investing $20/\text{acre}$ the farmer would gain $37/\text{acre}$, for a net profit of $17/\text{acre}$. Once phosphate fertilizer has been spot applied in this way, in subsequent years the whole field may be fertilized uniformly at rates indicated by soil test analyses.

This method was developed for use on soils having relatively higher phosphorus concentrations in their topsoil than their subsoil, a very common occurrence in Utah. The unusual situation, in which the subsoil has a relatively high phosphorus concentration, would be identified by the laboratory analysis results.


**References**

Weights of Hunter-Harvested Mule Deer in Utah

Dennis D. Austin and Philip J. Unness

Deer hunters are often astounded at checking stations when the 200 to 250 pound buck they dragged down a mountain has somehow shrunk to less than 180 pounds on the scale. The hunters care about weights from a meat-eating view-point. Game managers are interested in deer weights as potential measures of interacting environmental and heredity influences such as food availability, winter severity, health, genetic make-up and age.

Three weight measurements are commonly taken in reference to deer: Live or total weight of the animal; field dressed weight, which equals total weight including heart and liver minus the viscera; and hog-dressed weight, which is field dressed weight minus heart and liver. In all cases, hide, feet, and head are intact. The relationship of hog-dressed weight to live weight, and the corresponding weights of edible meat and organs are illustrated in Figure 1. Hog-dressed weights are used in this paper, unless otherwise indicated.

Weights have been collected on hunter-harvested mule deer throughout Utah in past years (Table 1). The data indicate that does attain their adult size at the end of their second summer, or when they are about 16 months old. The lack of appreciable weight gain during subsequent years is probably due to the energy consumed by their production of fawns. A rare infertile doe may exceed 160 pounds by the time she is 3 or older (Utah Division of Wildlife Resources, unpublished data 1965-1972).

The average yearling buck weighs about the same as an average mature, fertile doe. The bucks, however, will continue to make significant weight gains for 7 to 9 years if they manage to elude death. At 5, a buck will often weigh over 200 pounds. However, in this

Table 1. Mean hog-dressed weight and normal range of weight for hunter-harvested mule deer in Utah (1965-72)

<table>
<thead>
<tr>
<th>Age (years)</th>
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March 1976
Figure 1. Approximate relationships of hog-dressed weight to weight of other body parts.

Figure 2. Carrying deer to the scale at Daniels checking station.

In 1975, 211 buck deer were examined at Utah’s Daniel’s Canyon checking station. Deer were weighed on a platform scale (Figures 2 and 3) and age was determined by tooth eruption and wear. Mean weight by age class (years) was:

Sample of 146 prime bucks (3-1/3 years and older), fewer than 1 in 10 exceeded 200 pounds. The hog-dressed weights of bucks cited in Table 1 are similar to those obtained in adjacent states (Julander et al. 1961, Russo 1964, Hunter 1947, Mackie 1964).

Figure 3. Weighing deer and checking teeth.

Photo by Chris Chaffin
Of the 44 prime bucks examined, only 1 in 11 weighed over 200 pounds, the heaviest being 242 pounds. The mean hog-dressed weight of all deer weighed at the Daniel's Canyon check station in 1975 was 118.5 pounds. As implied in Figure 4, the edible meat per carcass would then average 83 pounds.

The data collected at the Daniel's Canyon check station in 1975, and the Utah deer harvest statistics for 1974 (John 1975) were correlated (Figure 4). In 1974, 50 percent of the buck deer harvested were yearlings, 22 percent were 2-1/3 years old, and 28 percent were in the prime class. More than 60 percent of the buck deer harvested weighed less than 120 pounds, and fewer than 10 percent weighed more than 180 pounds.

Deer weights are obviously influenced by quantity and quality of available forage. Ranges in good condition, without excess animals, will naturally produce heavier deer than poor ranges. During 1967-1969 deer taken from the LaSal Mountains were significantly heavier than those from the Henry Mountains. The differences were attributed to variations in quantity and quality of forbs from two ranges of contrasting summer use (Pederson 1970). Between 1954-1956 deer weights were 65-90 percent less on the Antimony Unit in Utah, where overgrazing had been evident for many years, than on the Sublett Unit in Idaho, which contained abundant forage (Julander et al. 1961).

Hog-dressed weights of deer were obtained from adjacent ranges on Blue Mountain in northeastern Utah and northwestern Colorado during the fall of 1973. Summer range conditions were similar, except that vast acreages on the Utah unit had previously been sprayed to control sagebrush, thus eliminating much of the browse forage. The weights of the Utah deer in various age classes averaged 6 percent to 24 per cent less than those from Colorado.

Deer weight data provide game managers with an additional tool with which to evaluate various management plans for optimizing range (deer) productivity.

References


Philip J. Urness is Associate Professor, Department of Range Science, USU.

Dennis D. Austin is Game Biologist, Utah Division of Wildlife Resources and Collaborator, Department of Range Science, USU.

This research was partially funded by the Pitman and Robinson Act, Project W105R in the Utah Division of Wildlife Resources.
Sand and gravel, like any other natural resource, can only be extracted where evolutionary processes have placed them. Since sand and gravel are low cost, high-bulk materials however, potential transportation costs are important to the economic feasibility of mining any given deposit. Consequently, the most profitable deposits are those located in close proximity to their consumers. Because these consumers tend to be concentrated in urban areas, mining sites generally cluster around cities and towns. This generates competition with other urban activities and poses major problems for sand and gravel operations.

The Utah Scene

Many of Utah's remarkably extensive and high quality sand and gravel deposits are located along the shorelines of the ice-age lake, Lake Bonneville. In the Pleistocene environment, vigorous stream erosion in the highlands around the lake produced debris from even the most resistant rocks. The streams carried the rock debris to the ancient lake shore where sand- and gravel-size particles were deposited near the stream mouths, while the finer materials were carried away by the lake currents. Some sand and gravel deposits along the shorelines are now more than 100 feet thick.

Utah also has alluvial fan deposits of sand and gravel, where steep gradient tributaries enter gently sloping valleys. These deposits are usually extremely variable in composition, often poorly sorted and partially cemented. Actually, every county in the state contains some sand and gravel deposits. The major supplies of the best quality material however, are concentrated along the Wasatch Front.

In 1973 about 14,911,000 tons of sand and gravel, valued at $16,402,000, were produced in Utah (Utah Geological and Mineralogical Survey, Stowe 1975), with most coming from the Wasatch Front deposits. Due to the growing population and urbanization in this area, the demand for high quality sand and gravel by the construction industry will inevitably increase. This means that landuse planners should already be devising ways to solve the predictable noise, safety, and aesthetic problems that irritate urbanities.

Environmental Impacts

Any sand and gravel operation has to use heavy earth-moving and processing equipment and requires large storage areas for stockpiles and machinery. The results include a drastically altered landscape, dust, noise, and heavy traffic volumes, characteristics that are incompatible with many urban landuses.

Visual Description

In Utah, the steep, denuded cut bank is a dominant visual insult since most mines are on the bench areas. Many of these banks rise considerably above the pit floor and may extend for one half mile or more. When not stabilized through revegetation or other means, the cut
banks constitute constantly eroding eyesores.

**Air Pollution**

Sand and gravel excavation sites inevitably contain large quantities of materials that are subject to wind transport. Even moderate winds can lift the fine sand particles into the air and carry them for more than two miles. Larger particles can be lifted into the air by vehicles or excavating machinery and carried by light winds beyond the mine site. During Utah’s dry summers, dust problems can become a serious irritant to users of the adjacent lands.

**Noise**

The noise pollution created by excavation equipment at the site and by trucks moving to and from the area has different effects on different people. Noise is commonly measured on a so-called dBA scale, which weights each frequency according to the magnitude of its effects on the human ear. The dBA range of most interest to the planner is from 45 dBA to about 85 dBA, with 60 dBA representing the level at which conversations are normally accomplished. If noise levels introduced by an outside source (such as traffic or heavy equipment) exceeds the 60 dBA level it is usually considered to be an annoyance. According to Federal Highway Administration standards, a 70 dBA level is the maximum that should be permitted in areas having residences, hotels, motels, recreation areas, playgrounds, and parks. Trucks similar to those that haul sand and gravel average 66 dBA at a distance of 150 feet (Cook 1974).

**Traffic**

Another problem associated with a sand and gravel operation is the damage done to public roads. Unless specifically designed for heavy truck traffic, the roads break up. They then require constant maintenance or sometimes complete rebuilding. Pedestrian and cross traffic safety is another major problem when hauling routes go through residential areas.

**Who Is Responsible?**

In Utah, as in most states, jurisdiction over the location or operation of sand and gravel mines has been delegated to county and city governments, and only a very few Utah communities have developed regulating ordinances. As a consequence, examples of wasted land resources and abandoned eyesores can be found adjacent to nearly every city and town, while complaints about noise and dust from mines continue to appear in local newspapers. Although there appears to be no immediate shortage of sand and gravel in Utah, many high quality deposits which could have been mined with minimal environmental and cultural impacts have been buried under other developments. In addition, the cost of sand and gravel products to the building industry continues to rise as mining operations are forced further away from their markets.

By contrast, cities and counties in other states have enacted highly restrictive and debatable zoning ordinances. New sand and gravel operations are not allowed except in industrial or agricultural zones. Existing mines are designated as nonconforming uses and prohibited from expanding or modernizing. As a consequence, thousands of acres, and millions of tons of high quality sand and gravel are lost to production each year. More and more producers of sand and gravel are finding it increasingly difficult to stay in business.

**A Reasonable Approach**

Far-sighted, comprehensive planning is essential if Utah is to make the wisest and best use of its sand and gravel resources to meet the needs of an expanding population. Fortunately, we can draw upon the experience of others.

The major supplies of quality sand and gravel are concentrated along the Wasatch Front.
Several cities and counties, including Fairfax County, Virginia, Los Angeles County, California, and Denver, Colorado, have used multidisciplined teams of planning professionals and mining industry operators to formulate resource plans, regulatory policies, and operational guidelines. The National Sand and Gravel Association has funded research to explore innovative approaches to mining operations and reclamation practices (Bauer 1965). Our review of these regulatory ordinances and research materials showed Utah could advantageously follow their lead.

Resource Inventory

The wise use of a natural resource such as sand and gravel requires identification of where it occurs. Numerous cities, townships, counties, and some states have identified and mapped natural resources including sand and gravel deposits as a part of their comprehensive planning effort. Utah's Geological and Mineralogical Survey office has excellent information on the location of our own sand and gravel deposits. Very few counties, however,
have availed themselves of this data or attempted to prepare comprehensive plans (Figure 1.)

Zoned Natural Resource Districts

The concept of conserving sand and gravel through the creation of natural resource districts is relatively new but receiving continually wider acceptance by planners. Such zoning recognizes sand and gravel mining as an established land use. It also recognizes that the mined site can be put to various desirable uses after mining operations are completed (Ahearn 1964).

Performance Standards

Performance standards are usually divided into operation and reclamation categories. Typically, operation standards deal with controlling noise, dust, appearance, traffic and safety. Reclamation standards regulate slopes, use of topsoil, and revegetation. Unfortunately, in many instances the performance standards developed and imposed have been unreasonable, frequently being drawn up without an understanding of the technological, ecological, or economic realities of sand and gravel mining.

Operational Concerns

Noise. By specifying setbacks from adjacent land uses, the source of noise is moved to the interior of the mining site. Mounding earth and establishing vegetation around the site’s periphery can further buffer sound. Recent research indicates that mounding and planting can reduce the dBA level by 25 percent, which normally modifies the noise to levels acceptable in adjacent residential and public-use areas.

Dust. Research has demonstrated that the major sources of dust associated with sand and gravel operations are unpaved haul roads and paved roads covered with dirt (Ahearn 1964). Ordinances can require that all haul roads and

unpaved areas around the processing plant be watered during the dry season.

Appearance. Most ordinances address this issue by requiring that plant materials and earth berms be used to screen the processing equipment, storage areas, and sometimes the mined area itself.

Traffic. Truck traffic is a primary source of public objection to sand and gravel operations. A long-term solution requires development of a comprehensive plan in which major deposits are located and zoned, and access to them is incorporated into the area’s traffic plan. Short-term palliatives include:

1. Requiring minimum sheet or highway frontage from property to be used for sand and gravel operations.

2. Route traffic over appropriate streets and highways.

3. The producer himself should seek to prohibit sand and gravel trucks from traveling over residential streets (except of course, when the delivery site is a residential area), or to allow trucks to use a residential short cut. (Ahern 1964).

Safety. Sand to play in, hills to slide down, and a bank to tunnel into all make sand and gravel sites exciting but potentially dangerous places for children. Legally, these conditions are defined as constituting an “attractive nuisance.” Most ordinances state that sand and gravel operations adjacent to residential or public areas must be enclosed by a fence 3 to 4 feet high, so as to prevent easy access to the hazardous areas. Reclamation standards governing percents of slope and site drainage can help eliminate potential hazards once operations have terminated.

Reclamation Concerns

Research funded by the National Sand and Gravel Association demonstrated that the time to begin

Comprehensive planning is essential if Utah is to make the wisest and best use of its sand and gravel resources.
Figure 2. Grading plans and plans for second use for a sand and gravel operation.
planning reclamation efforts was prior to excavation. Concern for the site's appearance after extraction is completed, is usually covered in reclamation regulations that stipulate site grading, revegetation and mandatory removal of processing equipment. Proper planning, which does not require the creation of conditions that exceed premining site characteristics, can make reclamation economically and technologically feasible. In fact, many producers are finding that development of sand and gravel sites with a second use in mind substantially enhances total profits, particularly in rapidly growing urban areas where the demand for land is active (Figure 2).

Slope and draining. Ideally, the reclaimed area should resemble as closely as possible its adjacent landscape. However, deposit characteristics and the nature of the mining operations frequently make this impossible. Consequently, ordinances usually ask that maximum slopes be slightly less than the angle of repose of sand and gravel (1:1 to 2:1), with minimum slopes set to insure positive drainage. Internal drainageways should connect to all original drainage points on the site periphery. The anticipated volumes of runoff water to each external drainageway should not surpass premining volumes. A grading plan for Nordic Square, Apple Valley, Minnesota, as created by Bauer and Associates, landscape architects, is illustrated in Figure 2. This plan was completed prior to mining to comply with Apple Valley's zoning ordinance and was designed to accommodate the anticipated large housing development.

Topsoil. The preservation and replacement of topsoil which is initially stripped from the site is specified in many ordinances. This requirement helps insure a suitable medium for subsequent vegetative growth.

Revegetation. Revegetation to prevent erosion by wind and water on the re-topsoiled contours is also required by many ordinances. Ordinances cannot validly specify the types of plants to be used since the best choices will depend upon local climatic and edaphic conditions. Plants native to the area are generally desirable, however, since they will be visually and ecologically compatible with the surrounding landscape.

Conclusion

As demand for sand and gravel products in Utah continues to grow, so will conflicts between sand and gravel operations and other urban land uses. The public, its elected and appointed officials, and the sand and gravel producer will all be embroiled. To avoid unrealistically restrictive ordinances such as those that have proven unsatisfactory in other parts of the country, Utah's cities and counties should ask interdisciplinary teams of elected officials, sand and gravel operators, geologists, professional planners, and landscape architects to develop realistic regulations that allow for local environmental, technological, and social conditions.

References

Ahearn, V. P., Landuse planning and the sand and gravel producer. National Sand and Gravel Association, Silver Spring, MD. 1964


Maps courtesy of Bauer and Associates, Inc.

Craig W. Johnson is Associate Professor, Department of Landscape Architecture and Environmental Planning, USU.

James Gropper is a graduate student in the Department of Landscape Architecture and Environmental Planning, USU.

Who cares?

Who cares about smoggy skies
About empty and polluted lakes.
Cans and trash littering our country side.
About plants and trees dying in our forests.
And animals too. Who cares?
Woodsy Owl, the Nation's new battler for a clean environment cares. And so should you.
Join Woodsy in the fight against pollution.

Maps courtesy of Bauer and Associates, Inc.

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Join Woodsy in the fight against pollution.

Join Woodsy Owl's fight against pollution. Today.

Maps courtesy of Bauer and Associates, Inc.
Raising Dairy Calves in Northern Utah

E. W. Wisniewski, C. W. Arave, and R. C. Lamb

Over the last several years Utah dairymen have been voicing concern about the ability of a young dairy calf to withstand the stresses of the severe northern Utah winters. Many questions have been raised about the effects of different calf housing systems and calf management practices on calf mortality.

To find answers to such questions, USU and USDA scientists conducted a 6-month survey starting in December 1973.

Thirty-four DHI dairy farms in three northern Utah counties were visited monthly during the course of the survey. Information was recorded on number of calves born, diseases, calf losses, and calf management practices. Detailed analysis of the survey data pointed out a few management factors which, if followed, could significantly improve calf raising success.

Management Tips

The survey indicates that dairy calves can be successfully raised in northern Utah if common sense attention is paid to a relatively few details. Prevention is the best treatment for disease. A bale of straw properly used may be as effective in keeping calves healthy as the most expensive bottle of antibiotics.

1. Keep maternity facilities clean and dry. If adequate facilities are lacking, construction of a simple maternity stall is a profitable investment.
2. Feed colostrum as soon as possible after birth and for the next two days.
3. Allow the dam to lick the newborn calf, but prevent the calf from nursing unless the udder has been washed and sanitized.
4. Unsaleable milk can be used successfully as feed for the calf.
5. High quality milk replacer is an economical substitute for whole milk. To reduce the usual incidence of diarrhea, the calf should be switched gradually to a milk replacer diet.
6. Outside hutchcs and open sheds are preferable to enclosed buildings and in most cases are cheaper to construct. If an existing building must be used, adequate ventilation is essential.
7. Keep each calf separately, at least for the first week or two. If the calves must be raised under group conditions, extra care must be taken to detect sick calves and remove them promptly.
8. Keep calf pens clean, dry, and well bedded at all times. Thoroughly clean and sanitize pens in which a calf has died before putting another calf in its place.

Overall Results

Of the 3,227 cows involved in the survey, 1,540 calved during the 6-month interval. Of cows calving, 9.8 percent experienced dystocia and required assistance during calving.

Five percent of all calves were stillborn and 10.5 percent of the calves born alive died before weaning age (2 to 3 months), with 36.4 percent of the deaths occurring during the first week of life. Total calf losses ranged from 0 to 28.0 percent in individual herds, with an average of 15.6 percent.

The greatest mortality occurred during the cold winter months of December and January. Diarrhea was the principal cause of death, accounting for 51.9 percent of all deaths. Pneumonia was next causing 28.6 percent of the mortality.

Herd Size

The relationship between calf loss and herd size is shown in Table 1.

The greatest calf loss occurred in the larger herds. As herd size increased, each calf received less individual attention. The smallest herds, however, experienced the highest percentage of stillbirths because they lacked adequate maternity facilities. Calves died during parturition in these herds because the cows calved in the open corral or free-stall area.

Diarrhea and pneumonia were present in all herds regardless of size. In addition, cases of IBR (red nose), polyarthritis, diphtheria, infected navel, enterotoxemia, salmonella, and genetic abnormalities were reported in some herds.

Housing

Calves were housed in enclosed barns in 20.6 per cent of the herds. These calf barns were primarily converted chicken coops or old milking barns. Calves were raised in open sheds or outside hutchcs on 41.2 per cent of the farms. On 38.2 per cent of the farms, calves were housed in enclosed barns for a few weeks and then moved to open sheds or hutchcs.

The type of housing profoundly affected calf morbidity and mortality. Calf losses were substantially lower in herds that utilized outside hutchcs or open sheds rather than totally enclosed buildings. Mortality was intermediate in herds using a combination of enclosed and open housing.

Temperatures in enclosed barns are higher than in open sheds and hutchcs, but so is the humidity. Apparently calves are better able to tolerate cold temperatures than high

Keep calf pens clean, dry, and well bedded at all times.
humidity.

The remodeled chicken coops and old milk barns tended to be hard to clean, and their built-up bedding packs greatly increased the humidity inside the building. This was especially evident when the floor was concrete and windows and doors were kept closed most of the time.

Open sheds and outside hutches are easily cleaned manually or with a tractor. Hutchs can readily be moved from place to place and a build-up of bedding can be avoided. In open sheds the desirable heat is retained while potentially dangerous humidity is dissipated. Several inches of gravel can be placed under hutches or in open sheds to aid in draining excess moisture from the bedding.

Unfortunately, enclosed sheds are becoming more popular because they offer protection to the calf feeder from cold and stormy weather. Our survey indicates that when a new housing facility is being planned or an existing structure remodeled, it must be decided which is more important, the health and well being of the calves or the comfort of the calf feeder.

Pen Types

Individual pens (either in enclosed or open structures) were most common (52.9 per cent). Group pens were used in 11.8 per cent of the herds while 35.3 per cent of the herds had a combination of both types.

Herds using just individual pens, and those that used individual pens for the first few weeks followed by group pens had less sickness and fewer deaths than did herds relying on group pens. Disease problems are easier to control and sucking problems are avoided if calves are raised separately. Then too, individual pens are easier to keep clean and dry and hence the calves are more comfortable and stay healthier.

Cleaning and sanitizing the pens between calves did not significantly reduce morbidity or mortality. However, cleaning and sanitizing a pen in which a calf had died did substantially reduce losses of subsequent calves put in the same pen. Death losses were also decreased below average in group-raised calves when the sick were separated from healthy calves.

In severely cold weather calves can be doubled up in outside hutches to keep them warmer. It must be remembered, however, that the amount of bedding must also be doubled to keep the calves clean and dry.

Feeding Practices

All the dairymen surveyed recognized the importance of feeding colostrum to the newborn calf, and did so for at least the first two days of the calf’s life. When the colostrum was fed to calves within 3 hours after birth (as was done by 58.8 per cent of the dairymen) the incidence of diarrhea was substantially reduced but ultimate mortality rates were unaffected.

Calves are better able to tolerate cold temperatures than high humidity.
On 35.3 per cent of the farms the calf was allowed to nurse. Because the cow's udder was often dirty at the time of calving, however, both diarrhea and mortality were relatively high in these calves.

Mastitic and unsaleable milk was fed to calves by 79.4 per cent of the dairymen. Milk replacer only was fed after the second day in 20.6 per cent of the herds and milk only was fed after the second day in 47.1 per cent of the herds. The remaining herds used a combination of whole milk and milk replacer.

Calves fed milk replacer had a greater incidence of diarrhea than those fed whole milk, but death losses were substantially lower. Most cases of diarrhea caused by switching to milk replacer were mild and required no treatment other than slightly reducing the amount fed for a few days.

The amount of liquid fed to the calves also affected calf morbidity and mortality. Calves were fed less than 1 gallon per day in 20.6 per cent of the herds, 1 gallon per day in 58.8 per cent, and over 1 gallon per day in 20.6 per cent of herds. Although the amount fed is commonly reduced in an attempt to reduce the occurrence of diarrhea, herds feeding less than the recommended 1 gallon per calf per day had the highest incidence of diarrhea. Mortality, however, was highest in those herds feeding over 1 gallon of milk or milk replacer per day.

In 50.0 per cent of the herds the owner fed the calves; in 38.2 per cent, other family members (wife or children) had the primary calf feeding responsibility; and in the remaining 11.8 per cent of the herds, a hired employee fed the calves. Calf mortality was lowest in owner-fed herds and only slightly higher if other family members fed the calves. The mortality was three times higher, however, when hired labor fed the calves.

E. W. Wisniewski is now a doctoral student at Purdue University.
C. W. Arave is Assistant Professor, Department of Dairy Science, USU.
R. C. Lamb is Associate Professor, Department of Dairy Science and Federal Collaborator, ARS, USU.

Impact of Manufacturing Firms on Rural Economies

Rondo A. Christensen, Lynn H. Davis and Kimball R. Humphrey

When new manufacturing firms move into a rural area do they all produce identical effects on the local economy? If not, rural development committees might more effectively reverse the flow of their labor and capital to urban areas by concentrating their recruitment efforts on certain types of companies. Based on personal interviews of the managers of 88 manufacturing firms located in 23 of Utah's rural counties, we concluded that manufacturing companies benefit local economies by expending money for labor, goods, and services.
different kinds of companies varied substantially in their local effects. The 88 firms that we surveyed could be grouped as follows: food products, 12; textiles, 11; wood products, 12; stone, clay, and glass, 11; printing and publishing, 9; transportation equipment, 9; machinery, 6; chemicals and petroleum, 7; and other, 11.

We evaluated how each company affected the economy of its area by determining its propensity to consume locally and its propensity to sell outside the local area. The tendency to consume locally was defined as the percent of total expenditures made within the local economy. The tendency to sell outside the local area was defined as the percent of total expenditures made outside the local economy divided by total sales. The local economy was usually considered to be the county within which the firm was located, but included portions of surrounding counties when these were an integral part of the local trading area.

Companies benefit local economies by expending money for labor, goods, and services. These monies are then respent by the individuals and firms that receive them. This cycling effect continues round after round, diminishing each time by the proportion of expenditures made outside the local economy, until the original expenditure is completely lost to the outside economy.

Payments received by a company for sales outside its local area inject money into the income stream of the local economy and thus provide additional purchasing power. The greater the propensity for manufacturing firms to sell outside the local area, the more they contribute to the growth and development of the local economy.

**Propensity to Consume Locally**

The manufacturing firms included in the study spent an average of 45.2 percent of total expenditures within their local economies for labor, goods, and services (Table 1). The other 54.8 percent was spent for imports. Companies having high propensities to consume locally included those manufacturing wood and food products, 55.2 and 52.3 percent, respectively. The intermediates included textiles; stone, clay and glass; printing and publishing; chemicals and petroleum; and machinery. Firms manufacturing transportation equipment made only 19.4 percent of their expenditures locally. The differences between the various manufacturing groups were statistically significant.

In addition to type of manufacturing, other firm characteristics significantly affected propensity to consume locally. These included semifinished materials intensity (semi-finished materials cost as a percent of total sales), labor intensity (wages and salaries as a percent of total sales), and sales volume.

The more semi-finished materials intensive the operations of a firm tended to be, the less they spent in the local area. On the other hand, the more labor intensive it is, the more it will contribute to the local economy. The larger the sales volume of a firm the lower its propensity to consume locally. In absolute terms, however, a large firm would probably inject more money into a local economy than a small firm that had a high propensity to consume locally.

Many firms have been purposely located so as to be near a source of raw materials. For the manufacturing firms in the study as a group, however, raw materials intensity (raw materials costs as a percent of total sales) was not a significant factor affecting propensity to consume locally. One reason for this is that firms that bought substantial quantities of raw materials locally, expended far more for labor, services, and other materials because of the relatively low price per unit of the raw materials.

**Propensity to Sell Outside of the Local Economy**

The percent of sales made outside of the local area averaged 88.7 percent for all firms surveyed (Table 2). Firms manufacturing chemical and petroleum and textile products sold almost all of their products nonlocally, 99.8 and 99.2 percent, respectively. Companies manufacturing machinery, transportation equipment, wood, and miscellaneous products also sold more than 90 percent of their output beyond the local area. Stone, clay, and glass, and printing and publishing firms sold the least outside, 74.1 and 45.4 percent.

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### Table 1. Per cent of expenditures made locally, by manufacturing group, rural Utah, 1974

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<td>Printing and publishing</td>
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*Source: Utah Science*
Table 2. Percent of total sales made outside the local economy, by manufacturing group, rural Utah, 1974

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respectively. The differences between the various manufacturing groups were statistically significant.

In addition to type of manufacturing, sales volume, organizational structure of the firm, and size of the local market all significantly affected propensity to sell outside of the local economy. A large sales volume and a small local population obviously dictated substantial propensity to sell outside of the local area. Single proprietorships and partnerships tended to sell more in the local area while corporations were likely to sell more outside the local economy.

Summary

Our survey results indicate that firms having low semifinished materials intensity and high labor intensity, and that manufactured food or wood products were the most likely to spend significant sums locally. This conclusion is based only on the cycling of the initial flow of money spent by manufacturing firms into the local economy. No attempt was made to determine the multiplier effect of expenditures as they recycled through the local economy.

Firms having the greatest propensity to sell outside the local area included those that manufacture machinery, chemicals and petroleum, textiles, and wood products. Within our survey group, these were also the largest in terms of total sales volume. The companies manufacturing stone, clay, and glass products, and printing and publishing firms had the least propensities to sell beyond the local area. Outside sales are important because they bring new dollars into the local economy, giving it a basis for growth and development.

Local development and planning groups may want to keep these facts in mind as they identify new manufacturing firms that they want to recruit into their areas to help improve income and increase employment.

Rondo A. Christensen is Professor, Department of Agricultural Economics, USU.
Lynn H. Davis is Professor, Department of Agricultural Economics, USU.
Kimball R. Humphrey is Graduate Research Assistant, Department of Agricultural Economics, USU.
Field Criteria for Predator Damage Assessment

James E. Bowns

A great deal of interest has been generated during the past few years concerning predators and their effects on domestic livestock and game populations. Data are needed on the extent of damage attributable to predators and how predation varies from time to time and place to place. The reliability of such data depends on uniform application of criteria that 1) distinguish predator kills from other deaths, and 2) discriminate between kills of different species of predators. Suitable criteria were developed in southwestern Utah in conjunction with a study reported by Bowns et al. (1973) and Davenport, Bowns, and Workman (1973). We here describe these criteria for coyote, cougar, domestic dogs, bear, and bobcat.

Coyote Predation on Sheep

Coyotes are very common in southwestern Utah and account for the greatest number of sheep predation losses. Coyotes more commonly take lambs than mature sheep and characteristically kill with a bite in the throat. The cause of death is generally suffocation as the trachea is damaged.

Blood on the throat wool is prima-facie evidence of predation. Where external bleeding is not apparent, the hide must be removed from the neck, throat, and head of the carcass. If the animal has been killed by a coyote this necropsy will reveal subcutaneous hemorrhage, fang holes in the hide, and tissue damage (Figure 1). The hemorrhage occurs only if the animal was bitten while still alive. The fang holes are usually seen below the ear and in the throat immediately behind the mandibles. On very small lambs, however, the fangs of the upper jaw may penetrate the top of the neck or even the skull. The contrast between a lamb killed by a coyote and one that died from other causes is evident in Figure 2. Animals that die from causes other than predation show no subcutaneous or external bleeding and only an occasional bloody nasal discharge.

It is difficult if not impossible to determine cause of death if the carcass has reached an advanced stage of decomposition. If the dead animal's head happens to be elevated above the rest of its body, however, and the bitten side is off the ground, evidence of the bite may still be visible. Blood on the ground near the mouth or neck of a long-dead animals is also indicative of predation. But care should be taken to distinguish blood from other body fluids that drain from a decomposing carcass. During the winter, mature sheep may be attacked in the hindquarters rather than in the neck. The typical neck bite still occurs in the winter, however, with the hindquarter attack most commonly seen in late winter or early spring just prior to...
lambing. It is thought that the hindquarter attack takes place because winter wool is long and thick on the neck, while the exposed hindquarters are more vulnerable. Coyotes killing in groups may attack the neck and also the hind quarters and udder of a sheep. The edible portions of sheep that die of any cause during the winter months are usually completely consumed in one or a few days by coyotes and/or birds such as eagles, ravens and vultures. Obviously, then, the cause of death is extremely difficult to determine, although the first step is still to check the neck region for fang holes and subcutaneous hemorrhage. An animal pulled down from the hindquarters will exhibit blood on the hind legs and tail region. Large quantities of blood on the ground and vegetation near the carcass are indicative of predation (Figure 3).

Bitten or wounded lambs are commonly seen in herds that are subjected to coyote predation. These animals usually have blood on their neck areas and often trail along at the rear of the herd. The actual damage may vary from little or no blood externally on the neck, to severed trachea, broken jaws, or hide torn from the sides and legs. If noticed, the injured are often treated with a combination of antibiotics, pine tar, and insect repellants. Very few of these lambs survive to maturity even though they may appear active and have few problems eating or drinking. Those that do live until shipping time, are generally rejected by buyers because of poor condition, or malformed necks. Shock and infection have been proposed as reasons for the low survival rates, but some animals do not die for weeks and infection was not evident at the time of necropsy. A form of biological stress may also be involved. Careful periodic checks of the herds are necessary to reveal bitten lambs. These lambs characteristically have drooping ears and a stiff neck carried in a low, horizontal position. Drainage from the wound is often adequate evidence that the animal will not survive the bite.

Researchers should make certain that carcasses found and examined are marked in some manner so that they will not be counted a second time on subsequent visits to the area. This is particularly important when sheep remain in one area for a long period of time or when two or more investigators are working in the same area. Painting the carcass and a nearby rock or tree with easily seen spray paint has proven effective. Particular attention should be paid to painting the legs, skull and vertebral column, because these are the parts most likely to be carried off.

Of serious concern to damage-assessment researchers are missing animals that cannot be accounted for either as predator kills or as losses due to other causes. In dense vegetation, rough terrain, or large areas it can be virtually impossible to find all the dead animals, particularly after the carcass has decomposed and no longer produces an odor. Also, carcasses, particularly of small lambs, may be carried away from the kill site, leaving only a pool of blood and coyote tracks at the site of a kill. In one instance a dead lamb had been observed by the herder, but when a subsequent visit was made to the site the carcass was gone. A drag trail and wool on the brush indicated that the carcass had been dragged away. In another incident, part of a lamb carcass was in the possession of a male coyote when he was caught in a trap as he left an area of severe predation losses. A coyote den was discovered in the vicinity that contained the carcasses of several partially eaten lambs (Figure 4).

Coyote predation on our observed herds was most severe when the herds contained lambs while the coyote pups were small and dependent on the mature coyotes for food.

During late winter mature sheep may be attacked in the hind quarters rather than in the neck.
Mule Deer Killed by Coyotes

Figure 5 shows a mule deer fawn killed by coyotes. Examination of the neck showed considerable tissue damage to the forepart and side of the neck and fang holes in the hide. The main difference between fawn and lamb kills is that lambs are bitten from the side while fawns are bitten on either side of the neck from below. This difference might occur because the fawn is taller. The deer’s neck is also thinner, which allows the coyote to bite both sides simultaneously. Deer carcasses are often completely dismembered and eaten, which makes verification of predation very difficult. If the head is found, however, it is often possible to achieve accurate verification from that alone. Mature deer are killed in a manner similar to that used on mature sheep. The neck is usually bruised, but the fangs do not penetrate the hide. The animal could be grabbed by the throat, but actually pulled down from behind and the hind quarter eaten.

Calves Killed by Coyotes

Calf predation by coyotes is most common at the time calves are born or shortly thereafter. Calf carcasses are often so completely consumed that the exact method of killing is difficult to determine. Subcutaneous hemorrhaging in the necks that were observed indicates that the method of killing may be similar to that used on sheep and deer. Blood on the ground vegetation, and bloody drag trails imply kill procedures similar to those observed many times with sheep. An interesting aspect of some dead calves is the nose having been chewed off or fang holes in the nose. This could indicate that coyotes grasp the calf by the nose in the process of killing or the nose is chewed away in the process of eating the tongue as has been reported with wolves killing caribou.

Calves bitten, but not killed, exhibit wounds in the flank, hind quarters, or front shoulders that may be serious. Tails chewed off near the tail head are considered evidence of coyote predation.

Domestic Dog Predation

Domestic dogs are a serious problem to livestock, especially sheep, pastured near towns or housing subdivisions. It is sometimes difficult to distinguish between a coyote and a dog kill. In general, however, a dog will mutilate an animal much more severely than a coyote. Sheep-killing dogs usually work in pairs or larger groups and can inflict a considerable amount of damage. Dogs often attack the hindquarters of ewes in much the same manner as coyotes, but little flesh is actually consumed (Figure 6). An animal attacked in the hind quarter is also likely to be wounded in the neck and front shoulders. The front shoulders of lambs have been damaged by dogs and although the external damage does not appear to be severe a necropsy reveals severe muscular damage. The ears of mature sheep are often badly torn by attacking dogs. Many times sheep attacked by dogs are not killed, but mutilated to the point where they must be destroyed.

Cougar Predation

The cougar, being a large cat with a relatively short, powerful jaw, kills sheep with a bite in the neck inflicted from above (Figure 7). Removal of the hide from such a sheep will expose the large holes made by the canine teeth. A cougar’s bite often severs the vertebral column with the resulting broken neck. Observations have also been made of cougars biting through the skull.

Cougars kill on sheep bedgrounds, which is also a favored location for coyotes. In these positions, the bite is the primary criterion used to identify the predator involved. Our experience indicates that cougars kill in areas of thick brush or trees more commonly than do coyotes. In three instances cougars are known to have left deep canyons to kill sheep near the canyon rim, often in thick brush. Observations have been made of lambs that have fallen off ledges during or following cougar attacks. Cougars frequently drag their prey from the kill site to a more remote area which causes problems in location and verification. Cougars also tend to cover a partially eaten carcass with leaves or loose soil.

Bear Predation

Predation by bear has not been a very serious problem in our study area, though verified and possible kills have been attributed to bear. In one instance a lamb was killed and eaten while another was severely mauled, but not killed. Tracks at the kill site determined this as bear predation. The animal that was still alive had a bite between the front shoulders, one on each hind quarter and the left side of the head removed. Bears will also attack ewes. Often the bear removes the udder, presumable to obtain the milk, and may or may not kill the ewe. Figure 8 shows a ewe killed and eaten by bear. This animal was probably killed by several bites in the neck. The carcass was consumed to a greater degree than is observed from other predators. Feces at the kill site indicates that two bear were probably involved in this incident.

Bobcat Predation

Only one incident of suspected bobcat predation on a lamb was observed during this study. The lamb was alive when found, and had small patches of dried blood on the neck and one shoulder. Antibiotics were administered, but the lamb died in a few days, presumably from these wounds.
Figure 1. Subcutaneous hemorrhage, fang holes, and tissue damage.

Figure 2. Lamb killed by coyote on left; lamb which died from other causes on right.

Figure 3. Indications of predation: blood on ground and vegetation near the carcass.

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Figure 4. Carcasses of several partially eaten lambs.

Figure 5. Mule deer fawn killed by coyotes.

Figure 6. Ewe killed by a dog.

Figure 7. Sheep killed by cougar.

Figure 8. Ewe killed and eaten by a bear.

Figure 9. Bobcat predation on a lamb.
Necropsy revealed a bite on the neck, and hemorrhaging on the ribs and shoulders, presumably inflicted by claws (Figure 9). The hemorrhages produced by claws were apparent on both sides of the carcass, probably indicating that the bobcat was on the back of the lamb when the neck was bitten.

Criteria presented in this paper and used for determining predator kills and distinguishing between different species of predators are a result of three years of research into damage assessment. Although it is difficult to distinguish between kills by different predator species and decomposed carcasses, present problems that make accurate determinations difficult to impossible, experience and the criteria outlined above can provide a certain proficiency in verification of predator kills.

James E. Bowns is Associate Professor, School of Science, SUJC and Adjunct Associate Professor, College of Natural Resources, USU.

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