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**ANIMAL UNIT  
EQUIVALENTS:  
AN EXAMINATION OF  
THE SHEEP TO CATTLE  
RATIO FOR STOCKING  
RANGELANDS**

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## Summary:

- ◆ **An Animal Unit is a mature nonlactating 1,100 lb beef cow.**
- ◆ **An Animal Unit Equivalent (AUE) is any factor used to equate other species/class/types of animals to an Animal Unit.**
- ◆ **The Standard Livestock Unit was recently proposed as a specific AUE factor. The Standard Livestock Unit provides equivalency for sheep and cattle based on metabolic body size, forage intake and energetic demand. One Standard Livestock Unit equals one Animal Unit.**
- ◆ **6.5 ewes are equivalent to one Standard Livestock Unit.**
- ◆ **Standard Livestock Units are probably more accurate than other AUE's. However, none of the existing or proposed methods are completely suitable for management decisions. A degree of flexibility must be maintained when formulating substitution ratios for replacing one group of livestock for another. Site specific conditions such as forage species and availability, environmental and topographical factors, and supplementation practices, influence determination of ecologically appropriate substitution ratios of sheep for cattle.**

## **Purpose:**

Efforts to properly manage forage resources on our nation's rangelands led to development of the ideas: "carrying capacity" and "stocking rate." Carrying capacity refers to how many and how long livestock can be placed on an area of land without damaging the ecosystem. Stocking rate is the density of livestock (animals / acre) for a given unit of time, and is generally determined by management objectives and estimates of carrying capacity. Because several species and types of grazing animals are used by livestock producers, attempts have been made to develop a standardized animal unit so that differences in forage demand across animal physiological classes and among species could be expressed on a common basis. A mature nonlactating 1100 lb beef cow is an animal unit. Ratios of other species and classes compared with an animal unit are called animal unit equivalents (AUE's). Animal units are currently used as a basis for grazing fee assessments on private and public lands, and for economic assessments such as appraised value of a ranch or its loan value. Due to the possibility of increasing costs charged by Federal and State agencies for an animal unit, there is a need to examine animal unit equivalents for accuracy so parity can be ensured. This paper will examine the development of AUE's for sheep and suggest a change to the current system.

## **Historical Perspective:**

During early (1907 - 1911) surveys of Forest Service grazing land, the term cow day was used to calculate stocking rates<sup>1,2</sup>, while variation in livestock classes or species was not considered. Although the need for a basis for comparison of cattle and sheep was recognized earlier<sup>1</sup>, ratios were not suggested until 1923 when Sampson<sup>2</sup> wrote that one cow unit (undefined) was equivalent to five sheep or five goats. This ratio was based on a subjective assessment of forage demand by each species on mountain summer rangeland, rather than quantified, objective information. In 1940, Pickford<sup>3</sup> defined the cow unit as the forage consumed by a mature cow during one year, and reaffirmed the same 1:5 beef cow to sheep ratio suggested by Sampson.

The definition of an animal unit has been continually refined since 1940. Animal unit equivalents were reevaluated from different perspectives, including quantified differences among animal species, and by physiological state, forage intake and energetic demand.

During the 1950's, Stoddart and Smith<sup>4</sup> defined the animal unit as 1,000 pounds of any species of livestock, which was roughly equivalent to the weight of one cow and her calf<sup>2</sup>. This definition supported the use of AUE's based on animal weight comparisons. Voisin<sup>5</sup> suggested defining an animal unit as 1,100 pounds of live weight, with no reference to species. In his discussion, he focused on forage intake as a primary consideration in determining AUE's, but mistakenly assumed that a 500 pound animal would eat half as much as 1,000 pound animal. Nevertheless, a focus on forage demand by an animal has prevailed in subsequent definitions of both animal units and AUE's.

In 1965, Vallentine<sup>6</sup> reiterated the need to define an animal unit based upon forage demand. Valentine reaffirmed that an animal unit should be defined as a 1,000 lb nonlactating cow in maintenance or gestation, or its equivalent. In addition, Vallentine made two important points: 1) carrying capacity on rangeland is more closely related to forage consumption by livestock than their demand for energy, and 2) an animal unit concept that fully considers all factors affecting consumption and quality of forage has not been found.

The Society for Range Management<sup>7</sup> published standardized terms for animal unit and AUE's in 1974. An animal unit was defined as a 1,000 lb cow with a forage requirement of 26 lbs per day. Two main factors contributed to this estimate of forage demand. First, estimates were typically obtained from lactating cows grazing spring or summer rangeland. Under these conditions, the animal has a high physiological demand and available forage is usually of high quality; thus, a daily intake of 2.6% of body weight (26 lbs forage per 1,000 lb cow) is possible. Second, estimates of forage dietary intake were primarily derived using agronomic techniques. These techniques estimate the amount of forage that disappears after an area is grazed by livestock. Indirect agronomic techniques measure all forage losses, even losses not related to livestock, such as forage consumption by other herbivores (especially insects and small mammals). This methodology can create intake estimates that are unrealistically high.

The Range Society defined an AUE as a numerical factor expressing forage requirements of a particular species and/or class of animal relative to the forage requirement (26 lbs/day) of an animal unit. However, the Society's

publication hedged on this definition of AUE's by stating that this numerical factor may change due to dietary differences among animal species and variations in types of forages present on specific rangelands. The Society recognized that the suitability of a rangeland for a livestock species will vary with the types of forage plants available.

The basis for the current AUE's used by federal land management agencies is the research of C. Wayne Cook<sup>8</sup>. Cook used the concept of metabolic body weight (live weight to the 3/4 power) as the best reflection of differences in nutritional demand among species. Using estimates of energy expenditures for various physiological and grazing activities, Cook compiled what is probably the most complete set of estimates of energy requirements for range livestock. Data obtained from both sheep and cattle grazing in Utah's Great Basin region from 1949 to 1967 were used to derive these estimates. Table 1 presents the summary of Cook's data with the estimates of AUE's based on forage consumption required to meet energetic demands under rangeland conditions. These estimates are based upon a 914 lb lactating cow and her calf as an animal unit, and daily forage consumption by a ewe with a lamb totaling 3.74% of the ewe's body weight, a figure derived using agronomic techniques. These estimates form the basis of the Bureau of Land Management's rationale for AUE's of 0.20 for sheep (a 1:5 cow-to-sheep ratio).

TABLE 1. Average Intake and Animal Unit Equivalent for Various Kinds of Livestock<sup>a</sup>.

Kind of animal	Average weight (lbs)	Daily consumption (lbs/day)	Animal unit equivalent	Intake per cwt (lbs)
Ewe & lamb	139	5.2	0.19	3.74
Cow & calf	914	28.4	1.06	3.1
Steer	551	16.9	0.63	3.06
Dry cow	1029	23.6	0.88	2.29

<sup>a</sup>Adapted from Cook, 1970<sup>8</sup>.

Interestingly, Cook concluded that "these calculations do not represent a conversion factor for exchanging numbers of one kind of animal for another on the range." Dr. Cook recognized that for estimates of this type, knowledge of animal dietary habits and grazing behavior must be incorporated into management decisions relating to carrying capacity.

Given this statement, it is ironic that Cook's conclusions form the basis of the Bureau of Land Management's AUE standard of five sheep to one cow-calf pair. However, the reasons for this decision are understandable since other comprehensive data meeting the needs of the Bureau were unavailable.

### **Current Situation:**

The Forage and Grazing Terminology Committee, formed by the American Forage and Grassland Council, with representation from the Departments of Interior and Agriculture, published new standardized definitions of animal unit and AUE's in 1991<sup>9</sup>. The animal unit is defined as a 1,100 lb nonlactating bovine. This unit is based on a standardized forage demand of 17.6 lbs (1.6% of body weight) per day, which is the National Research Council's<sup>10</sup> published dietary requirement for a mature cow at maintenance. This forage demand reflects both the reduced intake of a nonlactating cow at maintenance and forage intake estimates using animal based techniques designed to overcome the limitations of earlier agronomic techniques. The AUE is a proportionate fraction of the animal unit based on forage intake. Therefore, a mature 147 lb ewe at maintenance with a daily forage intake of 2.0% of body weight ( $147 \times 0.02 = 2.9$  lbs) would be equivalent to 0.16 animal units (2.9 lbs/17.6 lbs). The resulting sheep to cattle ratio would be 6.25:1. Table 2 summarizes information on dietary forage intake of sheep under rangeland conditions.

The 100 lb increase in body weight of an animal unit reflects various changes in the beef cattle industry over the past four decades. Figure 1 represents changes in cow slaughter weights from 1950 to present<sup>11</sup> in the 11 western states. These data form the basis for proposing an updated definition of an animal unit. During 1950, the average weight of slaughter cows was about 920 pounds, similar to the cow size examined by Cook<sup>8</sup>. Since 1950, the weight of slaughter cows has steadily increased to approximately 1120 pounds in 1992. This change was due to introduction of larger breeds and selection for cows with greater growth and milk production potential, resulting in larger calves at weaning when most calves are marketed. Conversely, slaughter weights of range

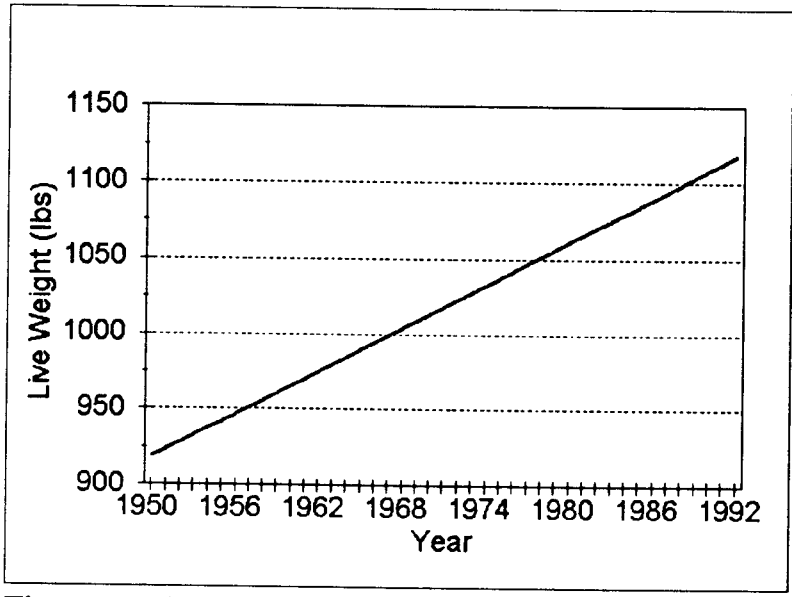
sheep have changed very little as range sheep breeders have typically focused on wool quality rather than growth. Currently, the average weight of a ewe is about 147 lbs<sup>12</sup>, which is similar to the weights of sheep used by Cook.

**TABLE 2. Summary of Forage Intake by Non-supplemented Sheep<sup>a</sup>.**

Fall-Winter Range			
Investigator	Animals	Pasture Type	Forage Intake % Body weight
Soder, 1993 <sup>13</sup>	Pregnant ewes	Montana winter range	1.4
Harris et al., 1989 <sup>14</sup>	Pregnant ewes 1985- 1986	Montana winter range	1.8
		Montana winter range	1.7
Huston and Engdahl, 1983 <sup>15</sup>	Non-pregnant ewes 140 lb.	Texas winter range	1.9*
	Late pregnant ewes 140 lb.	Texas winter range	2.3*
	Non-pregnant ewes 140 lb.	Texas fall range	2.6*
	Early pregnant ewes 140 lb.	Texas fall range	2.5*
Cook and Harris, 1951 <sup>16</sup>	Ewes	Winter desert range	2.2
Average			2.0%
Summer			
Hodgson et al., 1991 <sup>17</sup>	Nonlactating ewes 123 lb.	Summer pasture Scotland	2.2*
Jung and Sahlu, 1989 <sup>18</sup>	Lambs, 53 lb.	Smooth brome grass, summer	3.3*
Huston and Engdahl, 1983 <sup>15</sup>	Nonlactating ewe 140 lb.	Texas spring range	2.8*
Gibb et al., 1961 <sup>19</sup>	Lactating ewes 140 lb.	Summer pasture United Kingdom	3.6*
Cook et al., 1962 <sup>20</sup>	Ewes, 140 lb.	Poor and good desert ranges	1.8 - 2.3
Average			2.9%

<sup>a</sup>Information compiled by V. Thomas, Montana State University, Bozeman.

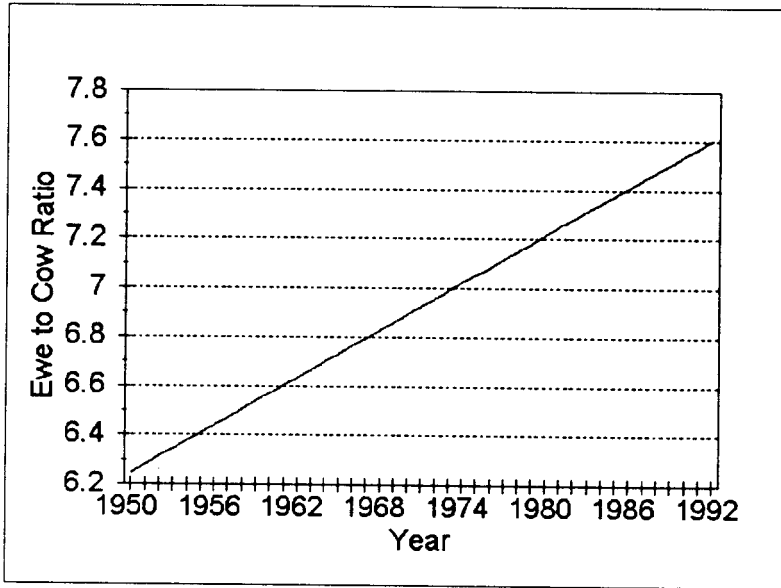
\*Approximate values because no body weight given.



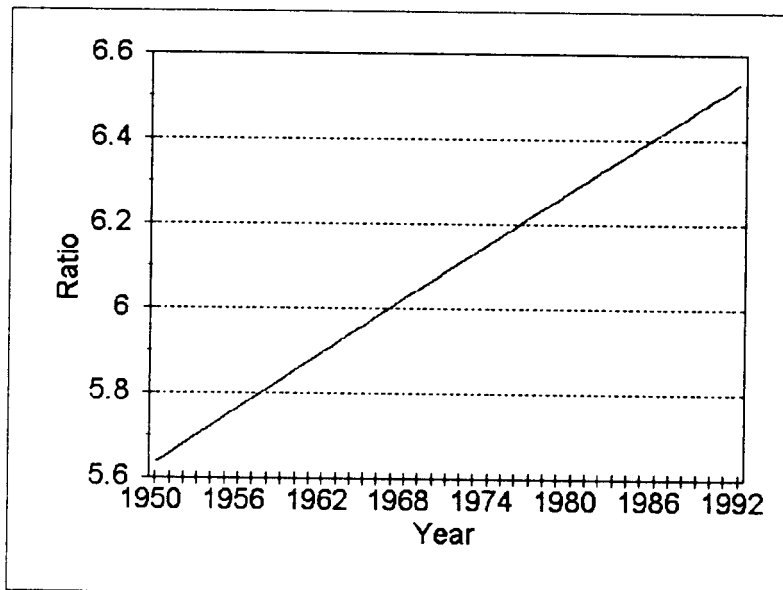
**Figure 1.** Change in cow slaughter weight from 1950 to 1992 in the 11 western states<sup>11</sup>

Based only on live weight (Figure 2), the number of sheep per cow calculates to approximately 6.2 during 1950 and 7.6 during 1992. The difference is due to changes over time in average beef cow weight. Similarly, an examination of energy required for maintenance for sheep and cattle also suggests the ratio of sheep to cattle should be reconsidered (Figure 3). Using net energy requirements for maintenance as suggested by Lofgreen and Garrett<sup>21</sup> for beef cattle and Rattray et al.<sup>22</sup> for sheep, the ratio of sheep to cattle would have been approximately 5.6 in 1950 and 6.5 in 1992. The 1950 estimate is similar to that of Cook's while the 1992 figure reflects the larger beef cow that predominates today. When adjusting 1992 values for differences in lactating animals, the ratio of sheep per beef cow may be larger due to the increased milk production potential of beef cows.





**Figure 2.** Ratio of sheep to cattle live weight.



**Figure 3.** Ratio of sheep to beef cattle based on net energy required for maintenance.

The Forage and Grazing Terminology Committee also recommended the adoption of the Standard Livestock Unit (SLU). This unit incorporates the fact that sheep consume about 20% more forage on a live body weight basis than cattle. The SLU is the numerical conversion factor for sheep and cattle AUE's. Based on research by Minson and Whiteman<sup>23</sup>, the SLU (Table 3) considers metabolic body weight, forage intake and energetic demand. Using these calculations, 6.5 ewes weighing 147 pounds are equal to one Standard Livestock Unit. This value approximates our estimate of 6.5 ewes per cow in 1992 using maintenance energy requirements for each species. Our comparison further suggests that differences between estimates derived by Cook and those based on the SLU may be largely due to a difference in cow size and an overestimation of ewe dietary forage intake by Cook<sup>8</sup>. Based upon current information, we suggest that Standard Livestock Units serve as generic factors for quantifying AUE's.

TABLE 3. Factors for Converting the Number of Grazing Animals of Different Species and Weight into Standard Livestock Units (1,100 lb nonlactating bovine)<sup>23</sup>.

Sheep		Cattle	
Live weight lbs	Livestock units	Live weight lbs	Livestock units
22	0.038	220	0.30
44	0.063	440	0.50
66	0.086	660	0.68
88	0.106	880	0.84
110	0.126	1100	1.00
132	0.145	1322	1.15
154	0.163	1543	1.29

## **Management Implications**

Given Cook's cautionary comments about conversion factors, and our increased knowledge in the last 20 years of the grazing behavior of different species, we need to make an important distinction between AUE's and substitution ratios. The AUE is a standardized conversion factor to equate different species and types of animals. The AUE's reflect forage demand differences between animal types, physiological states and species. Calculation of an AUE depends upon the reference point (the definition of an animal unit) and the estimation of forage demand for the specific animal species and type.

In brief, substitution ratios are site-specific conversion factors and should reflect dietary differences among animal species and the specifics of forage composition of a rangeland site<sup>24</sup>. As indicated by Cook<sup>8</sup> and Vallentine<sup>6</sup>, many other factors need to be considered when calculating substitution ratios. Forage intake, diet selection and energetic demand are affected by many environmental conditions, including weather, topography, forage availability and forage quality. Furthermore, management practices such as dietary supplementation and animal health practices can greatly influence forage use. Substitution ratios may range from 1:1 to 15:1 or more for individual sites and management objectives. Identification of site-specific ratios will depend on thorough knowledge of forage resources and grazing preferences of livestock species. Standardized AUEs do not account for attributes of the rangeland site; consequently, they have only limited practical value as a management tool.

## **Conclusion**

It must be recognized that use of Standard Livestock Units is more accurate than currently used animal unit equivalents given present information, but use of either is a matter of convenience. Neither set of factors is entirely accurate, nor promises to improve resource management and economic stability in the long run. An optimum stocking rate is one that is flexible, using the experience of a manager that can integrate the many environmental and animal factors, with a goal of maintaining or improving the natural resource and economic returns.

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