Table 8.10
Suggested Reductions in Cattle Grazing Capacity with Distance from Water.

Distance from Water		
Miles	Km	Percent Reduction in Grazing Capacity[a]
0–1	0–1.6	None
1–2	1.6–3.2	50
2	Over 3.2	100 (consider this area ungrazable)

Source: Holechek (1988).

[a]Supporting literature includes Valentine (1947), Martin and Ward (1973), Sneva et al. (1973), Squires (1973), Beck (1978), Pinchak et al. (1991), and Hart et al. (1993).

Sheep and goats make much better use of rugged terrain than do cattle. Because of smaller size, more surefootedness, and a stronger climbing instinct, they naturally use steep areas much more than do cattle. In most cases, sheep are under the control of a herder and can readily be forced to use the steeper hillsides, minimizing overuse of the valley bottoms. McDaniel and Tiedeman (1981) found that sheep on winter range in New Mexico uniformly used slopes of less than 45 percent. However, utilization was reduced sharply when slopes exceeded 45 percent. Based on their study, slopes greater than 45 percent should be considered unusable by sheep, but little or no adjustment appears necessary for slopes under 45 percent.

Forage Demand by Grazing Animals

Forage demand is a function of the number of animals and the number of days they will occupy a particular range. We believe that the best way to derive daily forage demand (dry-matter basis) of ruminant animals is to multiply their body weight by 2 percent. In Chapter 11 (Table 11.2), we will review a wide range of studies that were consistent in showing that range ruminants consume 2 percent of body weight per day in dry matter when forage availability is not restricted. Intake may go as high as 2.6 percent of body weight for short periods when forage quality is high, and it may drop to 1.5 percent or lower when quality and/or quantity is low. However, the yearly averages given for cattle, sheep, goats, deer, elk, pronghorn, moose, and so on are all about 2 percent. Forage intake by horses and donkeys averages about 50 percent higher than that for ruminants (see Chapter 11). Daily forage intake by various range animals is shown in Table 8.12.

Table 8.11
Suggested Reductions in Cattle Grazing Capacity for Different Percentages of Slope.

Percent Slope	Percent Reduction in Grazing Capacity[a]
0–10	None
11–30	30
31–60	60
Over 60	100 (consider these slopes ungrazable)

Source: Holechek (1988).

[a]Supporting literature includes Glendening (1944), Mueggler (1965), Cook (1966b), Gillen et al. (1984), Ganskopp and Vavra (1987), and Pinchak et al. (1991).

Selection of the Harvest Coefficient

The harvest coefficient is the percentage of total forage produced that is assigned to grazing animals for consumption. Holechek (1988) bases harvest coefficient selection on various stocking-rate studies from different range types. For most arid and semiarid areas, a harvest coefficient of 35 percent would be selected while 50 percent would usually be used for annual grasslands and humid areas if the goal is moderate grazing.

Galt et al. (2000) made detailed evaluations of actual forage use when the Holechek (1988) stocking procedure was applied on several New Mexico rangelands. Consistently, actual measured use was 10 percent to 15 percent higher than the intended use. This was attributed to livestock trampling, wildlife consumption, and weathering. On Chihuahuan Desert rangelands, Paulsen and Ares recommended that stocking levels be set for 35 percent use of perennial grasses. However, they noted that the harvest coefficient must be set at 30 percent to obtain 35 percent use because of trampling, wildlife, and weathering losses. Past and recent research has confirmed this wisdom.

Table 8.12
DAILY DRY-MATTER CONSUMPTION BY VARIOUS RANGE ANIMALS BASED ON THEIR BODY WEIGHT.

Animal	Animal Weight[a] lb	Animal Weight[a] kg	Daily Dry- Matter Intake (Percentage of Body Weight)	Daily Dry- Matter Intake lb	Daily Dry- Matter Intake kg	Animal Unit Equivalents (AU_1)
Cattle (mature)	1,000	455	2	20.0	9.1	1.00
Cattle (yearlings)	750	318	2	15.0	6.8	0.75
Sheep	150	68	2	3.0	1.4	0.15
Goat	100	45	2	2.0	0.9	0.10
Horse	1,200	545	3	36.0	10.9	1.80
Donkey	700	318	3	21.0	6.4	1.05
Bison	1,800	818	2	36.0	16.4	1.80
Elk	700	318	2	14.0	6.4	0.70
Moose	1,200	545	2	24.0	10.9	1.20
Bighorn sheep	180	82	2	3.6	1.6	0.18
Mule deer	150	68	2	3.0	1.4	0.15
White-tailed deer	100	45	2	2.0	0.9	0.10
Pronghorn antelope	120	55	2	2.4	1.1	0.12
Caribou	400	182	2	8.0	3.6	0.40

Source: Holechek (1988).

[a]Average weight of mature male or female animal.

Troxel and White (1989) have developed a simpler, more conservative procedure than Holechek (1988) that allocates 25 percent of current year forage production to livestock and another 25 percent to natural disappearance (insects, wildlife, weathering), with 50 percent left for site protection. The approach developed by Holechek (1988) is based on maximizing forage use by livestock, while that of Troxel and White (1989) works well for range betterment and minimization of risk. On most western ranges, partial or complete destocking would be necessary in only about 3 to 4 years out of 20 with the Troxel and White (1989) procedure.

Recently, other rangeland researchers (Lacey et al., 1994; Johnston et al., 1996; White and McGinty, 1997; Galt et al., 2000) as well as the USDA-Natural Resources Conservation Service (1997) have recommended that a 25 percent harvest coefficient be used when forage is allocated to livestock in stocking-rate decisions. It allows both forage species and livestock to maximize their productivity, allows for error in forage production estimates, greatly reduces problems from buying and selling livestock, reduces the risk of financial ruin during drought years, and promotes multiple-use values.

Variability in precipitation and forage production should play a key role in harvest coefficient selection. Forage production is much more erratic on the desert ranges of the intermountain West than in the central Great Plains (Table 8.13). This necessitates a more-conservative approach to stocking on the desert rangelands.

In the Chihuahuan Desert of New Mexico, Galt et al. (2000) found that ranchers who routinely stocked at capacity based on a 25 percent harvest coefficient would need to liquidate or drylot-feed about one-half their herd in 2 years out of 10 years (Table 8.13). In contrast, the rancher using a 35 percent harvest coefficient would need to completely destock in 2 years out of 10 years and partially destock in another 1 to 2 years. However, Galt et al. (2000) acknowledge that ranchers in the more-humid Great Plains rangelands might do better with a harvest coefficient of 35 percent rather than 25 percent because of less annual variation in forage production.

The real problem is that few ranchers have the skills or time/labor resources to annually quantify forage production (Galt et al., 2000). Unless this is done, use of harvest coefficients higher than 25 percent invariably leads to land degradation and severe financial losses when drought occurs because of rancher reluctance to destock. These losses can quickly eliminate any accumulated benefits of more-efficient forage use. Unused forage in wet years provides a reserve of forage for drought and increases plant vigor and soil water infiltration (Molinar et al., 2001). Rather than a waste, it is an investment in the future.

Table 8.13
TEN-YEAR VARIATION IN FORAGE PRODUCTION ON MODERATELY GRAZED NEW MEXICO CHIHUAHUAN DESERT AND COLORADO MIDGRASS PRAIRIE RANGELANDS.

Chihuahuan Desert New Mexico[a]			Midgrass Prairie Colorado[b]		
Year	Annual Precipitation (in.)	Forage Production (lbs/acre)	Year	Annual Precipitation (in.)	Forage Production (lbs/acre)
1989	7.6	189	1957	13.2	1141
1990	10.7	270	1958	17.3	1489
1991	15.1	488	1959	13.5	1095
1992	15.4	750	1960	12.5	1140
1993	9.9	203	1961	17.9	1508
1994	7.0	6	1962	16.4	1314
1995	6.7	59	1963	18.7	1327
1996	7.9	145	1964	9.9	1179
1997	11.6	284	1965	19.4	1197
1998	8.2	173	1966	13.8	1267
Average	10.0	257		15.3	1266
Standard deviation	3.0	207		2.9	137
Coefficient variation	30.2	81		18.9	11

Source: Galt et al. (2000).
[a]*Source*: Holechek et al. (1999b).
[b]*Source*: Sims et al. (1976).

Calculation of Stocking Rate

Once the average forage production and the minimum residue required to maintain the site are determined, the initial stocking rate can be set. It is important to recognize that this rate will often need to be modified as experience is gained for the particular range. The stocking rate is determined by dividing the total usable forage per unit area by the total forage demand of the grazing animals for the grazing period.

We are now ready to solve some hypothetical stocking-rate problems using the procedures developed by Holechek (1988) and validated by Holechek and Pieper (1992). Three cases will be used as examples.

GRAZING CAPACITY PROBLEMS

Location: Northeastern New Mexico
Situation: Short grass Prairie Ranch
Ranch Size: 20,000 acres
Forage Production: × 600 lbs/acre
12,000,000 lbs/forage
× .35 harvest coefficient
4,200,000 lbs. forage usable
÷ 7300 lbs/1000 cow/year
575 Animal Unit Years (AUY)

Total Forage Production:
1996 – 400 lbs/acre
1997 – 700 lbs/acre
1998 – 600 lbs/acre
1999 – 800 lbs/acre
2000 – 500 lbs/acre
Average: 600 lbs/acre

Primary Grasses:
Blue grama
Dropseed
Threeawn
Bluestem

Average: Annual Net Return/All for last 10 years = $80/AU

Questions:

1. What is the grazing capacity of this ranch?

   575 AUYs

2. What is the fair market value of this ranch?

   $80/AU × 575 AUY × 15* = $690,000

GRAZING CAPACITY PROBLEMS (*Continued*)

3. How many 150 lb. sheep will this ranch carry?

$$\frac{1000 \text{ lbs/cows}}{150 \text{ lbs/sheep}} \times 575 = 3{,}833 \text{ sheep}$$

4. What is the average net return acre for this ranch?

$$\$80 \text{ AU} \times 575 \text{ AUs} \div 20{,}000 \text{ AC} = \$2.30$$

*15 is the average multiple investors of stocks have been willing to pay for $1.00 of earnings. This equates to a 6.67 percent return on investment or a 15-year time period for recovery of investment.

CASE 1

You are contemplating buying a ranch on shortgrass prairie range in eastern Colorado. You have determined that the range condition is good. The range is flat and well-watered (no part of the pasture is over 2.4 km from water). Based on information from the Natural Resources Conservation Service and your own ocular estimates, production of key forage species averages about 700 kg/ha of dry matter per year. The ranch is 2,000 ha in size, and you are planning a cow-calf operation.

Question

How many 400-kg cows can you have in your base herd?

Calculation of total usable forage:

Forage production (kg/ha) × percent allowable use
× area(ha)
= total forage (kg) available for grazing

$$700 \times 0.50 \times 2{,}000 = 700{,}000 \text{ kg}$$

Calculation of forage demand:

Weight of cows (kg) × daily dry-matter intake (2% body weight)
× number of days pasture will be grazed (365)
= forage demand per cow per year

$$400 \times 0.02 \times 365 = 2{,}920 \text{ kg of forage/cow/year}$$

Calculation of stocking rate:

Total usable forage (kg) ÷ forage/cow/year
= number of cows pasture will carry

$$700{,}000 \div 2{,}920 = 240 \text{ total cattle}$$

One bull is recommended per 20 cows. Therefore, this range would support a base herd of about 228 cows and 12 bulls.

Question

If sheep (ewes) were substituted for cattle, the number of sheep in the base herd (assume that sheep weigh 65 kg) would be calculated as follows:

$$240 \div \frac{65 \text{ kg (weight per sheep)}}{400 \text{ kg (weight per cow)}} = 1{,}447 \text{ sheep}$$

If this range were used for only 9 months, the total number of cattle would be calculated as follows:

$$\frac{12 \text{ months}}{9 \text{ months}} \times 240 \text{ cattle} = 320 \text{ cattle}$$

At the end of the dormant season (mid-April), 350 kg/ha should remain to protect the site.

CASE 2

You have summer range in the mountains of northeastern Oregon. Condition of the range is poor. Although the terrain is rugged, water is well distributed. You graze this range for 4 months (June through September). Production of key forage species averages about 200 kg/ha/year. The total area is 1,000 ha. Slope on this range is as follows: 40 percent of the range has 0 to 10 percent slope, 20 percent has 11 percent to 30 percent slope, 30 percent has 31 percent to 60 percent slope, and 10 percent has over 60 percent slope.

Question

How many 400-kg cows can you have in your base herd?

Calculation of total usable forage:

Forage production (kg/ha) = × percent allowable use
× area (ha)
= total forage (kg) available for grazing

$$200 \times 0.25 \times 1{,}000 = 50{,}000 \text{ kg}$$

(*continued*)

Calculation of forage demand:

Weight of cows (kg) = × daily dry-matter intake (% of body weight)
= × number of days pasture will be grazed (120 days)
= forage demand per cow per 120 days

400 × 0.02 × 120 = 960 kg/cow/120 days

Calculation of stocking rate:

Total usable forage (kg) ÷ forage/cow/120 days
= number of cows pasture will carry (unadjusted for slope)

50,000 ÷ 960 = 52 cows (unadjusted for slope)

Adjustment for slope:

[Amount of area with 0 − 10 percent slope (40 percent)
× adjustment for slope (100 − 0 percent)]
+ [amount of area with 11 − 30 percent slope (20 percent)
× adjustment for slope (100 − 30 percent)]
+ [amount of area with 31 − 60 percent slope (30 percent)
× adjustment for slope (100 − 60 percent)]
+ [amount of area with over 60 percent slope (10 percent)
× adjustment for slope (100 − 100 percent)] × 52 cows
= grazing capacity of pasture adjusted for slope

[0.40 × 1] + [0.2 × 0.7] + [0.3 × 0.4] + [0.1 × 0] × 52 = 34 cattle (32 cows + 2 bulls)

CASE 3

You have semidesert grassland range in south-central New Mexico. The condition of your range is highly variable (ranging from poor to excellent) due to poor water distribution. About 60 percent of the range is within 1.6 km of water, 30 percent is between 1.6 km and 3.2 km from water, and 10 percent is over 3.2 km from water. Pasture terrain is generally flat. Based on past experience, you know that production of key forage species averages about 300 kg/ha per year. The total area of the pasture is 4,000 ha. The range is grazed yearlong (365 days).

Question

How many 400-kg cows would this range support without adjustment for water distribution?

Calculation of total usable forage:

Forage production (kg/ha) × percent allowable use
× area (ha)
= total forage (kg) available for grazing

300 × 0.30 × 4,000 = 360,000 kg

Calculation of forage demand:

Weight of cows (kg) × daily dry-matter intake (2 percent of body weight)
× number of days pasture will be grazed (365)
= forage demand per cow per year

400 × 0.02 × 365 = 2,920 kg/cow/year

Calculation of stocking rate:

Total usable forage (kg) ÷ forage/cow/year
= number of cows the pasture will carry unadjusted for distance from water

360,000 ÷ 2,920 = 123 cows (unadjusted for distance from water)

Adjustment for water distribution:

[Amount of area within 1.6 km of water (60 percent)
× adjustment for distance from water (100 − 0 percent)]
+ [amount of area 1.6 − 3.2 km from water (30 percent)
× adjustment for distance from water (100 − 50 percent)]
+ [amount of area over 3.2 km from water (10 percent)
× adjustment for distance from water (100 − 100 percent)]
= 123 cows grazing capacity of pasture adjusted for distance to water

[0.6 × 1] + [0.3 × 0.5] + [0.1 × 0] × 123 = 92 cows

We recommend keeping the base herd at 90 percent of grazing capacity on this range to maximize stability during drought. This would result in grazing capacity of 83 total cattle (79 cows + 4 bulls).

(*continued*)

Question

How many cows and how many yearlings should you have in your herd in an average forage production year if 30 percent of your grazing capacity is used for 275-kg yearlings?

$$92 \text{ cows} \times 0.7(\% \text{ cows in base herd}) = 64 \text{ cows}$$

92 cows in base herd (unadjusted for yearlings)
− 64 cows (adjusted for yearlings)
= 28 cows that can be converted to yearlings

$$28 \text{ cows} \frac{400 \text{ kg (average weight/cow)}}{275 \text{ kg (average weight/yearling)}} = \text{yearlings}$$

In an average year, the base herd would be comprised of 61 cows, 3 bulls, and 41 yearlings.

Question

During a drought year when forage production is only 150 kg/ha, how should cattle numbers be adjusted in mid-October after the growing season?

On this range, 210 kg/ha of residue is required for protection (300 kg/ha forage production in average years × 0.70). Theoretically, based on the current year's forage production, nearly all cattle must be removed to protect this range. However, this could be financially disastrous to the rancher and probably is not necessary to maintain the health of the range. In this situation, empirical judgment on the part of the rancher would be of critical importance. If the drought followed 2 or more years of average or above-average forage production, sufficient carryover residue from previous years should maintain site stability. Grazing on perennial grasses would not become heavy until after the growing season. In some years, winter precipitation in south-central New Mexico results in substantial growth of palatable forbs in late winter and early spring. These forbs take much of the pressure off perennial grasses. Areas long distances from permanent water with large forage supplies can serve as a forage reserve in drought. Utilization is possible by hauling water to these areas.

The best plan would be to sell all yearlings in mid-October and any dry or otherwise undesirable cows. If there was little fall-winter precipitation and forage was showing signs of depletion, the remaining cow herd could be brought into a drylot and fed harvested forage until initiation of forage growth on the range in the spring or summer. Herbel et al. (1984) provide guidelines for feeding confined cattle and marketing calves on desert ranges during drought. Their data show that a part-year confinement of the cow herd (spring), coupled with early weaning of calves in late spring or summer rather than in October, can be economically advantageous over yearlong grazing during periods of drought in south-central New Mexico. Good ranchers plan for drought by having reserves of range forage and/or harvested forage. They cull heavily and reduce herd size after 3 to 4 wet years when the probability of drought becomes high. Consecutive droughts lasting 2 or more years are the ones most damaging to good ranchers and the range. Under these conditions, the most effective strategy financially has been to sell livestock down to levels supportable by range forage resources (Boykin, et al. 1962; Holechek, 1996b).

KEY-PLANT AND KEY-AREA PRINCIPLES

The key-plant and key-area concepts have proven highly useful to managers in evaluating grazing effects on range vegetation (Holechek, 1988). A ***key species*** is defined as "a forage species whose use serves as an indicator to the degree of use of associated species, and because of its importance, must be considered in any management program" (Society for Range Management, 1989a). Key management species are those on which management of grazing on a specific range is based. The key species and key area serve as indicators of management effectiveness. Generally, when the key species and key area are considered properly used, the entire pasture is considered correctly used.

In most cases, one to three plant species are used as key species. These plants should be abundant, productive, and palatable. They should provide the bulk of the forage for grazing animals within the pasture. The "ice-cream" plants (rare but highly profitable plants) are not used because of their scarcity and low resistance to grazing. Key species are usually decreaser plants that are an important part of the climax vegetation. If the range has been grazed heavily, decreasers may be in short supply, but they have the potential to become abundant if grazing pressure is reduced. Conditions do exist in which the climax plants are not the most desirable or a reduction in stocking rate will not restore the climax plants within a reasonable period (5 to 15 years). In these cases, a palatable increaser plant may be selected as a key species. It is important to recognize that key species for one type of animal may be different for another type due to differences in food habits. As an example, bitterbrush (*Purshia tridentata*) is the key species for mule deer on many eastern Oregon ranges, but the key species for cattle on these same ranges is bluebunch wheatgrass (*Agropyron spicatum*). The key species for elk is Idaho fescue (*Festuca idahoensis*) in most of this country.

Under the key-species approach, secondary forage species (e.g., sandberg bluegrass [*Poa sandbergii*] in eastern

Oregon) will receive light use (10 percent to 25 percent), key species (bluebunch wheatgrass) will receive moderate use (30 percent to 40 percent), and the ice-cream plants (arrowleaf, balsamroot [*Balsamorhiza sagittata*]) may be used excessively (over 40 percent).

The ***key area*** is a portion of range that, because of its location, grazing or browsing value, and/or use, serves as an indicative sample of range conditions, trend, or degree of seasonal use (Society for Range Management, 1989a). The key area guides the general management of the entire area of which it is part. Successful range management practices within a pasture are usually judged by the response of the key plant species on the key area.

The key-area concept is based on the premise that no range of appreciable size will be utilized uniformly. Even under light grazing intensities, areas around watering points, salt grounds, valley bottoms, and driveways will often be heavily used. These preferred areas are referred to as sacrifice areas because setting stocking rates for proper use of these areas will result in underuse of the bulk of the pasture. A major objective of specialized grazing systems is to minimize the size of sacrifice areas and provide them with periodic opportunity for recovery. These strategies are discussed in detail in Chapter 9.

When selecting the key area, parts of the pasture remote from water, on steep slopes, or with poor accessibility due to physical barriers should be disregarded. Proper use of these areas will generally result in destructive grazing on most of the pasture. These areas should be omitted when carrying capacity is estimated.

Evaluating Grazing Intensity

A number of qualitative guidelines have been developed for judging intensity of grazing on a range. We have found that a simple categorization into heavy, moderate, and light use is most practical using the following criteria:

- Heavy use. Range has a "clipped" or mowed appearance. Over half of the fair and poor forage-value plants are used. All accessible parts of the range show use, and key areas are cropped closely. They may appear stripped if grazing is very severe (Figure 8.3). There is evidence of livestock trailing to forage.
- Moderate use (proper use). About one-half of the good and fair forage-value plants are used. There is little evidence of livestock trailing. Most of the accessible range shows some use. The range has a patchy appearance (see Figure 8.3).
- Light use. Only choice plants and areas are used. There is no use of poor forage plants. The range appears practically undisturbed.

On key areas, average stubble heights of 30 to 35 cm (12 to 14 in.) for tallgrasses, 15 to 20 cm (6 to 8 in.) for midgrasses, 5 to 8 cm (2 to 3 in.) for shortgrasses, and 2.54 to 3.81 cm (1 to 1.5 in.) for extra shortgrass are recommended minimums for proper use (Holechek and Galt, 2000, 2004).

Figure 8.3
This photo from southeastern Arizona shows the patchy appearance of a moderately grazed pasture on the left and the complete lack of standing forage on the severely grazed pasture on the right.

Guidelines for minimum stubble heights under proper use for selected grass species are provided in Table 8.14. Considerable research exists on minimum stubble height guidelines for grass species such as Kentucky bluegrass, blue grama, and black grama, while for other plants, such as big bluestem and sideoats grama, the main basis for our guidelines is practical experience by range professionals. We freely acknowledge that situations exist where these guidelines may be conservative. However, in nearly all situations, their application should ensure protection of soil and vegetation resources as well as maintenance of livestock performance and wildlife habitat.

In our opinion, it seems reasonable to allow public land ranchers to exceed grazing intensity guidelines (stubble heights and/or residues) on 30 percent of the key areas during any particular year. We believe that these guidelines should be tailored to management objectives for specific allotments. Considerable information is available from various grazing studies that allow development of specific guidelines based on residues, stubble heights, and/or percent use. Generally, management changes are

Table 8.14
MINIMUM RECOMMENDED STUBBLE HEIGHTS FOR SELECTED GRASS SPECIES UNDER PROPER GRAZING USE.

Grass Species	Minimum Stubble Height (in.)[a]	Range Type	Authority
Shortgrasses			
Blue grama	1½–2	Shortgrass	Crafts and Glendening, 1942
Buffalo grass	1–2	Shortgrass	Costello and Turner, 1944
Curly mesquite	1½	Chihuahuan desert	Parker and Glendening, 1942
Black grama	3	Chihuahuan desert	Paulsen and Ares, 1962; Valentine, 1970
Sandberg bluegrass	3–4	Sagebrush-palouse	Practical experience
Mountain muhly	4	Coniferous forest	Johnson, 1953
Kentucky bluegrass	3–5	Mountain meadows	Clary, 1995; Hall and Bryant, 1995
Sedges	3–5	Mountain meadows	Clary, 1995
Midgrasses			
Arizona fescue	6–7	Coniferous forest	Johnson, 1953
Idaho fescue	5–6	Coniferous forest-palouse	Practical experience
Bluebunch wheatgrass	6	Sagebrush-palouse	Anderson, 1969
Little bluestem	6–8	Tallgrass-mixed prairie	Practical experience
Sand dropseed	6–8	Mixed prairie Chihuahuan desert	Practical experience
Sideoats grama	6	Mixed prairie-Chihuahuan desert	Practical experience
Green needlegrass	6	Northern mixed prairie	Practical experience
Western wheatgrass	3–4	Shortgrass-mixed prairie	Holscher and Woolfolk, 1953
Crested wheatgrass	3–4½	Sagebrush	Frischknecht and Harris, 1968
Threeawns	3–5	Mixed prairie Chihuahuan desert	Practical experience
Tallgrasses			
Big bluestem	12–14	Tallgrass	Practical experience
Indiangrass	12–14	Tallgrass	Practical experience
Switchgrass	12–14	Tallgrass	Practical experience
Giant sacaton	12–14	Chihuahuan desert	Practical experience
Basin wildrye	12–14	Sagebrush	Practical experience
Riparian grasses	3–7	Coniferous forest	Clary and Webster, 1990; Clary, 1995; Hall and Bryant, 1995; Clary et al., 1996
Annual grasses	2	California annual grassland	Bentley and Talbot, 1951; Hooper and Heady, 1970

[a]Recommended stubble height minimums should maintain or improve soil, vegetation, and wildlife resources, and provide adequate plant material to meet livestock nutritional needs. We recognize that in some cases, our guidelines may be conservative if the only goal is maintenance of key forage plants.

Table 8.15
GENERAL GRAZING INTENSITY GUIDE FOR CONVERTING STUBBLE HEIGHTS OF SHORTGRASSES, MIDGRASSES, AND TALLGRASSES INTO PERCENTAGE UTILIZATION.

Qualitative Grazing Intensity Category	Stubble Height Guide (Inches)			Percentage of Forage Use by Weight
	Shortgrasses	Midgrasses	Tallgrasses	
Light use to nonuse	2.5+	9+	16+	0–30
Conservative	2.0–2.5	8–9	14–16	31–40
Moderate	1.5–2.0	6–8	12–14	41–50
Heavy	1.0–1.5	4–6	10–12	51–60
Severe	<1.0	<4	<10	<60

Source: Based on Holechek and Galt (2000).

needed if grazing intensity guidelines are exceeded on over 30 percent of the pasture or allotment for 2 consecutive years or in any 2 years out of 5 (Holechek et al., 1998b). If in any year grazing intensity becomes severe (complete lack of stubble height) on one-third or more of the range, management changes should be implemented. An important part of this approach is to encourage ranchers to avoid exceeding residue or stubble height guidelines year after year on the same key areas and to make every effort to keep individual key areas from being severely grazed in any year.

Stubble height is one of the few measurements of range use that is highly repeatable and can be collected quickly. We have found that measurement of 40 randomly or systematically selected plants of each key forage species in key areas usually gives a reliable estimate of grazing use. Long-term studies by Johnson (1953), Paulsen and Ares (1962), and Valentine (1970) have shown grass heights to be well related to grazing intensity and forage productivity. Readers are referred to Clary and Webster (1990), Clary (1995), Hall and Bryant (1995), and Clary and Leininger (2000) for detailed stubble height guidelines on riparian zones. Detailed approaches for evaluating grazing intensity are provided by Anderson and Currier (1973) and Holechek and Galt (2000, 2004b).

Generally, percent forage use as a measure of grazing intensity is more understandable to ranchers and the public, while grass stubble heights are easier to measure and may better reflect grazing severity. Holechek and Galt (2000) developed guides for New Mexico rangelands that permit converting stubble height measurements into percent use. Based on their research and other studies, we have developed a simple guide that should be helpful to managers if its limitations are recognized (Table 8.15). This guide will not apply in all situations (see Holechek and Galt, 2004b), and we encourage managers to develop their own guides for their specific range types.

On some rangelands, shrubs such as common winterfat, fourwing saltbush, and mountain mahogany are the primary forage species. Techniques for evaluating grazing use on shrubs are somewhat different than for herbaceous forage. Holechek and Galt (2000) have developed a guide that relates percentage of leaders (shoot of shrub on tree) browsed to percent use of browse for common New Mexico shrubs (Table 8.16).

Table 8.16
GRAZING INTENSITY GUIDE FOR KEY SHRUB SPECIES.[a]

Qualitative Grazing Intensity Category	Use of Current Year Browse Production by Percentage of Weight	Leaders Browsed
Light use to nonuse	<30	<15%
Conservative	31–50	16–50%
Moderate	51–75	51–80%
Heavy	75–90	81–100%
Severe	<90	All leaders plus old growth used

Source: From Holechek and Galt (2000).
[a]Common winterfat, fourwing saltbush, mountain mahogany.

Figure 8.4 *Moderately browsed antelope bitterbush plants in central Utah.*

Generally, moderate browsing on shrubs involves visible use on 51 percent to 80 percent of the leaders or 51 percent to 75 percent use of current year's growth by weight (Figure 8.4). Other more-quantitative techniques for determining shrub utilization are discussed by Cook and Stubbendieck (1986) and Bonham (1989).

FORAGE ALLOCATION TO MORE THAN ONE ANIMAL SPECIES

Many ranges are grazed by a combination of animals rather than by a single species. The grazing of two or more animals on the same range to obtain more efficient use is referred to as ***common use***. It is well recognized that forage species selection varies considerably among different animal species on the same range. Mule deer on northwestern Colorado ranges heavily use big sagebrush but make little use of needlegrass (*Stipa* sp.) (Hansen et al., 1977). Conversely, on these same ranges, needlegrass is an important component of cattle diets, but cattle will not consume big sagebrush. This range can be used more efficiently by a combination of cattle and deer than by deer or cattle alone. The important questions relate to how much grazing capacity can be increased by the use of both animals, and what amount of the grazing capacity on these ranges should be allocated to deer and to cattle.

In the preceding case, little dietary overlap (less than 5 percent) occurs between the two animals, and, therefore, grazing capacity is additive when both animals are grazing. Because the key species are different for the two animals, no adjustment in cattle or deer numbers is necessary to compensate for forage consumed by the other animal.

On low-elevation winter range in north-central New Mexico, cattle and sheep use the same ranges and have high dietary overlap (over 80 percent) (Holechek et al., 1986). On these ranges, common winterfat (*Ceratoides lanata*) and western wheatgrass (*Agropyron smithii*) are key species for both animals. Here, grazing with cattle and sheep in combination is nonadditive, and animal unit equivalents of one animal can be substituted directly for the other animal. Grazing by both animals in combination gives little improvement in efficiency of use of the forage resource.

However, on many ranges, cattle and sheep have moderate dietary overlaps (30 percent to 60 percent). This is also often true of cattle and elk. Here, allocation of forage is more complicated.

Controversy exists over how grazing capacity should be evaluated when common use is involved. Scarnecchia (1985, 1986) argues that grazing capacity should be based on animal-related factors because dietary overlaps between different animal species vary with terrain, season of use, grazing system, stocking rate, and year-to-year weather fluctuations that affect forage production and species composition.

In contrast, Hobbs and Carpenter (1986) advocate that animal unit equivalents should be weighted