REGARDLESS OF WHETHER YOU HAVE CHOSEN A CONTINUOUS or rotational grazing system (chapter 14), pasture forage is the basis of your livestock-pasture system. Understanding the condition and level of production in your pastures is key to making good day-to-day grazing decisions. This chapter covers three topics:

- Methods for estimating forage production
- Examples of how to use the information in daily, weekly, and yearly planning and forage allocation decisions
- The importance of observing and recording information about pasture growth and utilization

Key Points

- By knowing the amount of forage and expected growth in your pastures, you can anticipate a forage surplus or deficit and manage proactively rather than reacting to crises.
- Inventory your forage yield per grazing paddock every 2 weeks during the growing season. During the dormant period, a monthly inventory is adequate.
- Repeated observations allow you to track trends and responses to management changes.
- With several years of data, you should be able to notice if available forage production is below or above normal for a given time of year. Then you can adjust grazing while there is still time to have an effect.
Estimating forage production

Estimating pasture production will help you make grazing management decisions. By knowing the amount of forage and expected growth, you can manage proactively, rather than reacting to crises. The goal is to effectively estimate forage availability and balance forage supply with animal requirements.

Estimates of forage production are useful for allocating paddock area or projecting carrying capacity. They are especially useful when moving into the non-growing season. Estimating forage production can help you answer the following questions:

• How large should the paddock be in order to meet my production goals and optimize uniform grazing to a predetermined height (see chapter 15)?
• When should I move the livestock to the next paddock?
• Is there enough forage in the next paddock to support the current group of animals and meet my production goals?
• Am I leaving enough residual?
• Is the regrowth rate adequate so that livestock can return to this paddock at the planned time?

As you move through the grazing season, monitor pasture growth and utilization. Monitoring enables you to fine tune paddock size, animal numbers, and grazing periods. Observe utilization daily in the current paddock, and monitor production in the last two paddocks and the next two or three paddocks. Periodically estimate the total forage in all paddocks.

With this information, you can construct a forage budget, as discussed later in this chapter. The balance sheet will help you reallocate animal numbers if needed. If forage exceeds grazing needs, or if you anticipate a need for supplemental feeding, you can plan to harvest hay.

Forage production can be estimated by several methods, each of which has advantages and disadvantages. Direct methods are more accurate, but they usually are destructive from a grazing standpoint and are time- and labor-consuming. Thus, they are not practical for inventory and monitoring purposes. Indirect methods may not be as accurate, but usually are quicker, easier, and less costly. The accuracy of indirect methods generally improves as you gain experience.

Fresh forage must be converted to a dry matter (DM) basis for most comparisons. We base our calculations on oven-dried forage.

Various direct and indirect methods are discussed below.

Key Terms

Grazing cell—An area of pasture managed as a planning unit from which forage is allocated to a specific group of animals for the grazing season. A grazing cell usually has permanent fence on its borders and is separated into paddocks with temporary fencing or by herding.

Grazing cycle—The time elapsed between the beginning of one grazing period and the beginning of the next grazing period. One grazing cycle includes one grazing period plus one rest period.

Grazing period—The time that animals are present on the paddock.

Grazing season—The total period of time during which animals may harvest standing forage from pasture. Composed of the “growing season,” when temperature and moisture are conducive to plant growth, and the “non-growing season,” when animals may harvest any forage remaining after the growing season.

Growing season—The time of year when temperature and moisture are conducive to plant growth.

Non-growing season—The season when animals may harvest forage remaining after the growing season.

Paddock—A subdivision of a grazing cell to which the animals are confined for a grazing period (hours or days). A paddock may be of fixed or variable size.

Rest period—The grazing cycle minus the grazing period.

Seasonal carrying capacity—The stocking rate that is economically and environmentally sustainable for a particular grazing unit over the entire grazing season.

Seasonal utilization rate—The fraction of annual forage production that will be harvested by grazing livestock during the entire grazing season.
DIRECT METHODS

Converting hay yield to pasture yield

Harvesting and weighing hay from the entire paddock is the best measure of forage production. You can use this method to roughly estimate the amount of annual forage production.

Grazing is not the same as haying, however, because of different forage quality and regrowth periods. Hay is more mature than grazed forage; thus, it contains more stem and is lower quality. Continuously stocked pastures generally produce less animal days of forage than harvested hay—perhaps 15 to 35 percent less. Intensively managed pastures, on the other hand, can produce as much or more animal production as harvested hay.

Both haying and grazing animals waste some forage. Depending on stocking rate, type of grazing, and plant height at the start of grazing, waste may range from 10 to 30 percent of usable forage.

Hand clipping

Clipping, drying, and weighing samples is the most commonly used direct method of estimating forage production. The precision of hand clipping depends largely on pasture variability and sampling efficiency.

Although hand clipping is precise, it is time-consuming, which makes routine use impractical. The most practical use of hand clipping is for calibrating the indirect methods discussed below.

Collecting samples—To obtain a good estimate by hand clipping, select areas representing low, medium, and high production. Choose at least three samples from each level of production. This sample selection method assures that you will get a good estimate of overall production without having to take a large number of randomly selected samples (20 to 100). You will need a separate cloth or paper bag for each sample. Take samples as follows:

1. Use a frame of known area to surround a sample area. We prefer a 1-foot x 1-foot U-shaped frame. Place the frame on the ground by working it down through the forage. Comb tillers to either side of the frame as necessary to arrange them in their natural positions. Make sure that tillers from plants rooted outside the frame are not bent into the frame area and vice versa. It is important to clip only forage rooted inside the frame.

2. Label the first bag with location and production level.

3. Gather an easy handful of forage from inside the frame with one hand and clip parallel to the ground at 0.5 to 1 inch height (figure 16.1). Place the forage in the bag. Repeat this process for all of the forage inside the frame, collecting all of the clipped material into the bag. It is not necessary to remove dead material.

4. Move to the next sample area and repeat, using a separate bag.

Stocking density—The relationship between the number of animals (or live weight) and area of land at any given instant of time. May be expressed as animal units or forage intake units per unit of land area (for example, “50 animal units per acre,” which is equivalent to 55,000 pounds of live weight per acre).

Stocking rate—The relationship between the number of animals (or live weight) and the grazing management unit over a specified time period. May be expressed as animal units or forage intake units over a time period per unit of land area such as “50 animal units per acre-day” (equivalent to 55,000 pounds live weight per acre-day).

Temporal utilization rate—The fraction of available forage expected to be consumed during a grazing period.
Calculating forage DM per acre—Now dry and weigh the samples as follows and calculate pounds of DM per acre:

1. This example assumes weights are in pounds. If you weighed in grams, convert from grams/ft² to pounds/acre by multiplying by 96.
2. Dry all of the bags of forage and an empty tare bag in a convection oven at 140°F until the bags have a constant weight. (Dry and weigh the bags repeatedly until the weight does not change.)
3. Weigh each bag and sample, and then subtract the tare weight of the bag to determine forage DM weight for each bag.
4. For each level of production, find the average DM weight of the samples by adding together the weights of the samples and dividing by the number of samples.
5. Multiply the average weight for each production level by the percentage of the pasture represented by that level of production. (The sum of the three percentages must equal 100.)
6. Sum these amounts.
7. Calculate pounds of DM per acre:

\[
\text{lb DM/acre} = \frac{\text{sample DM (from step 6)}}{\text{total net fresh weight (from step 1)}} \times \frac{\text{fresh weight of grab sample (from step 2)}}{\text{frame size in square feet}}
\]

INDIRECT METHODS
There are several indirect methods of estimating forage production. In each case, forage DM weight is estimated from measurements taken in standing forage. We will present the most practical for daily use.

- Pasture sticks (rulers) measure forage canopy height.
- Rising plate and falling plate meters measure compressed forage height. This measure integrates plant density, structure, and height.
- Capacitance meters measure electrical current in forage.

Microwave oven drying
If you do not have a drying oven, you can use a microwave oven to determine DM weight.

1. For the first level of production, weigh each bag and sample, and then subtract the tare weight of the bag to determine the net fresh forage weight for each bag. Sum these fresh weights to find the total net fresh weight for this level of production.
2. Collect a small grab sample from each sample bag from this level of production. Thoroughly mix the subsamples and pull out about 0.25 lb (100 grams) of wet material. Record the exact fresh weight.
3. Cut the subsample into small pieces (smaller than 1-inch segments). Place the pieces in a microwave oven along with a glass of water to prevent fire and smoke. Dry the sample for 2 minutes, check the weight, and dry for another 30 seconds.
4. Repeat the drying for 30 seconds and weighing process until you have two successive weights that do not change. Subtract the dried tare bag weight. This is the DM weight.
5. Calculate the average DM weight for this production level:

\[
\text{average DM weight} = \frac{\text{DM weight (from step 4)}}{\text{total net fresh weight (from step 1)}} \times \frac{\text{fresh weight of grab sample (from step 2)}}{\text{frame size in square feet}}
\]
6. Repeat this process for the other two levels of production.
7. Use these average DM weights in step 5 of the hand clipping instructions on this page. Continue with steps 5-7 to calculate pounds of DM per acre.
Pasture sticks and rising plate meters are used most often. All indirect methods need to be calibrated to specific situations, including pasture species and mixes, time of year, irrigated versus rain fed, before versus after grazing, operator, etc. Calibration instructions are given in appendix A.

**Pasture sticks**

There are two ways to use pasture sticks. The simplest is to estimate production based on forage height alone. The second takes into account forage species and stand condition. Although the pasture stick method is fast, simple, and cheap, it is not as precise as hand clipping. Precision is increased by taking numerous measurements.

**Sward height**—This method works on the principle of relating sward height to yield. Therefore, you need to calculate the average pasture sward height.

1. First, walk through the paddock in a W pattern, or transect (figure 16.2), and use the ruler to determine the height below which 90 percent of the forage mass is found (figure 16.3). With a little practice, you can approximate this height visually. Initially, you may want to lower your hand into the canopy perpendicular to the ruler until you think 90 percent of the forage mass is below your hand. Do not pull the forage to its tallest height to measure it. Record the 90 percent height to the nearest 0.5 inch. In figure 16.3, the height at the bottom of the hand is 8 inches.

2. Repeat step 1 at regular intervals, for example, every 20 to 35 steps (figure 16.2). It is important to take measurements at a consistent spacing regardless of forage condition at that spot. The height of both bare spots and dense (manure-affected) spots must be recorded. Avoiding certain spots will lead to a biased calculation of average height and yield.

3. After collecting the height data, find the average height. (Add together all of the heights and divide by the number of measurements.)

If the sward height is greater than 12 to 16 inches, consider taking a hay crop. Waste from grazing probably would be excessive at this height. Cutting for hay will uniformly reduce all plants to a common residual, and most new growth will be vegetative rather than reproductive. This will allow you to better manage the paddock for grazing during the next cycle.

Generally, about 200 to 500 pounds of forage DM per acre are available per inch of sward height. For example, you might use an average yield of 300 pounds per acre per inch of sward height. In this case, to convert average sward height to yield, simply multiply sward height (inches) by 300. The result is the estimated DM yield in pounds per acre.

**Sward height, species composition, and stand condition**—Estimates based on sward height alone are not as accurate as those that combine height and stand condition. Stand condition is a function of stand density and vigor of desirable plants. Research in the Northwest suggests that determining whether a sward has low, medium, or high stand condition will improve the accuracy of forage yield estimates based on pasture stick measurements.
The yield per inch of sward height measured with a pasture stick is the average weight of forage per inch. However, the center of gravity in a sward is somewhere around one-third of the total sward height. Most of the mass is in the lower 3 inches of the sward. Yield per inch also varies among grass species. Smooth brome and timothy, for example, have leaves that extend higher in the canopy than do Kentucky bluegrass and perennial ryegrass.

Table 16.1 provides estimated forage DM yields (pounds per acre per inch of sward height) based on species and stand condition. For each species and stand condition, a range of yields is given. Use a lower yield for taller swards and a higher yield for shorter swards, especially in post-grazing estimation.

The values for orchardgrass, smooth brome, and perennial ryegrass in table 16.1 are averages across the growing season. They are based on studies conducted on irrigated pastures. During 2006 and 2007, a total of 472 samples were taken at weekly intervals from May 1 to September 30. All pastures were mixes of grasses with a minor component of legumes; the dominant species is listed in table 16.1.

The values for tall fescue, Kentucky bluegrass plus white clover, red clover, alfalfa, and mixed pasture are based on values from several sites (mostly non-irrigated pastures) in the midwestern and eastern United States. Notice that the forage estimates per inch of sward height are similar regardless of longitude, latitude, or elevation, as long as adequate irrigation or precipitation is available.

Although the values in table 16.1 can give you a good starting point, you should calibrate your pasture stick to your conditions. See appendix A for instructions.

An example of using the pasture stick to determine pasture yield and forage consumed—A producer wants to determine the initial orchardgrass yield and the amount of forage consumed in a paddock. To

Table 16.1. Estimated forage dry matter yield in pounds per acre-inch measured with a pasture stick (ruler).

<table>
<thead>
<tr>
<th>Forage type**</th>
<th>Stand condition Ground cover</th>
<th>Pre-grazing plant height (inches)</th>
<th>Post-grazing plant height (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fair: 60 to 75% ground cover (lb/acre-inch)</td>
<td>Good: 75 to 90% ground cover (lb/acre-inch)</td>
<td>Excellent: &gt;90% ground cover (lb/acre-inch)</td>
</tr>
<tr>
<td>Orchardgrass</td>
<td>150 to 250</td>
<td>250 to 350</td>
<td>350 to 500</td>
</tr>
<tr>
<td>Smooth brome</td>
<td>150 to 200</td>
<td>200 to 300</td>
<td>300 to 400</td>
</tr>
<tr>
<td>Perennial ryegrass</td>
<td>150 to 250</td>
<td>250 to 350</td>
<td>350 to 500</td>
</tr>
<tr>
<td>Tall fescue</td>
<td>150 to 250</td>
<td>250 to 350</td>
<td>350 to 450</td>
</tr>
<tr>
<td>Kentucky bluegrass + white clover</td>
<td>100 to 250</td>
<td>250 to 350</td>
<td>350 to 450</td>
</tr>
<tr>
<td>Red clover or alfalfa</td>
<td>150 to 200</td>
<td>200 to 250</td>
<td>250 to 300</td>
</tr>
<tr>
<td>Mixed pasture</td>
<td>150 to 250</td>
<td>250 to 350</td>
<td>350 to 400</td>
</tr>
</tbody>
</table>

*Dominant vegetation

Table 16.2. Pasture stick measurement of orchardgrass height for estimation of yield and consumption.

<table>
<thead>
<tr>
<th>Sample number</th>
<th>Pre-grazing plant height (inches)</th>
<th>Post-grazing plant height (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>3.5</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>3.5</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>10</td>
<td>4.5</td>
</tr>
<tr>
<td>12</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>13</td>
<td>9</td>
<td>3.5</td>
</tr>
<tr>
<td>14</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>15</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>16</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>17</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>18</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>19</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>20</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Sum</td>
<td>180</td>
<td>74</td>
</tr>
<tr>
<td>Average height</td>
<td>9</td>
<td>3.7</td>
</tr>
</tbody>
</table>
estimate how much forage is consumed by the grazing animals, he needs to estimate the DM before and after each grazing event. Subtracting the post-grazing DM from the pre-grazing DM will give the actual forage consumed.

\[
\text{total forage consumed} = \text{pre-grazing DM} - \text{post-grazing DM}
\]

The producer takes 20 measurements with a pasture stick before and after grazing and records the data (table 16.2). The average pre-grazing height was 9 inches, and the average post-grazing height was 3.7 inches. From table 16.1, he selects 250 pounds DM per acre-inch as the pre-grazing yield estimate and 350 pounds DM per acre-inch as the post-grazing estimate.

\[
\begin{align*}
\text{pre-grazing yield} & = 9 \times 250 \text{ lb DM/acre-inch} = 2,250 \text{ lb DM/acre} \\
\text{post-grazing yield} & = 3.7 \times 350 \text{ lb DM/acre-inch} = 1,295 \text{ lb DM/acre} \\
\text{total forage consumed} & = 2,250 - 1,295 \text{ lb DM/acre} = 955 \text{ lb DM/acre}
\end{align*}
\]

**Rising plate meters**

This method combines plant height, structure, and density into one measurement referred to as bulk density or compressed sward height. It is more precise than the pasture stick method, but requires a greater investment in time (for calibration) and money. The meter consists of a disk or plate on a threaded (or notched) pole or rod that meshes with counter wheels to tally accumulated heights and numbers of observation points (figure 16.4). It works best on uniform, dense vegetation. It is not useful on arid rangelands.

Before data collection, set the sample counter to zero or record the number. Also record the rising plate value. Then take measurements as follows:

1. To take the first measurement, lower the meter vertically into the sward until the rod hits the ground. The plate will be held at the compressed sward height by the vegetation. Units are about 0.2 inch per click. Make sure the sample counter counts the sample.

2. Next, walk through the pasture in a W pattern and take additional readings at an interval of 25 steps (figure 16.2). Readings must be taken at a consistent interval to avoid bias. Collect at least 20 readings regardless of paddock size; more are better. With a properly calibrated meter, 30 to 50 measurements usually give a reasonable estimate of paddock production.

3. When you have finished collecting the readings, record the final plate number.

4. Calculate the average plate meter rise by subtracting the initial value from the final value and dividing by the number of samples.

The average plate rise is correlated with forage bulk density. Use the appropriate calibration formula from table 16.3 to estimate forage production. However, rising plate meters vary in size, shape, weight, and area. Because the weight and area of the disk are important in determining the compressed sward height, you should calibrate your meter to your conditions. See appendix A for instructions.

**An example of using the rising plate meter to determine pasture yield and forage consumed**—A producer wants to determine the initial orchardgrass yield and the amount of forage consumed in a paddock. He takes 25 measurements with a rising plate meter.

![Figure 16.4. Using a rising plate meter to determine compressed sward height. (Photo by Glenn Shewmaker)](image)

**Table 16.3. Calibration formula for estimating dry matter yield (pounds per acre-inch) with a rising plate meter and estimated dry matter yield (pounds per acre-inch) for a falling plate meter.**

<table>
<thead>
<tr>
<th>Forage type (^c)</th>
<th>Calibration formula for rising plate meter (lb/acre)</th>
<th>Falling plate meter (lb/acre-inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orchardgrass</td>
<td>((76 \times \text{avg RPM}) + 1,087)</td>
<td>640</td>
</tr>
<tr>
<td>Smooth brome</td>
<td>((103 \times \text{avg RPM}) + 364)</td>
<td>520</td>
</tr>
<tr>
<td>Perennial ryegrass</td>
<td>((100 \times \text{avg RPM}) + 398)</td>
<td>560</td>
</tr>
</tbody>
</table>

\(^a\) Ellinbank-type constructed by the University of Missouri  
\(^b\) 3.2 pounds and 18 inches square  
\(^c\) Dominant vegetation
before and after grazing (table 16.4). The average rising plate meter (RPM) reading was 42 for the pre-grazing measurement and 17 for the post-grazing measurement. Our calibration equation for orchardgrass is: yield = (76 x avg RPM) + 1,087 (from table 16.3).

Pre-grazing yield = (76 x 42 avg RPM) + 1,087
= 4,279 lb DM/acre

Post-grazing yield = (76 x 17 avg RPM) + 1,087
= 2,379 lb DM/acre

Total forage consumed = 4,279 - 2,379
= 1,900 lb DM/acre

Table 16.4. Rising plate meter estimation of orchardgrass yield and consumption.

<table>
<thead>
<tr>
<th>Formula</th>
<th>Pre-grazing meter reading</th>
<th>Post-grazing meter reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial reading</td>
<td>893</td>
<td>1,245</td>
</tr>
<tr>
<td>Final reading</td>
<td>1,943</td>
<td>1,670</td>
</tr>
<tr>
<td>Counter</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Final reading - initial reading</td>
<td>1,050</td>
<td>425</td>
</tr>
<tr>
<td>Average RPM</td>
<td>42</td>
<td>17</td>
</tr>
<tr>
<td>Estimated yield (lb DM/acre)</td>
<td>(76 x avg RPM) + 1,087</td>
<td>4,279</td>
</tr>
<tr>
<td>Forage consumed (lb DM/acre)</td>
<td>pre-grazing DM - post-grazing DM</td>
<td>1,900</td>
</tr>
</tbody>
</table>

Falling plate meters

Falling plate meters (figure 16.5) are similar to rising plate meters. Both types of meter measure compressed sward height, structure, and stand density. Falling plate meters are less expensive, but measurements take more time because you must manually record each plot.

Falling plate meters normally consist of an 18-inch square plate with a center hole. The plate can be made of Plexiglas, cardboard, or plywood. To use the meter, push a yardstick through the center hole until it touches the ground. Then lower the plate onto the forage until the herbage supports the weight of the plate. Measure the compressed sward height by reading the yardstick at the top of the plate.

Table 16.3 provides average estimated forage DM yields (pounds per acre-inch) based on compressed sward height (inches). These estimates are based on experiments conducted in Idaho on irrigated pasture. Our falling plate meter was an 0.25-inch thick acrylic sheet measuring 18 x 18 inches. It weighed 3.2 pounds and provided compression of 1.42 pounds per square foot. With this falling plate meter, each inch of compressed height represents 520 to 640 pounds DM per acre. We recommend a lighter sheet exerting compression of about 1 pound per square foot. As with rising plate meters, you should calibrate your meter to your conditions. See appendix A for instructions.

A spreadsheet for entering data and calculating pounds DM from rising plate and falling plate meters is available from the University of Idaho on the “pastures and grazing page” at http://www.extension.uidaho.edu/forage/.

Capacitance probes

New Zealand researchers have developed an electronic capacitance meter to estimate standing forage. The meter works on the principle that electrical conductivity increases as the mass of forage increases. The computerized hand-held probe measures electrical capacitance. It then converts this value to estimated forage DM yields. Capacitance probes are not useful on rangeland.

Our research has shown no advantage of capacitance probes over pasture sticks or rising plate meters. However, they are convenient because they display estimated yield instantly. The equations used to calculate yield may not be accurate in your situation, so calibrate your probe.
Visual estimates

With training and experience using one or more of the above methods, plus a season or two of grazing observations, you may learn to visually estimate pasture forage mass. You then can estimate production as you move livestock or as part of an all-paddock inventory (recommended every 2 weeks). Sweeping your hand through the pasture canopy to sense density can add another perspective and improve your estimates of forage mass.

Your estimate likely will fall within 50 pounds per acre-inch above or below actual production (plus or minus 250 pounds per acre on 5-inch-tall pasture). This level of accuracy is sufficient for daily management decisions and adjustments based on forage and livestock responses.

Forage inventory and budgeting (the grazing wedge)

Inventory your forage yield per grazing paddock every 2 weeks during the growing season. (During the dormant period, a monthly inventory is adequate.) By knowing yield per paddock and paddock size, you can construct a forage budget. Combine your pasture inventory with pest scouting and other monitoring activities (irrigation, grazing, livestock, etc.).

Forage yield is dynamic and can be thought of in terms of a "wedge." In a rotational grazing system, the forage in a series of paddocks forms a declining pattern, or wedge, when sorted by the highest to lowest amount of available forage (figure 16.6). A grazing wedge indicates the optimum order of paddock rotation, which may not be sequential.

In figure 16.6, pasture growth is divided into three phases. Phase I (below the line at 1,250 pounds per acre) is residual or permanent base growth. Phase II (between the two lines) represents vegetative growth. This phase is suitable for grazing. Phase III (above the line at 2,750 pounds) is excess growth.

Your goal as a grazing manager is to keep forage growth in Phase II (between the lines shown in figure 16.6). Do not graze Phase I forage because this permanent base growth is needed for rapid regrowth following grazing. When forage is in Phase III, it should be cut for hay or stockpiled for later fall or winter grazing.

Grazing wedge example

A producer has a grazing cell with permanent fence on borders (figure 16.6). Using temporary fence, he can easily subdivide the cell into 15 paddocks for daily moves. Grazing began on April 15 in paddock 1, and livestock were quickly rotated through all paddocks. Although the paddocks were grazed in numerical sequence during the first grazing cycle, they likely won't be grazed in the same order during all cycles.

We are now in a subsequent grazing cycle. Grazing again began in paddock 1 and has progressed through paddock 11, where the livestock are now. Paddocks 13, 14, and 15 have not been grazed during this cycle. They are in Phase III (plants are more than 10 inches tall, with more than 3,000 pounds of forage DM per acre). These paddocks should be cut for hay to improve harvest efficiency and conserve the spring growth for winter use. The next grazing paddock should be paddock 1. It has the most usable production and is on the high side of the Phase II growth curve. Regrowth should be adequate if enough residual is left.

A grazing wedge spreadsheet allowing data entry, easy sorting, and graphical display of the grazing wedge is available on the "pastures and grazing" page at http://www.extension.uidaho.edu/forage/.

It is important to estimate forage growth rates in order to anticipate a forage surplus or deficit. In paddocks
yielding from 1,200 to 3,000 pounds DM per acre, the
daily growth rate may be only 40 pounds per acre with
dry soil moisture conditions. With moderate soil mois-
ture conditions, growth may be 70 pounds per acre.
With higher soil moisture, growth may reach
100 pounds per acre. The growth rate for paddocks
below 1,200 pounds DM per acre is much lower.

With several years of data, you should be able to notice
if available forage production is below or above nor-
mal for a given time of year. Then you can adjust graz-
ing while there is still time to have an effect. Many
producers don’t realize they are in trouble until it is too
late to adjust the stocking rate easily. Also, if you no-
tice a decline in production during the spring, good
records will enable you to relate the change to man-
agement practices and adjust your plan.

Inventories also serve as a “reality check” if you occa-
sionally compare estimated and actual forage produc-
tion. For example, you may find that your livestock are
bigger or more productive than you estimated and are
consuming more than you had budgeted.

The example on page 169 shows how to use a grazing
wedge.

Monitoring pasture condition

Good pasture condition is critical to a successful graz-
ing system. Regularly monitor your forage production,
livestock performance, and progress toward economic,
environmental, and other goals. Pasture quality may
vary greatly from one area to another, but the trend
over time should show the direction in which pasture
condition is moving. Pasture monitoring is a tool to
help determine whether pastures need improvement
and what areas need the most improvement. It can also
help you evaluate results of management decisions.

The best time to monitor pastures is 15 days after a
grazing period. Use the Pasture Condition and Trend
Score Sheet (appendix B) to rate pastures on 10 criti-
cal pasture, grazing, and soil resource factors. The
scale is 0 to 4, with 4 being the most desirable condi-
tion and 0 being least desirable. If you can’t decide ex-
actly how to rate a factor, use ½-point scores.

A single evaluation gives you a snapshot of pasture
condition at a given time. Repeated observations allow
you to track trends and responses to your management
changes.

Monitoring animal
performance

Observe livestock for amount of rumen fill, as well as
when and how they are grazing, resting, and ruminat-
ing. See chapter 13 for information on grazing behavior.

We recommend monitoring what passes through the
livestock as well as what animals consume. Scatology,
the study of feces, can reveal a lot about whether live-
stock are meeting your production goals. For example,
with experience you can establish a relationship be-
tween fiber in the feces and weight gain or milk pro-
duction.

Scrape the surface off a dung pat with the bottom of
your boot or a shovel and observe the amount and size
of fiber. A high concentration of fiber in the feces indi-
cates that forage digestibility is too low for good pro-
duction. If the dung pat is still intact by the time the
next grazing period begins, you will know that the live-
stock did not get high-quality forage during the previ-
ous grazing period.

The amount of fiber is less critical for maintenance of
dry cows or horses than for growing or lactating ani-
mal. A high fiber concentration still indicates, how-
ever, that you may be grazing too high on the Phase II
curve.

Allocating forage

Generally, there are two scenarios for allocating for-
ages:

• You are using a fixed grazing system and a slow rota-
tion and need to calculate how many days a paddock
will support your herd. In this case, the paddock size
is fixed, and you need to calculate the length of the
grazing period.

• You are using temporary fence and allocating acreage
to feed your animals for a specific number of days.

Below we discuss how to calculate a grazing period for
the first scenario. See chapter 15 for a discussion of
how to calculate paddock size in the second scenario.

CALCULATING LENGTH OF THE GRAZING
PERIOD

When allocating forage on a day-to-day basis, you may
need to adjust the average grazing period that you cal-
culated for the season (see chapter 15). Assuming a
fixed paddock size (from chapter 15) and a given herd
size (from chapter 14), the grazing period for the paddock is a function of available forage in the paddock, animal weight, and daily DM intake (as a percentage of body weight).

Begin with your estimation of total forage DM per acre from one of the methods discussed earlier in this chapter. Then calculate total forage in the paddock as follows:

\[
\text{total forage (lb DM/paddock)} = \text{total forage (lb DM/acre)} \times \text{paddock area (acres)}
\]

For example, if a 15-acre paddock has an estimated forage production of 2,250 pounds DM per acre:

\[
\text{total forage} = 2,250 \times 15 = 33,750 \text{ lb DM/paddock}
\]

Now calculate the available forage in the paddock. Available forage is the total forage times the desired temporal utilization rate. The temporal utilization rate is the percentage of the total forage expected to be consumed during the grazing period. In a continuous grazing system, animals use only 30 to 35 percent of the total forage. With pasture rotation, the grazing period is shortened, animals cannot be as selective, and less forage is wasted. With more than seven paddocks and daily moves, utilization rates can exceed 60 percent.

\[
\text{available forage (lb DM/paddock)} = \frac{\text{total forage (lb DM/paddock)}}{\times \text{temporal utilization rate (\%)}
\]

If the producer uses a 15-paddock rotation and knows from experience to expect a 70 percent temporal utilization rate:

\[
\text{available forage} = 33,750 \times 0.7
\]

\[
= 23,625 \text{ lb DM/paddock}
\]

Now choose a DM intake rate based on your desired level of animal performance. The following values are general guidelines based on level of livestock performance:

- High performance: 3.5 percent of body weight (BW)
- Medium performance: 3 percent of BW
- Low performance: 2.5 percent of BW

For example, a forage DM intake of 3.5 percent predicts that each day an animal will consume 3.5 pounds of forage DM per 100 pounds of BW. A 1,200-pound animal would be expected to consume 42 pounds of forage DM each day (1,200 x 0.035). If forage has a DM content of 25 percent, this is the equivalent of 168 pounds of standing forage (42 / 0.25). Caution: if forage of appropriate quality is not sufficiently abundant, the livestock cannot attain the desired intake rate! Low-quality, high-fiber forages reduce intake. See chapters 10 and 11 for information on forage nutritional value and animal requirements.

Finally, calculate the length of the grazing period from the available forage (lb DM/paddock), the number of animals, the body weight per animal (lb), and the daily DM intake (lb DM day / 100 lb BW) as follows. (Assume 110 animals).

\[
\text{grazing period (days)} = \frac{\text{available forage}}{\# \text{ of animals} \times \text{BW/animal} \times \text{daily DM intake}}
\]

In this example:

\[
\text{grazing period (days)} = \frac{23,625}{(110 \times 1,200) \times (3 / 100)}
\]

\[
= \frac{23,625}{132,000 \times 0.03} = 3,960
\]

\[
= 5.96 \text{ days}
\]

The grazing period in this example is about 6 days.

For more information

University of Idaho forage web page.
http://www.extension.uidaho.edu/forage/
APPENDIX A

Calibrating Pasture Sticks, Rising Plate Meters, and Falling Plate Meters

You will need the following:

- Hand shears
- Clipping frame
- Drying oven or microwave oven
- Pasture stick (ruler), rising plate meter, or falling plate meter
- 15–20 bags labeled with sequential numbers
- Scale

PROCEDURE FOR PASTURE STICKS

1. Record the air-dry tare weight of an empty bag (Tw).

2. Begin walking through the pasture in a W pattern. After about 20 to 35 steps, measure and record sward height at the end of your toe. Place a clipping frame at the same spot and collect a hand clipping to 1 inch above ground level. Place clippings in bag #1.

3. Continue walking through the paddock in a W pattern, repeating step 2 at a fixed interval of 20 to 35 steps. If the paddock is small, take at least 15 measurements and samples. Record the sward height for each sample, and place clippings into the numbered bags in the order in which you take the samples.

4. Weigh each of the bags and samples to get the gross wet weight (GWw) of each bag.

5. Calculate the net wet weight of each bag and record it:

   \[
   NWw = GWw - Tw
   \]

6. Randomly select three of the bags.

7. Dry the three selected bags and a tare bag to get an oven-dry weight. (For information on how to dry forage, see page 164.)

8. Weigh each selected bag after drying. This is the gross dry weight (GWd).

9. Calculate percent DM content (% DM) of each selected bag:

   \[
   \% DM = \frac{(GWd - Tw)}{(GWw - Tw)} \times 100
   \]

10. Calculate average percent DM of the three selected bags by summing the percent DM for the three bags and dividing by 3.

11. Calculate bag DM for each of the 15 or more samples:

   \[
   \text{bag DM} = NWw \text{ (from step 5)} \times \text{average } \% \text{ DM (from step 10)}
   \]

12. Sum all of the bag DMs to find the total sample DM.

13. Calculate pounds of DM per acre:

   \[
   \text{lb DM/acre} = \text{total sample DM (from step 12)} \times \left(43,560 \div \text{[# of samples} \times \text{frame size in square feet]}\right)
   \]

   If you weighed in grams, multiply by 0.00221 to convert to pounds.

14. Calculate average sward height:

   \[
   \text{average height (inches)} = \frac{\text{sum of individual heights (inches)}}{\text{number of samples}}
   \]

15. Determine the relationship between DM production and sward height.

   \[
   \text{average lb DM/acre-inch} = \frac{\text{lb DM/acre (from step 13)}}{\text{average sward height (from step 14)}}
   \]

Repeat this process at least 10 times to develop a reliable relationship between sward height and DM production. You can then substitute this value for the value given for this species and pasture condition in table 16.1. Once you have determined a reliable relationship, occasional checks are recommended. Take about three samples per transect (W pattern) each time you use your pasture stick to estimate forage production. You can download a spreadsheet and example to assist in calibrating the pasture stick at http://www.extension.uidaho.edu/forage/.
PROCEDURE FOR RISING PLATE OR FALLING PLATE METERS

1. Record the tare weight of an empty bag (Tw).

2. Begin walking through the pasture in a W pattern. After about 20 to 35 steps, lower the meter onto the forage at the end of your toe and record the compressed height.

3. Place a clipping frame directly under the meter and collect a hand clipping to the 1-inch level. Place clippings in bag #1.

4. Walking through the paddock in a W pattern, repeat steps 2 and 3 at a fixed interval of 20 to 35 steps. If the paddock is small, take at least 15 measurements and samples. Record the compressed height for each sample and place clippings into the numbered bags in the order in which you take the samples.

5. Weigh each of the bags and samples to get the gross wet weight (GWw) of each bag. Record this weight for each bag.

   If you weighed in grams, multiply by 0.00221 to convert to pounds.

6. Calculate the net wet weight of each bag and record it:
   \[ NWw = GWw - Tw \]

7. Randomly select three of the bags.

8. Dry the three selected bags to get an oven-dry weight. (For information on how to dry forage, see page 164.)

9. Weigh each selected bag after drying. This is the gross dry weight (GWd). Record these weights.

10. Calculate the net dry weight (NWd) of each selected bag.
   \[ NWd = GWd - Tw \]

11. Calculate percent DM content (% DM) of each selected bag:
   \[ % \text{ DM} = \frac{NWd \text{ (from step 10)}}{NWw \text{ (from step 6)}} \times 100 \]

12. Add together the percent DM (from step 11) for the three bags.

13. Divide the total found in step 12 by 3 to find the average percent DM for the three bags.

14. Calculate bag DM for each of the samples taken in step 4:
   \[ \text{bag DM} = \frac{NWw \text{ (from step 6)}}{\times \text{average } % \text{ DM (from step 13)}} \]

15. Go to the University of Idaho “pastures and grazing” page (http://www.extension.uidaho.edu/forage/) and download the spreadsheet “Idaho RPM Calibration.xls.” Follow instructions (mouse over the red marks on cells to see instructions). Note: Check that the number for the average RPM value in cell F4 is correct. Use the slope and intercept calculated in the spreadsheet to develop your own calibration formula. For example, if the slope is 86 and the intercept is 1,212, your calibration formula would be \( (86 \times \text{avg RPM}) + 1,212 \). Substitute your calibration formula for the formula given for your forage species in table 16.3.

Repeat this process at least 10 times to develop a reliable relationship between sward height and DM production. Once you have determined a reliable relationship, occasional checks are recommended. Take about three samples per transect (W pattern) each time you use your rising or falling plate meter to estimate forage production.
APPENDIX B
Pasture Condition and Trend Score Sheet

Use this worksheet to monitor natural rainfall or irrigated pastures. You will rate pastures on 10 critical pasture, grazing, and soil factors. Use a scale of 0 to 4, with 0 being the least desirable condition and 4 being most desirable. It's best to rate pastures 10 to 15 days after grazing at about the same time each year. A single evaluation gives you a snapshot of pasture condition at a moment in time. Repeated observations allow you to track trends and responses to management changes. Following are the evaluation criteria for each factor. Feel free to use ½-point scores if you can't decide exactly how to score a factor.

1. **Plant population**—Desirable plant species are those that can best meet production needs. Desirable plant species are specific to the operation, soil conditions, and season of use. Intermediate species are those that are acceptable for the site and operation. Undesirable species are those that create more problems than they solve.

2. **Plant diversity**—Plant diversity contributes to seasonal stability of forage yield and quality. It also provides greater wildlife opportunities. Look for multiple desirable and intermediate plant species. Also look for different functional groups (e.g., cool-season vs. warm-season grasses, legumes vs. grasses, sod formers vs. bunch types). At the top of the worksheet, record the species present.

3. **Plant density**—What percentage of the soil surface is covered by desirable and intermediate plant species? You can estimate stand density either visually or by using a step-point transect line. For visual estimates, first calibrate your eye by looking at stands of known density. For the step-point method, take a predetermined number of steps and touch the ground with your pasture stick. Record whether it touches plant material or bare ground. Calculate plant density and bare ground from the total number of hits.

4. **Plant vigor**—How vigorous are the desirable and intermediate plants? Look at plant color and leaf size. Dark green indicates high vigor, while yellowing indicates low vigor. Large leaves indicate vigorous growth, while small leaves indicate stress. Presence of insect and disease damage indicates low vigor.

5. **Legumes in stand**—Legumes make valuable contributions to the pasture by increasing forage yield, quality, and nitrogen fixation. Too few or too many legumes can be undesirable. The optimal range is 40 to 60 percent. Give a lower score for legume presence above or below this range.

6. **Severity of use**—Has the pasture been grazed appropriately? Grasslands must be grazed to stay in a healthy condition. Undergrazing can be just as detrimental as overgrazing. Score appropriate grazing as 4 and give a lower score for overuse or underuse. Note whether the problem was over- or underuse.

7. **Uniformity of use**—Consider uniformity of grazing in two ways. First, is there localized spot grazing? Are there Phase I and Phase III plant growth stages side by side? Then look across the entire pasture. Are there large areas of overuse or underuse? Pasteure-wide patterns are known as spatial grazing distribution.

8. **Soil resources**—Are there visible signs of soil erosion, compaction, or other degradation? Look for bare soil with rill and gully development, plant pedestaling, or hardened soil surface. This score is based on the percentage of the area affected by these factors.

9. **Undesirable canopy**—How much of the potential solar panel area of the pasture is shaded by undesirable plant species? Examples include woody brush encroachment and low-growing weeds. Annual weed cover can be seasonal but serious. Evaluate the pasture when you have a known problem.

10. **Plant residue**—Plant residue on the soil surface is an important part of the pasture ecosystem. It enhances water infiltration, moderates soil temperature, and forms the transition between plant organic matter and the mineral soil. Too little residue results in excess runoff and high soil temperatures. Too much residue can smother existing plants and inhibit seedling establishment. Give this factor a score of 4 if the amount of residue is appropriate. Give a lower score for too little or too much residue. Note whether the problem was too much or too little.
**Pasture Condition and Trend Score Sheet**

<table>
<thead>
<tr>
<th>Observation date</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abundant desirable plant species found in the pasture:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Pasture condition scores:**
1–8 = Very poor
9–16 = Poor
25–32 = Good
33–40 = Very good

<table>
<thead>
<tr>
<th>Category</th>
<th>Criteria</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) PLANT POPULATION</td>
<td>Plant species (estimated by weight) are mostly: desirable</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>intermediate</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>undesirable</td>
<td>0</td>
</tr>
<tr>
<td>2) PLANT DIVERSITY</td>
<td>Diversity of forage species is: broad: &gt;7–9 species</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>medium: 4–6 species</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>narrow: &lt;3 species</td>
<td>0</td>
</tr>
<tr>
<td>3) PLANT DENSITY</td>
<td>Desirables and intermediates are: dense: &gt;90%</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>medium: 60–70%</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>sparse: &lt;40%</td>
<td>0</td>
</tr>
<tr>
<td>4) PLANT VIGOR</td>
<td>Desirable and intermediate plants are: strong</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>medium</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>weak</td>
<td>0</td>
</tr>
<tr>
<td>5) LEGUMES IN STAND</td>
<td>Legumes (by weight) make up: 40–60%</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>20–30% or &gt;70%</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>&lt;10% or &gt;90%</td>
<td>0</td>
</tr>
<tr>
<td>6) SEVERITY OF USE</td>
<td>Degree and frequency of use is: heavy</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>appropriate</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>light</td>
<td>0</td>
</tr>
<tr>
<td>7) UNIFORMITY OF USE</td>
<td>Grazing use across the pasture is: uniform</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>intermediate</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>spotty</td>
<td>0</td>
</tr>
<tr>
<td>8) SOIL RESOURCES</td>
<td>Amount of area affected by erosion, compaction, concentration is: &lt;5%</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>10–15%</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>&gt;25%</td>
<td>0</td>
</tr>
<tr>
<td>9) UNDESIRABLE CANOPY</td>
<td>Percent of canopy made up by undesirables is: &lt;10%</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>20%</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>&gt;30%</td>
<td>0</td>
</tr>
<tr>
<td>10) PLANT RESIDUE</td>
<td>Dead and decaying plant material is: excessive</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>appropriate</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>deficient</td>
<td>0</td>
</tr>
</tbody>
</table>

**Total pasture score**