Traditionally, little control is exerted over grazing on irrigated pasture. Today, however, with controlled grazing and feed budgeting, the pasture manager can use grazing stock to control forage levels, and forage levels can be used to control animal performance. Pasture budgeting can be applied to California’s irrigated pastures when estimates of expected pasture growth are available, according to an ongoing study.

Ranchers in New Zealand allocate forage in intensive grazing systems by budgeting pasture use along with rotating pasture use. The advantages are (1) grazing can be used to control forage levels and (2) forage levels can be used to control animal performance. Pasture forage budgeting requires knowing:
- The pregrazing herbage mass (HM) present in each paddock at the beginning of a rotation,
- The postgrazing herbage mass target,
- Expected pasture growth rate (PGR),
- Forage energy concentration, and
- The quantity and quality of supplemental feeds.

Because information on pasture growth rates is not readily available for California’s irrigated pastures, we began monitoring pasture HM on five Northern California irrigated pastures where time-controlled grazing was practiced. Preliminary observations on this monitoring, begun in 1988, and the use of PGR in a pasture budget are reported here. Although forage budgeting does not require pasture conditions like those in New Zealand, we will compare PGRs of New Zealand with those of California.

How much HM is available?
Herbage mass (HM) is an internationally recognized term for the amount of dry matter in a pasture at any one time. Not all HM is available for consumption by stock. Some must be left behind to protect soil and support future pasture production; some is wasted by trampling and fouling.

The first step in feed budgeting is to estimate HM (lb/ac) present at the beginning of a rotation. With reasonable accuracy, determining HM can be done visually by clipping or, as was done in this study, using a pasture probe. The pasture probe measures changes in electronic capacitance to estimate the weight of above-
Pasture mass (DM lb/ac)
Postgrazing pasture mass (DM lb/ac)
Pasture height (in.)

Fig. 1. Influence of forage level on forage intake and animal performance.

Fig. 2. Mean pasture growth rate for five Northern California irrigated pastures compared to inland and coastal pastures on New Zealand’s North Island.

The amount of forage left after grazing can be used to control animal production. During the non-nutrient phase of figure 1, animal performance improves as the amount of forage left behind increases. To achieve maximum milk or meat production, it is common to have a target postgrazing mass between 1,200 lb/ac and 1,600 lb/ac, usually the equivalent of 3 to 4 inches of forage. Our example forage budget in table 2 uses a postgrazing HM of 1,400 lb/ac. Stock that can be maintained on a lower plane of nutrition than milk cows, growing calves and lambs may have a lower postgrazing HM target. New Zealand’s postgrazing DM target for dry beef cows is 600 to 700 lb/ac; postgrazing target for beef cows in late pregnancy or late lactation is about 1,000 to 1,200 lb/ac DM.

Although California researchers have not conducted studies determining the postgrazing HM at which intake or performance is near maximum, research during the 1950s showed that animal performance increased if pastures were not closely grazed. The result: Cooperative Extension Service recommended leaving 4 to 6 inches of forage at the end of a grazing period.

What is the PGR?

Pasture growth rate (PGR) is the daily rate of forage production. In winter, PGR is slow, often less than 10 lb/ac/day. Dur-
### TABLE 2. Feed budgeting example

<table>
<thead>
<tr>
<th>Pasture</th>
<th>Area</th>
<th>HM</th>
<th>Total DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>a</td>
<td>lb/ac</td>
<td>lb</td>
</tr>
<tr>
<td>1</td>
<td>1.5</td>
<td>2,200</td>
<td>3,300</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>2,500</td>
<td>2,500</td>
</tr>
<tr>
<td>3</td>
<td>1.5</td>
<td>2,200</td>
<td>3,300</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>1,800</td>
<td>3,600</td>
</tr>
<tr>
<td>5</td>
<td>1.5</td>
<td>1,800</td>
<td>2,700</td>
</tr>
<tr>
<td>6</td>
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<td>2,000</td>
<td>2,000</td>
</tr>
<tr>
<td>7</td>
<td>1.5</td>
<td>1,500</td>
<td>2,250</td>
</tr>
<tr>
<td>TOTAL</td>
<td>10</td>
<td>19,850</td>
<td></td>
</tr>
</tbody>
</table>

*Grazing 30 head of 500-lb steers with a production target average daily gain of 1 lb/head/day.

*The NRC daily dry matter requirement for a 500-lb medium frame steer gaining 1 lb/day = 12.3 lb DM. This assumes a daily ME requirement of 11.8 Mcal and a pasture energy concentration of 36 Mcal ME/lb DM.

*Predicted PGR is taken from the Sutter County data in table 3.

*Steers growing 1.0 lb/day will have to leave a postgrazing HM of about 1,400 lb DM/ac after grazing; the pregrazing dry matter levels should be about 2,000 to 2,500 lb DM/ac.

### Feed Budget

Total pasture present (lb) = 19,850

Subtract pasture which will be uneaten (postgrazing HM) 1,400 lb DM × 10 acres = 14,000

Therefore, pasture available at beginning of rotation = 5,850

Calculate additional pasture produced during 3 months of growth (see table 3):

| Aug.     | 51 lb DM/ac/day × 10 acres × 31 days = 15,810 |
| Sep.     | 26 lb DM/ac/day × 10 acres × 30 days = 7,800  |
| Oct.     | 17 lb DM/ac/day × 10 acres × 31 days = 5,270  |
| TOTAL    | 92 days = 28,880 |

Therefore, total feed available to the steers is:

5,850 lb + 28,880 lb DM = 34,530 lb DM

Now calculate the feed requirements of the steers for the 3 months, if their growth rate is 1 lb/day. First, calculate the midpoint weight:

Weight at end of 3 months

500 lb + 1 lb/day × 92 days = 592

Midpoint weight at 46 days = 546

Use this midpoint weight to calculate the total feed requirements for steers over 92 days. Obtain the feed requirements of a 546-lb steer growing at 1 lb/day from the NRC tables; (12.3 lb DM/day/head)

25 steers × 12.3 lb DM × 92 days = 26,290 lb DM

Now, balance the available feed with the expected feed requirements of the steers:

Total feed available = 34,530 lb
Total feed demand = 28,290 lb

Surplus feed = 6,240 lb

### Grazing Plan

Having established that there is sufficient feed, a grazing plan can be worked out by doing mini feed budgets for each of the paddocks, for example:

**Paddock 1 (1.5 acres)**

Total feed:

minus uneaten feed: 1,400 lb/ac × 1.50 acres = -2,100 lb DM

Feed available:

1,200 lb DM

Daily feed requirement for 25 steers:

25 steers × 12.3 lb DM × 307.5 lb DM/day = 307.5 lb DM/day

So, the number of days steers can feed in Paddock 1: 1,200 lb DM × 307.5 lb DM/day = 3.90 days (4 days)

**Paddock 2 (1 acre)**

Total feed:

minus uneaten feed: 1,400 lb/ac × 1.00 acres = -1,400 lb DM

Feed available:

1,100 lb DM

Add to this the daily pasture growth, while the steers are in Paddock 1:

51 lb DM/ac/day × 1 acre × 4 days = 204 lb DM
26 lb DM/ac/day × 1 acre × 2 days = 0 lb DM
17 lb DM/ac/day × 1 acre × 0 days = 0 lb DM

Total feed available = 1,304 lb DM

So, the number of days steers can feed in Paddock 2: 1,304 lb DM × 307.5 lb DM/day = 4.24 days (4 days)

Repeat above calculations for all paddocks for one rotation and develop a summary table:

### FORAGE BUDGET SUMMARY FOR ALL PADDOCKS

<table>
<thead>
<tr>
<th>Paddock number</th>
<th>Area</th>
<th>Pre-grazing herbage mass</th>
<th>Pre-grazing dry matter</th>
<th>Post-grazing herbage mass</th>
<th>Pre-grazing forage available</th>
<th>New growth</th>
<th>Available/Grazing forage</th>
<th>Grazing period</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>1.5</td>
<td>2,200</td>
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<td>4</td>
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</tbody>
</table>

The feed budget projected forage DM for 44 days. A second rotation could be planned starting on day 45. However, it is preferable to check actual forage levels and calculate a new budget at the beginning of a new rotation.
ing rapid spring growth, PGR can exceed 50 lb/ac/day. This is the amount of daily HM increase. Pasture growth rates were determined on five ranches in Northern California from 1988 to 1990, using an earth-plate capacitance meter (pasture probe). Pasture growth rate was determined from the change in HM between the beginning and end of a pasture rest period.

Ending HM – beginning HM
PGR (lb/ac/d) = \frac{Ending date – beginning date}{(days)}

Herbage mass was estimated weekly during rapid growth, biweekly during moderate growth and monthly during slow winter growth. Pasture growth rates for each month were averaged to get PGR estimates (table 3). Monthly PGR patterns and magnitude from the five irrigated pastures are similar to those of inland pastures on New Zealand’s North Island (fig. 2).

How much energy is in forage?

Metabolizable energy (ME) is a measure of dietary energy available for metabolism after energy losses in the urine; combustible gasses (chiefly methane) are subtracted from digestible energy (DE). Metabolizable energy can be estimated from total digestible nutrients (TDN) or DE (2.2 lb of TDN = 1 Mcal ME/lb DM). Other feeds can be compared with pasture on a relative basis. For example, ME for good quality hay is 0.87 Mcal ME/lb DM and pasture contains 1.2 Mcal ME/lb DM. Therefore, 1 lb DM of hay will provide 0.73 times the energy of 1 lb DM from pasture. In other words, 1.38 lb hay is required to provide the same amount of energy as 1 lb pasture.

Feed demand

Feed requirements for different kinds and classes of stock at different levels of production can be determined from the National Research Council’s “Nutrient Requirements of Domestic Animals.” Feed budgeting is an imprecise process. If postgrazing HM for paddock 1 is lower than the target of 1,400 lb/ac, it may be desirable to reduce the grazing period or to decrease stock numbers. Feed budgets should overestimate feed requirements by 10 to 20% initially to reduce the risk of overstocking or of running out of feed prematurely. With experience, the pasture manager can fine tune the feed budget.

Feed budgeting example

Table 2, the feed budget, can be used to project answers to the following:
- Will forage run out and supplemental feeding be required?
- Will the target live weight gain or stocking rate need to be reduced?
- How long will the grazing period for each paddock be?

Conclusion

The PGR data presented here represent 3 years of monitoring five Northern California pastures. Monthly PGR varies annually according to changes in weather and management. However, these data can be used to illustrate the application of feed budgeting to Northern California. In the long run, knowing monthly PGR and the range of PGR variation (standard error) can improve assessments of weather-related risks associated with feed budget projections. Ranch feed budgets, however, should always include an emergency feed plan.

The premise of controlled grazing and feed budgeting is that the pasture manager can use grazing stock to control forage levels and the forage levels can be used to control animal performance. With this approach, pasture management becomes an active process of setting production targets and monitoring progress rather than a passive process resulting in low productivity. Controlled grazing requires planning and preparation. For those interested in pursuing intensive grazing management, livestock farm advisors throughout California offer short courses on ranch planning and grazing management.

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The authors would like to thank the ranchers who cooperated on this project: Rich and Dean Hunt, Jerry Cox, Jack and Jeff Somerville, David DiBenedetti and Lloyd Stueve. The lead author would also like to thank the Frazer Graham family of Hamilton, New Zealand for their hospitality and for their grazing management expertise that stimulated his investigation of intensive grazing management.

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**TABLE 3. Pasture growth rates for five Northern California* irrigated pastures compared to inland and coastal pastures on New Zealand’s North Island†**

<table>
<thead>
<tr>
<th></th>
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<td>56</td>
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<td>26</td>
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</tr>
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<td>22</td>
<td>54</td>
<td>50</td>
<td>56</td>
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<tr>
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<td>52</td>
<td>63</td>
<td>46</td>
<td>39</td>
<td>37</td>
<td>30</td>
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</tbody>
</table>

* California pastures are various mixtures of perennial ryegrass (Lolium perenne), orchardgrass (Dactylis glomerata), tall fescue (Festuca arundinacea), "Ladino" white clover (Trifolium repens), and strawberry clover (T. fragiliturum).
† New Zealand (NZ) pastures are dominated by perennial ryegrass and white clover. NZ was adjusted by 6 months, so that July data are listed under January.

**TABLE 4. Monthly irrigated pasture energy concentration (Mcal ME/lb DM)**

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
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<th>Nov</th>
<th>Dec</th>
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</thead>
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<tr>
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<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
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<td>1.20</td>
<td>1.20</td>
<td>1.20</td>
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</table>