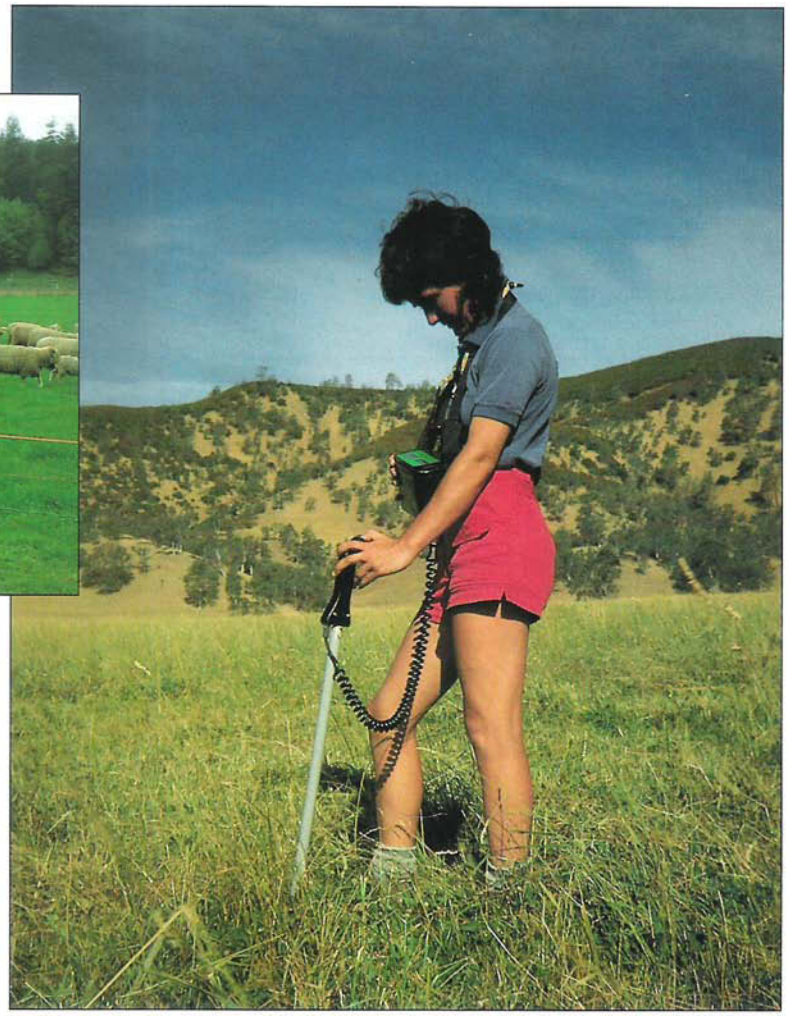

Above, controlled grazing system with grazed area (post-grazing herbage mass) in the foreground. At right, graduate research assistant Marya Robbins estimates herbage mass using a pasture probe.

By budgeting irrigated pasture growth rates . . .

Managers control forage levels and animal performance

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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-

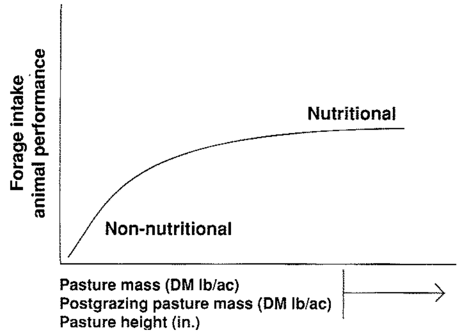

Fig. 1. Influence of forage level on forage intake and animal performance.

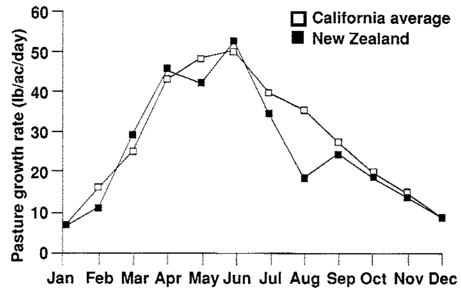

Fig. 2. Mean pasture growth rate for five Northern California irrigated pastures compared to inland and coastal pastures on New Zealand's North Island.

ground dry matter (DM). The pasture probe was calibrated with a large number of clipped samples.

Visual estimation of HM can be learned in a few hours by comparing estimates with clipped samples or with the pasture probe (several farm advisors have pasture probes). Estimate HM in units of 100 DM lb/ac. Pasture height can be used to roughly estimate pasture DM. Table 1 shows the general relationship between height and weight for cool-season irrigated pastures having a mixture of grass and clover. More accurate estimation of pasture DM is difficult because species composition, plant density, season and stage of growth vary. However, for feed budgeting purposes, estimates are usually adequate.

After grazing, what's left?

The amount of forage left after grazing depends on the level of animal performance desired. Figure 1 illustrates that to achieve high intake and high animal performance, high HM and allowance must be provided and stock must be moved before postgrazing HM declines to a low level. The practical importance of this relationship between pasture intake and pasture availability is that intake and animal performance can be controlled by rationing pasture to stock.

Figure 1 is divided into two distinct sections: non-nutritional and nutritional. The non-nutritional section, the ascending part of the curve, indicates how the animal's ability to harvest pasture limits intake and performance. These factors (intake and performance) are influenced by pasture structure and animal grazing behavior. In this part of the curve, intake and performance are very sensitive to changes in the amount of pasture allocated, so any errors in pasture allocation greatly affect animal performance.

At the plateau of the curve, such nutritional factors as digestibility and nutrient concentration appear to control intake and animal performance.

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 on pastures containing temperate forage species, 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 1. Approximate amounts of irrigated pasture dry matter present for Northern California irrigated pastures 1-12 in. in height

Height	Dry matter
in.	*lb/ac*
1	400 – 800
2	800 – 1,200
3-4	1,200 – 1,600
5-6	1,600 – 2,200
7-8	2,200 – 2,800
9-12	2,500 – 3,200
>12	3,000+

Definitions

Continuous grazing is grazing for extended periods without rotating to another paddock (pasture). Continuous grazing for several months or all year is common in California. It is called *set stocking* in New Zealand.

A *controlled grazing system* is a mixture of continuous and time-controlled grazing that is planned to meet farm production targets. Time-controlled grazing can be used to ration forage when PGRs are low or forage is being accumulated for later use. Continuous grazing is most useful when feed supply greatly exceeds demand and accumulation for later use is unnecessary.

Herbage mass (HM) is the amount of pasture per unit area. The amount of pasture is all that is above ground level and is expressed as lb DM/ac, where DM equals dry matter. Herbage mass is also called herbage dry matter or pasture mass.

Paddock is the term used internationally for individual fields in a grazing system. In the United States, these fields are usually called pastures. Rotational grazing systems, including cell grazing, have several paddocks, often separated by permanent electric fences.

Pasture allowance is the amount of pasture allocated to livestock; it is calculated by dividing pregrazing herbage mass by the number of animals per unit area and is expressed as lb DM/head/day or lb DM/lb liveweight/day.

Pasture growth rate (PGR) is the amount of daily forage increase on a dry matter basis (lb/ac/day).

Postgrazing herbage mass is the amount of pasture per unit area left after grazing. An indication of the intensity of grazing, it is expressed as lb DM/ac. It is also called postgrazing pasture mass.

Time-controlled grazing is a grazing rotation where rest periods vary with pasture growth rate (PGR). When PGR is rapid, grazing periods are short (2 to 4 days), followed by 20- to 35-day rest periods. When PGR is slow, grazing periods are longer (7 to 10 days), followed by 60 to 90 days of rest from grazing.

TABLE 2. Feed budgeting example

Assumptions

*10-acre pasture subdivided into seven paddocks with the following herbage mass (pregrazing HM):

Pasture	Area	HM	Total DM
No.	*a*	*lb/ac*	*lb*
1	1.5	2,200	3,300
2	1	2,500	2,500
3	1.5	2,200	3,300
4	2	1,800	3,600
5	1.5	1,800	2,700
6	1	2,000	2,000
7	1.5	1,500	2,250
TOTAL	10		19,650

*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 .96 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) = 19,650

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

Therefore, pasture available at beginning of rotation = 5,650

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

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

Therefore, total feed available to the steers is:

5,650 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 = 28,290 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:	3,300 lb DM
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

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	2,500 lb DM
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 × 0 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

Paddock number	Area	Pre-grazing herbage mass	Pre-grazing dry matter	Post-grazing herbage mass	Pre-grazing available forage	New growth	Available forage	Grazing period
	ac	*lb/ac*	*lb*	*lb/ac*	*lb*	*lb/ac*	*lb*	*days*
1	1.5	2,200	3,300	1,400	1,200	0	1,200	4
2	1	2,500	2,500	1,400	1,100	204	1,304	4
3	1.5	2,200	3,300	1,400	1,200	612	1,812	6
4	2	1,800	3,600	1,400	800	1,428	2,228	7
5	1.5	1,800	2,700	1,400	600	1,607	2,207	7
6	1	2,000	2,000	1,400	600	1,428	2,028	7
7	1.5	1,500	2,250	1,400	150	2,372	2,678	9
								44

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.

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

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 = 4.4 Mcal of DE and ME = 0.82 × DE). Metabolizable energy is sometimes reported in metric megajoules (1 Mcal = 4.18 MJ). In New Zealand, growing perennial ryegrass/white clover pasture between 800 and 3,000 lb/ac HM has an energy concentration of 1.1 to 1.25 Mcal ME/lb DM. To simplify feed budgeting, growing pasture is usually assumed to have 1.2 Mcal ME/lb DM. In California, irrigated pasture ME ranged from 1.1 to 1.3 Mcal ME/lb DM (table 4).

Including supplements

Supplements included in a feed budget can make up for pasture deficits, provided the energy concentration of pasture DM is known. Irrigated pasture energy concentration varies from 1.1 to 1.3 Mcal of ME/lb DM. Other feeds can be compared with pasture on a relative basis. For example, the 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.

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

	Pasture growth rate											
	Jan (Jul)	Feb (Aug)	Mar (Sep)	Apr (Oct)	May (Nov)	Jun (Dec)	Jul (Jan)	Aug (Feb)	Sep (Mar)	Oct (Apr)	Nov (May)	Dec (Jun)
	lb/ac/d											
NZ coast	24	33	50	58	63	73	59	61	50	41	32	25
NZ inland	7	11	29	45	42	52	34	18	24	18	13	8
Stanislaus	5	23	26	34	58	49	34	27	24	18	12	9
Glenn	7	11	27	43	52	39	41	34	25	17	9	7
Humboldt A	10	22	27	54	50	51	30	45	34	28	17	12
Sutter	7	13	28	45	50	56	49	51	26	17	8	4
Humboldt B	8	10	18	39	33	56	43	20	27	17	24	8
Calif. Average	7	16	25	43	48	50	39	35	27	19	14	8
NZ Average	15	22	39	51	52	63	46	39	37	30	22	16

*California pastures are various mixtures of perennial ryegrass (*Lolium perenne*), orchardgrass (*Dactylis glomerata*), tall fescue (*Festuca arundinaceae*), "Ladino" white clover (*Trifolium repens*), and strawberry clover (*T. fragiferum*).
†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)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.20	1.30	1.30	1.20	1.20	1.09	1.09	1.09	1.09	1.20	1.20	1.20

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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 DiBennedetti 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.