Short-duration grazing on irrigated pasture

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First-year results are now available in a long-term study of the popular short-duration grazing system, also known as controlled or intensive grazing, under way at the UC Sierra Foothill Range Field Station. The 1988 experiment compared two grazing intensities in an eight-paddock rotation with 3-day grazing and 21-day forage regrowth intervals. A stocking rate predictor was developed based on plant height, and a close relationship was found between heifer weight gains per acre and amount of forage removed.

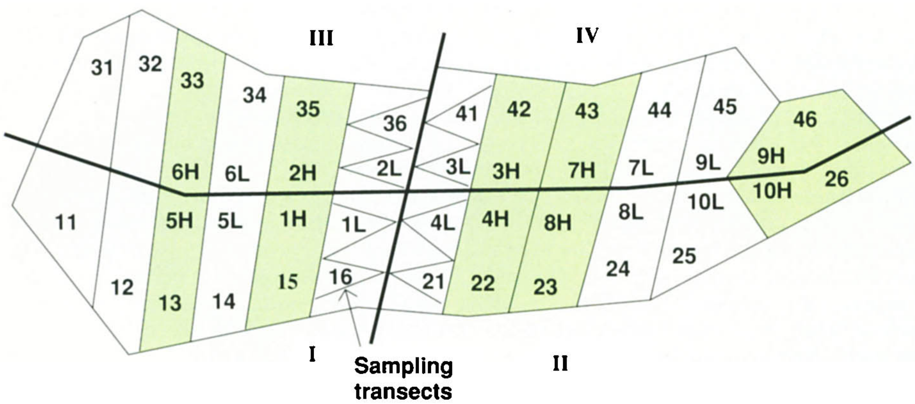
The past decade has witnessed a resurgence of interest in grazing management and the use of specialized systems to increase both plant productivity and the efficiency of forage transfer from plant to animal. Much of the stimulus has come from resource management consultant Alan Savory, who developed, largely from principles published earlier by the French author Voisin and others, the so-called short-duration grazing system. This system was later modified and expanded to take into account all resources allocated to whole-ranch operation (holistic resource management).

Short-duration grazing is a form of rotational grazing based on a short grazing period (usually 1 to 3 days) at very high stocking rates (up to 100 head per acre, usually of cattle) and a long pasture regrowth period. The length of the regrowth period is determined by the number of paddocks in the rotation sequence and the rate of plant growth. Proponents of short-duration grazing consider it to be a highly efficient method of grazing that also is beneficial to pasture growth and stability.

At the plant level, one of the most fundamental relationships of concern to the pasture manager is the characteristic forage growth-regrowth pattern. It often is presented graphically as a sigmoid (S-shaped) response of the post-grazing increase in forage mass or height over time (fig. 1a).

Figure 1a shows the outcomes of two utilization management approaches. The first, "high accumulation-moderate utilization (high A-U)," should provide maximum forage yield. It assumes that forage is allowed to accumulate until regrowth has nearly ceased and that utilization removes forage only to the level where regrowth may again be resumed at its previous rate (dotted line i). The second, "low accumulation-high utilization (low A-U)," assumes that forage accumulation is allowed only to the regrowth midpoint and that forage is grazed to a level where regrowth is initially much slower (dotted line ii) than it is under high A-U conditions. This simple model also implies that the growth-utilization-regrowth cycle may be repeated in essentially the same manner a number of times, depending on the length and conditions of the growing season. Under the conditions of figure 1a, unequal amounts of forage are produced in equal lengths of regrowth time.

Variations in the shape of the characteristic curve may occur because of seasonal changes in plant growth, or as a cumulative result of management influences on plant density and/or regrowth vigor. Figure 1b then shows that, if the general shape or



Irrigated pasture research facility at the University of California Sierra Foothill Range Field Station (photo at left, as viewed from left side of diagram above). The pasture is divided into four six-field irrigation blocks. Ten pairs of paddocks are assigned to high (H) and low (L) forage accumulation-utilization grazing sequences. The four center paddocks in the diagram show sampling line transects that were established in all paddocks.

steepness of the regrowth curve changes (lines iii and iv), the ratios between regrowth time and forage produced also change. Many different outcomes are possible, and the pasture manager compensates by adjustments such as changing stocking rate, by adding pasture area (regrowth slower), or by seasonally harvesting excess forage as hay to be fed at another time of year (regrowth faster).

Research project

We have begun a long-term research project with three main objectives: (1) to demonstrate the existence of a quantifiable, consistent, and reproducible regrowth response under typical conditions for perennial irrigated pasture; (2) to assess the management and yield (plant and animal) outcomes of the high and low accumulation-utilization treatments; and (3) to document changes related to season and soil nutrients as they are shown in the forage regrowth response. If successful, we should be able to develop monitoring and prediction methods that both pasture managers and researchers can use.

A research irrigated pasture at the University of California Sierra Foothill Range Field Station, near Browns Valley, has been established for long-term study of species composition, plant height and yield measurements, and for sampling of soil for nutrient budget analysis. The pasture consists of 24 paddocks of 1 acre, organized into four blocks of six paddocks each (see diagram above). Each six-paddock block is independently irrigated, permitting separation of grazing effects from irrigation. Irrigation is by a system of pump-driven solid-set sprinklers using surface-delivered water from a local irrigation district. "Permanent" line transects were laid out in all paddocks to provide four replicates of generally equal length per paddock (example shown in the diagram).

A grazing sequence for the 10 pairs of paddocks assigned to the high and low A-U grazing treatments was begun June 1, 1988. The pastures had previously been maintenance-grazed with cattle as available from field station herds, with no single defined grazing system used. Four paddocks (11, 12, 31, and 32) at one end of the pasture were reserved in 1988 for use in developing and refining plant sampling methods and livestock management.

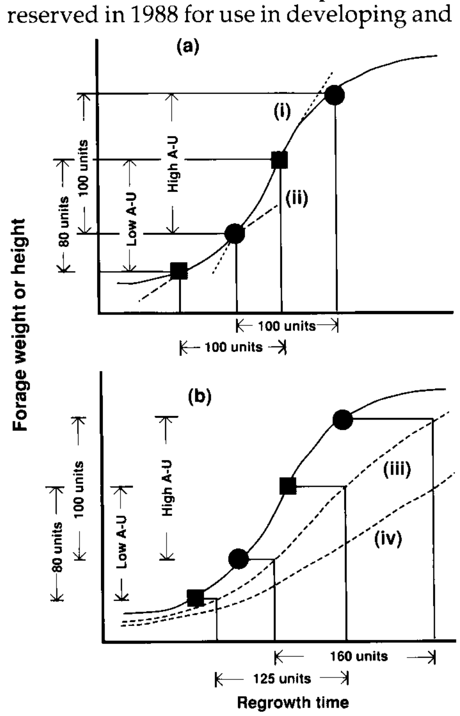


Fig. 1. Theoretical pasture forage growth-regrowth curve shows relationship between (a) length of regrowth time and amount accumulated and (b) variation in both with change in slope and amplitude of the curve.

The regrowth interval for both A-U treatments was set at 21 days and the grazing interval at 3 days. While grazing could have been set at 2 or even 1 day, 3 days provided reaction time, in this first season, for adjusting stocking rates to achieve a desired extent of pasture use.

Lacking sufficient information for forage weight estimates, we used forage heights to describe and monitor forage accumulation and utilization patterns. We based the first conditions for the two A-U treatments on forage heights as shown in table 1. Experience in the first cycle of grazing dictated a lowering of values, especially for entrance heights.

TABLE 1. Basis for treatments

A-U treatment	Height in*	Height out*
	...........inches..........	
High	18 (10-12)	6-8 (4-6)
Low	12 (6-8)	2-3 (3-4)

* Values in parentheses were used after the first grazing cycle.

We worked out an irrigation schedule that met the following conditions:

(1) It fit the 3-day grazing period so that (a) no irrigation occurred with stock in the paddock; (b) no irrigation occurred less than 3 days before entry; and (c) the nonirrigated interval did not exceed 7 days, unless it was necessary to avoid compromising rules (a) and (b).

(2) A grazed paddock was irrigated the same day (evening) that stock left it.

(3) Normally, the field next in the grazing sequence was irrigated the day before the currently grazed field was entered.

Irrigation amounts were adjusted across the season based on standard evaporation pan data acquired at the field station. Assumptions for actual evapotranspiration versus pan evaporation and irrigation efficiency were essentially self-canceling, and application amounts were generally equal to pan evaporation.

With experience, we developed a stocking rate estimator based on the total number of animal grazing hours per inch of forage removed (GHIFR) in a 3-day grazing period. (Grazing hours are calculated from the total elapsed time between entrance and exit of a given number of animals; for example, 40 animals over 72 hours equals 2,880 GH.) We calculated this estimator as follows:

Predicted forage height at entry (PFHE) = current height + [days to entry x height increment/day]

$$\frac{\text{PFHE} \times \text{GHIFR}}{72} = \text{stocking rate for the 3-day period}$$

Single-probe capacitance meter is used to monitor the changes in forage mass before and after grazing.

Between-species and between-plant variations in plant heights were minimized by monitoring only orchardgrass, which was widely and uniformly distributed in the pasture. The height was taken as that point where up to 10% of forage mass (visually estimated) was displayed above the indicated height.

The "tester-grazer" approach to stocking was used. Tester animals were maintained throughout the grazing season. These were Hereford heifers, initially weighing an average of 450 pounds with a final weight at 96 days of 580 to 600 pounds. Grazers were added and removed when necessary to increase or decrease consumptive demand to achieve the forage height desired at the end of a 3-day grazing period. These also were females, some of which weighed more than the testers. Grazer animals were added either at the beginning of this 3-day period (when actual forage height at entry exceeded target height) or during the period, and were removed either before or at its end. A microcomputer-based spreadsheet was developed to keep animal records and to calculate grazing hours, stocking weights, animal unit days and animal unit months. The latter two calculations were based on the convention of a 1000-pound animal unit.

Following spring and early-summer maintenance grazing, the experimental grazing season began June 1, 1988, and concluded September 5, 1988, at the end of the fourth full 24-day (eight-paddock) grazing cycle. Shrunk weights taken on tester animals initially and at the end of the grazing season were used to calculate average daily gains. Land-based weight gains were calculated using tester average daily gain and grazing day totals obtained by adding grazing hours for all animals used.

In addition to monitoring forage height, we used a Gallegher single-probe capacitance meter to record forage mass before and after grazing and to monitor changes in accumulated forage across the period of regrowth, as time permitted. Standard double-sampling clipping in a number of sampling plots was done separately to calibrate the capacitance meter.

Results

Proportions of the four main perennial pasture species show that in 1987 the pastures were in the legume dominance phase (total legume percentage = 71) (table 2). The groups of paddocks subsequently allocated to the two grazing experiment treatments did not differ in proportions of the four major sown species except for perennial ryegrass. Other species accounted for less than 1% of the total. A year later, after the first year's experiment, Ladino clover had declined nearly 30%, orchardgrass had increased by a corresponding amount, perennial ryegrass had declined slightly, and other species had shown a numerically small but proportionately large increase. Our previous research with similar pastures has indicated that such year-to-year changes may be expected during post-establishment adjustments in species balance resulting from grazing management, climate, plant species competition, and soil fertility. There was no evidence of specific treatment (accumulation-utilization level) effects on species composition during this first study year.

It became apparent that a sufficiently reliable correlation existed between animal stocking (as measured by total grazing hours per 3-day grazing period, GH) and initial minus residual grass heights (inches of forage removed, IFR) to use this relationship (GHIFR) for estimating beginning stocking rates for the next paddock to be grazed. Table 3 summarizes these values for the four grazing cycles between June 1 and September 5, 1988.

Figure 2 combines the accumulation-utilization patterns of grass height increase and decrease over four grazing cycles. Initial entry for each of the eight paddocks in an A-U treatment sequence was set at day one to synchronize them for easier visual comparison.

Statistical analysis showed that the regrowth form was very similar for the high

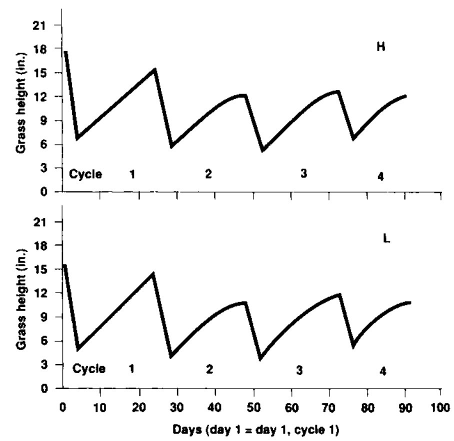


Fig. 2. Forage heights for high (H) and low (L) accumulation-utilization treatments over four grazing cycles and eight paddocks. All are placed on a common time basis (first day of 3-day grazing period) to allow direct comparison.

TABLE 2. Botanical composition averaged for eight paddocks in the high and low accumulation-utilization treatments

Treatment	Orchard-grass	Per. rye-grass	Ladino clover	Strawberry clover	Other species
			%		
September 1987 (pre-experiment):					
High	19	7*	71	2	1
Low	17	12	69	1	1
Average	18	10	70	1	1
September 1988 (post-experiment):					
High	51	5	40	1	3
Low	47	5	44	1	4
Average	49	5	42	1	3

*Values for high and low treatments differ at $P < 0.05$.

TABLE 3. Summary of grazing hours per acre per inch forage removed (GHIFR) during 3-day grazing cycle and high and low A-U treatments

	Grazing hours/acre/inch forage removed		
Cycle	High	Low	Average
1	276	312	294
2	328	346	337
3	283	294	288
4	288	271	280
Average	294	306	300
Std. dev.	23	32	
CV	8%	10%	

NOTE: Each value is the average of eight paddocks.

One-acre paddock contains 40 heifers. In this study, researchers used stocking rates of up to 60 head per acre, and rates may be as high as 100 per acre in some intensive grazing systems.

A-U and low A-U treatments over all four grazing cycles.

The change in grass height for a 3-day grazing period (most frequently from 3 to 15 inches), in addition to providing a basis for setting stocking rates, was also well correlated with the estimated **per acre** animal liveweight gain for that 3-day period. When data were combined over all four grazing cycles, the resulting equations suggested that per-animal energy intake or forage availability may have been higher for the low A-U treatment at grass-height removal values above 9 inches. At values less than 9 inches, the equations gave similar estimates for both A-U treatments. For example, at a grass-height removal of 8 inches, **per acre** liveweight gain predicted was about 130 pounds. However, available resources did not permit assessment of intake or forage quality factors.

We calculated stocking rates (as animal unit months) for each grazing cycle and the 96-day season, as well as liveweight gains per acre using tester animals (table 4). We used 11 and 12 animals for the low and high A-U treatments, respectively, average daily gain, and the total grazing days for tester and grazer animals. We recognize the additional error inherent in estimating liveweight gain by using the tester-grazer method, but the similarity of stocking numbers and procedures within treatments makes a between-treatment bias unlikely. On a numerical basis, the low A-U treatment was consistently stocked at animal-unit-month levels that were either higher than or equal to the high A-U treatment. This represented a season-long differential of approximately 13%. The similarity in average daily gain between the two treatments (1.40 and 1.44, table 4) was reflected in a significant liveweight gain difference of 15% (614 versus 533 pounds per acre). The closeness of the two values (13% and 15%) suggests that forage quality and/or intake were similar between the two A-U treatments but that forage utilization was better in the low A-U treatment. Because neither forage nor animal data suggest responses characteristic of the low end of the sigmoid regrowth curve, we must conclude that both of the treatments represented mid- to high-end sections of the curve.

TABLE 4. Animal unit months (AUM) and liveweight gain per acre (LG) for four grazing cycles

Cycle	AUM	LG*
		lb/acre
Low A-U		
1	2.5	200
2	2.0	195
3	1.2	108
4	1.3	111
Total	7.0	614°
High A-U:		
1	2.0	164
2	1.8	168
3	1.2	108
4	1.1	94
Total	6.1	533°

NOTE: Averaged for eight paddocks for four grazing cycles and the 96-day total.
* In Low A-U treatment, LG based on seasonal average daily gain of 1.44 lb. In high-A-U treatment, LG based on seasonal average daily gain of 1.40 lb.
° Total LG are significantly different for low and high accumulation-utilization treatments.

Conclusions

Neither of the two A-U treatments demonstrated a complete regrowth response. However, results were consistent with the existence of a sigmoid regrowth curve where the treatments were operating on the intermediate to upper portions of it.

The collection of plant height data along established transects was rapid and generally had small operator-associated error. The usefulness of the data to pasture managers was demonstrated by the satisfactory performance of a stocking rate predictor based on the desired entry-height minus exit-height difference. Also, seasonal liveweight gains per acre were well correlated with inches of forage removed per 3-day grazing period.

Despite relatively small statistical variations in pasture forage level estimates made with a single-probe capacitance meter, attempts to calibrate the instrument using standard double-sampling procedures were only marginally successful. Correlations of liveweight gain per acre with probe meter readings were much lower than for liveweight gain and forage height difference. A much more thorough study will be required to establish the comparative value of height versus single-probe capacitance meter measurements as a predictor of liveweight gain per unit area.

Although forage regrowth behavior was almost identical for the two A-U treatments within a grazing cycle, the low accumulation-high utilization treatment yielded a significantly higher season-long per acre liveweight gain. This treatment probably provided a higher transfer efficiency at forage availability and quality levels that were high enough in both A-U treatments to result in nearly identical average daily gain. Loss of potentially grazeable forage by trampling and fouling was not measured, but it seemed obvious that these losses were especially large in the high A-U treatment, and that management of forage accumulation-utilization at the upper end of the regrowth curve is not justified without a much greater degree of control over animal movement.

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