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# Perennial Irrigated Pastures. III. Beef Calf Production from Irrigated Pasture and Winter Annual Range[1]

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## ABSTRACT

Irrigated pastures in the Western arid and semi-arid regions provide support to the beef cattle industry through the maintenance of beef cow herds and the production of calves. Increasingly unfavorable production economics, including the rising cost and logistical difficulty of seasonally moving cattle from seasonal range to other pastures (e.g., high mountain Federal grazing allotments), necessitate evaluation of management options which permit increased stocking rate and year-around home ranch operation.

The objective of this study was to compare simple (range-only, yearlong) and complex [improved range and irrigated pasture plus winter supplementation with alfalfa (*Medicago sativa* L.) cubes] systems for beef calf production using a fall calving (November-December), early summer weaning (May-June) reproduction cycle.

In the complex system, cleared and reseeded range was used (winter) an average (4 years) of 6 months per year at a stocking rate of 2.2 ha/cow (2.8 AUM/ha). Irrigated pasture was used (summer) an average of 6 months per year at a stocking rate of 0.5 ha/cow (10.3 AUM/ha). Alfalfa cube supplement was fed (about 1 kg/ha per day) during fall and winter. In the simple system, cleared range was used yearlong at an average stocking rate of 5 ha/cow (2.4 AUM/ha). No supplements were fed except during the last year when drought prevailed. An average of 70 kg calf/ha was produced in the complex system. Average birth weight was 34 kg and average daily gain (ADG) to 205 days was 0.76 kg. In the simple system, comparable values were 37.5 kg calf/ha, 32 kg birth weight, and 0.75 ADG. Birth weights and ADGs were not significantly different between systems. Average cow weights reflected seasonal changes in forage availability and quality. Cows in the simple system tended to lose weight more consistently during the months July-October than did those in the complex system, which, instead, more consistently lost weight during the months November-March. Economic return was similar but low in both systems. While total land per cow/calf unit was less for the complex system and total investment higher for the simple system, operating costs, depreciation, and interest were higher for the complex system.

It appeared that second and third trimester cow stresses, as evidenced by negative bodyweight changes, did not adversely affect calf birth weights and ADG, at least at the levels found under these experimental conditions.


*Additional index words:* Grazing management, Annual clovers, Economics of range beef cattle production, Cow/calf systems on annual range.

IN the United States, major support of beef cattle production is derived from the grazing of natural or improved pastures on land generally unsuited for tillage and conventional agronomic crop production. For example, grazing lands in California constitute from 25 to 36% of the state's 40,500,000 ha and provide about 60% of the total feed fed to meat-producing livestock or about 20% of the total meat production (15).

Regions with a Mediterranean climate are characterized by cool, wet winters and hot, dry summers, which results in essentially three range forage seasons (3): 1) inadequate or uncertain green forage (generally late October to late January); 2) adequate green forage (late January to early June); and 3) dry forage (mid June to late October). Available dry matter, energy content and/or protein content will be limiting in a livestock feeding program singly or in combination for 6 to 9 months of the year. Where irrigation water is available, summer-growing irrigated pasture has long been used to supplement seasonal dry matter production and to correct dietary deficiencies of the range forage (2, 4, 9, 12). This is especially applicable where a year-around management system for the maintenance of breeding herds and growth of calves or stockers is desired in lieu of seasonal livestock purchases or movement of livestock from seasonally deficient areas of forage production.

The study reported here was conducted to investigate the current biological and economic feasibility of maintaining a year-around cow-calf operation on improved lower foothill rangeland with and without seasonal supplementation with irrigated pasture. Emphasis was placed on attaining maximum stocking rates in order to fully utilize available forage and to reduce capitalization and the costs contributed by the land.

## MATERIALS AND METHODS

The research was conducted from 1973 to 1977 at the Univ. of California's Sierra Foothill Range Field Station, Browns Valley, Yuba Co. using three land-forage classes: 1) approximately 80 ha of annual rangeland converted from oak woodland to an essentially complete herbaceous cover by type conversion techniques employing herbicidal killing of woody vegetation followed by control burning and reseeding with desirable range annual legumes and summer-dormant perennial grasses; 2) approximately 44 ha of land similar to class 1 except that no reseeding and fertilization was done following control burning; and 3) approximately 20 ha of irrigated pasture of low to moderate productive capacity.

Soils of the general foothill area are quite mixed (8) but the experimental areas consisted principally of the Argonaut, Los Posas, and Sobrante series. These are members of the alfisol order, the typic Rhodoxeralf and Mollic Haploxeralf subgroups, and fine to fine-loamy, mixed, thermic families. Resident herbaceous range vegetation, as with the soils, is quite diverse, with numerous families, genera, and species of largely annual grasses, forbs, and legumes. Only those species of greatest quantitative importance or those deliberately introduced during reseeding were considered in botanical composition and dry matter estimates.

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The irrigated pasture was an old, established stand consisting of a mixture of perennial grasses and perennial legumes including orchardgrass (*Dactylis glomerata* L.), Dallisgrass (*Paspalum dilatatum* Poir.), perennial ryegrass (*Lolium perenne* L.), velvetgrass (*Holcus lanatus* L.), Ladino clover (*Trifolium repens* L.), strawberry clover (*Trifolium fragiferum* L.), and narrowleaf birdsfoot trefoil (*Lotus tenuis* Waldst. & Kit.).

Previous work had established that system of grazing management, while altering botanical composition of sensitive species (13), may have only minor effects on the conversion of available forage to livestock product (10) when grazing pressure is appropriate. It also had been established (14) that the pattern of average forage heights is an adequate indicator of satisfactory seasonal grazing pressure. Seasonal average values for the proportions of pasture surface area covered in four forage height categories were obtained from periodic measurements of irrigated pasture heights made during the season. Averages for the 4 years of the experiment were: 1 to 5 cm, 20 ± 10%; 5 to 10 cm, 30 ± 8%; 10 to 15 cm, 25 ± 6%; and ⩾ 20 cm, 20 ± 10%.

Previously (unpublished data), N content of the principal grass and legume species managed as described above was found to be 2.9 ± 0.6% for the grasses and 4.6 ± 1.2% for the legumes.

Suitable land areas and availability of livestock both were limited, because the field station was still in an early phase of facility development. The work, therefore, was conducted as a non-replicated treatment comparison of 1) a breeding herd of Hereford cattle maintained yearlong on cleared but non-reseeded and fertilized rangeland (this was considered the control or reference herd); and 2) a breeding herd of Hereford cattle maintained on a) annual range cleared, reseeded, and fertilized at reseeding for approximately half of the year and b) irrigated pasture for the remainder of the year. Replications in time (4 years) are available, however, for both plant and animal responses.

Reseeding of the rangeland used for treatment 2 was done in 1970 and 1971, with a mixture of annual legume varieties of *Trifolium subterraneum* and *T. hirtum* (4 kg/ha of the mixture) together with the summer-dormant perennial grass species *Phalaris tuberosa*, *P. hirtiglumis* and *Dactylis glomerata* (1.5 kg/ha of the mixture). Subsequent to reseeding the area (ca 80 ha) was subdivided into four fenced fields to facilitate seasonal rotation of grazing. By initiation of the experiment in 1973 the botanical composition of the fields had stabilized. A single permanent line transect was established in each of the four range fields. The path of the transect was arranged to permit representative sampling of the herbaceous forage, taking into account physiographic variation, including rock outcrops, which had influenced the reseeding operation. Botanical composition was measured following the procedure of Evans and Love (6). Four sets of 100 points per field were considered an adequate sampling level. Species percentage occurrence means from each of the four fields were weighted to reflect differences in field area and reported as single values for each year. Botanical composition of the non-reseeded range field used in treatment 1 was similar, except for absence of the introduced species.

Estimates of seasonal dry matter accumulation were made within 11- 3 × 3 m exclosures during the period from mid-February to early June, with at least one early-season and one late-season sampling each year. The exclosures were arranged so as to represent important physiographic, edaphic, and botanical variations in the four range fields used in the complex system, and were moved to new locations each year. Plants were clipped at 5-cm height from four quadrats, each 30-cm square, within each exclosure. The samples were visually selected to represent median forage accumulation in low (1 sample), intermediate (2 samples), and high (1 sample) accumulation classes.

The animals used in the trial were mature Hereford cows. Breeding was initiated on 1 January each year with artificial insemination practiced for the first 21 days followed by natural service for an additional 30 to 45 days. All calves were individually identified and weighed at birth. The calves were weaned late May to early June each year and all cows were pregnancy checked. At weaning, cows that were not pregnant or had health problems (eye cancer, bad udder, etc.) were culled. Replacements were added at this time; these were cows pregnant with their second calf.

Supplements were fed during the winter months to those cows receiving perennial irrigated pasture and improved annual rangeland according to forage availability to prevent drastic loss of weight during these months (Table 2). The reference herd received no supplements except during the last year (drought conditions) of the trial (Table 1). In all cases, supplements were hand-fed daily or three times per week. All animals were weighed monthly during each year of the trials. Weaning weights of the calves were adjusted to a standard 205-day weight.

Initially (1973-74), 30 cows were used for the improved range-irrigated pasture treatment. Yearlong stocking rates were 2.7 ha of range and 0.8 ha of irrigated pasture per cow-calf unit. In 1974-75 and for the remainder of the experiment, 40 cows were used, with corresponding stocking rates of 2.0 and 0.5 ha per cow-calf unit, respectively. The reference herd (Treatment 1) consisted of eight cows initially, with an increase to 10 in 1975-76. Yearlong stocking rates were 5.5 and 4.4 ha per cow-calf unit, respectively. The 43.8 ha used for the reference treatment was divided into two fields of 19.0 and 24.8 ha used in rotation of approximately monthly intervals. Movement of the

**Table 1. Summary of comparative annual performance of fall calving cow/calf herds on cleared, non-reseeded, non-fertilized annual range.**

| | 1973–74 | 1974–75 | 1975–76 | 1976–77 |
|---|---|---|---|---|
| Cow data: | | | | |
| Area/cow, ha of range | 5.5 (year around) | 5.5 (year around) | 4.4 (year around) | 4.4 (year around) |
| Animal unit months on range/cow | 12 | 12 | 12 | 12 |
| Animal unit months/ha of range | 2.2 | 2.2 | 2.7 | 2.7 |
| Area/cow, ha of irrigated pasture | None | None | None | None |
| Animal unit months on irrigated pasture | None | None | None | None |
| Number of cows | 8 | 8 | 10 | 10 |
| Weight at calving, kg | 424 ± 41 | 381 ± 37 | 389 ± 49 | 360 ± 31 |
| Weight at breeding, kg | 402 ± 42 | 401 ± 35 | 381 ± 42 | 349 ± 36 |
| Weight at weaning, kg | 480 ± 46 | 460 ± 53 | 434 ± 43 | 418 ± 39 |
| Weight at start of supplementation, kg | 440 ± 37 | 361 ± 36 | 377 ± 44 | 341 ± 37 |
| Supplement fed/head per day, kg | None | None | None | † |
| Days supplemented | 0 | 0 | 0 | 96 |
| Weight at end of supplementation, kg | 404 ± 41 | 407 ± 43 | 384 ± 42 | 379 ± 33 |
| Percent rebreeding | 100% | 100% | 70% | 70% |
| Calf data: | | | | |
| Number of calves | 8 | 8 | 10 | 10 |
| Birth weight, kg | 35 ± 3.8 | 32 ± 4.6 | 33 ± 4.2 | 28 ± 3.3 |
| Weaning weight, adjusted to 205 days, kg | 209 ± 12.6 | 200 ± 13.2 | 188 ± 34.4 | 146 ± 19.3 |
| Average daily gain, birth to weaning, kg (not adjusted for sex) | 0.85 ± 0.07 | 0.82 ± 0.12 | 0.75 ± 0.14 | 0.58 ± 0.09 |
| Calf produced/ha, kg: to weaning date (in parentheses) | 38 (24 May 1974) | 36 (23 May 1975) | 43 (4 June 1976) | 33 (3 June 1977) |

† 3:1 ground corn: CSM 1 Dec. 1976 to 23 Mar. 1977, 2 kg/hd per day; pasture day 30 Dec. 1976 to 3 Mar. 1977, 5 kg/hd per day; alfalfa hay 4 Mar. 1977 to 23 Mar. 1977, 5 kg/hd per day.

cattle in treatment 2 varied seasonally and from year to year. Based on previous experience at the station and elsewhere in similar systems (16) cattle were moved in response to forage availability, calving and breeding requirements, annual legume seed set, winter treading damage, and for summer grazing of dry annual range to utilize residue forage in combination with irrigated pasture and to shatter mature legume seed.

Plant data were analyzed by computing standard error of means for the botanical composition data and by computing linear regressions to estimate a seasonal (January-June) value for rate of dry matter accumulation.

Animal data were analyzed by computing standard deviations for 1) cow weights at breeding, weaning, and calving, and at beginning and end of supplementation; and 2) calf weights at birth and weaning (adjusted to 205 days). Using years as replications mean cow and calf weights for the two management systems were compared using the Student's "t" test. An Animal Unit Month (AUM), where used was defined as one 454-kg cow.

## RESULTS AND DISCUSSION

Tables 1 and 2 present the essential physical and biological parameters for relatively simple and complex beef calf production systems maintained on the same land resources on a year-around basis.

For the simple system (Table 1, range-only), the stocking rate of 4.4 to 5.5 ha per cow is high for the area, especially in the absence of winter supplementation. Land clearing to remove most of the trees and shrubs enabled maximum production of resident herbaceous forage, and most was consumed. In an annual-based system, grazing pressure can be moderate to heavy as long as some protective litter is left and seed production is adequate to provide for the next season's growth (3). Similarly, the 2 ha/cow of range and 0.5 ha/cow of irrigated pasture in the complex system (improved range plus irrigated pasture and supplement, Table 2) are high, particularly in view of the fact that the irrigated pasture was not highly productive and on soils generally considered as being marginal for this purpose.

Average cow weights are given for the physiological and management stages of greatest interest for the sake of completeness, while recognizing that statistically-valid conclusions cannot be drawn from them due to limitations of experimental design and animal variability. Some apparent trends, however, are note worthy. There was a consistent and relatively large positive bodyweight change (65 ± 11.0 kg) for the range-only herd between breeding (January) and weaning (May-June) following a smaller, and less consistent (3 years out of 4) negative change (−5 ± 18) between calving (November) and breeding. Comparable values for the complex system (Table 2) were 36 ± 4.2 kg and −22 ± 14.8. There was a greater year-to-year variation associated with the fall-winter season which also accurately reflects a greater variability in the date when adequate grazing levels of new forage become available.

Interpretation of the cow weight results is enhanced by considering some characteristics of the Mediterranean annual climate as they relate to forage growth and livestock production. Figure 1 portrays seasonal changes in maximum and minimum temperatures together with the normal rainfall period. An arbitrary set of seasons is shown in conjunction with times of use for range, pasture, and supplements. Average changes in cow weights also are given as they occurred during those seasons. Germination and initial growth of the resident range annual vegetation in any given year may occur as early as late September or as late as mid-December. The 4 months November through February generally provide the highest rainfall amounts, as well as the coolest temperatures. Maximum range forage growth occurs from February

**Table 2. Summary of comparative annual performance of fall calving cow/calf herds maintained year-around on perennial irrigated pasture and on cleared and improved annual range.**

| | 1973–74 | 1974–75 | 1975–76 | 1976–77 |
|---|---|---|---|---|
| Cow data: | | | | |
| Area/cow, ha of range | 2.7 (136 days) | 2.0 (205 days) | 2.0 (197 days) | 2.0 (180 days) |
| Months on range/cow | 4.47 | 6.74 | 6.48 | 5.92 |
| Animal unit months/ha of range | 1.7 | 3.3 | 3.2 | 3.0 |
| Area/cow, ha of irrigated pasture | 0.8 (229 days) | 0.5 (160 days) | 0.5 (168 days) | 0.5 (157 days) |
| Months on irrigated pasture/cow | 7.53 | 5.26 | 5.52 | 5.16 |
| Animal unit months/ha of irrigated pasture | 9.41 | 10.52 | 11.05 | 10.32 |
| Number of cows | 30 | 40 | 40 | 40 |
| Weight at calving, kg | 488 ± 51 | 468 ± 64 | 435 ± 53 | 458 ± 60 |
| Weight at breeding, kg | 469 ± 46 | 435 ± 54 | 432 ± 45 | 423 ± 53 |
| Weight at weaning, kg | 501 ± 50 | 476 ± 49 | 471 ± 47 | 457 ± 49 |
| Weight at start of supplementation, kg | 530 ± 50 | 456 ± 63 | 418 ± 45 | 449 ± 52 |
| Supplement fed/head per day, Kg† | 1.5 | 1 | 1 | § |
| Days supplemented‡ | 112 | 84 | 58 | 125 |
| Weight at end of supplementation, kg | 447 ± 44 | 442 ± 53 | 439 ± 46 | 419 ± 53 |
| Percent rebreeding | 70% | 95% | 85% | 75% |
| Calf data: | | | | |
| Number of calves | 30 | 40 | 39 | 39 |
| Birth weight, kg | 36 ± 3.7 | 33 ● 4.5 | 34 ± 4.8 | 33 ± 4.6 |
| Weaning weight, adjusted to 205 days, kg | 217 ± 27 | 197 ± 30 | 185 ± 32 | 163 ± 33 |
| Average daily gain, birth to weaning, kg (not adjusted for sex) | 0.87 ± 0.09 | 0.80 ● 0.11 | 0.74 ± 0.11 | 0.64 ± 0.13 |
| Calf produced/ha, kg to weaning date (in parentheses) | 62 (21 June 1974) | 78 (20 June 1975) | 74 (4 June 1976) | 65 (3 June 1977) |

† Alfalfa cubes. ‡ 26 Oct. 1973–15 Feb. 1974, 8 Nov. 1974–31 Jan. 1975, 4 Dec. 1975–2 Feb. 1976, 19 Nov. 1976–25 Mar. 1977.

§ Alfalfa cubes 19 Nov. 1976–29 Nov. 1976, 1 kg/hd/day; ground corn 1 Dec. 1976–10 Dec. 1976, 1 kg/hd/day; 3:1 ground corn: CSM 13 Dec. 1976–23 Mar. 1977, 2 kg/hd/day; pasture day 20 Dec. 1976–23 Mar. 1977, avg. 2 kg/hd/day.

to May, whereupon the forage matures, dries, and becomes marginal in feeding value (11). For the 4-year period, the algebraic sum of animal gains and losses was the same for the two cow herds. Moreover, using the Student's "t" test with years as replications no significant differences were found for calf birth weight, average daily gain, and weaning weight between the two systems (Tables 1, 2). In effect, the greater animal productivity per unit land area in the complex system apparently resulted from the higher stocking rate enabled by soil and forage management differences and the seasonal use of energy-protein supplements.

Re-breeding percentages, a parameter of fundamental importance in this kind of production system, were low (4-year avg. of 81 and 85%, respectively, for the complex and simple systems, but the small number of animals in the simple system treatment and large year-to-year variations in both systems rule out any inferences as to treatment influences. The generally negative values found for cow body-weight changes between calving and breeding would generally be considered an undesirable condition in a range cow/calf production system (1).

The 4-year average ratio of grazing time on range to grazing time on irrigated pasture was essentially 0.5:0.5 (Tables 1 and 2). The average animal unit months (AUM) per ha of range for the complex system was 2.8 and for the irrigated pasture 10.3 (Table 2). These values, considering the soils, climate and physiographic limitations of the area, are high for the range component and low for the irrigated pasture. The comparable value for the simple system (2.4 AUM/ha range) also is higher than average and reflects the fact that simple vegetation-type conversion from tree-shrub to herbaceous vegetation is one of the most important range improvement practices which can be chosen in relation to a range production system based on mainteinance of a breeding herd where calving is timed to permit substantial conversion of the seasonal flush of forage production (February-May) to animal product yield as a suckling calf.

Figure 2 portrays the 4-year sequence of cattle rotation in the complex system among the four annual range fields and the perennial, summer-growing irrigated pasture. Seasonal use of irrigated pasture was begun mid to late-April and was continued into November or December, except for the final year. A severe drought year occurred in 1976/77, which forced some departures from planned procedures, (e.g., supplementation of cows in the simple system because of earlier cessation of plant growth and early termination of the experiments in 1977). The latter was of little importance since it occurred at the end of the 4-year period and did not introduce a "carry-over" effect.

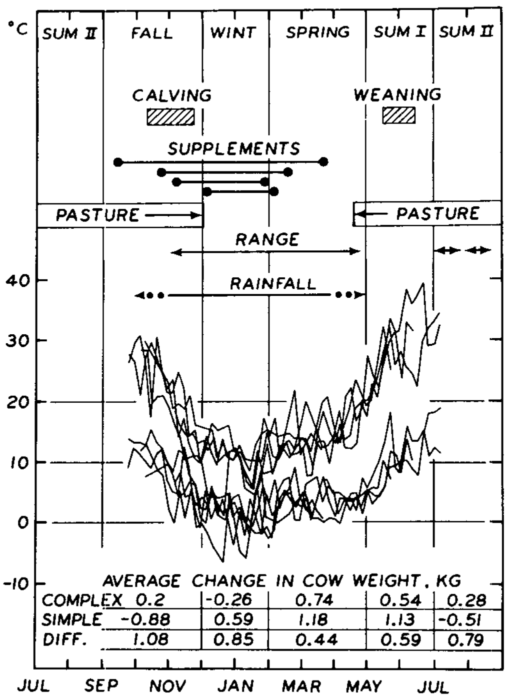


**Fig. 1. Average maximum and minimum air temperatures for four of five ecological seasons and 4-year average changes in cow weights for the simple and complex grazing systems during those seasons.**

**Table 3. Average botanical composition (step-point quadrat) in the four cleared and re-seeded range fields (R1–R4 of Fig. 2) used in combination with perennial irrigated pasture.**

| | 1972-1973 | 1973-1974 | 1974-1975 | 1975-1976 | 1976-1977 | X | SE |
|---|---|---|---|---|---|---|---|
| | %† | | | | | | |
| Sub clover | 3.9 | 7.2 | 3.9 | 7.9 | 3.2 | 5.2 | 0.97 |
| Rose clover | 7.2 | 9.9 | 5.4 | 10.7 | 4.7 | 7.6 | 1.19 |
| Perennial grasses | 8.2 | 5.4 | 8.4 | 5.9 | 6.1 | 6.8 | 0.62 |
| Annual ryegrass | 5.7 | 5.3 | 7.8 | 4.8 | 5.5 | 5.8 | 0.52 |
| Resident annual grasses | 33.6 | 37.0 | 39.2 | 29.6 | 40.4 | 35.9 | 1.97 |
| Filaree | 8.6 | 13.5 | 6.3 | 8.4 | 21.3 | 11.6 | 2.69 |
| Bur clover | 0.3 | 0.7 | 0.0 | 0.2 | 0.5 | 1.8 | 0.12 |
| Annual forbs | 5.5 | 5.7 | 4.8 | 4.1 | 10.0 | 11.9 | 1.03 |
| Litter | 12.2 | 7.6 | 11.8 | 16.0 | 2.6 | 10.9 | 2.29 |
| Bare ground | 12.9 | 7.1 | 10.0 | 10.5 | 9.9 | 10.1 | 0.92 |

† Entries are yearly means weighted for varying acreages in the four fields.

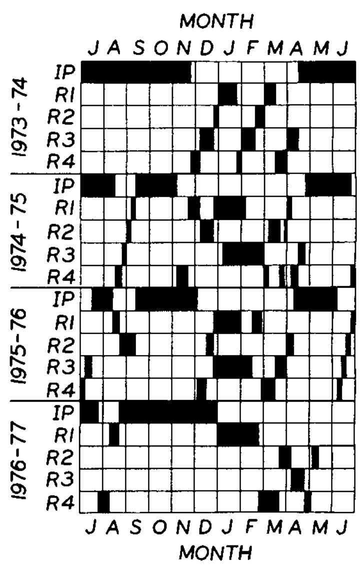


**Fig. 2. Seasonal use of irrigated pasture (IP) and four cleared and reseeded rangeland areas (R1-R4) by a beef cow-calf herd over a 4-year period.**

Timing and seasonal use (no. of grazing days) of the four range fields varied with seasonal differences in forage production (which always are more variable over time than for irrigated pasture) and through application of other grazing management criteria (7). On occasion, livestock were removed from specific range fields to permit seed maturation of the previously-introduced annual legumes (seed reserve enhancement). Mid-summer grazing of dry, mature range forage was done to utilize residual production and to shatter heads of rose clover (*Trifolium hirtum* L.) and, through livestock trampling, improve germination and seedling establishment in the fall. If possible, successive yearly heavy grazing use of a given range field during an excessively-wet part of the winter was avoided. Over the 4-year period the four range fields were each used an average of three times per 12-month season. Rotational grazing of Mediterranean climate annual rangelands remains a subject of some controversy and no single, generally-accepted management system exists.

Table 3 presents the average botanical composition of the four range fields used in the complex system. Fields used in the simple system consisted of variable but similar proportions of "soft chess" (*Bromus mollis* L.), other *Bromus* species, *Avena* spp., *Festuca* spp., miscellaneous forbs, and minor amounts of rose clover. Despite seeding of introduced annual legumes and summer-dormant perennial grasses (*Phalaris* and *Dactylis* spp.) annual-range vegetation of the Sierra Nevada foothills generally continues to be dominated by a complex of resident annual grasses, filaree (*Erodium* spp.) and miscellaneous annual forbs. No attempt was made in this study to assess the contribution of these introduced species to production at the animal level. It is known from both plant (11) and animal[3] studies that protein content drops precipitously as this annual range forage matures; correspondingly, there also is a marked increase in fiber content. Definitive studies of the importance of annual legume and perennial grass components to beef calf production have not been done. Proportions of species in the flora vary from year to year independently of grazing and other management influences; the drought year (1976-77) decline in annual clover with a concomitant increase in filaree (Table 3) is one well-known example.

Occasional samplings were made each year of accumulated herbage biomass (from exclosures) from the range fields in the complex system (Fig. 3). We did not attempt to carry out a statistically sound biomass sampling program because of its cost. Instead, a small number of samples were chosen to provide an estimate of forage accumulated in upper quartile, lower quartile, and mid-range weight categories during the spring and early summer seasons. While a curvilinear function would provide a better fit to the data, the dry matter production estimates (16 to 38 kg/ha per day) shown as linear regressions are adequate when considered within the error levels of the overall system. They would also provide opportunity for use in resource allocation models using linear regressions. The upper part of Fig. 3 shows how the dry matter samples were distributed among six forage weight classes over the period of maximum growth. In May, approximately 75% of the samples fell into three weight class categories from 2,100 to 8,000 kg/ha (Fig. 3). These values also agree with other published and unpublished data.

Table 4 presents a partial economic analysis of the two production systems. As Dean et al. (5) observed over two decades ago, beef cow herd livestock production on foothill lands (of marginal and seasonally-constrained forage production capability) is economically defensible only under circumstances other than those inferred by a conventional cost analysis. With the assumptions made in the present calculations (Table 4), return to investment was only 3.2% for the simple system and 1.6% for the complex system. Most of the investment entries under the complex system (Table 4) were judged to be liberal. As previously

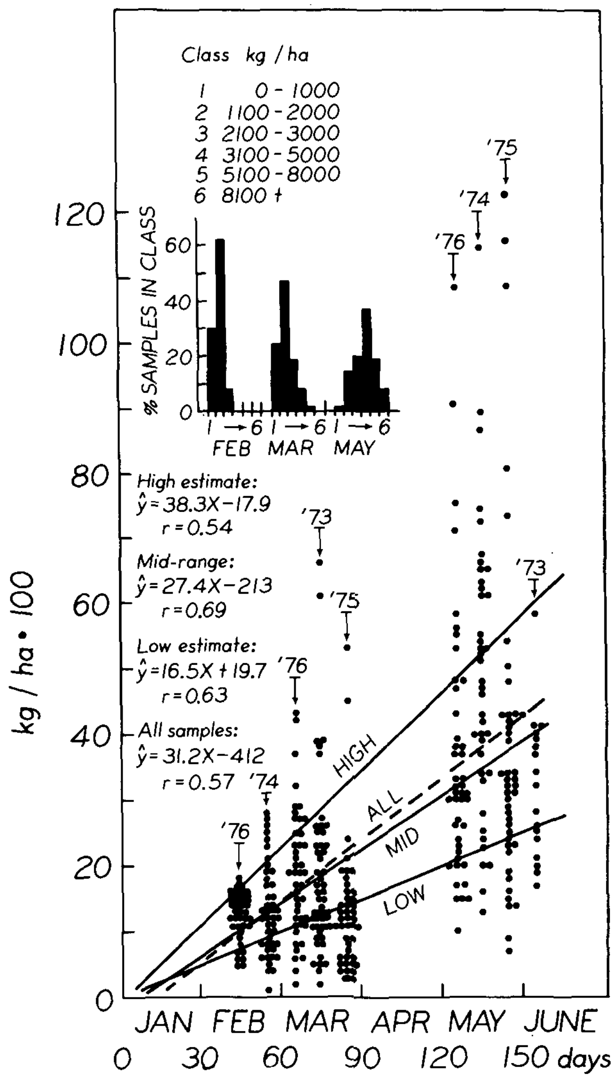


**Fig. 3. Seasonal dry matter accumulation on cleared and reseeded rangeland during the period February to June and progressive changes in distribution of dry matter weight classes with advance in season.**

[3] J. G. Morris, Dep. of Animal Sci., UC-Davis. Unpublished data from esophageal-fistulated steers grazing on similar rangelands.

**Table 4. Partial economic analysis of the use of irrigated pasture and improved range (1:5 ratio) vs. improved-range-only in year-long maintenance of beef breeding herds for the production of beef calves. Prepared by A. D. Reed, Dep. of Agric. Economics, UC-Davis.**

| Land required | Values adjusted to 100-cow herd size: Simple system (Cleared range alone) | Complex system (Cleared range plus irrigated pasture) |
|---|---|---|
| Land required | | |
| Range, ha | 445 | 202 |
| Irrigated pasture, ha | – | 53 |
| Total ha | 445 | 255 |
| Investment | | |
| Range, at $1,235/ha | $550,000 | $250,000 |
| Irrig. past., at $2,224/ha | – | 117,000 |
| Surface-flow irrigation system, at $1,500/ha | – | 79,500 |
| Fences, range, at $60/ha | 26,700 | 12,120 |
| Fences, irrigated pasture, at $100/ha | – | 5,300 |
| Pasture stand | – | 18,500 |
| Range re-seeding and fertilization (initial) | – | 13,100 |
| Water, roads, etc. | 4,450 | 2,020 |
| Equipment | – | 7,950 |
| Total investment | $581,150 | $505,490 |
| Operating costs† | | |
| Irrigation water, 25 miners inches/season at $30/m.i.‡ | – | 750 |
| Fertilizer, 253 kg/ha $(NH_4)_2SO_4$ at $171 metric ton | – | 2,293 |
| Irrigation and fertilization labor, 30 hours/ha $4.55/hour | – | 7,235 |
| Taxes, rangeland at $12/ha | 5,500 | 2,500 |
| Taxes, irrig. past. at $36/ha | – | 1,950 |
| Supplement; see Tables 1 & 2 for detail | 1,030§ | 1,105 |
| Total operating costs | $ 6,530 | $ 15,833 |
| Depreciation | | |
| Range | 1,780 | 810 |
| Pasture | – | 3,740 |
| Total depreciation | 1,780 | 4,550 |
| Interest on investment, at 8% | | |
| Land | $ 44,000 | $ 36,770 |
| Other | 1,245 | 1,835 |
| Total interest | $ 45,245 | $ 38,605 |
| Total cost | $ 53,555 | $ 58,988 |
| Value of production¶ | | |
| Steers, 45 at $1.70/kg# | 14,841 | 15,300 |
| Heifers, 45 at $1.65/kg†† | 13,068 | 13,385 |
| Total income | $ 27,909 | $ 28,685 |

† Only those costs which vary directly with the systems compared are included. ‡ One California statutory miner's inch equals 42.5 liter/min. Fields were irrigated at 14-day intervals over a 6-month season.
§ Supplement in this treatment actually fed only in final year due to drought; cost averaged over the 4-year period. ¶ For computations, assumed 90% survival to weaning, 0.5:0.5 steer:heifer ratio and sale of all calves. # Weights of 194 and 200 kg, respectively, used for the two treatments. †† Weights of 176 and 180 kg, respectively, used for the two treatments.

noted, the irrigated pasture was of relatively low productivity in relation to maximum potential compared to the range component in either system and, in effect, its contribution may have been underestimated.

A fundamental difference between the two production systems, when compared in terms of economic analysis, is in the amount of land required to support a cow/calf unit. In the present study, compensating factors worked to make the two systems economically comparable when total investment was used as the sole comparison criterion. In contrast, operating costs for the complex system were more than double those for the simple system. Taken together, depreciation and investment cost differences between the two systems tended to cancel each other, but favored the complex system because of a smaller land investment base. The value of production (weight of calf per 100-cow unit) differed by so small a value that for practical purposes the two systems could be considered equal. The net result is that an economic analysis approach to production system comparison is valid only when applied to a specific set of constraints, which should include operator objectives. For example, a land owner with a second, off-farm income, small hectorage, access to relatively inexpensive irrigation water and family labor will view the two systems much differently than will one with extensive but remote holdings of marginal land and a need for streamlined management.

## CONCLUSIONS

In grazing systems where the absolute level of productivity is marginal and subject to numerous and variable environmental constraints, simple production systems where certain levels of nutritional stress in the cow herd are tolerated may be justified over complex systems, at least when economic criteria are applied.

The overall result of these experiments was to raise as many questions as were tentatively answered. The subject of seasonal forage production and quality interacting with animal-level stress factors deserves further investigation. Particularly interesting is the implication found that some seasonal negative plane of nutrition stresses may not have an economically-perceptible impact on calf size and gain parameters.

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