

TEN YEARS OF CHANGE IN SIERRAN STRINGER MEADOWS: AN EVALUATION OF RANGE CONDITION MODELS¹

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Abstract: Grazed Sierra Nevada stringer meadow systems were sampled on Blodgett Forest Research Station in northern California between 1977 and 1987 to determine cattle use, and to examine changes in production and species composition over time. Utilization of meadow species averaged 61 percent over the 10 years, but use increased to more than 80 percent utilization after 1985. Production averaged 2733 kg/ha but has significantly declined in recent years. Relative species composition has not changed, nor has total vegetative cover between 1979 and 1986. Range condition models based on changes in species composition were not useful for assessing these stringer meadow systems. Managers should instead base livestock management on stream bank conditions and meadow productivity.

Montane meadows in California range in size from a few square meters to several hundred hectares interspersed through every forest type (Allen 1987). Meadows provide forage and cover for an estimated 260 animal species, including at least 12 sensitive, rare, or endangered animals (Timossi 1988). Water and recreation from meadows are valuable resources (State of California 1988).

Although small in extent, meadows in the Sierra provide up to half the summer forage for livestock. Historically, heavy stocking rates and consequent overuse changed meadow hydrology, species composition, and production. Although Federal laws have regulated livestock use since 1891, many meadow systems are still in poor condition (Ratliff 1985).

Range condition can be defined as "the current productivity of a range relative to what that range is naturally capable of producing" (Society for Range Management 1974). Most range condition models use species composition as the foundation for assessing condition or "range health". For example, the quantitative climax approach (Dyksterhuis 1949), compares current species composition to climax species composition. The Forest Service's score card approach adds vegetation production, soil erosion, and soil cover criteria to species composition when assessing condition (USDA 1969). Generally, productivity and forage values are assumed to be highest when the rangeland plant community is near climax, and lowest when the vegetation is in an early seral stage (Sampson 1952).

Early studies in the Midwest showed that grazing can cause changes in species composition through selective use of specific plant species (Dyksterhuis 1949, Ellison and others 1951). Continuous grazing at heavy stocking rates, or during the wrong season, decreases palatable (and also climax) plant species and increases invader and increaser species (Dyksterhuis 1949). Changes in rangeland vegetation resulting from overgrazing allow condition to be expressed in condition classes, generally 'excellent', 'good', 'fair', or 'poor' (Sampson 1919).

Reduction of grazing can result in a return of climax species and improved range condition (Branson 1985). Improvement can also be quantified by condition class—the changes retracing the path of range deterioration (Heady 1975). These concepts were applied to rangeland ecosystems throughout the western United States.

This paper reports a study to evaluate long-term changes in production and species composition on grazed stringer meadow systems, and to determine the value of range condition models for meadow management.

Methods

This study began in 1976 as part of a larger mixed conifer forest grazing study (Kosco 1980) at Blodgett Forest Research Station, near Georgetown, CA, at 1500 meters elevation on the west slope of the Sierra Nevada. The study site's Mediterranean climate has cool, wet winters and little summer rainfall. Precipitation is concentrated between October and March, averaging 171 cm/yr. The range between 1977 and 1987 included a low of 58 cm and a high of 279 cm. Winter high temperatures averaged 8°C, while daytime summer temperatures averaged 28°C.

Meadows comprise less than 1 percent of the study site. Some herbaceous vegetation grows in disturbed areas such as clearcuts, skid trails, and along roads, but most grows in stringer meadow systems, which follow natural drainages (fig. 1). Some areas remain wet throughout the year, while slightly higher areas dry out as the summer progresses. This results in a visual (as well as statistical) difference in botanical composition within and between meadows.

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Figure 1—Stringer meadows vary from a few meters across to about 40 m, following the water courses in the mixed conifer forest.

Cattle grazed the study area between May 30 and September 30 every year. The study area is not fenced; the cows and calves are free-roaming, following water courses and forage supplies in meadows and clearcuts. The permittees distribute animals over their allotment, which includes the study area, by riding, salting, and culling of animals. Thirty-five cow/calf pairs (140 animal unit months) were allocated to graze the study area.

Production/Utilization

Fourteen square meter, paired, caged and uncaged plots were used to determine meadow production and utilization between 1977 and 1987. Visibly distinct types based on species composition were recognized during a reconnaissance survey of the study site. Cages were placed to characterize meadow vegetation on the whole study area. This resulted in 14 cages being placed on 8 meadow systems.

Herbaceous production was determined from clipped 1/16 m² quadrats taken from the center of each caged plot. Clipping occurred at peak above-ground production, generally mid-September. Each spring the cage was moved to a new location near the previous one to reduce cage effects on production.

Utilization of herbaceous vegetation was estimated by clipping a 1/16 m² grazed plot paired with each caged plot used for the production estimates. Utilization was calculated from the equation:

$$\text{Utilization} = (\text{UGHW} - \text{GHW} / \text{UGHW}) \times 100$$

Comparisons of meadow production and utilization were made using analysis of variance (Zar 1984) over all years. Multiple comparisons between means for years were examined using Duncan's multiple range test at alpha of 0.05 (Norusis 1986).

Species Composition

Species composition was recorded using a 10-point frame within each cage before it was clipped in 1979 and 1986. Fifty points per cage were recorded; totaling 700 points per year on the meadows.

Species composition between 1979 and 1986 was compared using ANOVA and the nonparametric Mann-Whitney test for differences between means (Norusis 1986).

Permanent Exclosure

A 3.5 by 5 m exclosure was erected in 1977 to provide information on long-term changes in species composition without grazing. The exclosure represented Forest-wide meadow species composition with a mixture of grass, forbs, rushes, and sedges. The exclosure was sampled with 300 points using a 10-point frame in 1979 and again in 1986. Significant differences in plant groups were compared between years using the binomial distribution (Zar 1984). Exclosure production was sampled from 5 clipped plots and compared to average meadow production on caged plots in 1988.

Results

Changes in Production and Utilization

Average above ground biomass production on Blodgett Forest meadows varied significantly among years between 1977 and 1987 (fig. 2). In general, years prior to 1985 produced significantly more standing crop than after those years, except for 1977 which followed 3 consecutive years of drought. Mulch, the herbage remaining at the end of the grazing season, significantly changed during the study (fig. 2). With a pattern similar to production, mulch averaged 1046 kg/ha prior to 1984, but only 581 kg/ha between 1984 and 1987. The three wetter meadow types on Blodgett produced 4210 kg/ha in 1987. Dry meadow types produced an average of 1590 kg/ha, while nine moist types produced an average of 2495 kg/ha.

Utilization, or the proportion of vegetation consumed by grazing animals, differed significantly among years during the study (fig. 3). Utilization averaged 55 percent prior to 1984, and averaged 71 percent after that, peaking in 1986 at 82 percent. Specific plots consistently varied in utilization reflecting differences in production and species composition of the plots.

In 1979, no meadows on the study site had signs of erosion, streambank widening or bare eroded surfaces (Kosco 1980). This was not true in 1987 (fig. 4).

Species Composition

Meadows on Blodgett are relatively depauperate in number of species. Only five species of grasses, several species of sedges and rushes, and 11 forbs were recorded (Table 1). Total vegetative cover averaged 88 percent in 1979 and 84.4 percent in 1986. Grasses do not dominate these meadows. Grass composition totalled 20.8 percent in 1979 and 13.2 percent in 1986.

Forbs form the larger category with *Mimulus primuloides* dominating in 1979 and 1986 at 27.3 and 21.5 percent relative cover, respectively. Except for an increase in sedge cover, no category differed significantly between 1979 and 1986. No statistically significant difference occurred in percent bare ground/litter.

Following Ratliff (1985), species were designated as decreaseers, increaseers, or invaders (Table 1). Decreaseers declined from 19 to 14 percent, while increaseers also declined from 60 to 48 percent from 1979 to 1986. These statistically insignificant declines were largely offset by the increase in sedge species which may act as increaseers or decreaseers in meadows, depending on species.

Finally, the meadow species were assigned to categories of desirable, less desirable, and undesirable based on their relative palatability to cattle using standard USDA Forest Service scorecards for meadow species (USDA 1969). None of these categories changed significantly between 1977 and 1986.

Table 1 - Relative foliar cover of Blodgett Forest meadow species in 1979 and 1986.¹

Species	Percent Relative Cover ²		
	1979	1986	D,Inc,Inv ³
<i>Agrostis thurberiana</i>	3.1	-	Inc
<i>Agrostis</i> sp.	5.2	4.3	Inc
<i>Danthonia californica</i>	8.9	5.9	Inc
<i>Muhlenbergia filiformis</i>	2.8	1.0	Inc
<i>Panicum lanuginosum</i>	0.8	2.1	---
<i>Carex</i> spp.	6.6	23.6	D/Inc
<i>Juncus oxymeris</i>	19.3	13.8	D
<i>Juncos & Luzula</i> spp.	2.8	5.3	D/Inc/Inv
<i>Trifolium repens</i>	7.4	1.9	Inv
<i>Mimulus guttatus</i>	1.8	-	---
<i>M. primuloides</i>	27.3	21.5	Inc
<i>Hypericum anagalloides</i>	10.8	12.7	Inc
<i>Viola</i> sp.	1.9	2.6	Inc
Unknown forbs	0.3	1.6	---
Moss species	0.6	0.3	---

¹A dash indicates that the species was not found that year. Cover percentages calculated from 700 points using a 10-point frame within ungrazed cages.

²Differences in species composition are not significant ($p < .05$) between 1979 and 1986, except for the increase in *Carex* species.

³D = decreaseer, Inc = increaseer, Inv = invader. Category designations are from Ratliff (1985).

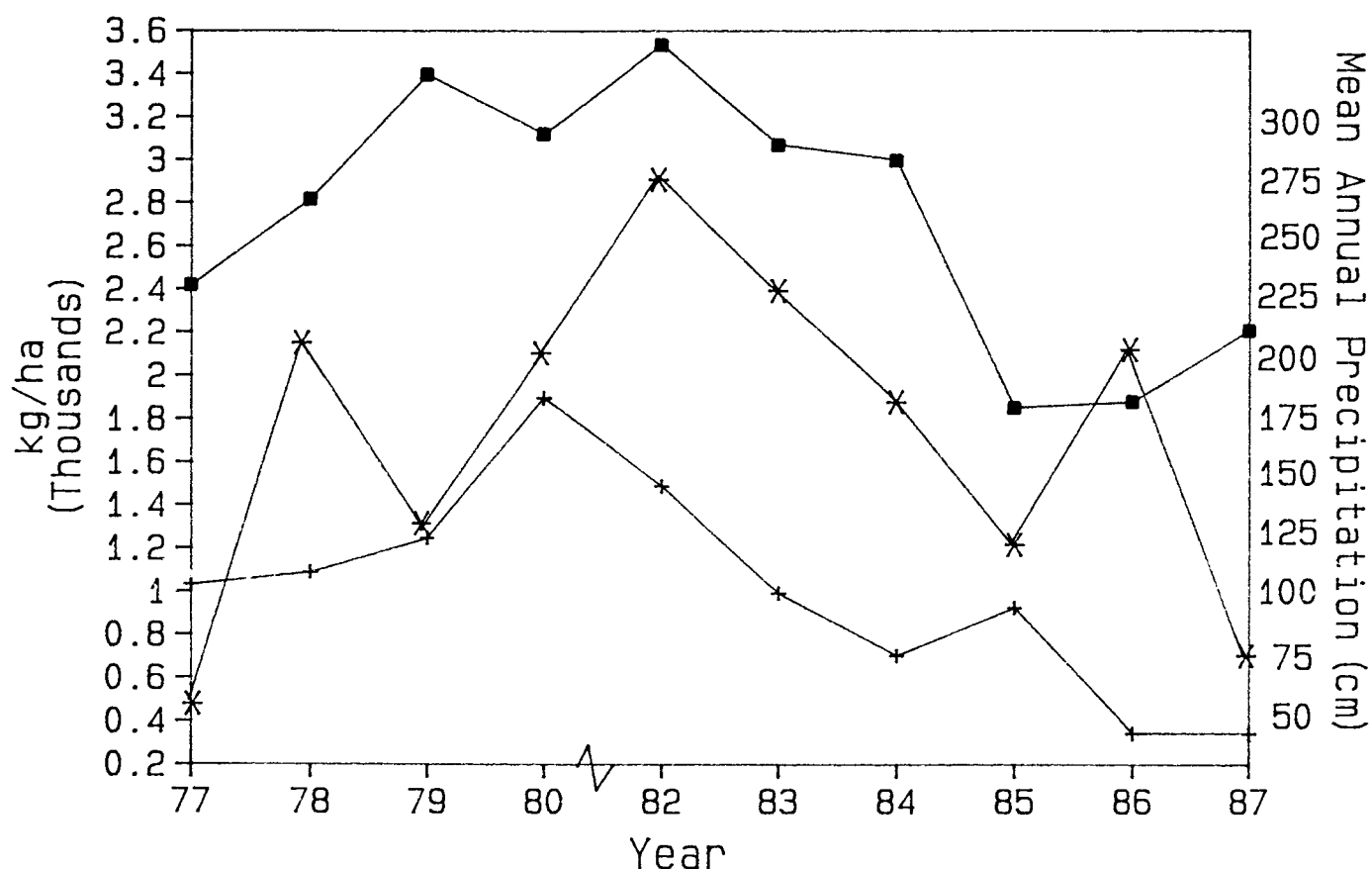


Figure 2—Production averaged approximately 3000 kg/ha prior to 1985 and 2000 kg/ha from 1985-1987. The years 1985 and 1986 produced significantly less standing crop than 1979 and 1982 which were high production years on Blodgett Forest. Mulch follows a similar pattern to production, with significantly more mulch remaining in 1980 than any other year.

Permanent Exclosure

The primary change in the permanent exclosure between 1979 and 1986 was in the statistically significant increase in *Carex* species from 5 to 13 percent cover. No other changes were significant, except for the decline in bare ground from 9 to .3 percent. Composition changes in the ungrazed exclosure were similar to grazed plots. Total grass cover declined from 20 to 13 percent. Rushes

slightly declined from 10 to 8 percent, while forbs remained relatively constant at 48 and 49 percent cover between 1979 and 1986. Although not statistically significant, litter increased from 8 to 15 percent and was visually apparent in the meadow. Standing crop production in 1988 was greater (2,733 kg/ha) than production on the rest of the study site (1854 kg/ha), but not significantly.

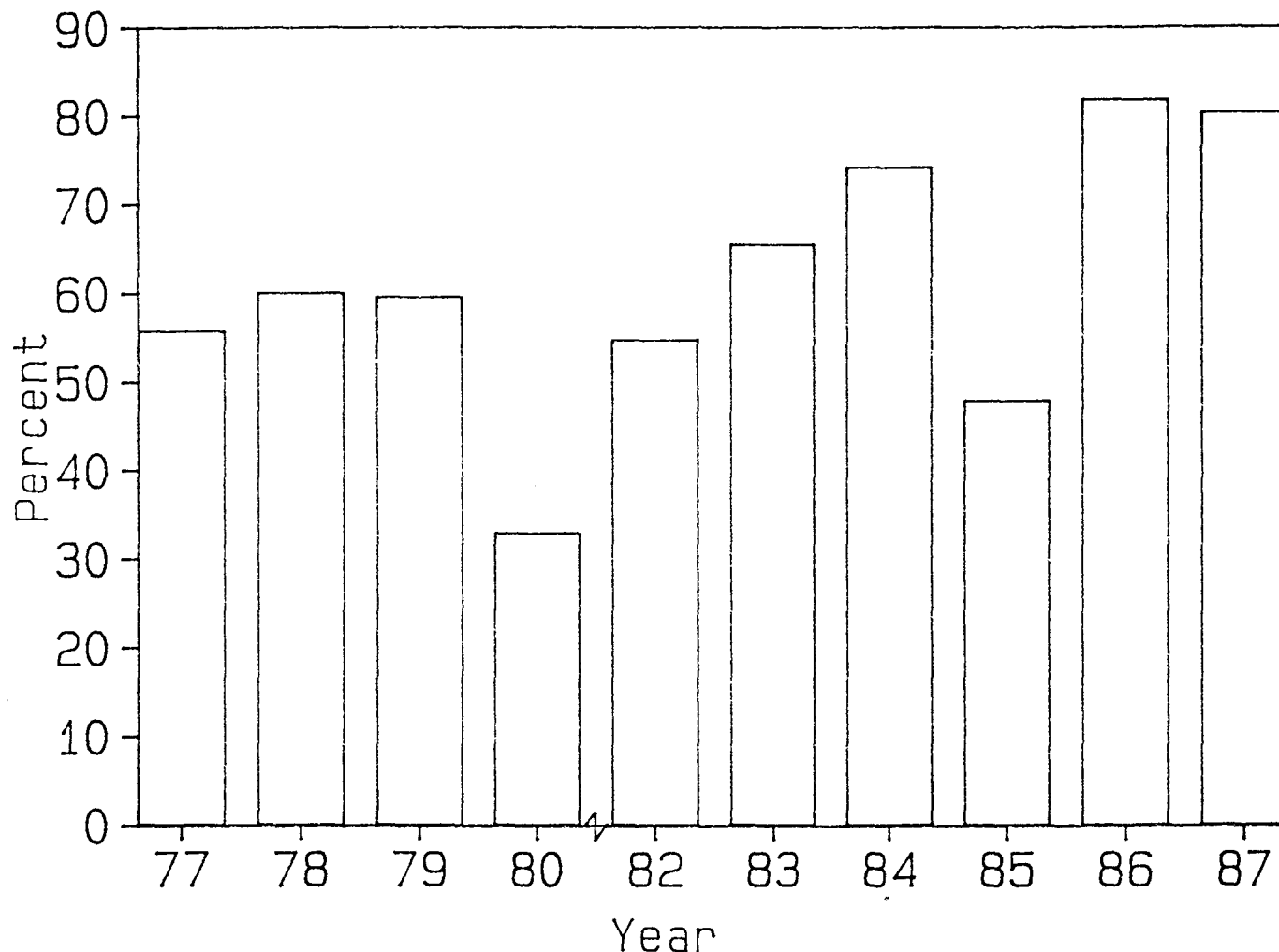


Figure 3—Utilization has generally increased, peaking at 82 percent in 1986. Low levels of utilization in 1980 and 1985 may be due to fewer animals on the study site in those years, or more forage available on the clearcuts.

Discussion / Conclusions

Application of the traditional range condition model based on percent composition of decreasers, increasers, and invaders would rate the current (and 1977) meadow conditions on Blodgett as fair to poor condition (Ratliff 1985). Using Crane's (1950) criteria for rating meadow condition based on the amount of bare ground or litter, the meadows on Blodgett would rate in excellent condition. Application of Forest Service (USDA 1969) soil cover criteria would rate the meadows as good. The

three models span all four possible condition ratings on the same meadows from the same data, suggesting low utility.

Species composition of the meadows on Blodgett has not changed (with the exception of an increase in *Carex*) in the last ten years, with or without grazing. Production has significantly declined, utilization has increased, and bare ground and litter have remained approximately the same. Thus, I conclude range condition models that link productivity to species composition are not useful for managing these types of stringer meadow systems.



Figure 4—Streambank erosion and meadow trampling caused by early season use may be contributing to the decline in meadow production.

The permanent exclosure indicates that species composition did not retrace the path of range deterioration as long standing theory predicts (Heady 1975). Cattle graze the meadows on Blodgett Forest seasonlong, recently at high levels of utilization. Meadow species within reach of the livestock are grazed by the end of the grazing season, with the possible exception of the coarse, wetland rush species. One hypothesis is that the meadows were in poor condition ten years ago and remain that way today.

These meadow systems have changed over the last 10 years, however. The data in the literature suggest that these meadows are not producing their potential (Ratliff and others 1983, Crane 1950, Bennett 1965). The available references suggest that these meadows should produce 5000 kg/ha on wet or moist sites, and 2400 kg/ha on dry sites. Using these criteria, peak standing crop on the wetter meadows on Blodgett is approximately 84 percent of potential. Dry meadow peak standing crop is 66 percent of potential. And moist meadow peak standing crop is only 50 percent of

potential. Low productivity may be largely due to the large component of forbs in these moist meadows, and relative lack of productive grasses and sedges.

Stringer meadows are a small, but important, component of the mixed conifer ecosystem. Photographic evidence (fig. 4) indicates broken down stream banks, widened stream beds, and locally broken meadow sod in the meadows on Blodgett Forest. These factors may be contributing to low productivity, and damage to streams. Managers face a difficult problem to achieve timber management objectives through heavy livestock grazing on the clearcuts, without damage to the riparian meadow resource. More effective grazing systems to improve these meadow systems need development. Traditional range condition models are of little value either in assessing needs for improved management of these riparian systems, or evaluating the effectiveness of any newly developed practices.

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