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DRY-YEAR GRAZING AND NEBRASKA SEDGE (*CAREX NEBRASKENSIS*)

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ABSTRACT.—In 1984 (a dry year), Tule Meadow, in the Sierra National Forest, California, was well grazed after several years of light use. This situation provided the opportunity to study responses of Nebraska sedge (*Carex nebraskensis*), an important forage species in mountain meadows, to protection and grazing. Rooted shoot frequencies and densities in fall 1984 and spring 1985 were the same within an exclosure and on the grazed area. Residual herbage (shoot weight) in fall and shoot heights in spring were greater within the exclosure. Lower spring shoot heights on the grazed area may relate to fall regrowth and reduced insulation induced by grazing. Nitrogen and potassium content of fall herbage was greater on the grazed area. Phosphorus content was the same both inside and outside the exclosure.

Nebraska sedge (*Carex nebraskensis*) is found from Kansas to California and from New Mexico to Canada (Hermann 1970). It is generally palatable to cattle and horses. A valuable species on many mountain meadows, Nebraska sedge is often grazed heavily during summer. However, at Tule Meadow (Sierra National Forest, California) grazing of Nebraska sedge and the meadow as a whole is largely controlled by weather.

Under average conditions, Tule Meadow has a wet center and relatively dry edges. In wet years only the edges of the meadow receive significant use, although cattle occasionally wade out to graze on preferred parts of specific plant species. In dry years all parts of the meadow receive significant use. From 1979 to 1983 cattle grazed mainly along the edges of Tule Meadow, leaving most of it ungrazed or lightly grazed. Earlier, Pattee (1973) reported that cattle spent 100% of their time on the edges.

Cattle grazing Tule Meadow had made substantial use of Nebraska sedge by mid-July 1984. By the end of August no ungrazed patches of meadow remained (Fig. 1). By October surface water was present only at the lowest point—a very rare occurrence.

At Wishon Dam, a few miles east of Tule Meadow, precipitation in 1984 totaled 76 cm, only 50% of the 1977–1985 average (152 cm). In addition, monthly maximum and mean air temperatures from January through September were higher than the 1977–1985 average.

We took advantage of this extraordinary condition of dryness to ask how grazing in such a year would affect Nebraska sedge. Would shoot frequencies, shoot densities, shoot heights, residual herbage weights, and nutrient contents be the same inside a livestock exclosure and outside where grazing had occurred? Could grazing in a dry year benefit the Nebraska sedge population by stimulating vegetative reproduction?

METHODS AND MATERIALS

STUDY AREA.—Tule Meadow, in the montane zone at an elevation of 2,170 m, is a basin type with vegetated margins (Ratliff 1985). It lies in a swale formed by lateral moraines (Wood 1975) and usually has surface water all year. Beneath the sod an organically rich topsoil extends to depths of 90 to 120 cm. Soil texture ranges from sand to silt loam. Inorganic, gleyed material extends to 275 cm.

In 1979 we established an exclosure in a lotic Nebraska sedge site (Ratliff 1985). Within the exclosure we studied seasonal biomass trends, Nebraska sedge morphology, carbohydrate levels (Steele et al. 1984), and shoot life history (Ratliff 1983). Except for the life history plots, the exclosure has been undisturbed since fall 1981 and has returned to prestudy conditions.

SAMPLING.—We randomly located points on grid systems. Inside the exclosure we located 60 points on a half-meter grid within a 238-m^2 area. In the remainder of the Nebraska sedge site, about 1 ha, we located 120 points on a 1-m grid. Independent sets of grid points were selected for fall (3 October 1984) and

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Fig. 1. Tule Meadow, Sierra National Forest, California, showing extent of grazing by cattle in 1984.

spring (16 May 1985) sampling.

Quadrats (10 × 20 cm) were centered at the grid points. Presence or absence of Nebraska sedge shoots in the quadrats was noted. Rooted frequency (% presence) was computed for fall and spring samples. In fall, current mature shoots (vegetative and reproductive) and juvenile shoots (shoots with three or fewer leaves unfolded) of Nebraska sedge were counted to estimate shoot densities. The shoots were then cut off at the surface to estimate residual herbage weights.

The herbage was oven-dried (24 hrs at 60 C) and weighed. Total nitrogen (N), phosphorus (P), and potassium (K) in the shoot material was estimated at a commercial laboratory. Analysis procedures were N—Kjeldahl nitrogen, P—nitric, perchloric acid digestion, and spectrometry, and K—hydrochloric acid digestion and spectrometry. Some grazed quadrats did not contain sufficient Nebraska sedge for the chemical analyses; therefore, materials from up to four randomly selected, grazed quadrats were combined.

In spring, close observation was required to distinguish the previous year's mature vegetative shoots from the rapidly expanding younger shoots. Also, surface water depth precluded efficient cutting of shoots. Therefore, all live shoots of Nebraska sedge rooted in the quadrats were counted, and the height of the tallest one was measured.

Statistics.—We took advantage of current conditions of weather and grazing; replication of treatments was not possible. Differences between the exclosure and the grazed area should therefore not be extrapolated to other sites. Nevertheless, the comparisons provide new insight on response of an important meadow species, Nebraska sedge, to grazing.

For each data set we computed the 95% confidence intervals for the means. In the case of frequencies the confidence intervals were for the proportions of quadrats with Nebraska sedge. The hypothesis of no difference between analogous characteristics was rejected when the 95% confidence interval for the difference (grazed area vs. exclosure) covered zero. Standard methods of calculation (Steel and Torrie 1960) were used.

Fall and spring values were not compared since different kinds of data were involved. Also, reproductive shoots included in the fall sample died before spring. Total shoot densi-

TABLE 1. Means and confidence intervals for Nebraska sedge shoot frequency, density, residual herbage weight, height, and nutrient content and differences under grazing and protection at Tule Meadow, Sierra National Forest, California.

	Treatment		Difference
	Grazed	Protected	(G - P)
Measure	$\bar{X}$ + CI[a]	$\bar{X}$ + CI	$\bar{d}$ + CI[b]
Frequency (%)			
Fall 1984	91 ± 5	82 ± 10	9 ± 11
Spring 1985	91 ± 5	88 ± 8	3 ± 10
Density (shoots/m^2)			
Fall 1984			
Total	380 ± 63	357 ± 76	23 ± 103
Mature	274 ± 46	266 ± 56	8 ± 75
Juvenile	106 ± 22	91 ± 24	15 ± 35
Spring 1985	296 ± 44	231 ± 47	65 ± 69
Weight (g/m^2), fall 1984	62 ± 11	172 ± 43	−111 ± 33
Height (mm), spring 1985	144 ± 7	198 ± 14	−54 ± 13
Nutrients (%), fall 1984			
Crude protein[c]	6.31 ± 0.41	5.48 ± 0.28	0.81 ± 0.50
Phosphorus	0.11 ± 0.01	0.11 ± 0.01	0.00 ± 0.01
Potassium	1.33 ± 0.09	1.00 ± 0.04	0.33 ± 0.11

[a]95% confidence intervals for proportions and means
[b]95% confidence intervals for differences
[c]Nitrogen (%) × 6.25

ties between fall and spring were therefore expected to be different.

Results and Discussion

FREQUENCY.—In 1984, grazing did not affect rooted frequencies of Nebraska sedge shoots in the 10 × 20 cm quadrats (Table 1). The differences in proportions of occupied quadrats in the exclosure and in the grazed area in fall and spring were no more than expected by chance. All observations combined, Nebraska sedge frequency was 88.9% ± 3.2%.

Juvenile shoot frequency in the fall was neither enhanced nor reduced by grazing. The frequencies were 67% ± 12% inside and 68% ± 8% outside the exclosure.

DENSITY.—Greater density on the grazed area could occur if grazing stimulated tiller and rhizome production. However, grazing in 1984 did not affect densities of Nebraska sedge shoots (Table 1).

Nevertheless, interpreting the confidence interval, we are 95% confident that the maximum possible differences in fall were −80 shoots per m^2 (23 − 103) to 126 shoots per m^2 (23 + 103) more on the grazed area. Differences of such magnitudes, based on the average weight per shoot in the exclosure, translate to −0.8 AUM/ha and 1.3 AUM/ha; they could influence grazing management. An AUM (animal unit month) is the amount of forage required by a mature cow with calf for one month (Range Term Glossary Committee 1974). We are also 95% confident that the maximum possible differences in spring were −4 shoots per m^2 to 134 shoots per m^2 more on the grazed area. A difference in the magnitude of the upper confidence limit could influence composition of the current forage crop. Confidence intervals for mature and juvenile shoots may be similarly interpreted.

RESIDUAL HERBAGE.—As expected, residual herbage of Nebraska sedge was greater (78 to 143 g/m^2) inside than outside the exclosure (Table 1). Residue outside in 1984 averaged 36% (24 to 56%) of that inside. Use of Nebraska sedge therefore averaged 64%. Leaving just 62 g/m^2 on the grazed area every year would not maintain site productivity.

The total amount of residual herbage should, however, be adequate to maintain productivity even with 64% use of Nebraska sedge each year. For the elevation of Tule Meadow, Ratliff et al. (1987) estimated that residual herbage should average 1,740 kg/ha for good condition wet meadows. Nebraska sedge is not the only species in the stand. Assuming equal use of all species and average production (474 g/m^2 in 1980–1981), we would expect residue outside the exclosure to total about 170 g/m^2 (1,700 kg/ha).

SHOOT HEIGHTS.—In spring, Nebraska sedge shoots within the exclosure were 41 to 67 mm taller in mean height than those outside (Table 1). Two explanations for this difference are offered. First, initiation of regrowth followed by cold weather may lower the carbohydrate reserves on the grazed area. This would lower the carbohydrate levels available for, and thereby slow, spring shoot growth. Second, grazing removes dead vegetation that insulates the soil surface and overwintering shoots. Insufficient insulation may keep temperatures below those needed for growth longer and thereby slow spring shoot growth.

By the time growth was completed in 1985, shoots looked equally high outside and inside the exclosure. If really the same, growth outside had to accelerate more than growth inside. Less shading of new growth outside by old leaf tissue could produce such an effect.

NUTRIENTS.—Concentrations of both nitrogen and potassium were greater in the residual herbage on the grazed area, but phosphorus concentrations were no different (Table 1).

Residual Nebraska sedge herbage on the grazed area still contained sufficient protein for cow maintenance. Herbage inside the exclosure was deficient in protein. Mean crude protein concentration (N% × 6.25) in residual herbage was between 0.3 and 1.3% more outside than inside the exclosure. Inside the exclosure the upper confidence limit for crude protein content was 5.8%. Outside the exclosure the lower confidence limit for crude protein content was 5.9%; the upper limit was 6.7%. Dry, pregnant, mature cows (the expected condition as the grazing season ends) require 5.9% protein in their diet (Church 1984).

Phosphorus concentrations were deficient for cow maintenance both inside and outside the exclosure. Diets of dry, pregnant, mature cows should contain at least 0.18% phosphorus (Church 1984).

Potassium requirements for cows are from 0.5 to 0.7% (Church 1984). Therefore, residual herbage inside and outside the exclosure has ample potassium for cow maintenance. Nevertheless, the difference in potassium between the exclosure and the grazed area is biologically significant. Potassium tends to concentrate in growing plant tissue (Black 1957, Church 1984). Higher potassium concentration in shoots from the grazed area suggests greater fall growth outside than inside the exclosure. Fall growth could negatively affect carbohydrate reserves needed for winter respiration and early spring growth.

CONCLUSIONS

By altering grazing patterns, weather at Tule Meadow appears to offset adverse effects of grazing on Nebraska sedge. Grazing in the 1984 dry season did not stimulate vegetative reproduction but did slow shoot growth the following spring. Shoot frequency and density were little affected, however, suggesting that occasional seasons of significant herbage removal have no lasting effects.

After grazing, less abundant, but more nutritious, forage is available for animals using the Nebraska sedge site in fall. Availability of nutritious fall forage may benefit wild herbivores, especially in dry years.

Grazing of Nebraska sedge should aim to remove excessive amounts of old leaf tissue and promote growth of new, photosynthetically efficient tissue. Management plans for grazing Nebraska sedge should, nevertheless, include end-of-season regrowth periods to assure ample carbohydrate reserves for winter respiration and initial spring growth.

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