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ECOLOGICAL STUDIES ON THE VEGETATION OF AN UPLAND GRASSLAND (*Stipa pulchra*) RANGE SITE IN CUYAMACA RANCHO STATE PARK, SAN DIEGO COUNTY, CALIFORNIA

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The purpose of this project was to use manipulated-association experiments to detect possible combinations of treatments which might contribute to a plan to renovate degraded grasslands of Cuyamaca Rancho State Park, eastern San Diego County, California. Prior to becoming a State Park, the grasslands here were severely overgrazed and run down.

Grassland renovation projects have been conducted in other regions of the country, but such experiments in southern California are relatively new. There are sufficiently significant areas of similar grassland in Riverside and San Diego Counties to warrant an experiment of this type to be conducted here in southern California. The managers of Cuyamaca Rancho State Park were particularly interested in two plant species to be involved in this experiment: a native bunch grass, *Stipa pulchra* Hitchc. (purple needle grass) and *Eriogonum wrightii* Torr. ex Benth. ssp. *membranaceum* Strokes, a low matted shrub, considered to be an invader in upland *(Stipa)* grassland.

The grass species was to be harvested for seed as part of the renovation experiment and the shrub was considered because the park wanted to find a feasible means of controlling the unwanted spread of this low matted shrub into the upland grassland. With this view in mind, the authors and park managers developed an experimental design in the fall of 1979 and implemented it at the field plots in the park the following spring and summer of 1980. The treatment or treatment combinations in the experiment included: 1) seeding; 2) cultivation; 3) fumigation; 4) fertilization; 5) mulching; 6) burning; and 7) mowing, plus controls. The multiple treatment aspect of this project was perhaps somewhat unique for southern California, but this type of experiment is also subject to instant hazards (such as lack of rain when needed) compared to experiments with fewer variables to test. Our project was no exception. However, even if only one or a few treatment combinations proved to be effective toward renovation, these data alone would be worth reporting. The negative data for the treatments which failed may also be useful information.

METHODS

Study area

This study was conducted at an upland (*Stipa*) grassland site on East Mesa (elevation 1220-1524 m) in Cuyamaca Rancho State Park. Total annual precipitation for the period of the study was 163.3 cm, 62.2 cm and 142.1 cm for the years 1980, 1981, and 1982, respectively. More than 60 percent of the precipitation comes during the months of December through March. Yellow pine forest (Thorne 1976; Lathrop and Martin 1982) is the main plant community of the region, along with chaparral, riparian and extensive expanses of grassland. Upland grassland at the park is dominated by annual grasses such as *Bromus tectorum* L. and *Vulpia myuros* (L.) K. C. Geml., along with perennial grasses, *Stipa pulchra*, *Sitanion hystrix* (Nutt.) J. G. Sm., and *Elymus glaucus* Buckl.

Total foliage cover, or percentage of all foliage leaves covering the ground surface, was measured for the study plot by the point-frame method (N=750 pts.) prior to application of treatments, in late spring, 1980. The total foliage cover was 66.7 percent. The highest individual value (20 percent) was the shrub *Eriogonum wrightii*. Of the remaining cover, *Vulpia myuros* was 15.9 percent, *Bromus tectorum* 11.1 percent and an aggregate of other grasses and forbs made up the remaining 19.7 percent. Soils of the upland grassland study site are well drained and coarse textured to gravel-sized composition. By comparison, soils of grassland meadows in the park are not well drained (with a bleached clay layer at the 60-76 cm depth), and contain more organic matter compared to the upland soil.

Stipa pulchra, the dominant species of the pristine California grassland (Weaver and Clements 1938; Burcham 1957), and the most common native bunchgrass in Northern California (White 1967), along with several closely related species, is also widespread in the southern part of the state (Bartolome 1981). The production of large quantities of viable seeds and the presence of twisting awns and pointed large seeds ensure self-burial and enable the species to colonize disturbed areas. The rapid production of seeds by a young *Stipa* plant (about two years old) and the occurrence of vegetative reproduction by the breakage of the tufts, forming a clone after heavy defoliation, are also some of the ecological characteristics that make *Stipa pulchra* more abundant than other bunchgrasses (Bartolome 1981). This plant species germinates and survives in a wide variety of soil types, slopes, and habitats, including disturbed areas (Bartolome and Gemmill 1981). In recent studies done by Bartolome and Gemmill, they concluded that *Stipa pulchra* is an opportunistic species with a few characteristics of a typical climax species.

Plot size and preparation

Two 12.4 X 15 m plots were delineated on the ground with a 2 m buffer zone between the plots at the study site, and then subdivided into thirty 2 m X 2 m subplots with 0.6 m buffer zone between subplots. The terrain at each of the study sites varied from level to a 2° slope. The gradient was not appreciable; thus the experimental subplots did not have significant differences in runoff from rains.

The seven treatments, mentioned previously, were applied, singly or in combination, to the thirty 4 m^2 subplots within each of the two side by side replicate plots. The assignment of the treatments and treatment combinations was identical for each plot. While there were thirty treatment combinations applied to each of the two plots, results of only seven combinations showed potential for grassland renovation practices. Because of space limitations and practical results of the experiment, only these seven treatment combinations will be considered in the results section except for a brief discussion of negative data for treatments which were not effective.

Treatment application

The degree and/or concentrations of treatment preparations and seeding was finalized by the spring of 1980 and, with the help of Cuyamaca Rancho State Park, applications in the experimental 4 m^2 subplots began immediately. The methods of applications of the treatments at the two replicate study plots were: 1) Seeding-broadcast seeding at the rate of 400 seeds/4 m^2 subplot; 2) Mowing-Sickle-type (45.7) power mower with cutting a ground level; 3) Cultivation-5hp rototiller, to a depth of 15-20 cm.; 4) Fumigation-vapam applied to wet soil at the rate of 1 liter/10 m^2; 5) Fertilization-milorganic sewage sludge applied at the rate of 0.3 kg/4 m^2; 6) Mulching-redwood chips to a depth of 6 cm; and 7) Burning-drip torch. No treatments were applied to subplots used for control. All treatments, except burning and seeding and/or mulching of burned subplots were performed at the field sites in time to take advantage of the late fall rains of 1980. Burning was delayed until April of 1981 in order to kill the competing annual grasses shortly after their growth had started.

Stipa pulchra was selected for the seeding treatment, both because of the species adaptability and its availability as a seed source in several remote areas of the park. Seeds, for this purpose, were harvested in the park by hand stripping of the flowering culms using a crew of students and park personnel. The seeds were separated from the chaff in the laboratory.

Analysis of treatments

The primary methods of analyzing the plant response to the various treatments included: 1) above-ground biomass (g/m^2) of *Stipa pulchra*, forbs, annual grasses and the shrub *Eriogonum wrightii*, and 2) density ($no/4\ m^2$) and basal area (%) of *Stipa pulchra*. The measurements were made during the peak period of growth, in late May and June of 1981 and repeated at the same time in 1982.

Collection for biomass analysis was accomplished by clipping all shoot material inside a randomly-placed, one square meter quadrat, at the ground surface (Bartolome et al. 1980) within each of the 2 m X 2 m subplots at the study site. Care was taken not to clip the same square meter a second time in 1982. The plant material was collected in paper bags, marked and taken to the laboratory, where it was oven dried at 60°C. The material was sorted into the following habit categories: 1) annual grasses (including any sedges and rushes); 2) *Stipa pulchra*; 3) forbs (herbaceous vegetation other than grasses); and 4) the shrub *Eriogonum wrightii*. The dried material was weighted on a Sauter Model RL4 electronic balance with a resolution of 0.01 g. The weight was recorded for each sample as the number of grams per square meter (g/m^2).

Basal area (%) of *Stipa pulchra*, representing the percent of the ground covered by the species, was calculated from diameter measurements of the grass clumps within each of the 4 m^2 subplots, making allowance for dead material within the clump (Brower and Zar 1977). Density ($no/4\ m^2$) of *Stipa pulchra* was determined from counts of *Stipa* clumps within the subplots.

RESULTS

The effect of seven treatments and treatment combinations was significant for only one of the two replicate study plots and then only for the second growing season after treatment application. Thus the results reported here represent the effects of treatments applied to only one study plot, with seven subplots, two years (1982) after treatment applications in 1980, except that the effects on forbs are reported for the first years growth only, in 1981.

The effect of treatments and treatment combinations on biomass of *Stipa pulchra* is graphically illustrated in Fig. 1. Compared to the control, biomass increased for all treatments with seeding, and a combination of cultivation, fumigation, and fertilization receiving the highest values. Biomass of annual grasses increased in five of the seven treatments (Fig. 2). Forbs (Fig. 3) show a decrease in biomass except for the treatment fertilization. Biomass of the shrub *Eriogonum wrightii* (Fig. 4) was reduced, compared to the control, as a result of most of the treatments. Density (no/4 m^2 subplot) of *Stipa pulchra* (Fig. 5) showed an increase for the treatments of seeding and mulching and for the combination of treatments mowing, mulching, and seeding. Fig. 6, percent basal area of *Stipa pulchra*, indicates an increase for all treatments except the combination of cultivation, fumigation, and fertilization.

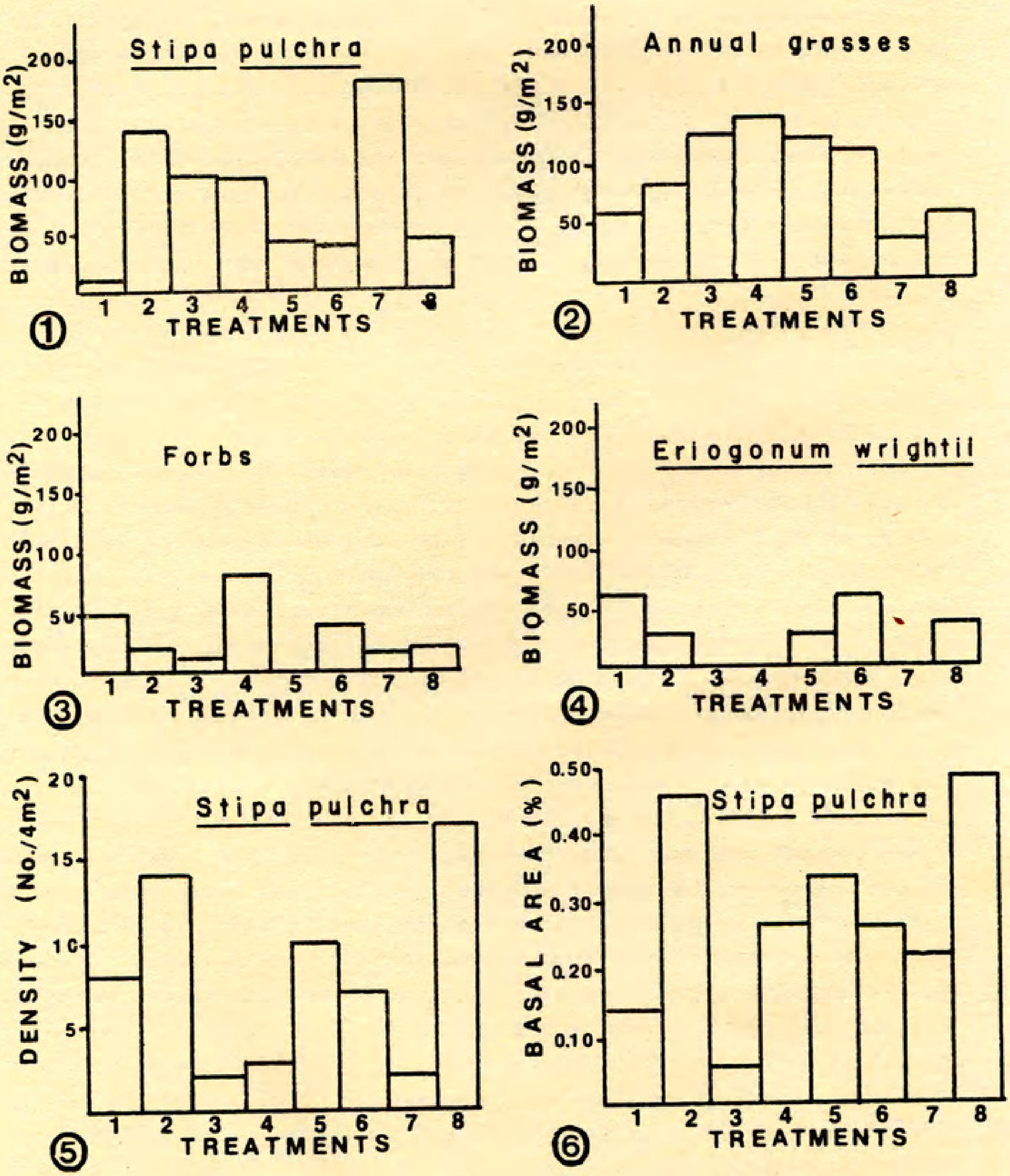
DISCUSSION and CONCLUSIONS

The dominant plant community of Cuyamaca Rancho State Park is yellow pine forest. Grassland, however, is found in meadow and upland slopes in large clearings of the forest. Prior to becoming a state park, the grasslands were heavily overgrazed (Lathrop and Martin 1982), depleting, to an extent, the native perennial grasses and creating conditions conducive to invasion by less desirable Mediterranean annual grasses. This project was envisioned as an experiment to test the feasibility of grassland renovation in the park.

A possible contributing factor for the poor response of the treatments in the experimental subplots of the first year after application might have been the greatly reduced rainfall during that season (less than half the normal yearly rainfall). Normal rainfall occurred during the second year after the treatment applications producing some positive responses which were absent during the first year. Another consideration is that the two replicate "side by side" study plots did not respond equally to equal treatments. This could possibly be due to the vagaries of soil texture (which reflect the amount of soil moisture retention) and the individual responses to the plants. Identical inferences, therefore, could not be drawn from the replicate plots. Because of this, the replicate plots (A and B) at the study site were treated separately and only the plot showing the more significant results was analyzed as a basis for this report (Plot A, Figs. 1-6).

Measurements were made once each year (1981 and 1982) on each of the subplots. Values of biomass, density, and basal area % were assessed for the growth response to the seven treatments and treatment combinations. This report contributes a few positive influences to the treatment applications as well as some negative responses. For example, the treatments which produced an overall increase in growth of *Stipa pulchra* also indicated an increase in exotic annual grasses. Since annual grasses compete with perennial grasses, these treatments may not be effective for restoration unless followed by other treatments. Seeding with *Stipa pulchra* along with fertiliza-

Key to
Treatments: 1 Control
2 Seeding
3 Cultivation, Fumigation, Fertilization
4 Fertilization
5 Mulching
6 Burning, Seeding
7 Cultivation, Fertilization, Seeding
8 Mowing, Mulching, Seeding



LIST OF FIGURES 1-6

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tion, for example, might be feasible if this treatment, applied in the fall season, was followed each of two or three years by early spring burning to eliminate the unwanted annual grasses and weedy forbs. *Stipa pulchra*, even the young bunches, can usually withstand light-intensity burning because of their sense thick caudices with many adventitious buds which sprout after fires. Most of the treatments applied were effective in eliminating the unwanted shrub *Eriogonum wrightii* (Fig. 4), a low-matted shrub which has a tendency to move into over-grazed drier parts of the upland grassland (personal communication, Joe Agazino, former California State Park ecologist).

MANAGEMENT RECOMMENDATIONS

Based on the results of this study, within its limitations, treatments recommended for future management practices at Cuyamaca Rancho State Park might be as follows: 1) Seeding-of native bunchgrasses (i.e. *Stipa pulchra*); 2) Fertilization-while fertilization initially gave advantage to annual grasses and forbs, perennial grasses also responded the second year. If this treatment is followed by early spring burning, as explained above, it should be effective where perennial grasses are present; 3) Cultivation-recommended only where invader shrubs need to be removed; 4) Mulching-recommended in combination with seeding; 5) Fumigation-not recommended except as a means of removing weedy forbs; 6) Burning-following an initial treatment of fertilization and seeding of a perennial grass, early spring burning could be an effective method to reduce annual competition; and 7) Mowing-probably effective only to reduce shrub or form competition.

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