

Some Effects of Grazing Intensity on Bitterbrush Dispersion¹

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Highlight

Three fence-line comparisons were made to determine the effect of grazing intensity on the density and dispersion of bitterbrush (*Purshia tridentata* (Pursh) DC.) in a uniform habitat. Bitterbrush density was reduced by heavy grazing but was not affected by moderate use. The large increases in mean area per plant that occurred under heavy grazing did not alter the overall form of random population dispersion. In a comparison of heavy versus moderate use, inclusion of 1-year-old plants on the moderately grazed area (10% of population) caused aggregation of the population. Even though a larger number of 1-year-old plants (22% of population) occurred in the heavily grazed comparison, the population remained random. The contrasting reaction probably resulted from a differential pattern of seedling mortality due to different amounts of herbaceous understory in the two shrub populations.

Measurement of the randomness of major species is one of the most important determinations to be made in the detailed analysis of a plant community (Curtis and McIntosh, 1950). If these species are randomly dispersed, certain conclusions are immediately in order. First, a chance distribution such as this would indicate that the most important factors in the plant's environment are at, or near, their optimum level. In some instances, no further investigation would be necessary beyond a description of prominent environmental features. Second, only a limited number of phytosociological characteristics would need study to provide an adequate picture of the community, since most others could be deduced through the use of interrelations. Third, random dispersion could also mean that the abundant species have reached peak performance in the community and, subsequently, that they have been present for a considerable length of time (Whitford, 1949). By contrast, in successional

communities random dispersion of a species may indicate that it will decline in the future (Greig-Smith, 1964).

Random distributions are exceptional in nature, however; and there is a general tendency for individuals to occur in groups or aggregations. Consequently, most considerations of population dispersion require more elaborate explanations than indicated above, and these may range from things such as the length of time a species has occupied a site to the presence of nonuniform habitat. Once established, however, nonrandomness demonstrates the existence of orderly, natural laws that should help us predict observed ecological patterns even though we may not, for the moment, know how to formulate them (Slobodkin, 1961). Thus, as has been pointed out by many other workers, the detection and analysis of nonrandomness is a starting place for further investigation of causal factors and not an end point in itself.

The present work was a part of a larger study of the effects of grazing on the structure and productivity of bitterbrush (*Purshia tridentata* (Pursh) DC.) communities. It was conducted on two areas (A and B in Table 1) in north-central Washington and another (C) in south-central Oregon. Each area was about 4 acres in size and had a distinct fence-line contrast in cattle use on bitterbrush.

Field sampling consisted of locating 100 or more random points in adjacent 2-acre study areas on each side of the fence in each of the three paired comparisons. At each random point the distance to the nearest established bitterbrush plant was measured to determine the spatial distribution of the shrub population, after Pielou (1959) as corrected by Mountford (1961).

The density of established shrubs was determined by counting shrubs rooted within forty 100 ft² circular sample plots located at a random subsample of the 100 random points. Differences between paired densities were subjected to a *t* test. In the event of random dispersion (or pronounced asymmetry in nonrandom distributions), density counts were subjected to square root transformation before tests of significance were conducted. Also, since the means were quite small, the square root of the observed number of plants plus 0.5 was applied as a correction factor. After tests of significance were made, the transformed values were converted back to mean numbers of shrubs

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Table 1. Density and spatial distribution of bitterbrush shrubs in paired pastures receiving different intensities of summer cattle grazing.

Area	Density/ 100 ft ²	Index of ¹ nonran- domness (α)	$\alpha - 1^2$ $\sqrt{\nu(\alpha)}$
A ₁ Heavily grazed	2.26	0.96	-0.43
A ₂ Lightly grazed	3.54		
B ₁ Moderately grazed	2.42	.86	-1.46
B ₂ Lightly grazed	2.11	.93	-.73
C ₁ Heavily grazed	3.95	1.03	.22
C ₂ Moderately grazed	4.54	1.29	2.40
(1-year-old plants omitted)			
C ₁ Heavily grazed	—	.86	-1.01
C ₂ Moderately grazed	—	1.16	1.29

¹Pielou (1959).

²Mountford (1961). If this quantity falls outside the interval -1.96 to +1.96 the distribution is judged nonrandom at the 95-percent significance level.

**Significantly different at the 0.01-probability level.

per sample plot as shown in Table 1. Thus, the converted mean densities in Table 1 are smaller than the arithmetic averages (LeClerc et al., 1962) listed in the tabulation in the following discussion of results.

Results

There was a highly significant difference in the density of bitterbrush plants on the heavy and light grazing treatments on area A. There was no real difference in the mean density of shrubs on the moderate versus light comparison on area B or the heavy versus moderate comparison on area C, but the latter is subject to qualification. Approximately 22% of the heavily grazed shrub population on area C was comprised of 1-year-old seedlings as compared with only 10% under moderate use. Also, it is possible that these seedlings were incorrectly classified as being established. Normally, as was done on area A, we do not consider bitterbrush seedlings established until they are at least 3 years old. Area C was considered an exception because the stand density data were obtained at the end of the second growing season after a rather severe spring and summer drought. Unfortunately, no detailed followup counts were made, but general observations suggested that a noticeable loss occurred before the end of the third growing season. For purposes of comparison, it seemed appropriate, therefore, to exclude the 1-year-old seedlings on area C from the base shrub population. When this was done, the reduction in density due to heavy grazing on areas A and C was comparable. We were unable to make specific tests of the latter difference in density

because 1-year-old plants could not be assigned to individual sample plots. As shown below, however, differences between arithmetic mean densities per 100-ft² plot on the two areas were roughly comparable:

Area	Heavy grazing	Light grazing	Moderate grazing
A	2.48	3.76	
C	3.25		4.20

Elimination of 1-year-old seedlings from the moderately grazed population on area C changed the corrected index of nonrandomness from non-random to random (Table 1). We can only guess why an even larger number of 1-year-old plants in the heavily grazed stand did not also influence overall dispersion. First, however, we should point out that the phenomenon of greater seedling survival on the heavily grazed area was not a short-term process. Intensive age structure analyses showed that over 75% of the heavily grazed population was under 20 years of age. In contrast, only 33% of the moderately grazed population was less than 20 years old. Obviously, conditions for bitterbrush seedling survival have been more favorable in the heavily grazed stand for a number of years.

The apparent aggregation of 1-year-old seedlings in the moderately grazed stand on area C could possibly be due to rodent seed caches near the same spots, or it could simply be the result of seeds falling close to parent plants. These same factors should also be operating in the heavily grazed population; but since this did not appear to be the case, other possibilities were considered. We believe that the most likely reason for the difference in seedling survival on the two areas was different amounts of herbaceous understory. Under moderate grazing there was more herbaceous cover in the shrub interspaces and a noticeable tendency for seedlings to grow under and around the canopies of larger shrubs, especially big sagebrush (*Artemisia tridentata*). Hormay (1943) states that such seedlings usually do not survive. On the other hand, under heavy grazing there was less herbaceous cover and bitterbrush seedlings were commonly observed in the shrub interspaces. Since these seedlings were able to establish themselves at varying distances from parent shrubs, they showed less tendency to aggregate.

The average cover of herbaceous annuals (mostly cheatgrass, *Bromus tectorum*) was 18% under moderate grazing as compared with 11 percent under heavy use. Holmgren (1956) has demonstrated the inability of bitterbrush seedlings to survive in cheatgrass stands and also pointed out the inhibiting influence of broad-leaved annuals.

Discussion

According to Kershaw (1963), departure from randomness occurs at various levels and can result from morphological, environmental, or sociological causes. Although randomness is considered exceptional in natural populations—even in small uniform habitats—it is not entirely lacking; e.g., see Connell (1956), Jackson (1968), and Park (1934) for animals and Pielou (1959), Ohman (1968), and others, including the present study, for plants. Regarding the latter, a 36% increase in mean area per shrub occurred on the heavily grazed part of area A without altering the basic form of population dispersion. Judged by the comparison of arithmetic mean densities presented earlier, a similar increase in mean area also occurred under heavy grazing on area C without causing a significant change in population dispersion after 1-year-old seedlings were omitted.

This could happen because severe grazing is also quite uniform; i.e., there is not enough unused forage for animals to be selective. In effect, severe grazing simply accelerated the process of random mortality assumed to be operating in these shrub populations in the absence of grazing. Obviously, if individuals are randomly eliminated from a random population it will remain random. More important, this sort of random elimination will also produce randomness in a nonrandom population where the density has been sufficiently reduced (Skellam, 1952).

Variations in bitterbrush dispersion were probably due to sociological and environmental reactions—both operating as functions of grazing intensity. Sociological causes were prominent in changing the dispersion of the moderately grazed population on area C through interspecific competition, but this was induced by grazing and related factors.

Greig-Smith (1964) states that dispersion offers a more objective criterion of population stability than has heretofore been available. This should interest range managers because grazing affects dispersion, and therefore stability, as much or more than many other factors. We believe that observations on the nature and extent of changes in dispersion should be considered with density data in interpreting the dynamics of key forage species in condition and trend work. Strickler and Stearns (1962) also indicate the possibility of using plant dispersion measures in studying the effects of livestock and big-game grazing.

The technique used in our study provided only

a test of randomness or relative degree of nonrandomness. Greig-Smith (1964) has developed a sensitive method that not only tests for randomness but also determines the scale and intensity of nonrandomness. Since the latter two data are complementary measures of population stability, they should contribute to more useful management guides.

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