DISTRIBUTION OF CATTLE ON SLOPE WITHOUT WATER RESTRICTIONS

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Contribution no. 3878911, received 7 June 1989, accepted 11 Oct. 1989.

WILLMS, W. D. 1990. Distribution of cattle on slope without water restrictions. Can. J. Anim. Sci. **70**: 1–8.

A study was made in the Porcupine Hills of southwestern Alberta to determine cattle distribution on slope when water is available at the top, middle, and bottom of the slope. Cows with calves were stocked at two rates (1.9 and 3.8 animal unit months (AUM) ha^{-1}) and three replications over six small pastures in a completely random design. The study was repeated in each of 4 yr over a 3-wk period starting in mid-June of 1985. Average forage utilization over a 4-yr period was similar among slope positions ($P > 0.05$) and stocking rate had no effect on its distribution. However, forage utilization differed among slope positions within a grazing period. In 1985, measurements of individual plants showed that the distribution of use shifted from the top or middle position in the first 4 d of the trial to the bottom in the last 3 d. The higher stocking rate reduced position differences. Cattle obtained about 80% of total water consumed at the top or middle positions. This also represented the daytime proportion of cows observed at these sites. These observations suggest a diurnal preference for slope position because forage use was uniform among slope positions while daytime occupation of the middle and top positions was disproportionately high. Providing water only at top of slopes will synchronize the time cattle require water with daytime site preference.

Key words: Cattle, feeding behavior, slope distribution, grazing, stocking rate

[Répartition de bovins sur la pente sans rationnement de l'eau.]
Titre abrégé: Répartition de bovins sur la pente.

On a effectué une étude dans les collines Porcupine du sub-ouest de l'Alberta pour déterminer la répartition de bovins sur la pente lorsque l'eau est disponible au sommet, au milieu et au bas de la pente. On a mis au pâturage des vaches suitées à deux taux de charge (1,9 et 3,8 mois-unité animale (AUM) ha^{-1}) et à raison de trois répétitions sur six petits pâturages dans un protocole complètement aléatoire. On a répété l'étude pour chacune de quatre années pendant une période de trois semaines à compter de la mi-juin de 1985. La consommation moyenne de fourrage pendant une période de quatre ans est comparable entre les diverses positions de pente et le taux de charge n'a aucun effet sur sa répartition. Toutefois, la consommation de fourrage diffère selon les positions de pente au cours d'une même période de paissance. En 1985, les mesures de plantes à pâturage ont révélé que la répartition de la consommation passait de la position du sommet ou du milieu de pente au cours des quatre premiers jours d'essai au bas de la pente au cours des trois derniers jours. L'augmentation du taux de charge réduit les différences de position. Les bovins obtiennent environ 80% de l'eau totale consommée dans les positions du sommet ou du milieu de pente, ce qui représente également la proportion diurne des vaches observées à ces emplacements. Ces observations suggèrent une préférence diurne pour les positions de pente car la consommation de fourrage est uniforme entre les diverses positions, alors que l'occupation diurne des positions du sommet et du milieu de pente est démesurément élevée. Le fait de fournir de l'eau seulement au sommet des pentes permettra de synchroniser le moment où les bovins ont besoin d'eau avec la préférence diurne des emplacements.

Mots clés: Bovins, comportement d'alimentation, répartition sur la pente, paissance, taux de charge

Cattle distribution on rangeland is affected by numerous site conditions that include forage and topography characteristics as well as distance from water but no single factor has a dominant effect on the distribution of cattle on mountain ranges (Cook 1966). Areas in close proximity to the water source are preferred (Senft et al. 1985). Ganskopp and Vavra (1987) reported sharply declining use of slopes by cattle as percent slope approached 20%. Percent slope and distance upslope from water accounted for 81% of cattle distribution in one study (Mueggler 1965). That distribution was partially explained by an interaction of distance upslope, which was also correlated with distance from water, and percent slope. Distribution was more restricted on steep slopes whereas distance from water was more important on shallow slopes.

Although cattle weight gains are not affected by restricting drinking to once every 2 d (Sneva et al. 1973), cattle on range normally drink in the morning and again in the afternoon on hot days (Kropp et al. 1973). Drinking interval is inversely related to temperature and may be only 2 h when temperatures are over 32°C (Winchester and Morris 1956). Therefore, cattle remain near a water source in the summer with the consequence that these areas experience greater use. On mountain ranges, the water source is usually at the bottom of slopes, which increases the reluctance of cattle to use the slopes extensively.

A major objective of most grazing systems is to distribute livestock uniformly to increase grazing efficiency. This is difficult on mountain ranges because of the combined influence of slope and location of water sources. This study was conducted to determine the effect of slope and stocking rate on the distribution of cattle and to test the hypothesis that forage use along the slope is uniform when the influence of distance from the water source is controlled.

MATERIALS AND METHODS

Site Description

The study site was in the foothills of southwestern Alberta, about 85 km northwest of Lethbridge at the Agriculture Canada Research Substation near Stavely, Alberta. The vegetation is typical of the Fescue Grassland Association (Moss and Campbell 1947) with rough fescue (*Festuca scabrella*) the dominant species in the area and Parry oatgrass (*Danthonia parryi*) co-dominant on xeric sites. The soils are a member of the Orthic Black subgroup of the Chernozemic Order (Udic Haploboroll), developed on till overlying sandstone, and have a clay-loam to loam structure. The climate is dry subhumid; annual precipitation is 610 mm with about 350 mm during the growing season. The topography is undulating, varying in elevation from 1280 to 1420 m above sea level. The study site had an elevation range of 30 m (Fig. 1).

Methods

Six small fields of equal area were fenced (30 × 120 m) perpendicular to the contours on an east-facing hillside having a uniform slope of about 25% (Fig. 1). The top, middle, and bottom slope positions were defined for each field by marking an area 15 m wide from 0 to 30 m, 45 to 75 m, and 90 to 120 m from the top. Water tanks were centered in each position but against the side fence. Water was provided ad libitum at each position and the tanks were filled daily after measuring depletion. Relative water consumption at each location was used as one estimate of cattle distribution.

The fields were stocked with either three or six Hereford cows, with calves, for a 7-d period to achieve rates of either 1.9 (M) or 3.8 (H) animal unit months (AUM) ha^{-1} and three replicates in a completely random design. The stocking rate treatments within a replicate were grazed concurrently but the replicates were grazed consecutively, over a 3-wk period beginning in late June, keeping the groups intact to minimize aggressive behavior between animals. The distance between treatments was constrained to a minimum of 60 m to remove possible interactions between animal groups. The cows were 3 or more years old and consisted of different animals in each year of the study. The study was repeated in each of 4 yr with the treatments and replicates fixed in the same location.

In each year of the study, available forage was estimated by clipping seven 0.5-m^2 plots, randomly distributed in each position, before grazing. Utilization was estimated by subtracting from available forage the average residual, determined by repeating the clipping on a new set of plots after grazing. Since the interval was only 7 d between clipping events, and most growth on this grassland had stopped by mid-June (Willms 1988), growth during this interval was assumed to be negligible.

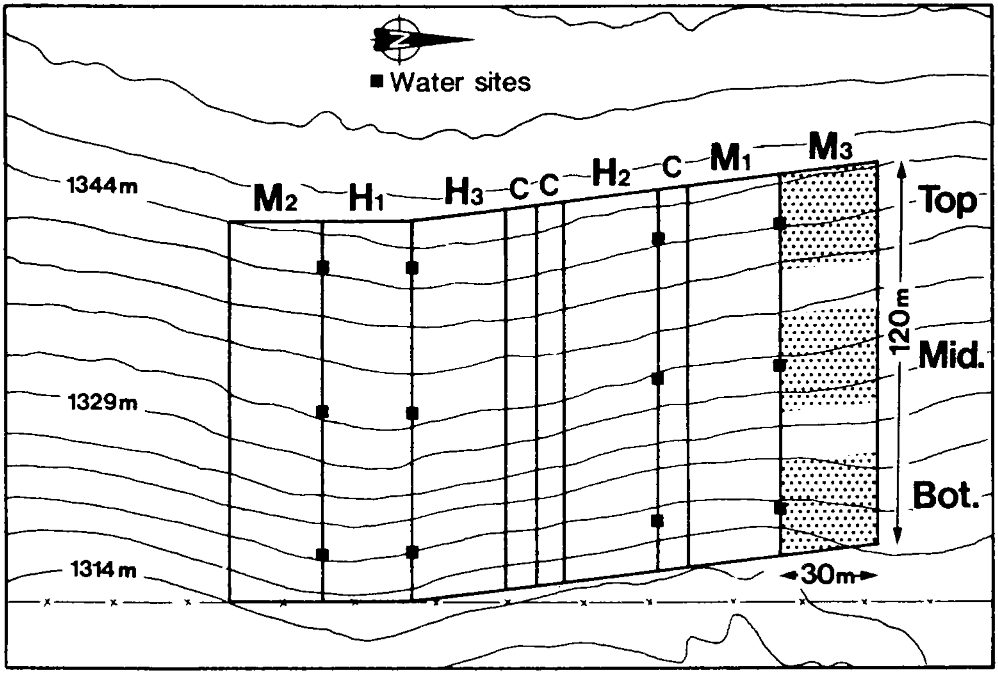

Fig. 1. Site description showing 3-m contours, location of stocking rate treatments (M=1.9 animal unit months ha^{-1}; H=3.8 animal unit months ha^{-1}) and sequence of grazing (1 to 3) in trial, location and size of fields and sampling areas (shaded portion), and location of water sources (c=control strips not used in study).

In 1985, accumulated daily utilization was also estimated in each field by measuring forage removal from a sample of 30 plants at each position. The relationships of height to weight were determined for the species represented in the sample. Daily measurements were made of residual height from which residual weight and utilized weight were determined as a proportion of the original weight.

The species ground cover was estimated using an 8-point scale representing 0, >0–1, 2–5, 6–25, 26–50, 51–75, 76–95, and 96–100% classes. Cover for each species was estimated in 15 plots, measuring 20 × 50 cm, located systematically within each of two transects that were randomly located in each slope position of every field. Species composition was calculated as a proportion of total cover present. Percent values were transformed by the log transformation prior to analysis for slope position differences.

In the final year of the study, 49 direct observations were made of cattle distributions in the morning (06:00–09:00h), noon, and evening (19:00–21:00h) as well as their activity, whether feeding or idling, their direction of movement if feeding, and counts of signs of irritability such as foot stamping, tail switching, or head lashing over the shoulder. The latter observations were made for 2 min on each cow at every observation from a vantage position on a hill overlooking the site. A stepwise procedure with foreward selection (Hocking 1976) was used to test the effect of time (h), RH (%), temperature (°C), light (kW m^{-2}), and wind speed (m s^{-1}) on cattle distribution (proportion of total at each position). Variables were selected in order of their contribution to the model and only those with $P > 0.10$ were retained. This test was repeated for each slope position over stocking rate treatments with the latter being a weighting factor. The effects of these variables, together with slope position, were also used in a similar test to identify variables contributing to irritability (number of signs).

The effect of location was defined as the proportion of water consumed, the proportion of cattle seen, the proportion of plant consumed, and the quantity of forage utilized. The effect of slope position on variables expressed as a relative proportion was evaluated by subtracting the proportion of one position from the proportion of the second position and testing the null hypothesis by a *t*-test. For all other data, the effect of slope position and, where relevant, year was evaluated with an *F*-test of the 1st or 2nd degree polynomial contrasts. Stocking rate was treated as the main effect in each analysis.

RESULTS

Forage utilization among slope positions was similar over 4 yr although a trend ($P=0.235$) of increasing use of lower slopes was noted (Table 1). Available forage was also similar among slope positions but varied among years. Average daily forage consumption for each cow and calf was 12.0 kg on the moderately stocked field and 11.8 kg on the heavily stocked field.

As measured on individual plants, cattle utilized a greater proportion of forage at the middle slope position during the first day of the trial in 1985 (Table 2). However, from day 4 to the end, incremental use increased linearly towards the bottom and this trend was significantly ($P=0.042$) increased by stocking rate. The net effect was greater ($P=0.019$) accumulated use at the middle position.

Daily water consumption per cow/calf unit averaged 91.6 ± 23.1 and 64.5 ± 8.5 L on the moderately and heavily stocked treatments ($P=0.14$). The proportion consumed differed significantly among slope positions with the greatest proportion used at midslope and the least at the bottom (Table 3). These trends were the same in the first 2 d as in the final 2 d of the trials. However, stocking rate affected the pattern of water consumption at different slope positions in the first 3-d period but not in the last (Table 3).

A greater proportion of cows was observed at the top slope position in the evening (0.51) than in the early morning (0.38) ($P>0.05$). Significant ($P<0.05$) differences between morning and evening were not detected at the mid- or bottom slope positions. A greater ($P=0.002$) proportion of cows was observed at the top than at the bottom slope position in the first 3 d of the trial (Table 4). In the last 3 d, a greater proportion was found in the middle position than at the top ($P=0.002$) or bottom ($P=0.007$). The shifts from period 1 to period 2 were detected ($P>0.13$). The high stocking rate reduced slope position differences (Table 4).

Important differences in forage species composition were noted among slope positions (Table 5). The mid-slope position had less grass and more shrubs than the top or

Table 1. Available and utilized forage (g m^{-2}) in relation to position on slope and stocking rate over 4 yr

	Stocking rate (AUM† ha^{-1})			
	1.9		3.8	
	Available	Utilized	Available	Utilized
Slope position				
Top	301.0	63.7	266.7	137.7
Middle	305.6	68.4	278.4	132.5
Bottom	276.1	77.9	271.3	142.7

Test (probability) of the effects of stocking rate and year and slope position with the 1st and 2nd degree polynomial contrasts (1,2 df):

Source	Available	Utilized
Stocking rate	0.422	0.116
Year		
1st degree	0.008	0.592
2nd degree	0.030	0.648
Slope position		
1st degree	0.481	0.235
2nd degree	0.654	0.766

†AUM. = animal unit month.

Table 2. Utilization (%), both accumulated and incremental, of marked plants in relation to stocking rate and slope position at three times during the trial in 1985

	Day 1	Day 4		Day 7	
	Increment/accumulated	Increm.	Accum.	Increm.	Accum.
		1.9 AUM† ha^{-1}			
Top	1.65	6.21	7.86	13.45	21.34
Middle	6.60	12.68	19.28	13.73	33.01
Bottom	1.58	8.38	9.96	14.82	24.78
		3.8 AUM ha^{-1}			
Top	5.77	21.01	26.78	15.69	42.47
Middle	9.55	16.40	25.95	22.93	48.88
Bottom	7.12	18.06	25.18	23.63	48.81
Test (probability) of the effects of stocking rate and slope position, tested with the 1st and 2nd degree polynomial contrast, and their interaction:					
Stocking rate (*a*)	0.189	0.088	0.002	0.042	0.006
Position					
1st (*b*)	0.755	0.762	0.886	0.004	0.110
a × *b*	0.670	0.294	0.238	0.008	0.601
2nd (*c*)	0.042	0.706	0.071	0.541	0.019
a × *c*	0.396	0.187	0.066	0.470	0.074

†AUM-Animal unit month.

Table 3. Proportion of water consumed at slope positions in relation to stocking rate (1.9 or 3.8 animal unit months ha^{-1}) and period of trial (P1 = first 3 d, P2 = last 3 d)

	Stocking rate			
	P1		P2	
	1.9	3.8	1.9	3.8
Slope position				
Top	0.409	0.320	0.303	0.354
Middle	0.415	0.460	0.448	0.496
Bottom	0.176	0.220	0.249	0.150

Tests (probability) of stocking rate (SR) and comparison differences between periods and between all possible combinations of slope position:

	By slope position		By period				
	Stocking rate†	Period (P1–P2)‡			Slope position (SP)‡ (T-M)	(T-B)	(M-B)
Top (T)	0.103	>0.90	P1	SR	0.094	0.061	0.977
				SP	0.053	0.006	<0.001
Middle (M)	0.880	0.56					
			P2	SR	0.639	0.307	0.303
Bottom (B)	0.097	>0.90		SP	0.005	0.068	0.007

†Effect of stocking rate on specific comparison.
‡*t*-test of the hypothesis that the difference between proportions=0 (1,2 df), after weighting by number of cows.

bottom, i.e., less rough fescue and Parry oatgrass but more saskatoon *Amelanchier alnifolia*.

The stepwise regression indicated that occupation of the top slope position was influenced (coefficient, *P*) by RH (−0.010, 0.012), light (−0.365, 0.033), and temperature (−0.022, 0.164) R^2=0.13); the mid-slope position by light (0.214, 0.086) (R^2=0.03); and the bottom slope by light (0.166, 0.073) and RH (0.004, 0.126) (R^2=0.04). Irritability was affected by wind (−6.992, <0.001), light (19.136, 0.020), and temperature (1.322, 0.035) (R^2=0.41).

Table 4. Proportion of cattle observed at slope positions in relation to stocking rate (1.9 or 3.8 animal unit months ha^{-1}) and period of trial (P1=first 3 d, P2=last 3 d)

	Stocking rate			
	P1		P2	
	1.9	3.8	1.9	3.8
Slope position				
Top	0.486	0.453	0.216	0.367
Middle	0.411	0.294	0.639	0.428
Bottom	0.103	0.253	0.145	0.205

Tests (probability) of stocking rate (SR) and comparison differences between periods and between all possible combinations of slope position:

	By slope position		By period				
	Stocking rate†	Period (P1–P2)‡			Slope position (SP)‡ (T-M)	(T-B)	(M-B)
Top (T)	0.331	0.134	P1	SR	0.762	0.024	0.340
				SP	0.434	0.002	0.244
Middle (M)	0.623	0.160					
			P2	SR	0.037	0.473	0.044
Bottom (B)	0.070	0.854		SP	0.021	0.154	0.007

†Effect of stocking rate on specific comparison.
‡*t*-test of the hypothesis that the difference between proportions = 0 (1,2 df), after weighting by number of cows.

Table 5. Composition (% ground cover, mean ± 1SD) of species or type in relation to slope position (n=6)

Species or type	Top	Middle	Bottom
Graminoides			
Festuca scabrella	30.70 ± 9.64*a*	12.10 ± 3.70*b*	27.56 ± 3.69*a*
F. idahoensis	5.82 ± 3.68*ab*	3.25 ± 2.04*b*	6.08 ± 2.57*a*
Danthonia parryi	19.82 ± 6.21*a*	2.61 ± 2.52*c*	7.61 ± 7.71*b*
Carex spp.	2.11 ± 1.89*a*	5.43 ± 5.66*a*	2.70 ± 2.64*a*
Bromus spp.	0.14 ± 0.24*c*	8.36 ± 6.24*a*	1.33 ± 1.31*b*
Agropyron dasystachyum/smithii	1.12 ± 1.12*a*	0.52 ± 0.61*a*	0.70 ± 0.66*a*
Stipa viridula	0.33 ± 0.56*b*	4.20 ± 2.93*a*	1.27 ± 1.65*b*
Total	61.33 ± 6.56*a*	47.07 ± 5.46*b*	51.42 ± 7.27*b*
Forbs			
Achillea millefolium	5.81 ± 3.57*a*	1.02 ± 0.68*b*	2.05 ± 1.57*b*
Galium boreale	5.03 ± 2.12*a*	4.96 ± 2.01*a*	7.50 ± 2.89*a*
Anemone patens	3.87 ± 2.90*a*	0.92 ± 1.11*b*	2.24 ± 1.79*ab*
Geum triflorum	5.34 ± 2.89*a*	0.32 ± 0.33*b*	1.31 ± 1.22*b*
Aster laevis	1.63 ± 0.90*a*	3.26 ± 2.51*a*	2.96 ± 0.94*a*
Fragaria virginiana	0.49 ± 0.76*b*	2.33 ± 2.17*a*	1.81 ± 1.68*a*
Total	30.62 ± 9.64*a*	28.64 ± 2.80	30.09 ± 5.01
Shrubs			
Potentilla fruticosa	6.54 ± 5.59*a*	2.18 ± 2.06*a*	4.75 ± 2.00*a*
Rosa arkansana	1.17 ± 1.17*a*	8.16 ± 3.55*a*	6.77 ± 3.86*a*
Symphoricarpos occidentalis	0.00 ± 0.01*a*	4.19 ± 3.11*a*	6.42 ± 5.40*a*
Amelanchier alnifolia	0.34 ± 0.83*b*	7.51 ± 7.77*a*	0.38 ± 0.80*b*
Total	8.05 ± 5.15*b*	24.29 ± 5.56*a*	18.49 ± 6.57*a*

a-c Means in row with the same letter do not differ significantly (P>0.05).

The proportion of cows observed feeding over the duration of the trial in 1988 was 0.55 on the moderately stocked treatment and 0.62 on the heavily stocked treatment ($P>0.05$). The proportion feeding increased ($P<0.05$) over both moderate and heavy stocking rate treatments from the first 3 days of the trial (0.42 and 0.58, respectively) to the last 3 d of the trial (0.70 and 0.66, respectively) with a marginal effect ($P=0.071$) observed from stocking rate. No trend was observed of feeding among slope positions. The orientation of the cows observed while feeding was 50% parallel to the slope, 27% directly or diagonally upslope, and 23% diagonally or directly downslope.

DISCUSSION

Slope position affected cattle behavior but not to the extent that forage use was greatly affected. Therefore, the hypothesis that distribution was the same over the slope can be accepted and the contention that foraging goals are nested in goals of seeking water (Senft et al. 1987) is supported.

The fact that water consumption was least at the bottom while forage use was essentially the same at the middle and bottom positions indicates that cattle occupied the upper slope positions during the day when most water is consumed (Sneva 1970). Their occupation of the upper positions during the day was confirmed by direct observations in the final year of the study. Since forage use was equally high at the bottom position and near the top, and most daytime activity occurred near the top, the indirect evidence is that feeding on the bottom position occurred between late evening and early morning, outside the hours of direct observations and when drinking requirements were low. This suggests that cattle exhibited a diurnal preference for slope position, preferring the bottom at night and the top during the day. Other studies also show that feeding by cattle occurs largely in late evening and early morning (Sneva 1970; Kropp et al. 1973).

Natural water sources on foothills grasslands are invariably found at the bottom of slopes. Therefore, while cattle may prefer the top-slope position during the day, their daytime dependence on water would ensure more frequent occupation and heavier utilization of the bottom areas near the water supply. This may be alleviated by providing water on a top-slope position and thereby synchronizing the time of demand for water with the time that cattle occupy the site, thus ensuring a more uniform spatial distribution of forage use. Reducing the distance to water would be a greater concern on steep slopes than on shallow slopes (Mueggler 1965; Cook 1966).

However, other pressures that are not well understood, such as harrassment by insects, may interact with habitat or slope position to affect livestock distribution. Therefore, while cattle may resist climbing slopes, the inducement of relief from insects combined with accessibility to water may lead to diurnal shifts in slope occupation. Weather seemed to have a small effect on daytime occupation of the top and mid-slope positions although harassment by insects might have caused cattle to seek the upper slope positions where the wind was greatest. This assumption could not be tested but irritability, presumably due to insect harassment, decreased with increased wind and decreased temperature.

The effect, if any, that the differences in forage species composition among slope position had on cattle distribution is not known. The shrub community, found in greater abundance at mid-slope, is favored by higher moisture which probably exists because of snow accumulation rather than the presence of a discharge area. However, shrubs were not so dense as to create an effective barrier to grazing. Moreover, forage quality, as influenced by soil moisture, would not be a factor in early summer prior to senescence and, particularly, over the course of the study when snow accumulation was well below average. In any case, shrubs are a natural component of the Fescue Grasslands and their presence cannot be controlled. Therefore, although the effect of the shrub community is confounded with the slope per se, its presence is, in fact, due to the slope and its effect is part of the slope effect.

The study was strictly controlled to minimize the influence of extraneous variables. While virtually no information is available on the effect of animal numbers or density on herd behavior, cattle on arid rangeland subdivided into herds that varied from 1 to 85 animals, but on the average varied from 3.9 to 11.2 (Arnold and Dudzinski 1978). This indicates that social stability rather than numbers may be relevant. In the present study, cattle did not display unusual aggressive behavior toward one another, perhaps because a social hierarchy was allowed to develop during a conditioning period.

The results of the study indicate that slopes can be fenced with the expectation that livestock distribution will be uniform on a sloped range if water is not restricted. This result is independent of stocking rate and indicates diurnal preferences by cattle for slope positions. High grazing pressure may contribute to reduced spatial variability in forage use but this condition was not present on the moderately stocked field where utilization averaged 24%. Although the study did not examine livestock distribution when water was fixed at one position, we might expect results similar to those found in the study if water were fixed at the top since that is where most daytime use occurred.

ACKNOWLEDGMENTS

Bart Kesler assisted with fencing and site preparation and, together with summer assistants, harvested plots and recorded observations.

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