Converting chaparral to grassland increases soil fertility

Milton B. Jones □ Robert L. Koenigs
Charles E. Vaughn □ Alfred H. Murphy

Before Europeans arrived, the native Americans burned chaparral brushlands to drive out wildlife in hunting, and to increase accessibility to the land. Now chaparral is often converted to grassland to help control wildfire, increase feed for livestock and wildlife, and increase water yield, as well as to improve accessibility. Reduced sheet erosion is often another benefit.

Burning is the usual method of removing the large volume of woody material from brushlands, although mechanical and chemical methods have also been used. Use of fire also increases the availability of nutrients in the soil immediately after the burn.

The objective of this study was to compare the long-term effects of brush conversion and brush regrowth, with and without grazing, on the availability of soil nutrients.

In 1956, chaparral growing on Los Gatos soil was crushed and burned. The area was seeded to grasses: Harding-grass (*Phalaris tuberosa* cv. Stenoptera), Palestine orchardgrass (*Dactylis glomerata* cv. Palestine), soft chess (*Bromus mollis*), and annual ryegrass (*Lolium multiflorum*), subclover, (*Trifolium subterraneum*); and rose clover (*T. hirtum*). Half of the area was fenced to exclude herbivores, giving a grazed and an ungrazed treatment. Resprouting brush was then treated periodically as follows: (1) reburning; (2) herbicide treatment; and (3) no follow-up treatment, which resulted in the brush growing to its original size and density in about five years.

In reburned plots, it was necessary to reburn in 1959 and 1963 because of brush sprout growth. Additional burning treatments were needed and done in the area protected from grazing in 1967, 1970, 1974, and 1978. The herbicide treatment was a standard brush killer (low volatile esters of 2,4-D and 2,4,5-T) at 4 pounds of active ingredient per acre in 100 gallons of water with 1 percent diesel oil. The herbicide was first applied in June 1958. In 1959 and 1963, the surviving sprouts were treated again, which was sufficient to control all brush growth.

Soil samples for chemical analysis and a greenhouse pot study were taken from the two replications of each treatment in spring of 1979. In the pot experiment, nitrogen (N), phosphorus (P), and sulfur (S) were applied separately and in all possible combinations. The N and P were each applied at the rate of 100 ppm, and S at 50 ppm. The 1-kilogram capacity pots were seeded with soft chess at the rate of 0.2 grams per pot.

In the field plots, the major influence of the follow-up brush treatments on soil chemical properties was on the inorganic N, followed by total S and available P; there were only small differences in total N and no significant difference in organic matter (table 1). The largest differences were on the grazed plots between soils with regrown brush and those with grass cover type. There were no differences between treatments for exchangeable cations. Exchangeable calcium (Ca) varied from 5.0 to 7.0, magnesium (Mg) from 1.1 to 1.6, potassium (K) from 0.6 to 1.1, and sodium (Na) from 0.1 to 0.3 meq per 100 grams soil.

Table 2 shows pot yields and uptake of nutrients by soft chess as influenced by the fertilizers and by brush control treatments and grazing. The column labeled grass is an average of the fire and herbicide follow-up treatments, because there was little difference in grass or nutrient uptake between these two treatments. The largest increase in grass yield occurred on grazed grass-covered soils where yields were about six times greater than those of the brush soils when no N was applied, and about three times greater where either no P or no S was applied. When N, P, and S were applied together, the increase in grass yield due to change in cover type was 1.3-fold (3.5 ÷ 2.7 grams per pot), indicating that most of the deficiencies were satisfied by N, P, and S. However, other nutrients may be involved, or different rates of N, P, and S may bring additional response. Differences between soils from the ungrazed plots were much smaller.

Uptake of N by unfertilized soft chess was about six times greater from grazed grass soil than from brush soil. The increase was 1.8-fold when N, P, and S

TABLE 1. Chemical properties of soils sampled in 1979 from plots converted from brush in 1956, as affected by follow-up treatment

Follow-up treatment	OM*	N	Inorganic N	S	Bray No. 1 P
	%	%	*ppm*	*ppm*	*ppm*
Ungrazed					
None (brush†)	5.6	.13	5.1	83	7.0
Fire (grass†)	5.2	.13	7.9	97	7.2
Herbicide (grass†)	4.7	.13	7.2	71	4.8
LSD (.10)	N.S.	N.S.	2.1	8	N.S.
Grazed					
None (brush†)	6.7	.17	7.8	94	5.5
Fire (grass†)	6.1	.19	44.1	116	10.6
Herbicide (grass†)	7.0	.20	35.6	123	12.8
LSD (.10)	N.S.	.03	23.6	22	6.8

* OM = organic matter.
† Cover type in 1979.

TABLE 2. Yield and nutrient uptake by soft chess in pots as affected by grazing, fertilization, and cover type conversion treatments

	Ungrazed			Grazed		
Fertilizer	Brush	Grass*	LSD†	Brush	Grass*	LSD†
	Grass yield (g/pot)					
NPS	2.6	2.9		2.7	3.5	
PS	0.3	0.4		0.3	1.7	
NS	1.0	0.8	0.3	0.6	1.9	0.5
NP	0.9	1.6		0.9	2.5	
Check	0.2	0.3		0.2	1.3	
	N uptake (mg/pot)					
NPS	42	51		41	72	
			6			14
Check	4	6		4	27	
	P uptake (mg/pot)					
NPS	9.0	7.7		8.2	10.4	
			0.8			1.3
Check	0.6	0.7		0.5	2.5	
	S uptake (mg/pot)					
NPS	5.6	6.8		4.8	6.8	
			0.7			0.8
Check	0.3	0.6		0.4	1.7	
	K uptake (mg/pot)					
NPS	53	66		53	81	
			11			13
Check	5	8		5	34	

* Mean of herbicide and fire control follow-up treatments of brush.
† LSD 0.05. LSDs within each yield and nutrient uptake section apply to the fertilizer and brush control treatment interactions.

TABLE 3. Botanical composition (live ground cover) in May 1979 of grass plots converted from brush in 1956 as affected by follow-up treatment (herbicide vs. fire) on ungrazed and grazed plots

	Ungrazed		Grazed	
	Herbicide	Fire	Herbicide	Fire
	% live ground cover			
Annual grass*	11	3	22	27
Perennial grass†	12	6	10	11
Erodium spp.	2	0	30	29
Legumes‡	5	1	18	11
Other forbs	4	4	1	1
Brush	0	2	0	3
Total	34	16	81	82

* Dominant species; red brome (*Bromus rubens*) in ungrazed; soft chess in grazed.
† Hardinggrass and Palestine orchard grass.
‡ Native annual *Lotus* spp. in ungrazed; native annual *Trifolium* spp. in grazed.

were applied. Uptake of N from ungrazed grass cover soils was about 1.5 times greater than from ungrazed brush soil when no fertilizer was applied, and 1.2 times when N, P, and S were applied. In pots with grazed soils, P and S uptake due to brush conversion to grass increased about four- to five-fold with no fertilizer applied and about 1.3-fold when N, P, and S were added.

When soil cover was converted from brush to grassland and grazed by herbivores for 23 years, available soil nutrients were higher than in comparable soil where grassland species were not grazed or where the cover type reverted back to the original brush. Nitrogen increased most, but available P and S also increased. Ca, Mg, and K were also taken up in greater amounts from grazed grass-covered soils than from brush-covered soils.

Several factors may have contributed to the increase in soil fertility. From previous work, we know that crushing and burning the brush increased the availability of soil nutrients immediately after a burn. These nutrients were then held in the surface soils by the shallower fibrous root systems of the grassland cover (table 3). A more rapid cycling of nutrients in the grazed plots may have increased the level of their availability. Previous pot studies have indicated that soils sampled from grazed subclover-grass pastures yielded much more ryegrass than did soils from ungrazed pastures. Grazing also resulted in a large increase in legumes (table 3) and, thus, in additional N fixation, accounting for a substantial increase in available N. Finally, brush soils have virtually no herbaceous ground cover beneath the brush, and erosion is often clearly visible. Such an environment is not conducive to holding nutrients or to soil formation.

Overview of test plots for 23-year soil-fertility study at Hopland Field Station.

Ungrazed plots one year after reburning.

Pot studies compared nutrient uptake under various treatments: C, chemically controlled brush regrowth, not grazed; C+, grazed; F, fire-controlled regrowth, not grazed; F+, grazed; check, no control of regrowth, not grazed; check-plus, grazed.

Milton B. Jones is Agronomist, Department of Agronomy and Range Science; Robert L. Koenigs is Post Graduate Researcher; Charles E. Vaughn is Staff Research Associate; and Alfred H. Murphy is Superintendent. All are at the University of California Hopland Field Station, Hopland.

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