Species Composition Changes in Seeded Grasslands Converted from Chaparral[1]

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Highlight

Perennial and annual grass composition changes were studied for several years in two locations formerly dominated by chaparral. Hardinggrass, smilo, and desert wheatgrass increased but other seeded perennial grasses decreased in abundance. Annual grasses and weeds fluctuated from year to year but generally increased in abundance.

A major problem in the conversion of chaparral to grassland is the selection of adapted grass and legume species to seed areas once dominated by brush. The term "conversion" is used to describe the several steps used to bring about a significant change in vegetation type. In some instances the change may be long-lasting while in others it may be only temporary. The permanency of the conversion often depends upon follow-up practices and the use of adapted seed species. Recommendations of various workers summarize the observed adaptation of forage species over a considerable range of environments and conditions (Love, 1956; Williams et al, 1957; Edmundson and Cornelius, 1961).

One aspect of brush-to-grass conversion that has not been reported in detail is the change in species composition during a period of years following the initial conversion. Of considerable importance as a means of evaluating many of the recommended species would be a record of the persistence of some seeded species and the gradual decline of others. Also important is the changing role played by resident annual species in the composition of a seeded area.

This paper reports results from two conversion projects in which an annual record of species composition was maintained for several years. Projects were at the Tule Springs Demonstration Range in San Diego County and the Manley Ranch Demonstration Range in Tulare County.

The Tule Springs Project was initiated with the cooperation of the Cleveland National Forest, U. S. Forest Service; Curt Massey, rancher-permittee; and the University of California. Valuable assistance was also received from the California Division of Forestry. The Manley ranch was sold to Mr. Buryl Hyde after work was begun. We wish to acknowledge excellent assistance of each cooperator.

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Study Areas and Methods

The Tule Springs Range.—Establishment of the Tule Springs Range followed a wildfire in 1950 which burned 63,000 acres of brushland in southeastern San Diego County. Considerable interest was expressed by ranchers and other local citizens concerning the possibility of avoiding recurrences of extensive wildfires by replacing dense brush with desirable forage species of minimum fuel volume. A range project was established to develop and demonstrate chaparral conversion techniques, to test on-site adaptation of forage species, and to study the persistence of newly established species.

The Tule Springs Range is located approximately 13 miles north of Alpine, California within the Cleveland National Forest at an elevation of 2500 feet. The average annual rainfall for the years 1950-1962 was 17.05 inches. Rainfall occurs generally during the months of November to May, but more than 65% falls in the 4-month period December to March. The great variation in rainfall within each year and from year to year poses a problem in seedling establishment and stand persistence. For example, in the winter of 1951-52, total rainfall was 33.8 inches as contrasted with 5.63 inches in the winter of 1960-61.

Soils of the area are typically residual, developed on granitic parent materials, and have been described as various phases of the Fallbrook series. Organic matter and moisture retention capability are low. The pH ranges from 6.0 to 7.0. Soil depth varies from a few inches to 5 feet. Frost heaving is not a problem, although occasional snowfall may occur. The area is subject to severe desiccating east winds from the desert, locally known as "Santanas," yet the Pacific Ocean is 40 air miles to the west.

Chamise *(Adenostoma fasciculatum)* with interspersed manzanita *(Arctostaphylos* spp.), buckwheat *(Eriogonum* spp.), buckbrush ceanothus *(Ceanothus cuneatus)*, California scrub oak *(Quercus dumosa)*, sage *(Salvia clevelandii)*, sugar sumac *(Rhus ovata)*, deer vetch *(Lotus scoparius)*, sunrose *(Helianthemum aldersonii)*, and California snakeweed *(Gutierrezia californica)* were brush species common to the area prior to conversion. Some of the common herbaceous species were: Filarees *(Erodium botrys* and *E. cicutarium)*, red brome *(Bromus rubens)*, needlegrasses *(Stipa* spp.), wild oats *(Avena barbata)*, and *Lotus* species.

The range was developed as a series of progressive brushland manipulation projects consisting of four pastures: A, B, C, and D (Fig. 1). Most of the data for this report were obtained from pastures B and C.

Pasture A was the proving ground for a succession of developments. It was within the 1950 wildfire area and contained 150 acres of tillable land. A "shotgun" mixture of perennial and annual species was broadcast following the fire.

Pasture B was started in 1952 when 40 acres of standing brush were disked and seeded but not burned. The balance of Pasture B, 140 acres, and all of C were control-burned by Forest Service personnel in August, 1953. After the control burn the burned portion of Pasture B was disked, then broadcast-seeded to selected forage species, and disked again for seed coverage.

Pasture C, containing 86 acres of tillable land and lying within the control burn, was disked and seeded to cereal oats in the fall of 1953. During the fall of 1954, the pasture was disked again, and band-seeded with a mixture of species by means of a commercial grain drill adapted for the drilling operation (Walker and Kay, 1955).

Pasture D was on the perimeter of the Inaja wildfire of 43,000 acres that burned to the northern edge of the demonstration range in 1956. Direct seeding into the burned chaparral with no seedbed preparation was accomplished in January, 1957, with the use of a heavy-duty range drill, designed by the Arcadia Equipment Development Center of the U.S. Forest Service.

One year after the seeding, the sprouting brush in each pasture was sprayed with a 2% solution of 2,4-D low-volatile ester plus 1% diesel oil. The amount of 2,4-D averaged from 2 to 4 lb/acre depending upon the density of the brush.

Manley Ranch Demonstration Range.—The Manley (now Hyde)

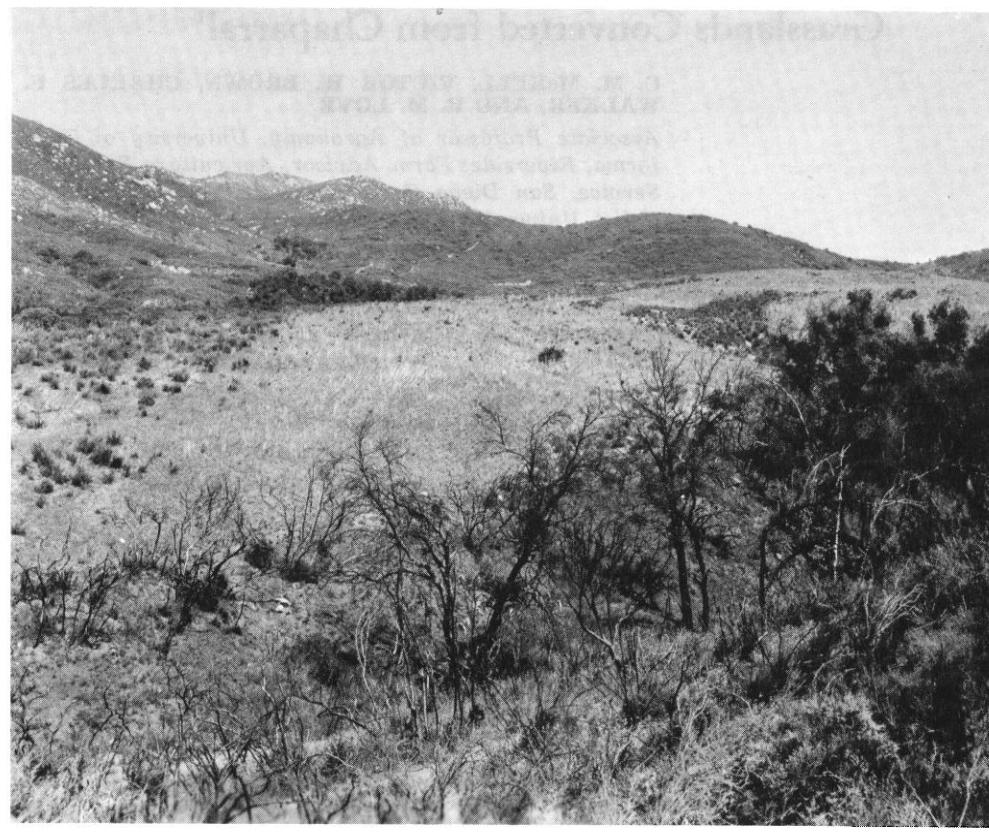

FIGURE 1. Tule Springs Demonstration Range, 1956. Conversion of chaparral to grassland on upland areas and retention of brush in gullies and ravines of Pasture C. Area was drill-seeded.

Ranch is located in the Sierra Nevada foothills at an elevation of approximately 3000 feet near the town of Badger in Tulare County. Average annual precipitation is near 35 inches, occurring principally as rain but also as snow during winter.

Demonstration and research work were initiated at this location because the environment was substantially different from other demonstration range locations in the state. The ranch extends to the upper edge of a ponderosa pine forest and supports a mixed chaparral vegetation principally of chamise, manzanita, live oaks *(Quercus* spp.), redbud *(Cercis occidentalis)*, redberry buckthorn *(Rhammus crocea)*, and scattered trees of digger pine *(Pinus sabiniana)* (Fig. 2).

Work at the Manley Ranch started in a 300-acre pasture which was control-burned in August, 1951 and seeded by airplane in September, 1951. Successes and failures experienced there were used as a guide to range improvement practices on a 1000-acre pasture where more complete records were obtained.

The 1000-acre pasture was control-burned in August, 1956, following months of preparation which included: crushing the brush with a bulldozer to concentrate the fuel; construction of fire breaks around the perimeter; and study of wind patterns to determine the best placement of five lines of electric ignition devices for firing the interior of the area at the same time the perimeter was fired.

After a successful control burn, most of the area was broadcast-seeded by aircraft with a mixture of species. At the same time, small plots were established with the use of the heavy duty range drill. In late October a rain of about 1.75 inches was followed by warm dry weather. A fair to good grass stand resulted from the broadcast-seeding, but the best stand occurred in the drill-seeded area.

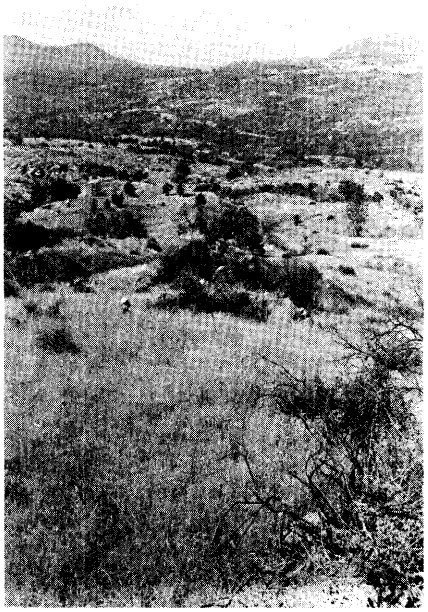

FIGURE 2. Manley Demonstration Range, 1957. One of the 5 type acres in the 1,000 acre pasture. The area was seeded by airplane after burning.

Forage Inventory

At the Tule Springs Range a forage inventory was conducted in Pastures B and C by means of the step-point method (Evans and Love, 1957). At the full flowering stage of perennial grasses, 50 points were sampled along each of 6 transects for a total of 300 points per pasture. Thus, over a 9-year period a record of changes in composition of the herbaceous ground cover was obtained.

In B pasture hardinggrass *(Phalaris tuberosa* var *stenoptera)*, smilo *(Oryzopsis miliacea)*, and veldtgrass *(Ehrharta calycina)* increased for the first 4 years, and in the following 3 years only smilo continued to increase (Table 1). In 1962, perennial grasses suffered a loss in ground cover which was taken up primarily by soft chess *(Bromus mollis)*. Over the 8-year period, weedy annual grasses indicated a continued increase.

In Pasture C, hardinggrass predominated more than smilo. After the sixth year veldtgrass failed to show up in the forage inventory (Table 2), although it is becoming part of the "landscape" among surrounding brush plants.

The 1962 perennial grass cover was about half that of the previous year. As in Pasture B, there had been a steady increase in weedy annual grasses. Leg-

Table 1. Species composition changes in Pasture B, Tule Springs Demonstration Range from 1955 to 1962. Data in percent species cover.[1]

	4/24 1955	4/29 1956	5/31 1957	4/12 1958	5/14 1959	5/2 1960	5/4 1961	5/2 1962
Perennials								
Hardinggrass[2]	1.7	2.5	4.0	6.3	2.7	5.6	3.0	0.7
Veldtgrass[2]	1.3	1.4	2.1	2.3	0.5	1.0	0.4	6.3
Smilo[2]	1.2	2.4	4.7	7.5	9.1	10.9	16.3	
Orchardgrass[2]	0.1							
Brome 25[2]	0.5							
Tall fescue[2]	0.1		0.1	0.3				
Annuals								
Soft chess[2]	3.3	3.9	4.0	20.0	7.4	14.6	7.8	14.1
Italian ryegrass[2]	2.8	8.3	6.8	7.3	0.2	1.0	0.1	
Wild oats	0.2							
Red brome	0.1	0.1	0.6	4.4	4.3	7.7	13.0	14.9
Ripgut	0.1			1.6	0.1			
Foxtail fescue				0.3	0.1	0.5	0.4	0.3
Filaree					0.2	0.1	0.2	0.8
Downy chess					0.7	0.1	0.4	0.1
Legumes								
Rose clover[2]		0.1						
Alfalfa[2]								0.1
Misc. Weeds	0.6	0.3	0.7	2.0	0.7	3.5	1.4	3.7
TOTAL GROUND COVER %	12.0	19.0	23.0	52.0	26.0	45.0	43.0	41.0

[1] Numbers in table represent the percentage that each species contributed to the total herbaceous ground cover. Three hundred step-points plus 20 square foot cover estimates were recorded from each pasture per year.
[2] Species that were broadcast-seeded during the fall of 1953.

umes, particularly rose clover *(Trifolium hirtum)*, persisted in Pasture C.

Differences noted in the forage inventory of the two pastures may be attributed to several causes. Hardinggrass and smilo were the predominant species in the two seeded pastures. While both were planted, smilo was more abundant in Pasture B which was broadcast-seeded and disked. Hardinggrass predominated where drill-seeding and band fertilization was followed. The banding of legume seed over phosphate fertilizer (11-48-0) may have been responsible for the retention of rose clover in Pasture C. Although only 0.25 lb/acre of soft chess was seeded originally, the high incidence of this species in Pasture B indicates its great reproductive and competitive abilities. Red brome *(Bromus rubens)* was the dominant weedy annual grass in both pastures and after 11 years Italian ryegrass *(Lolium multiflorum)* was a very minor component of both.

Considerable variation is evident in the amount of vegetative ground cover from year to year. Perennial grasses show a much higher degree of stability over a period of average and dry years than the annual grasses. A combination of perennial grasses for stability and prolonged green feed production and annual grasses for opportune use of extra moisture and fertility provides maximum ground cover and forage production.

The growing seasons of 1958-59 and 1960-61 were well below average in precipitation. During the summer of 1962, estimates were made of plant mortality and plant size of the sown perennial grass species by using a modification of the step-point method of analysis (Table 3). At each step-point, the total basal area in square feet and basal area consisting of dead portion (if any) of the nearest plant of the species under consideration were recorded. Totally dead plants were also noted. A one square foot frame was used by each observer to assist in these estimations.

After careful study of root crowns in an exclosure it was estimated that dead crowns of the perennial species would remain recognizable for at least 2 or possibly 3 years. Thus, this analysis records the plant mortality which occurred after the low rainfall years, 1958-59, 1960-

Table 2. Species composition changes in Pasture C, Tule Springs Demonstration Range from 1955 to 1962. Data in percent species cover.[1]

	4/24 1955	4/29 1956	5/31 1957	4/12 1958	5/14 1959	5/2 1960	5/4 1961	5/2 1962
Perennials:								
Hardinggrass[2]	2.9	4.3	11.7	11.7	8.3	9.6	11.8	5.1
Veldtgrass[2]	1.5	2.5	0.8	1.2	0.2	0.3		
Smilo[2]	0.3	1.0	0.8	1.2	1.4	0.6	1.6	1.0
Needlegrass								0.2
Annuals:								
Soft chess	0.1	0.3	1.3	2.9	1.4	2.0	0.8	4.4
Italian ryegrass	0.4	4.0	8.9	13.1	0.8	0.4	0.7	0.1
Cereal oats[3]	2.1	3.3	5.6	0.4	0.6			
Wild oats						1.0	0.3	0.7
Red brome	0.1	1.2	2.5	2.5	3.4	5.1	10.9	11.6
Ripgut			1.7	12.2	6.1	2.9	4.2	3.2
Foxtail fescue			0.2	0.8	0.1	0.5	0.3	0.7
Filaree			0.2	0.2	0.4	1.2	3.9	8.2
Legumes:								
Rose clover[2]	1.0	4.1	3.8	5.2		0.6	1.3	1.5
Alfalfa[2]	0.4	0.4	0.6	0.2				
Lotus spp.	0.1	0.1						
Bur clover							0.1	0.2
Misc. Weeds	1.1	2.8	0.4	6.4	2.3	3.8	6.1	7.0
TOTAL GROUND COVER %	10.0	24.0	38.5	58.0	25.0	28.0	42.0	44.0

[1] Numbers in table represent the percentage that each species contributed to the total herbaceous ground cover. Three hundred step-points plus 20 square foot cover estimates were recorded from each pasture per year.
[2] Species that were included in the drill-seeding, fall of 1954.
[3] The pasture was broadcast-seeded to tame oats in the fall of 1953.

Table 3. Summary of plant mortality in 1962 in pastures following three years of drought; Tule Springs Range.

Pasture	Species	Total no. of plants	Dead plants %	Mean basal area/ plant sq ft	Dead area of plant crown %
Pasture A S. Exposure	Hardinggrass	10	20.0	0.7	78
	Smilo	17	17.6	0.6	58
Pasture A N. Exposure	Hardinggrass	88	35.2	0.7	72
	Smilo	71	26.7	0.5	56
Pasture B	Hardinggrass	68	14.7	0.3	51
	Smilo	244	23.4	0.4	52
Pasture C	Hardinggrass	244	10.7	0.4	47
	Smilo	149	17.4	0.3	47
Pasture D	Hardinggrass	22	0	0.3	35
	Smilo	21	0	0.23	25
	Veldtgrass	50	2	0.1	15

61, and 1961-62.

Large differences were apparent between pastures in both total plant mortality and proportion of dead area in living plants. In general, plant mortality was highest in Pasture A and lowest in pasture D. Hardinggrass mortality on the north exposure of Pasture A was high both in plant numbers and in proportion of dead area in living plants.

Large differences were also apparent in the mean basal area of plants. In Pasture B where smilo was dominant over hardinggrass, the mean basal area of smilo was nearly twice that of hardinggrass. In Pasture C where hardinggrass was more abundant, the mean basal area of each species was more nearly equal. The mean basal area of all species in Pasture A, the oldest pasture, was large in contrast with the small mean basal area in Pasture D.

Each species survived the three drought years very well on most sites. Only in Pasture A was there a high rate of plant mortality. Several possible causes for this are being investigated.

Forage inventory at the Manley Ranch Demonstration Range consisted of selecting five type-acres within the aerial-seeded 1000-acre pasture for yearly sampling by the step-point method. Five transects of 20 points each were sampled in each type-acre in the same general location for 6 years.

The general trends in vegetation composition are toward a decrease in the amount of perennial grasses in relation to the total vegetative ground cover (Table 4). Significant changes in the importance of various seeded species during the 6-year period were observed. Perennial ryegrass *(Lolium perenne)* and orchardgrass *(Dactylis glomerata)* decreased in contrast with a general increase in smilo and hardinggrass. The final year of the inventory was one of less than average rainfall and undoubtedly accounted for the overall reduction of percent ground cover as compared with the previous year.

By the end of the sixth year the short-lived perennial ryegrass was of minor importance. The persistence of such seeded species as smilo, hardinggrass, intermediate wheatgrass *(Agropyron intermedium)* and desert wheatgrass *(Agropyron desertorum)* is also important in evaluating the benefits of a brush to grass conversion program.

Species Evaluation

From our evaluations in the two study areas and in other locations certain characteristics of the successful species appear to be important in choosing species for seeding.

Hardinggrass is a long-lived, palatable, and dependable perennial species on both the Tule Springs Range and the Manley Ranch where it does best in the deeper soils. Hardinggrass has low seedling vigor and, therefore, reseeds well only under favorable circumstances. The initial stand thins out until the density of plant populations appears to be balanced. Most plants of hardinggrass appear to persist well under moderately close grazing.

Smilo has a stem characteristic that renders it lower in palatability than hardinggrass or veldtgrass. The older stems become quite fibrous, and the plants should be closely grazed occasionally to keep them attractive to livestock. However, the stems remain green near the base and new leaves are often produced on old stems. Smilo persists on the poorer soils found on many range sites, and it is the principal species found in Pasture B where the seeding technique involved broadcasting and disking for seed coverage. Smilo produces abundant seed and it has become part of the "landscape" in some areas of the Santa Barbara, Ventura, Orange, and San Diego counties.

Veldtgrass is the most palatable of the perennial bunch grasses seeded at the Tule Springs Range. It is also a prolific seed producer and reseeds readily. However, its high degree of palatability presents problems in grazing management when sown in combination with other species because it is grazed

Table 4. Species composition changes from 1957 to 1962 in a 1,000-acre pasture at the Manly Demonstration Range, Tulare County. Data in percent species cover.[1]

Seeded grass species	1957	1958	1959	1960	1961	1962	Significance among years (.05 level)
Perennial ryegrass	4.42	15.78	2.32	1.90	.70	.56	*
Smilo	1.81	7.38	2.46	4.45	7.64	2.99	*
Hardinggrass	1.69	3.46	2.18	5.68	9.08	7.27	*
Orchardgrass	6.94	5.13	1.80	1.92	.88	.72	*
Desert wheatgrass	1.31	1.44	.81	1.86	2.08	1.11	N.S.
Tall fescue	.84	1.82	.22	1.08	.60	.66	N.S.
Tall oatgrass	1.08	1.23	.43	.58	.30	.33	N.S.
Mountain brome	1.21	.48	—	—	.42	.19	N.S.
Intermediate wheatgrass	.61	.66	.39	.41	1.14	.66	N.S.
Total seeded species	19.91	37.38	10.61	17.88	23.40	14.48	
Total Ground Cover (all species)	32.40	58.00	24.00	51.40	75.40	59.40	
Seeded Species as % of Total Ground Cover	61.45	64.44	44.20	34.70	31.03	24.39	

[1] Five hundred step-points plus 50 square-foot cover estimates were recorded each year.

more intensively than the other species. Veldtgrass is found growing within the cover of brush plants, on the steep banks of the barrancas, and beyond the fences around the pastures.

Soft chess is common in most annual range areas. At Tule Springs Range it was included at a light seeding rate in Pasture B to occupy the interspaces between perennials. This annual is palatable in all stages of maturity. It was not included in the general seeding in C pasture, and most of the interspaces there now support the less-desirable red brome and ripgut *(Bromus rigidus)*, both unpalatable when mature due to stiff, scabrous awns on the lemmas.

Rose clover persisted in Pasture C where phosphate was applied during initial seeding and again in 1957. Colonies formed in C and D pastures but at the termination of the study were still not a major forage source. Soil-moisture stress is a serious factor in limiting the success of this late-maturing accession at the Tule Springs Range. At the Manley Demonstration Range rose clover produced excellent stands where it was drill-seeded and fertilized. Very few plants were evident in the broadcast-seeded area.

Ryegrasses, both perennial and annual, have a vigorous seedling habit and are valuable for the rapid growth they produce in the early years after seeding. When less vigorous species are used in a mixture the intense competition from the ryegrasses can be a disadvantage. Persistence of the ryegrasses is of short duration and these species will be replaced in the total composition either by the longer-lived perennials or annuals.

Summary

Vegetation analyses of two brush-to-grass conversion projects were conducted for several years following seeding, and provide valuable information on the persistence or decline of various species. Species composition changes were studied for 9 years at the Tule Springs Range, San Diego County, California and for 6 years at the Manly Demonstration Range in Tulare County.

The changes in species composition consisted primarily of an increase in such perennial grasses as hardinggrass and smilo at Tule Springs Range, and these two grasses plus crested wheatgrass at the Manley Demonstration Range. At both locations, several perennial grass species which made average or better initial stands were almost totally missing from the pastures at the end of the study. Of the seeded annual grasses, ryegrass decreased rapidly from the stand in contrast to a large increase in soft chess.

In all pastures there was a substantial increase in non-seeded annual grasses and weeds. The annual species showed the greatest fluctuation from year to year in relation to the amount of precipitation.

Mortality of perennial grasses is high in dry years but many grasses survive even though a portion of the crown area dies. Long-term stability and persistence of several perennial grass species is evident from the records of the conversion projects described in this paper.

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