Reseeding to Aid Conservation of Annual Forage Range

H. W. MILLER, O. K. HOGLUND AND A. L. HAFENRICHTER

Nursery Manager and Nursery Agronomist, Soil Conservation Service, Pleasanton, California, and Chief, Regional Nursery Division, Soil Conservation Service, Portland, Oregon

IMPROVING the quantity and quality of forage is the best method for achieving conservation on range lands. In the foothill section of California, the annual forage range has a short green feed period and varies widely in production from year to year (Bentley and Talbot, 1951). Fertilization lengthened the green feed period and reduced the fluctuation in production (Hoglund *et al.*, 1952). Reseeding of suitable sites with adapted and improved perennials is another means of advancing range conservation. The perennials have a longer green feed period and a more consistent level of forage production (Love and Jones, 1952). They usually have a more extensive and deeper root system than annuals. Establishment of perennials requires proper site selection, cultivation to reduce competition, precision seeding, and protection.

This paper reports the results of trials conducted by the Pleasanton, California Soil Conservation Service Nursery to determine the best and most practical methods for establishing perennials on the annual forage range.

This work was conducted by the Nursery Division, Soil Conservation Service, U. S. Department of Agriculture, Pleasanton, California, in cooperation with the University of California Agricutural Experiment Station, Davis, California.

METHODS

Work on the establishment of perennials was begun in the fall of 1943 at Sunol, California on typical annual forage range owned by the City of San Francisco Water Department. The annual rainfall averages 16 inches. Prior to 1920, the land had been dry-farmed to grain, but low yield resulted in its being abandoned and used for grazing. Weir and Storie (1936) rated the soil as grade 4 (35 percent) and tentatively mapped it as Positas gravelly clay loam. The site was placed in land capability classes III and IV in a recent Soil Conservation Service survey. Erosion had removed from 25 to 75 percent of the surface soil. A stiff, red clay subsoil, 2 to 8 inches thick, was present at depths varying from 6 to 24 inches below the surface. This clay pan retards the downward movement and retains moisture.

Four methods of land preparation were used. In two of the methods the initial tillage operations were started in the spring before the earliest annuals produced seed. A summer crop of sudan grass for hay was then seeded to complete the preparatory land treatment in one method, and clean fallow was used in the other. The sudan grass was fertilized with 100 pounds per acre of ammonium sulphate (20-0-0) at the time of seeding. In the other two methods used to prepare land for seeding, the tillage operations were started in the fall. The land was worked and seeded to red winter oats for hay and to purple vetch for green manure as preparatory crops.

After the season of preparatory treatment and following the first fall rains, the land was disked, harrowed, and rolled to

prepare a fine firm seedbed. Two types of seeding were used to plant an adapted mixture—drilling shallow with a 10-foot double-disk grain drill equipped with depth regulators, and broadcasting. The broadcast seeding was done with the same drill by pulling the spouts and letting the seed mixture fall directly on the ground. All broadcast seeded plots were harrowed and rolled after seeding. The same mixture was seeded on an unprepared check plot at the same time. All plots were 10 by 400 feet and laid out on the contour.

The mixture used was Harding grass (*Phalaris stenoptera*), 4 pounds; burnet (*Sanguisorba minor*), 3 pounds; and Mt. Barker subterranean clover (*Trifolium subterraneum*), 5 pounds per acre.

One-half of each plot was fertilized with 200 pounds per acre of ammonium phosphate-sulphate (16-20-0) at the time of seeding and each fall thereafter.

A new series of seedings was made each year for four years to check the effect of climate on establishment. There were no replications within years, although the trials were designed to obtain an estimation of soil variation.

Stands were determined by an adaptation of the inclined point quadrat method which allowed the results to be expressed in numbers of plants per square foot. Two hundred point quadrat counts were taken per treatment about two months after seeding. All plots were clipped twice during the establishment year in order to reduce competition from the resident annuals. Air-dry yields of these clippings were obtained. In the second and subsequent years, production was determined by taking four $\frac{1}{4000}$ acre quadrats, 3.3 by 3.3 feet, per plot at the hay stage of the perennials. The Harding grass and resident annuals were separated and weighed.

Results and Discussion

Good stands of all seeded species were obtained on all tilled plots. There was an average of slightly more than 20 plants of the seeded species per square foot and a little more than half of them were Harding grass. This is shown in Table 1. No seedlings of seeded forage plants were ever obtained from the unprepared land.

TABLE 1

The influence of methods of land preparation on the establishment of three planted forage species and the density of volunteering annuals

TREATMENT AND CROP	PLANTS PER SQUARE FOOT			
	Harding grass	Subterranean clover	Burnet	Resident annuals*
Spring tilled				
Sudan grass..	11.75†	7.07	3.30	33.99
Summer fallow.....	13.68	6.49	3.53	30.03
Fall tilled				
Grain hay...	8.34	7.30	3.07	47.75
Purple vetch.....	7.80	6.41	3.34	77.42
Average...	10.39	6.82	3.31	47.30

* Annuals in order of importance were: *Festuca megalura, Hordeum murinum, Bromus rigidus, B. mollis, Avena fatua,* and *Erodium botrys.*

† Each value is the average of 32 determinations.

The data in Table 1 show that the method of preparing land for seeding influenced the number of seedlings that were established. The Harding grass stands were influenced more by land treatment than were those of subterranean clover and burnet. Preparing the land and growing a crop of sudan grass or fallowing was better for the establishment of the seedlings of perennials than preparation for and growing crops of winter oats or purple vetch. Spring tillage was used for the sudan grass and the fallow, but fall tillage was used for the oats and vetch. Spring tillage

followed by sudan grass or fallow was more effective in reducing the growth of resident annual forage plants than was fall tillage followed by a grain or green manure crop. The greatest density of competing annual forage plants resulted from the disking down of the vetch crop. The vetch contained annuals, and the method of land treatment by which vetch was grown kept all of the seed of the annuals on the plots. The winter oats contained a small amount of annuals, some of which matured and shattered seed before the oats were cut for hay. There were some broad-leaved annuals in the sudan grass, but they were less competitive to the planted species than were the annual grasses.

In Table 1, data for fertilized and unfertilized plots in each treatment were averaged because there were no significant differences in initial stand due to the use of fertilizer.

TABLE 2

The influence of method of seeding and fertilizer on number of plants per square foot 60 days after seeding

SEEDING METHOD	PLANTS PER SQUARE FOOT			
	Harding grass	Subterranean clover	Burnet	Resident annuals
Fertilized				
Broadcast	9.23*	8.02	2.94	55.59
Drilled	10.58	6.12	2.35	46.00
Average	9.90	7.07	2.64	50.79
Not fertilized				
Broadcast	9.04	6.75	3.70	47.75
Drilled	12.87	6.35	4.23	39.83
Average	10.95	6.55	3.96	43.79
Average for broadcast	9.13	7.38	3.32	51.67
Average for drilled	11.72	6.23	3.29	42.91

* Each value is the average of 32 determinations.

The effect of method of seeding on the number of plants per square foot 60 days after planting is shown in Table 2. The effect of the seeding methods was similar on each of the four land treatments. More Harding grass seedlings were obtained by drilling than by broadcasting. The difference was 28 percent. More resident annual forage plants volunteered on the broadcast than on the drilled plots. More subterranean clover plants resulted from broadcasting than drilling. The results with burnet depended on whether fertilizer was used. The result with Harding grass was the most important, because this perennial was the one among the seeded species that later contributed the forage. Drilling was superior to broadcasting even though special care was taken to prepare a good firm seedbed for broadcasting. It was superior especially when unfavorable moisture conditions occurred in the 1947–48 season. The data are not shown, but in this season the average number of Harding grass plants obtained from drilling and broadcasting were 16.91 and 7.55, respectively.

More plants of Harding grass and burnet and fewer of subterranean clover and resident annual forage species were found when no fertilizer (16-20-0) was applied, Although the differences are small, this result, when combined with subsequent yield data, allows the conclusion that fertilizer should not be applied at the time of seeding.

The seeded species, Harding grass, subterranean clover, and burnet, did not produce enough growth to measure during the first season. Resident annual grasses, legumes, and forbs always volunteered and produced a measurable crop. The resident annuals were clipped twice, about March 15 and April 15, because they offered competition for moisture, plant nutrients, and light. The amount of growth was measured and the major

differences in kind of annuals were recorded. The differences in kind and amount of resident annuals were due primarily to the treatment of the land before seeding. The use of fertilizers increased the amount but did not influence the kind of annuals on the plots.

Table 3 shows the total average yield of the two first-year clippings for all 4 years. More growth was always obtained when fertilizer was applied. When fertilized, the production of annuals was greatest following the vetch crop and the least following sudan grass. When no fertilizer was used, the greatest yield was again from the vetch plot but the least was from grain hay. Growing a crop of sudan grass was effective in reducing competitition from volunteering resident annuals whether fertilizer was applied or not.

TABLE 3

The influence of preparatory land treatment and fertilizer on first year resident annual forage yields

	YIELDS OF VOLUNTEERING ANNUALS				
	Sudan	Fallow	Grain hay	Vetch	Average
	Tons per acre, air-dry				
Fertilized	0.99*	1.24	1.28	1.58	1.27
Not fertilized	0.70	0.70	0.55	1.09	0.76
Average	0.84	0.97	0.91	1.33	

* Each value is the average of 8 plots and is the total of 2 clippings.

Forbs were the dominant annuals on the spring-tilled plots (sudan grass and fallow) while grasses were dominant on the fall-tilled plots (grain and vetch). The annual grasses appeared to offer more competitition to the seeded species in the establishment year than did the forbs.

The yield of the seeded species was influenced by the previous land treatment and by the application of fertilizer. The yield was also influenced by the age of stand. The data are shown in Table 4.

The only seeded species that contributed to the harvested yield was Harding grass. Subterranean clover and burnet were absent from the fertilized plots. These two species are not shade tolerant and harvesting the seeded species as hay eliminated them. (In other trials not reported in this paper, where plots were fertilized with 16-20-0 and clipped to simulate grazing, an excellent stand of subterranean clover is present.) On the unfertilized plots, there was a stand of clover but it had passed maturity and dried so that it was a negligible part of the harvested forage. Only a few plants of burnet were in the stand due to a lack of adaptation.

The highest average yield of Harding grass was obtained when the plots were fertilized. The highest average production of this grass from the plots that were fertilized came from those which had been seeded previously to sudan grass or fallowed. On these plots, the Harding grass reached full production by the second growing season. When the land had been seeded to grain for hay or to vetch for soil improvement, however, the Harding grass did not reach full production until the fourth season, even when fertilizer was used. The reduction in the initial stand of Harding grass due to previous crop, as shown in Table 1, was responsible for this result. There were

more plants on the plots that grew sudan grass or were fallowed.

The data in Table 4 show that the yield of volunteer resident annuals was influenced more by the application of fertilizer and less by crop year and previous land treatment than was the perennial, Harding grass. The effect of reducing the stand of annuals by growing sudan grass or by fallowing was reflected in the lower average yield by the volunteering annuals. The effect was most pronounced in the second crop year, but the data indicate that the yields were lower throughout the entire period of this trial. This was probably caused by greater vigor of the Harding grass plants.

The data in Table 4 were used to determine whether or not there was a correlation between the yield of the Harding grass and the annuals. Significant negative correlations, $r = -.527$ $(N=16)$ for the fertilized plots and $r = -.500$ for the non-fertilized plots, were obtained. This indicated that there was competition between the two kinds of grass.

The average yields of both Harding grass and annuals fluctuated with the season regardless of the age of stand or previous land treatment. The data are shown in Table 5. The annuals fluctuated more than did the perennial. This was caused by the carry-over of the influence of one season on the perennial into the next. The effect of season on the volunteering annuals was direct and there was no carry-over effect. Rainfall and temperature were responsible for the effect of season. Of the two factors, rainfall appeared to be the more important.

The use of fertilizer not only increased the yields of Harding grass and annuals,

TABLE 4

The influence of preparatory land treatment, fertilizer and age of stand on yields of Harding grass and of resident annuals

Tons per acre, air-dry

CROP YEAR	FERTILIZED					NOT FERTILIZED				
	Sudan	Fallow	Grain hay	Vetch	Average	Sudan	Fallow	Grain hay	Vetch	Average
					Harding grass					
2nd	0.47*	0.54	0.16	0.17	0.34	0.20	0.23	0.10	0.09	0.15
3rd	0.41	0.45	0.25	0.25	0.34	0.27	0.29	0.20	0.19	0.24
4th	0.35	0.45	0.33	0.34	0.37	0.28	0.31	0.34	0.29	0.31
5th	0.50	0.48	0.37	0.44	0.45	0.28	0.27	0.45	0.43	0.36
Av.	0.43	0.48	0.28	0.30	0.37	0.26	0.27	0.27	0.25	0.26
					Annuals					
2nd	1.19	0.98	1.23	1.60	1.25	0.56	0.43	0.66	1.07	0.68
3rd	0.99	0.93	1.02	1.13	1.02	0.42	0.29	0.43	0.42	0.39
4th	1.10	1.15	1.26	1.37	1.22	0.37	0.31	0.49	0.63	0.45
5th	1.20	1.14	1.18	1.14	1.17	0.40	0.43	0.48	0.60	0.48
Av.	1.12	1.05	1.17	1.31	1.16	0.44	0.36	0.51	0.68	0.50

* Each value is the average from four seedings made in successive years.

but reduced the fluctuation in yield by season. The effect was greater with annuals than with Harding grass because there was no carry-over effect with the annuals.

The volunteering resident annuals in these trials were grasses. There were no broad-leafed annuals after the establishment year and only traces of bur clover.

duce soil erosion noticeably after the land was worked and seeded.

Growing grain hay, which is a winter crop in the area where these trials were made, required fall tillage. Even though an average of 1.12 tons of hay was produced, this crop did not reduce the resident winter annuals sufficiently to allow a vigorous stand of Harding grass and other species to develop.

TABLE 5

Average yield of Harding grass and annuals by season as affected by fertilizer

CROP	TREATMENT	YEAR OF HARVEST							
		1946	1947	1948	1949	1950	1951	1952	AV.
		Tons per acre, air-dry							
Harding grass	Fertilized	0.61	0.40	0.31	0.35	0.27	0.52	0.42	0.38*
	Not fertilized	0.25	0.27	0.18	0.22	0.29	0.36	0.45	0.27
Annuals	Fertilized	1.44	1.41	0.58	1.24	1.09	1.67	1.03	1.12
	Not fertilized	0.46	1.01	0.32	0.35	0.47	0.61	0.52	0.52
Total yield	Fertilized	2.05	1.81	0.89	1.59	1.36	2.19	1.45	1.50
	Not fertilized	0.71	1.28	0.50	0.57	0.76	0.97	0.97	0.79
No. of plots		8	16	24	32	24	16	8	

* These are weighted averages.

The data from these trials show that good stands of Harding grass were established in each of 4 successive years by preparing the land for a crop of sudan grass or by fallowing. Both of these methods require early spring tillage before the resident annual range plants produce seed. Fallowing apparently had no marked advantage over growing sudan grass on this land either for conserving moisture, increasing available nitrogen, or further reducing weed competition. In addition, the sudan grass produced an average of .38 tons of feed, which was equivalent to .95 AUM per acre if pastured. This feed was produced during the summer months when other forage on the range was dry. The stubble and roots of the sudan were sufficient to re-

An average of 1.41 tons of purple vetch was produced. The entire crop was returned to the soil. The principal result of this practice was to stimulate the growth of volunteering resident annuals, especially in the first season after seeding the perennials. This resulted in fewer Harding grass plants becoming established. The data in Table 4 indicate that the effect of adding 1.41 tons of residue per acre may have lasted as much as 4 seaons.

Estimates of dates of grazing readiness were made in each of 6 years, 1946 through 1951, on both fertilized and unfertilized Harding grass. An average grass height of 4 to 6 inches was used in determining range readiness. The average date the Harding grass in fertilized plots

was ready for grazing was December 15 and the green feed period averaged 23 weeks. The average date of grazing readiness on the untreated Harding grass plots was January 7, and the green feed period averaged 20 weeks. The date of grazing readiness of the Harding grass fluctuated more with the season in the unfertilized plots than in the fertilized plots. The greatest difference was in the 1948–49 season when the first effective fall rains were not received until December and temperatures were unusually low. In that season, the Harding grass on the fertilized plots was ready to graze 6 weeks before that on the unfertilized plots.

The adequate green forage period of the annuals averaged 6 weeks with grazing readiness being reached about March 15. When fertilized, the annuals were ready to graze about February 1 or 6 weeks earlier than the unfertilized annuals. Both fertilized and unfertilized annual forage dried up at the same time. This was about May 1 each year.

Summary

Trials to determine the best method for establishing a Harding grass-burnet-subterranean clover mixture on lands in the annual forage range of California were begun in 1943. The work was done near Sunol, on Positas gravelly clay loam. Average rainfall was 16 inches but fluctuated widely among the years.

Four methods of land preparation and two methods of seeding were used, with and without fertilizer. The treatments and plantings were repeated for four consecutive years and forage production was measured on each established stand for four years.

All of the seeded species were established when good methods were used, but the Harding grass was the only one that produced measurable forage, because the method and date of harvesting were unfavorable to subterranean clover and burnet.

No stands were obtained when no land preparation was used and the seedings were made directly into the stubble of the annual forage range.

The success in establishing the seeded species, as measured by plants per square foot, was governed by the degree to which land preparation and treatment suppressed the volunteering resident annuals.

Initial tillage in the early spring was superior to fall tillage in reducing the density of the resident annuals. An average of 32 plants per square foot 60 days after planting was obtained on spring-tilled land. Growing a crop of sudan grass or fallowing the spring-tilled land were equally effective in reducing the stand of the volunteering annuals. Spring-tilled lands were seeded in the fall of the same year.

Initial tillage in the fall followed by a crop of winter oats for hay or vetch for green manure, and seeding of the perennials the next fall, resulted respectively in 49 and 142 percent denser stands of volunteering annuals than when spring tillage was used. This reduced the stands of the seeded species, especially Harding grass.

Drilling was superior to broadcast seeding for the establishment of Harding grass. The average difference in stand was 28 percent, but when below-normal annual rainfall occurred the difference was 55 percent. Method of seeding did not have a great effect on the stands of burnet or clover.

There were no significant differences in initial stands of the seeded species attributable to the addition of fertilizer (16-20-0), but there was a consistent trend in favor of not applying fertilizer at seeding time.

Previous land treatment and the application of fertilizer influenced the yield of volunteering annuals in the establishment year. Fertilizer increased their production by an average of 69 percent. The increase was greatest on the fall-tilled land that grew vetch and least on the spring-tilled land that grew sudan grass. Forbs were the dominant annuals on spring-tilled plots, and grasses on those that were fall tilled.

Previous land treatment influenced the yield of Harding grass and the number of years required for it to attain full production. The average yield was higher on the spring-tilled land and full production was reached in the second growing season. Average yield on fall-tilled land was lower and full production was not reached until the fourth growing season.

The annual application of fertilizer (16-20-0) increased the production of Harding grass on all treatments and in all years. The greatest increase was on stands that reached full production in the second growing season.

The application of fertilizer increased the yields of annuals that volunteered in the Harding grass stands. The influence of the fertilizer on the yield of annuals was greater than on Harding grass but was more erratic among years. There was evidence that the effect of a seasonal factor influencing yield "carried over" in the perennial grass.

The advantage of growing sudan grass instead of fallowing in preparation for reseeding was that the sudan grass produced an average .38 tons of feed, equivalent to .95 AUM per acre if pastured. The Harding grass reached full production on land that grew sudan grass as soon as it did on the fallowed land.

Grain grown for hay in preparation for seeding produced 1.12 tons per acre but retarded the Harding grass from reaching full production until the fourth growing season.

The green feed period of the seeded Harding grass when fertilized averaged 23 weeks beginning December 15. When not fertilized, the Harding grass did not reach grazing readiness until January 7 and the green feed period averaged 20 weeks. In contrast, fertilized annual range reached readiness February 1 and the green feed period was 12 weeks.

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Comparative Costs

No studies of costs for preparing land and seeding were made. The method of using comparative costs of land preparation in large-scale operations as suggested by Stark, *et al.* (1946) was adopted. Data presented by Adams and Reed (1950) were consulted. Costs of disking, weeding, rolling, and seeding would vary between $6.10 and $7.26 per acre. Fall tillage followed by crops of grain hay or vetch was cheapest. Spring tillage followed by sudan grass was the most expensive, but the higher cost of the later method was more than offset by the value of the sudan grass crop. This method also resulted in good stands of perennials that reached full production 2 years sooner than the seedings in the fall-tilled land.

BIBLIOGRAPHY

ADAMS, R. L. AND A. D. REED. 1950. Farm management crop manual. (Revised). Univ Calif. Syllabus Series No. 306.

BENTLEY, J. R., AND M. W. TALBOT. 1951. Efficient use of annual plants on cattle ranges in the California foothills. U. S. Dept. Agr. Cir. 870. 52 pp.

HOGLUND, O. K., H. W. MILLER AND A. L. HAFENRICHTER. 1952. Application of fertilizers to aid conservation on annual forage range. Jour. Range Mangt. 5: 55-61.

LOVE, R. MERTON AND BURLE J. JONES. 1952 (Revised). Improving California's brush ranges. Calif. Agr. Expt. Sta. Cir. 371. 38 pp.

STARK, R. H., J. L. TOEVS AND A. L. HAFENRICHTER. 1946. Grasses and cultural methods for reseeding abandoned farm lands in southern Idaho. Idaho Agr. Expt. Sta. Bul. 267. 36 pp.

WEIR, W. W. AND R. E. STORIE. 1936. A rating of California Soils. Calif. Agr. Expt. Sta. Bul. 599.

IT'S STILL NOT TOO LATE TO GET A NEW MEMBER IN 1953

RANGE PHOTOGRAPHY CONTEST AND EXHIBITION

A range photography contest and exhibition will be held at the Seventh Annual Meeting of the American Society of Range Management in Omaha, Nebraska, January 26 to 29, 1954. There will be the following five divisions, the first four being black and white, and the last color:

1. Range landscape.
2. Individual range plant (without portrait lens).
3. Range conditions and fence-line contrasts.
4. Close-up (with portrait lens or higher magnification).
5. Color print, any size.

All entries must have been taken by a member of the Society. All black and white photos must be mounted, unframed, and 8 by 10-inch or larger. Any range subject is eligible with the provision that neither animals nor mechanical devices shall be the principal subject.

Photographs shall be accompanied by up to a 25-word description, plus name and address of photographer, typed on separate white background that can be attached to the bottom of the photograph with gummed tape from the back. These will be numbered at the meeting. (Names and addresses may be helpful to Society members in locating good photographs to illustrate publications.)

Individuals may enter not more than one photo in each of the five divisions. Photographs will be taken to and from the exhibition room by the member displaying them or by someone designated by the member who is attending the meeting.

Viewing members at the Annual Meeting will vote on signed ballots to be deposited in a conveniently located box. Voting will be for the one photograph the individual likes best in each division; and for the best in the show.—*H. W. Cooper*, Chairman, Display Committee.