Published in the proceedings of the X International Grassland Congress, printed in Helsinki, Finland 1966

SECTION 4
PAPER No. 14

PRINCIPLES AND TECHNIQUES IN CONVERTING NATIVE CHAPARRAL TO STABLE GRASSLAND IN CALIFORNIA

JAY R. BENTLEY, LISLE R. GREEN, AND A. B. EVANKO

Pacific Southwest Forest and Range Experiment Station, Berkeley, California, U.S.A.

Summary

After typical dense chaparral has burned, many forbs grow from seed present before the fire. Annual grasses become conspicuous by the fourth year, or earlier. Shrub sprouts and seedlings, which start growth in the first year, dominate the cover in 5 to 10 years.

Grass sown immediately after chaparral burns can alter natural succession by competing with shrub seedlings for soil moisture. This effect is temporary, unless the shrubs also are controlled with herbicides. This chemical treatment — continued until the shrubs have been virtually eliminated — completes the conversion process. The relatively stable grass cover can be maintained with little effort.

Introduction

Chaparral, as we use the term, refers to dense stands of evergreen, shrubby vegetation, dominated by species that sprout profusely after burning. The formations consist of many species with extensive root systems and the capacity to endure long, dry summers [6].

Chaparral-covered lands typically have steep terrain and shallow stony soils. On such land, much of it government owned, the primary value of chaparral is as a watershed cover. Flood hazard to adjacent areas becomes high if this cover is destroyed by wildfire. Consequently fire prevention and control is vital.

Dense chaparral is poor range for livestock and game animals. Changing it to grass on extensive areas of steep terrain is not justified. But many small areas with suitable slope gradient and productive soil can be economically developed as permanent grassland range.

Conversion to grass is usually done for one or more specific purposes, such as producing forage for livestock and game, breaking up brush fields for safer an dmore effective fire-fighting, making recreational resources more usable, or increasing water yield [1]. Instead of attempting to maintain an unstable grass-shrub mixture, the chaparall is converted to a stable grass cover. Maintenance of unstable cover is expensive, and it uses resources needed for clearing additional acreage. If maintenance falls behind, then shrubs reoccupy the site.

Chaparral species

The most characteristic and widely distributed species is *Adenostoma fasciculatum*. It commonly grows in almost pure stands, or as the dominant shrub. Such associations are called chamise chaparral; all other associations are grouped as mixed chaparral. Both types of association include *Quercus dumosa,* other scrubby *Quercus* species, *Arctostaphylos glandulosa, Heteromeles arbutifolia, Cercocarpus betuloides,* and many others species. *Rhus diversiloba* is widely spread; *R. laurina* and *R. ovata* are common in these associations in southern california.

Nonsprouting species of *Ceanothus* and *Arctostaphylos* grow commolly in all chaparral formations. Species of *Eriodictyon, Salvia, Lotus,* and *Eriogonum* are common in chamise chaparral and in some mixed chaparral — especially in southern California.

Elevation and climate

The chaparral referred to in this paper occupies several million acres on foothill and mountain slopes below commercial timber in the Central Valley and coastal valleys of California. Elevation ranges from 150 to 1400 m.

The climate is Mediterranean, but it may differ with elevation, latitude, proximity to ocean or desert, and orientation of mountain masses. Average annual precipitation ranges from about 350 to 950 mm, occurring mainly as rain, with snow falling occassionally at upper elevations. Precipitation usually starts in October, increases during the winter months and stops during spring. The dry season — typically without effective precipitation — extends over 4 to 6 months each year. Winters are cool; temperatures below 0° C. occur frequently, especially at upper elevations. Summers are hot, with maximum air temperature near 38° C. during several days each month.

Herbaceous plant growth

Few herbaceous plants produce seed annually under unburned dense chaparral, but a limited amount of seed is produced under a semi-dense cover. Soil, which is fully wet during the winter, typically dries to the permanent wilting point in the upper foot (0—30 cm) by June, and to 90 cm, or deeper, by August or September [3].

Recently burned areas

The first herbaceous cover develops from viable seed present before chaparral burns. Typical plants are annual forbs genetically pre-adapted to the fluctuating environmental conditions in chaparral subject to fire [9]. *Emananthe penduliflora* and *Phacelia* spp. are most common. Species of *Lotus, Gilia, Mentzelia, Mimulus, Oenothera,* and *Cryptantha* are also typical, [2] [5].

Native perennial grasses are scarce. Annual grasses, mainly naturalized *Bromus* and native *Festuca,* grow sparsely during the first year after chaparral has burned. They may be abundant if the chaparral was more open. Grasses usually dominate the herbaceous cover by the fourth year, or by the second if the chaparral was semi-dense.

Numerous shrub seedlings — mainly *Adenostoma, Cenothus,* or *Arctostaphylos* — grow

during the first spring if the chaparral fire occurred during the preceding dry season. Few seedlings grow on areas burned during winter or spring, when the soil surface is moist. Mortality is high during the first summer [1] [7], but many seedlings persist as part of the future chaparral cover.

For 2 years or longer after burning, the vegetation density and volume of top growth on burnt areas are much less than that of unburned chaparral. Plants use water slowly during summer. By the end of the long dry season, however, most available moisture has been removed from soils on both burned and unburned areas [3].

After 5—10 years, vigorous shrub sprouts and seedlings dominate the cover, and develop a full canopy that excludes most herbaceous plants.

Areas sown with annual grass

Sowing seed of annual grass after chaparral has burned can change the herbaceous cover for a few years, but its effects on plant succession differ by locations and years. Success of sowing depends on favorable combinations of seedbed and weather that do not occur consistently [1].

By the end of the first year, successful stands of sown *Lolium* will dominate the cover, retard forbs, and kill many shrub seedlings [1] [7]. Grass, conspicuous for 3 to 5 years, affects plant succession only temporarily. A chaparral cover usually develops after 6 to 10 years, but needs a longer period if fire has killed many sprouting shrubs and grass competition has killed most shrub seedlings.

Dense stands of annual grass, established during cool fall and winter, grow rapidly during the warm spring. They can extract all available moisture before roots of shrub seedlings, which establish in spring, can reach below the grass roots. Shultz *et al.* [7] demonstrated how grass competition controls shrub seedlings in woodland chaparral.

Yet, annual grass competition by itself cannot be depended on to control all chaparral reinvasion. Success with this method is not consistent and openings exist, even in the most successful grass stands. Deep-rooted sprouting shrubs reduce the grass and eventually develop a full cover. Grazing and reburning can kill many shrubs and delay natural succession for many years, but the plant cover remains unstable. If management is relaxed, shrubby vegetation gradually recaptures the site.

Areas treated with herbicides

Herbicide treatment is the additional tool needed to change completely the natural plant succession after burning of chaparral. Herbicides control shrub sprouts and seedlings while a solid grass cover is being established. If continued, herbicide treatments can kill virtually all the shrubs that establish themselves soon after burning.

Rowe and Reiman [4] found that a grass cover, maintained by herbicide spraying of shrubs, removed all available moisture each year from the upper soil. Field observations have indicated that this heavy use of soil moisture by grass can control shrub reinvasion indefinitely and thus make possible conversion to relatively stable grassland. Californian foothills offer this unique situation—favorable weather during winter and spring followed by a long period of hot dry weather.

Conversion techniques

Selection of area

On mountainous terrain, conversion is attempted only on selected sites, which may total less than 10 % of the land. If forage production is the goal, site prerequisites are: (1) productive soil with adequate water-holding capacity, and (2) moderate slopes—preferably under 40 % gradient. To increase water yield, the soil should be more than 3 ft deep. To improve fire control posibilities, a strategic location, such as a ridgetop, is the basic requirement for areas of heavy fuels converted to light grass cover, even if site qualities are low [1].

Removal of chaparral

Chaparral top-growth must be completely removed by mechanical means or fire. Broadcast burning under prescribed conditions is preferred, if it can be safely accomplished. It produces a firm seedbed relatively free of highly competitive weeds, and temporarily increases the available soil nutrients [1].

Chaparral must be properly prepared so that it will burn in safe weather conditions. It

should be crushed by a heavy tractor so as to compact and dry the fuel, but desiccation of standing shrubs with a chemical spray can be used. Special ignition techniques may be required for safe clean burning. These usually involve closely spaced "sets", so that many small fires reinforce one another and produce intense heat.

Establishment of grass cover

Perennial grasses are preferred to annuals, which establish naturally; perennials have more extensive root systems, more consistent production, and a longer green period.

To establish perennials consistently is the most difficult step in converting chaparral to permanent grassland. Sowing should be done during the first fall after chaparral removal, before a competitive weed cover has developed. Sowing with a heavy-duty "rangeland" drill gives more consistent results than broadcast sowing.

Phalaris tuberosa var. *stenoptera* is the basic perennial grass. *Agropron* spp. are added at most locations; they replace *Phalaris* at upper elevations. Other species, such as *Oryzopsis mileacca, Festuca arundinacea, Poa ampla,* and *Erharta calycina,* can also be added.

Control of chaparral regrowth

The key to successful conversion is virtual elimination of the chaparral sprouts and seedlings that regenerate soon after burning. Herbicide application should start during the first 2 years while grass stands are developing, and must continue until shrubs have been reduced to the desired level.

2, 4-D, or mixtures with 2. 4, 5-T [1]. Follow-up spraying of surviving individual shrubs may be needed. Consistently effective, economical techniques have been developed for chamise-chaparral and certain mixed-chaparral associations. But better techniques are needed for scrub *Quercus* and some other species.

The recommended technique is 2 or more broadcast sprayings of low-volatile esters of

Results and conclusions

Two early tests of the conversion concept indicate conditions under which stable grassland can be maintained with minimum effort. Successful perennial grass stands were established in both tests: an area of 20 ac. (8 ha) burned by wildfire and sown broadcast in 1953; and a 100-ac area (40 ha) burned as prescribed and drill-sown in 1957. Sprouts and seedlings of chamise chaparral were controlled on each area by spraying during 2 years after burning.

Both areas are at Grindstone Canyon on the Mendocino National Forest. They lie at 760 m elevation; mean annual precipitation averages about 635 mm. The slope gradient is mainly between 30 and 40 %. Soils are stony clay loams, 60 cm or more in depth, with an estimated water-storage capacity greater than 7.6 cm. The selected soils are productive phases of a series mapped as Los Gatos—a series typically of shallow depth, on steep slopes, having a low rating for grass production [7].

Surveys of the 2 areas in 1965 showed that grass stands still persisted and shrubs had not invaded the areas. Shrubs were counted on belt transects (13.2 × 330 ft.) and the presence or absence of perennial grass plants was recorded on each of 10 quadrats (1 × 2 ft) per transect. The results were:

	1953 area 10 transects	1957 area 40 transects
Percent of quadrats stocked with perennial grasses	88	97
Number of shrub sprouts and older seedlings per ha.	20	38

On the area sowin in 1963 and lightly grazed by cattle since 1957, the vigor of the grass was noticeably declining by 1965. On the other area, stocked since 1959 at an average of 1.3 animal-uit-months per acre (3.2 per ha), the perennial grass appeared vigorous. Annual grasses were growing between the perennials on both areas.

Shrubs counted on the transects were sprouting *Adenostoma* plants and *Ceanothus*

seedlings. A few small *Rhus* sprouts were observed but were not counted. Estimates of age indicated that the shrubs had survived the herbicide treatments; only 2 of the observed seedlings could have germinated after treatments ended. The shrubs — closely browsed by deer and cattle — were not competing with the grass.

These results show that conversion from chaparral is possible, with only occasional control of shrub reinvasion. Conversion to permanent grassland appears possible; the grass cover should last indefinitely but the proportions of perennials and annuals might change. The term "stable" may not apply perfectly to such grassland. We use the term to contrast this cover with the definitely unstable mixtures of grasses and shrubs that will exist if conversion techniques are not fully applied.

In conversion, we still face some management problems: grazing systems are needed to maintain production of *Phalaris* and other perennilas; techniques are needed for improving soil fertility; and better criteria are needed for recognizing sites which conversion is possible. Even so, conversion of chaparral to grass is underway on many privately- and publicly-owned lands in California.

BIBLIOGRAPHY

1. BENTLEY, JAY R. 1966. Manuscript submitted for USDA Agricultural Handbook series.
2. HORTON, J. S. and C. J. KRABEL. 1955. Ecology 36: 244—62.
3. ROWE, P. R. and E. A. COLMAN. 1951. U.S. Forest Serv., Calif. Forest and Range Expt. Sta. Tech. Bul. 1048. 84 pp., illus.
4. ROWE, P. B. and L. F. REIMANN. 1961. Jour. of Forestry 59: 175—81.
5. SAMPSON, ARTHUR W. 1944. Calif. Agric. Expt. Sta. Bul. 685. 144 pp., illus.
6. SAMPSON, ARTHUR W., and BERYL S. JESPERSON. 1963. Univ. of Calif. Agric. Ext. Serv. Manual 33. 162 pp., illus.
7. SCHULTZ., A. M., J. L. LAUNCHBAUGH, and H. H. BISWELL. 1955. Ecology 36: 226—44.
8. SWEENEY, JAMES R. 1956. Univ. of Calif. Publications in Botany 28: 143—250.