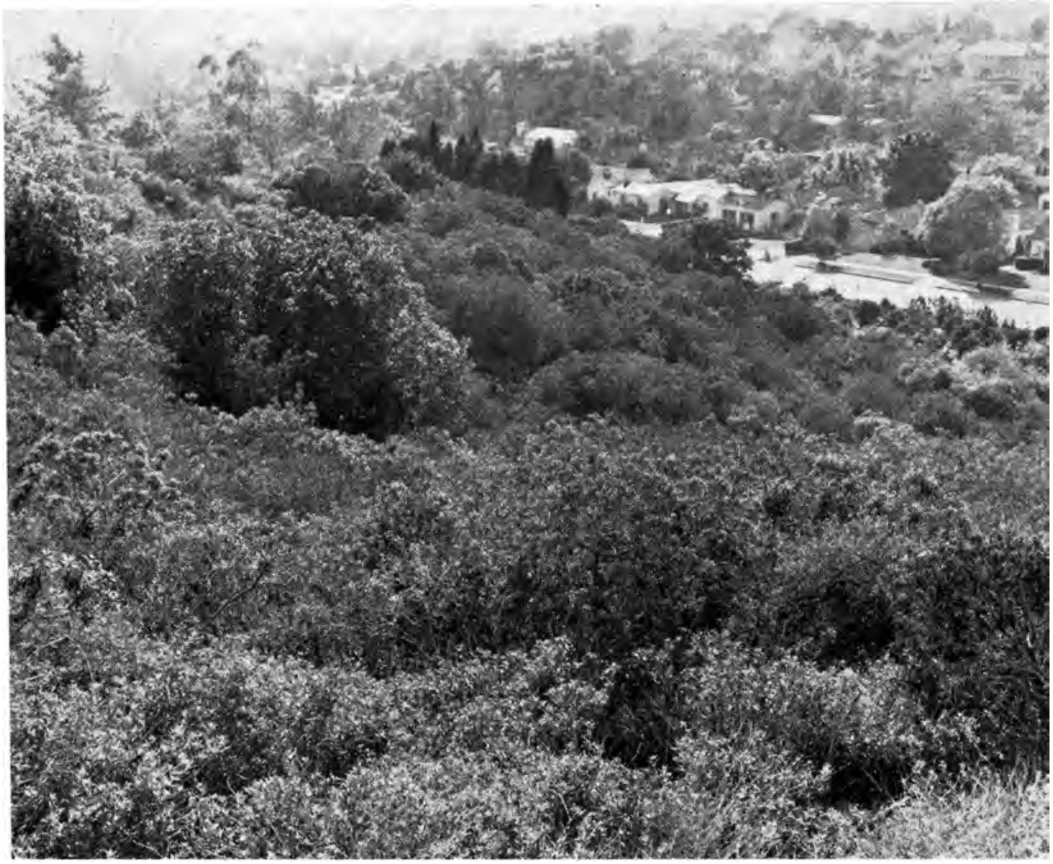

Original dense chaparral growth at UCLA test site before clearing, January 1962.

Hillside Clearin[

CYRUS M. MC KELL • VERNON S
LYLE PYEATT

This summary of four years' work at the
Angeles campus of the University of Ca
version capable of greatly reducing fir
residential areas. Grasses, ground covers
to provide erosion control and beautifica

Edge of University of California campus at Los Angeles showing hillside area along Veterans Avenue at Sunset Boulevard used as demonstration site for conversion of chaparral growth to low-fuel density plantings.

Grass plots established in irrigated area of the test site.

BRUSH FIRES on steep chaparral hillsides are a serious threat to communities in many areas of California. In addition to the immediate threat of fire to life and property, the denuded hillsides can cause serious flood control problems in some areas during the rainy season. The chaparral vegetation is highly combustible and is easily ignited by a careless match, cigarette, chance spark or even hot exhaust of automobiles. Chaparral fires are usually uncontrollable when fanned by the wind, but even on calm days, updrafts and wind currents from the intense heat of the burning brush can carry flaming embers over wide areas.

The brush-fire hazard is a particular problem to expanding metropolitan areas where homesites are adjacent to brush-covered hillsides. An exceptionally disastrous brush fire occurred in the exclusive Bel-Air section of Los Angeles near the UCLA campus in the fall of 1961, resulting in the loss of 484 homes plus 21 other buildings. Total cost of the fire was estimated at $24,135,000 for homes and $3,000,000 for fighting the 6,090-acre fire. The following year, a chaparral-covered hillside area at the edge of the UCLA campus was designated as a demonstration area to show methods of brush clearing and reseeding as well as to test varieties of ground cover and shrub species for revegetation to control erosion and maintain beauty.

Clearing

Seven acres were mechanically cleared of white sage (*Salvia apiana*), black sage (*Salvia mellifera*), sumac (*Rhus laurina*), wild buckwheat (*Eriogonum fasciculatum*), chamise (*Adenostoma fasciculatum*), and toyon (*Heteromeles arbutifolia*). Fuel (estimated at more than

; and Revegetation of Fire Hazard Areas

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J. R. GOODIN

lillside Management Project on the Los
ifornia details steps in brushland con-
hazards on steep chaparral lands in
and fire-resistant shrubs for replanting
ion are also considered.

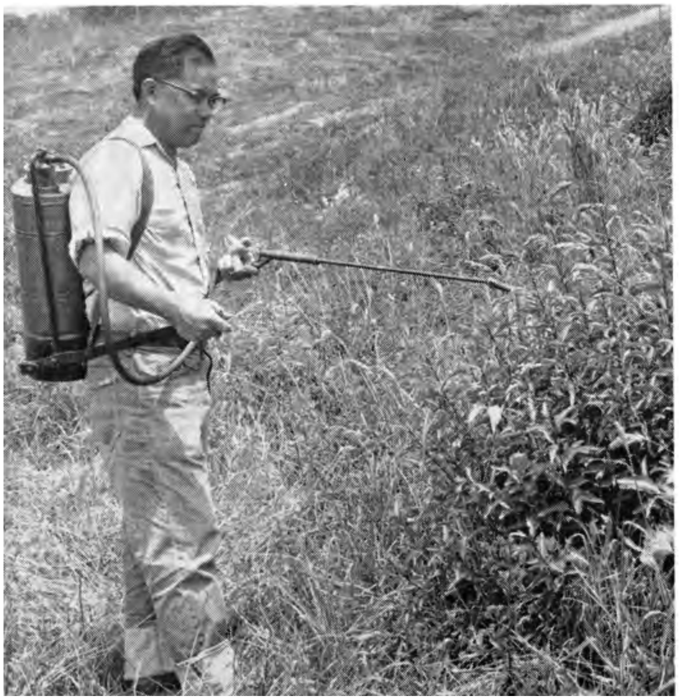
15 tons per acre) was bulldozed off the slopes and buried in three deep cuts in the ravines. The brush was covered and packed with soil during the process. A few toyon and elderberry (*Sambucus glauca*) were left standing to retain some of the hillside's natural aesthetic value. A total of 8 hours of crawler-tractor work with a D-7 and 18 hours with a D-8 was required to complete the 7-acre clearing job. For a comparative demonstration, one small ravine was not cleared.

One steep slope of about 7/8 acre, covered mostly with white sage and *Encelia californica* was hand cleared. It took 67 man-hours to cut the brush with hand-ax and grubbing-hoe and move it to the bottom of the slope. The soil was not greatly disturbed and most of the native grass cover remained on the slope. The hand-

Appearance of former brush covered hillside in June 1963. Note good cover of grasses and isolated shrubs left for their beauty.

Bulldozers used for brush clearing and trench for debris disposal at Los Angeles test plots.

Grass seeding on steep slope at the test site was done with a rangeland drill pulled by a crawler tractor.



Left photo, maintenance of the hillside project at UCLA by spraying with herbicides (2,4-D plus 2,4,5-T). Right photo, ground cover species planted in an ornamental arrangement.

cleared slope had about half the original amount of brush cover as the bulldozed area.

Nonirrigated grasses and legumes

A major portion of the bulldozer-cleared area was seeded with perennial grasses and clovers (Mixture No. 1, see table 1) using a rangeland drill. Seeding was done in the fall prior to early rains. The steep slopes made it sometimes necessary to drill up and down the slopes rather than on the contour. Erosion was minimal, however, and may have been reduced by the imprints left in the soil by the tractor.

A one-acre area was seeded with annual ryegrass and clovers (Mixture No. 2), using the rangeland drill, and another slope of about 2 acres was broadcast-seeded with blando brome and clovers (Mixture No. 3). The brome grass seed was scattered by hand and covered by traveling over the slope with a tractor. Ryegrass at 50 lbs of seed per acre was also sprayed on some of the steep banks with a hydro-mulch applicator.

Good results from seeding were obtained when the seed was covered with soil. Seed coverage was provided on various slopes either with the rangeland drill, the hydro-mulch seeder or by rolling over broadcast-seeded areas with a crawler tractor.

The grass and legume mixtures were managed under both dryland and irrigated conditions (table 1). During the first year, bur and rose clover, along with resident grasses and weeds, provided a large portion of the ground cover in the areas seeded with the perennial grass mix. In subsequent years, the clover population has decreased as the perennial grass sod thickened. The annual ryegrass-bur clover seeding produced the quickest growth following irrigation and fall rains. On the hydro-mulch seeded banks an excellent cover of annual ryegrass was obtained. The blando brome-bur clover mix made good first-year growth and outlasted the ryegrass mix under natural rainfall conditions.

Annual vs. perennial grasses

Blando brome, annual ryegrass, and resident annual grasses produced a quick vegetative cover and provided excellent erosion control. Perennial grasses were not fully effective in reducing soil erosion until the second and third years after seeding. However, perennial grasses have a deeper root system and, once established, provide greater soil stability than do annuals. Perennial grasses also remain green long into the summer, thus reducing fire hazard conditions. Some reduction in litter accumulation may be necessary after a few years of perennial grass growth.

Chemical brush control

Spot treatment of brush regrowth has been necessary each of the four years. During the second year a broadcast treatment with herbicides was applied to control heavy regrowth of broadleaf weeds and California sagebrush (*Artemisia californica*). The California sagebrush was a very aggressive invader (starting as seedlings), although it made up only a small amount of the original chaparral.

One gallon of commercial brushkiller (2 lbs each of 2,4,-D and 2,4,5-T acid equivalent per gallon) mixed with 100 gallons of water was sprayed on the brush. One quart of brushkiller mixed with 100 gallons of water was used for general broadleaf weed control. Although a dense stand of grass covers the area today (four years later), brush seedlings of various types continue to appear. Spot treatment appears to be necessary for complete brush regrowth control for a three-to-four-year period following mechanical clearing.

Fertilization

All plantings were fertilized at the time of seeding. A commercial fertilizer containing nitrogen and phosphorus was applied with the rangeland drill or the hydro-mulch applicator at rates of 60 lbs nitrogen and 44 lbs phosphorus per acre. The grasses and legumes responded well to the treatment and made rapid early growth.

Eighty-two different grasses were seeded in rows to determine their adaptability under dryland conditions. Once seeded, no attempt was made to reduce native plant competition. Few of the new species survived the climatic conditions or weed competition. Only the ricegrasses (*Oryzopsis* spp.) and the wheatgrasses (*Agropyron* spp.)—other than the ones already seeded on the hillside—have shown any promise up to this year.

TABLE 1. SEEDING RATES; GRASSES AND LEGUME MIXTURES FOR HILLSIDE PLANTING

	Nonirrigated	Light Irrigation*
MIXTURE 1—(perennial grasses and clover)	Seeding rates (lbs/acre)	
Smilo	2	4
Hardinggrass	2	4
Veldtgrass	2	4
Rose clover	3	4
Bur clover	3	4
Total	12	20
MIXTURE 2—(annual grasses and clover)		
Annual ryegrass	30	40
Bur clover	4	6
Rose clover	4	0
Birdsfoot trefoil	0	6
Total	38	52
MIXTURE 3—(annual grasses and clover)		
Blando brome	20	30
Bur clover	4	6
Rose clover	4	0
Birdsfoot trefoil	0	6
Total	28	42

* Minimum irrigation applied to germinate the seed and establish the stand.

In 1965, 12 different grasses and 11 different legumes native to Mediterranean countries were seeded in a row-nursery. Lack of spring rain stunted their growth following good seed germination, however.

Slow-burning shrubs

Shrubs with a high kindling point (as compared with the native chaparral) were planted in 1962 (see table 2). Two varieties of rock rose (*Cistus ladaniferous* and *C. villosus*), saltbush (*Atriplex breweri*), and Yerba Santa (*Erodictyon trichocalyx*) were successfully established. It was necessary to irrigate them the first summer following planting. Lack of moisture in subsequent years restricted their growth, but the survival rate was good. They are adapted to the area and make attractive shrubs, but need watering during dry summers until they become deep rooted.

In late 1964 and early 1965, eight shrub species reputed to be superior in slow-burning characteristics were planted on a slope in an ornamental arrangement. The plantings were made as an evaluation of ornamental use under minimum maintenance conditions in hillside residential areas. All species were transplanted from flats and careful attention was given to irrigation during the first spring and summer. In 1966 the planting was sprinkler irrigated only once (in July) during the 9-month dry period between effective rains.

Weed control by hand and contact herbicides was minimized to determine the competitive abilities of the slow-burning species. No fertilization, shearing, training or other practices have been carried out. Simple planting designs and contrasting foliage colors and textures were used to achieve a pleasing ornamental effect.

A one-acre area was provided with an overhead sprinkler system for regular irrigation and in 1962 the grasses and ground covers in the following list were planted. The purpose of these test plots was to determine which plant materials would provide a satisfactory low-growing cover on slopes where water is available and there is no need for mowing. Each variety was planted with and without preplant weed control (calcium cyanamide at 5 lbs per 100 sq ft) for an evaluation of the ability of each species to compete with the annual weeds that occur on such hillsides.

A second area was used for testing materials under limited irrigation. Here Tifgreen bermudagrass stolons were sprayed onto an area with a slurry of a patented, wood-fiber mulch. This appears to be a promising method of quickly planting stolons or seed on steep slopes.

Early observations of these test plots indicate that weed competition retarded the rate of establishment of all plant materials used and entirely prevented establishment of some materials.

GRASSES AND GROUND COVERS CONSIDERED FOR IRRIGATED SLOPES

Zoysia matrella (vegetative)
Newport Kentucky bluegrass
Centipede grass
White clover
Carpetgrass
Zoysia japanica (seed)
Bur clover
Lotus tenuis
Puccinellia distans
Red fescue clone (vegetative)
Red fescue (seed)
St. Augustinegrass
Bermudagrass—RC 140
Dichondra
Tifway bermudagrass
Lippia
Sunturf bermudagrass

Summary

The uncleared area continues to support an increasing amount of chaparral cover and constitutes a high fire hazard. In contrast, the brush-cleared slopes are protected by a dense low-growing grass sod that offers no significant wildfire danger.

Chaparral was successfully cleared from slopes with bulldozers and disposed of on the site by a cut-and-fill method. Hand clearing of brush cost 33% more per acre than did mechanical clearing and required 13.4 hours of work for each one hour of bulldozer time.

Brush regrowth was controlled by applications of brushkiller as new seedlings and sprouts occurred. An over-all spray

TABLE 2. UCLA PLANTINGS OF GROUND COVER ORNAMENTALS

Common name	Species	Spacing used on UCLA plots	Comments
Saltbush	Atriplex breweri	Open	Silvery foliaged shrub to 6 ft high. Flowers inconspicuous. Tolerates saline soils and adverse conditions. Slow-burning characteristics. Reseeds abundantly. Rapid growth.
Australian Saltbush	Atriplex semibaccata	1½ ft	Prostrate perennial herb with inconspicuous flowers. Tolerates saline soils and adverse conditions. Not in the trade. Slow-burning characteristics.
Dwarf coyotebush	Baccharis pilularis 'Dwarf'	2 ft	To 24 inches high. Flowers inconspicuous. Drought resistant once established. Good surface erosion control.
White rockrose	Cistus hybridus	2½ ft	Not noted for its beauty. Spreading growth 2–3 ft high and 4 ft wide. White flowers 2 inches across. Drought resistant once established. Slow-burning characteristics. Would not provide good initial erosion control.
Gum rockrose	Cistus ladaniferous	———	Shrub to 6 ft high with sticky foliage. Flowers white, 3 inches across. Slow-burning characteristics.
Hairy canary clover	Dorycnium hirsutum	2 ft	Low growing perennial with small pea-like flowers. Not in the trade. Drought resistant.
Yerba santa	Eriodictyon trichocalyx	open	Glossy, dark-green leaves, shrub 3 to 5 ft high. Grows in thickets. Slow-burning characteristics. Drought resistant.
Parrot's beak	Lotus berthelotii	2 ft	Gray refined foliage to 12 inches high. Striking scarlet flowers of narrow, sweet pea shape. Requires good drainage.
———	Portulacoria afra	———	Fleshy shrub eventually reaching 10 ft in height. Stems purple. Clusters of tiny, rosy, starlike flowers. Tolerates adverse conditions.
Arabian scurfpea	Psoralea bituminosa	———	Perennial herb. Shrub growth to approx. 2 ft. Small purple, pealike flowers. Drought resistant. Old plant residue may provide unwanted litter.
Dwarf rosemary	Rosmarinus officinalis 'Prostrate'	2 ft	Woody shrub to 1½ ft. Small light blue, sagelike flowers in spring. Drought resistant.
Gray santolina	Santolina chamaecyparissus	2 ft	½ inch flowers like bright yellow buttons. May require occasional shearing to prevent woodiness. Poor erosion protection initially. Excellent foliage contrast. Old flower heads and stems must be removed.
Green santolina	Santolina virens	1½ ft	Soft yellow flowers like buttons. May require occasional shearing to prevent woodiness. Same general characteristics as gray santolina.
Prostrate germander	Teucrium chamaedrys	1½ ft	Rose or red-purple, sagelike flowers in summer. Heat and drought resistant.

of herbicide the second year after clearing, followed by spot treatment of individual sprouts for three years, was necessary to control brush regrowth.

Selected annual and perennial grasses, seeded after brush clearing, provided excellent soil erosion control (once established). Bur clover and rose clover were quick to germinate and can be used alone or together, under conditions of rainfall or irrigation.

Birdsfoot trefoil seeded with the annual grasses helped to provide excellent vegetative cover where slopes were irrigated. The perennial grasses became well established and can be seeded as a mixture or alone. Clover included with perennial grasses gave added soil protection the first year.

From the list of grasses and ground covers commonly used for lawns, four grasses have shown favorable characteristics which make them adaptable to hillside planting: Newport Kentucky bluegrass, St. Augustinegrass, Bermudagrass RC-140, and sheep's fescue. All four provided a thick sod without mowing, stayed green, produced vegetative growth between three and eight inches high, and competed against native herbaceous invaders. These grasses required only monthly irrigation after establishment to survive in the local climate. The ground cover Lippia performed equally as well. A preplant weed-control program with calcium cyanamide proved beneficial.

Certain slow-burning species can protect the soil from erosion and provide ornamental characteristics when they are given only minimum maintenance. All species tested appear to be very drought tolerant and with few exceptions provide erosion protection within a reasonable period of time.

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INFLUENCE OF ON THE CITRUS

This experiment was conducted in a greenhouse to study the influence of five irrigation and three soil-oxygen levels on the uptake of 12 nutrients in citrus seedlings. Different irrigation treatments used in this experiment significantly decreased the total amounts of nitrogen, chloride, sodium, zinc, copper, and iron in the whole seedling, while dry weights of seedlings—and the total amounts of phosphorus, potassium, calcium, magnesium, manganese, and boron—were not affected. A decrease of the soil-oxygen supply to seedling roots decreased the amounts of all elements except sodium, which was increased.

TABLE 1. INFLUENCE OF IRRIGATION ON THE AMOUNTS OF NUTRIENTS PER CITRUS SEEDLING

Nutrient*	Control (A)	Water table (B)	Saturated every 4 days (C)	Saturated 3 times per month (D)	Saturated 2 times (E)	C.V.†
Dry wgt/g	5.42	4.81	4.77	4.75	5.18	15
N	62.00 b	53.00 ab	52.00 a	50.00 a	57.00 ab	15
Cl	12.00 a	14.00 b	13.00 ab	13.00 ab	14.00 b	18
Na	2.00 a	2.00 a	4.00 b	9.00 c	4.00 b	26
Zn	0.11 b	0.08 a	0.08 a	0.08 a	0.09 a	14
Cu	0.03 b	0.02 a	0.02 a	0.01 a	0.02 a	28
Fe	2.89 c	1.28 a	1.78 b	1.59 ab	2.42 c	22

* All nutrient weight differences were significant at the 1% level and expressed in mg.

† C.V. is coefficient of variability, expressed in per cent. Mean values are different only if they do not have a letter in common.

AN ADEQUATE AMOUNT OF OXYGEN in the root zone is necessary to maintain plant respiration. The diffusion of oxygen in soils is determined to a large extent by the soil pore-space arrangement and the degree to which these pores are filled with water. This paper presents data on the influence of five irrigation levels and three soil-oxygen treatments (in a factorial setup) on the amounts of nutrients taken up per seedling.

Six-week-old citrus seedlings were transplanted into Ramona sandy loam in 1-liter glass cylinders painted on the outside. An unpainted vertical strip 1 cm wide was covered with black tape, which