Operational Use of Prescribed Fire in Southern California Chaparral[1]

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Abstract: The use of prescribed fire in the chaparral could reduce the incidence and impacts of severe wildfires and enhance watershed resources. This paper describes the operational planning needed for a successful prescribed fire and discusses the recent experience with this technique on the Cleveland National Forest.

Fire is a dominant natural feature in Mediterranean-type ecosystems throughout the world. With their characteristic summer droughts and highly flammable vegetation, these ecosystems are frequently coursed by catastrophic wildfires.

Nowhere is the threat to human life and property more acute than in the complex association of wildland chaparral and developed urban areas in southern California. Here, in November 1980, over 320 homes were destroyed and 36,000 ha of chaparral watershed were burned by major wildfires raging under the influence of foehn-type Santa Ana winds. These were not uncommon events; in modern times, homes are destroyed and thousands of hectares are burned every year by wildfire. Loss of life and property can be even greater in the flooding and debris production that often follows major chaparral fires.

Fire suppression and prevention programs have reduced the frequency and size of wildfires, but this approach alone has not prevented catastrophic wildfires, and natural fire regimes may have been altered, with profound effects upon this fire-adapted ecosystem. In response to these problems, efforts are being made to use fire under prescribed conditions to manage chaparral fuels and provide positive resource benefits.

A program designed to develop and demonstrate the use of prescribed fire and other management techniques in the chaparral has been underway since 1977 on the Laguna-Morena Demonstration Area in San Diego County. This paper discusses the rationale for prescribed burning in the chaparral and associated ecosystems, presents an overview of the operational planning needed for a successful prescribed fire, and discusses our recent experience with this technique.

PRESCRIBED FIRE OBJECTIVES

Fire Hazard Reduction

The use of prescribed fire in chaparral has potential for reducing the occurrence, size, and impact of large wildfires. Mosaics of different-aged chaparral stands can be produced and maintained by periodic burning under low to moderate fire intensity conditions. These mosaics break up large areas of heavy fuel accumulation and maintain a substantial area of chaparral in a young, productive state. The occurrence and adverse effects of large wildfires should be reduced since fire propagation and resistance to control are considerably less in well-stocked young stands with their low dead fuel volumes (Rothermel and Philpot 1973, Philpot 1974).

Areas of young chaparral have been useful in the suppression of large wildfires burning under extreme conditions. In 1979, the 1900-ha Monte Fire in the Angeles National Forest was contained on the south and west when driven by moderate Santa Ana winds into areas burned 4 years previously by the Mill and Pacoima Fires. Fire activity in the young age classes was greatly reduced, with only uneven fire spread through grass and light fuels on the north-facing slopes.[3] The southward advance of the 1980 Turner Fire in and adjacent to the Trabuco District, Cleveland National Forest, was halted under 30 to 50 km/h winds when it reached an age-class boundary of the 1975 Tenaja Fire.[4] The 1980 Thunder Fire in the Mt. Baldy District, Angeles National Forest, burned southward along San Antonio Canyon under the influence of strong Santa Ana winds. Long distance spotting into 27-year-old chaparral on the east side of the canyon propagated the fire and required sustained fire suppression action. Spotting into chaparral burned during the 1975 Village Fire on the west side of the canyon produced only poorly propagating fires that presented little resistance to control.[5] While even young stands of chaparral may propagate fire under the most extreme conditions, both the resistance to

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control and potential for mid- and long-range spotting are greatly reduced.

These benefits are particularly valuable at the wildland-urban interface where a mosaic of natural and planted vegetation often presents extreme fire hazards. Embers from large chaparral wildfires, such as the highly destructive Stable and Panorama Fires of 1980, can be carried a considerable distance into the developed community by long-range spotting. Carefully applied prescribed burning and age-class management in heavy chaparral adjacent to the interface could substantially reduce this problem. Less is known about the value of prescribed burning where the fuels are coastal sage scrub.

Prescribed fire can also be applied for the protection of high-value riparian and woodland resources. In stands of California live oak (*Quercus agrifolia* Nee), substantial mortality in younger age classes can occur during severe wildfires, and larger trees can suffer damage to the cambium and lower stem that makes them more susceptible to disease and insects (Plumb 1980). California black oak (*Quercus kelloggii* Newb.) is more susceptible and can be largely topkilled during wildfire. Understory prescribed burning can be successfully applied in stands of these species to reduce fuel accumulations (Green 1980) and provide protection against severe wildfires. Understory burning may also encourage seedling regeneration in areas of heavy litter accumulation, aid in the control of forest pathogens (Parmeter 1977), and mineralize nutrients in the forest floor litter.

Serious fire hazard problems also exist in many of the coniferous forest areas of southern California. Before 1905, ponderosa (*Pinus ponderosa* Laws.) and Jeffrey (*Pinus jeffreyi* Grev. and Balf.) pine stands in the San Bernardino Mountains were coursed by low intensity fires at a frequency averaging 10 to 12 years (McBride and Laven 1976). The mature overstory was not readily damaged by these fires, yet fuel accumulations are now large enough to virtually assure destruction of the mature stand. Prescribed fire can be used successfully to reduce these accumulations, but care must be taken to minimize tree damage and control the fire.

Enhancement and Management of Watershed Resources

The application of prescribed fire may provide a variety of watershed and wildlife benefits. Foremost among these is a reduction in the impacts of severe wildfires. In recent years, wildfires have frequently burned under the most extreme conditions due to suppression of low and moderate intensity wildfires, a high incidence of human-related ignitions during severe fire weather, and a possible buildup of fuels because of active fire suppression. Fire frequencies also may have increased in some areas of coastal sage at the urban interface.

A large-scale age-class management program could be designed to substantially reduce the adverse impacts of high intensity wildfire. Prescribed fires can be conducted under weather and fuel conditions chosen to minimize fire intensity and planned to encompass specific terrain of limited area. Cooler fire temperatures reduce nutrient loss (Dunn and DeBano 1977), soil water repellency (DeBano 1981) and erosion (Wells, in press), and seed destruction. Prescribed fires frequently burn only 40 to 70 percent of the vegetation within the fire perimeter, thus creating both a diversity of habitat and more nutrient-rich browse that are favorable for wildlife (Lillywhite 1977, Bissel and others 1955). The area burned within major watersheds can also be controlled, and this helps to reduce downstream flooding potential. A planned sediment management program using prescribed fire on important watersheds could be designed to minimize and regulate debris production.

The intensity and effects of a prescribed fire in chaparral may necessarily be greater than those associated with prescribed burning in coniferous forests or other woodlands. In conifer forests, light ground fires with flame lengths less than 1/2 m could be used to achieve good fuel reduction. Flame lengths greater than 2 m could well be excessive, causing undue damage to tree crowns and boles, and the forest floor. In the chaparral however, flame lengths greater than 2 to 3 m may be necessary to propagate the fire and attain desired fuel reduction. The amount of soil heating can be acceptable since the duration of heating is short and the alternative is burning under wildfire conditions with possibly extreme fire effects. Flame lengths in themselves are not here a cause for concern, as they are in forest understory burning where canopy damage must be avoided.

PLANNING THE PRESCRIBED FIRE

Site Selection

The selection of sites for prescribed burning on the National forests is an interdisciplinary process involving professionals from fire, resource, wildlife, and planning disciplines. Priorities are determined by the land and resource management objectives specified in the National forest management plan. A prescribed fire may have one or more major resource objectives related to fire hazard reduction, range improvement, sediment and flood management, or wildlife habitat improvement. These objectives are important in determining the size, layout, season, intensity, and frequency of burning in the prescribed fire operation. They will also determine the proportion of the area to be burned within the planned perimeter. For these reasons, a clear statement of resource objectives is necessary for planning and evaluating the prescribed fire.

For example, if fire hazard reduction is the primary goal, the resource objectives might have the following form:

> Within a 5-km radius of residential communities and for Santa Ana conditions with windspeeds of 60 km/h, (a) reduce long-range spotting to distances less than 200 m and (b) maintain 50 percent of the chaparral with fuels that will propagate fire at a rate of spread less than 0.4 m/sec.

The fire planner can use existing models (for example, see Helfman and others 1975) to evaluate the effects of different patterns of prescribed burning on wildfire behavior in specific areas of terrain and chaparral. In this way, different burning options for the management area can be compared so as to determine if the resource objectives are realistic. When the primary goals are forest protection, flood and debris control, or wildlife habitat improvement, similarly specific resource objectives can be stated.

Environmental Analysis

An essential step in planning the prescribed fire is the environmental analysis. This analysis weighs the possible benefits and impacts of the management action and outlines mitigating measures that may be required. It serves as a compendium of information on the vegetation, wildlife, sensitive or threatened and endangered species, soils, and archaeological or cultural resources of the project area.

Project Layout and Preparation

The size and extent of the prescribed fire are determined jointly by the fire management officer and the appropriate resource officers. The planned fire perimeter is designed for ease of containment within the framework of the burning objectives and requirements of the environmental analysis. Often, the burn can be easily enlarged or reduced to improve the operation while still achieving the planned objectives.

Whenever possible, existing barriers to fire propagation should be used as control points. Not only are existing roads and fuelbreaks useful, but natural barriers such as ridge lines, riparian areas, and age-class boundaries in the chaparral can be used effectively for containment. Prescribed fires are often conducted under conditions that are just severe enough to propagate the fire. Changes in humidity or topography may have a strong influence on the rate of spread and can be used to contain the fire. The construction of artificial control lines should be minimized due to their high cost and possible soil disturbance. Understory burning in riparian areas, such as California live oak woodlands, can provide an effective control line for broadcast burning chaparral. If California black oak or mixed pine forests are present in adjacent areas, they should be understory burned under low intensity conditions before the planned chaparral burn. If high accumulations of fuel are present around isolated groups of trees within the planned chaparral fire perimeter, hand or mechanical clearing in their vicinity may be required to assure their survival.

The burning prescription should be designed to meet the specific resource objectives for the planned fire. Guidelines for developing a prescription are available (Green 1981); they require a knowledge of the local fuels, terrain, and weather behavior. Conditions required to propagate fire and achieve reasonable objectives in one stand may be extreme in another. Fuels information, including total biomass and especially the dead fuel loading and live fuel moistures, should be gathered from a range of locations representing the different aspects, vegetation types, and terrain present within the fire area. Some interpretation of the available prescription guidelines may be necessary since the important variables influencing fire behavior will strongly interact. For example, an area with relatively low dead fuel volumes may require a prescription with relatively low relative humidity and moderate windspeeds in order to achieve burning objectives. It is important that the forest officer in charge of the prescribed fire be familiar with fire behavior in the local fuels and have the experience to determine realistic objectives and prescriptions.

A knowledge of regional and local weather conditions is imperative for a successful prescribed fire. Foremost is a knowledge of the probability of dangerous fire weather during or after the burn. High pressure systems that create strong Santa Ana winds may develop rapidly, so it is important to have reliable weather forecasts before, during, and after the fire. Local weather conditions should also be monitored for a minimum of 1 week before the burn, and the trends in humidity and wind for the day should be estimated. If you are "in prescription" at 1000 h, you must have a reasonable idea whether or not you will still be in prescription at 1400 h.

When local fuels and expected weather conditions are known, fire behavior may be partly controlled by the nature of the planned ignition pattern (Martin and Dell 1978). In heavy fuels with a high proportion of dead material, backing fires may be required to control the rate and progress of burning and to contain the fire. In lighter fuels, head fires or multiple ignitions may be required to achieve an acceptable fuel reduction or fire coverage. Areas of flashy fuels or higher dead material accumulations may be used to build heat and propagate fire into upslope areas of less flammable vegetation.

The placement and requirements for fire suppression crews should be determined by a potential escape analysis from which clear action plans can be developed to control problem areas in the fire. The burning operation for large fires can also be broken into stages, each of which should be brought to a degree of completion before crews proceed to the next.

The burning objectives should provide an assessment of the fire behavior required, including proportion of the area to be burned, fraction of the litter layer to be consumed and allowable flame height (in forest stands), rates of spread, and amount of standing vegetation consumed. These factors should be subjectively assessed as the burning operation proceeds. A more complete evaluation should be conducted following the prescribed fire to determine (1) whether resource objectives were fulfilled, (2) if any adverse fire effects occurred and how they should be minimized in future operations, and (3) if improvements are needed in ignition patterns and holding operations.

CASE HISTORIES

Operational prescribed fires conducted recently on the Descanso District of the Cleveland National Forest have demonstrated that large prescribed fires can be conducted safely in a variety of chaparral and woodland communities. Four of these, the Noble Canyon, Kitchen Creek, Troy Canyon, and Mt. Laguna-Flathead Flats projects, illustrate the use of prescribed fire under a variety of conditions. Site characteristics and burning conditions of these fires are shown in tables 1 and 2.

Noble Canyon

The first large prescribed fire in southern California was the 400-ha Noble Canyon Fire conducted June 13-14, 1978, at the beginning of the summer drought. The primary objective of this fire was the 100 percent reduction of the dead fuels and fine live fuels in 50 to 70 percent of the heavy chaparral on the site.

The Noble Canyon project presented a complex situation (fig. 1). The site included a variety of terrain and vegetation, including steep hill slopes covered by 60-year-old chaparral, California live oak woodlands along the riparian zones, and California black oak-Jeffrey pine woodland along the upper project boundary.

Preburn treatments included hand and mechanical line construction, understory burning in the oak communities, and a few preparatory burns (fig. 1). Existing or recleared roads were used as control lines along 7 km of the project boundaries. Handlines were also constructed through the chaparral over a distance of. 1.8 km. The mixed oak-pine woodland was understory burned when the annual grasses there were still green. Dead leaves and needle litter carried this fire with little reduction in live understory fuels.

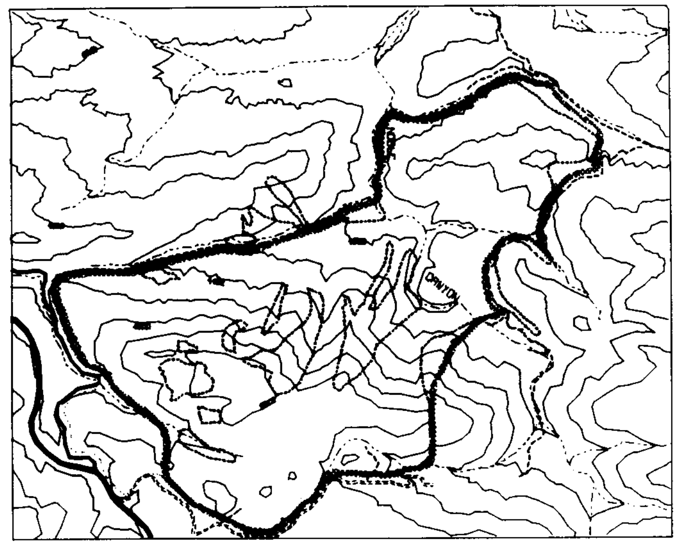

Figure 1--Topography and layout of the 400-ha Noble Canyon prescribed fire. The planned fire perimeter is indicated by cross-hatching, and the actual burn boundaries are shown by the dotted line. Unburned islands occurred on the main hill slope, and two out-of-bounds fire runs occurred at the west perimeter. The fire perimeter could have been easily extended to the paved road at the lower right and to the riparian area at the upper right.

Weather observations prior to the fire revealed that the normal southwesterly airflow pattern, humidity recovery, and the marine influence occurred by 1800 h, and the desert influence and low humidities (20 to 25 percent) returned at approximately 0200 h.

The prescribed fire was ignited by two crews using hand-held drip torches. They began by burning the upper project perimeter with a backing fire. Then they moved down the flanks and across the lower boundary, burning the lower reaches and most of the hill slopes with a head fire. Flame lengths on the hill slopes averaged 3 to 4 m with a maximum of 8 m.

Two small burns were ignited outside the project perimeter by spotting across areas of untreated riparian woodland. When these occurred, burning crews were held in place on the main fire while holding crews concentrated on control of the out-of-bounds fires. These were contained at a total size of 1.5 to 2 ha. No holding problems were encountered where the woodland understory had been previously prescribed burned.

With the onset of marine influence at about 1800 h, the relative humidity rose above 35 to 40 percent and fire could not be sustained in the standing chaparral. Recovery of higher relative humidity and lower air temperatures proved effective in suppressing fire activity.

Table 1--Site characteristics of four prescribed fire projects

Project and date	Objectives	Vegetation	Size	Slope	Elevation	Aspect	Chaparral stand age (approx.)
			ha	Percent	m		
Noble Canyon 6/13-14/78	Fuelbreak construction and fuel reduction	Mixed oak-pine woodland upper elevation Mixed chaparral on hill slopes--Af., Cg, Qd Qag woodland in major drainages	400	35 to 75 on hill slopes	1130 to 1600	All, slopes predominantly SW	60
Kitchen Creek 11/14-15/79	Fire effects research	Qd-dominated mixed chaparral--Qd, Cg, Af, Ag, Cl	2	60+	1340 to 1580	East	35
Troy Canyon 4/9, 14/80	Wildlife habitat and fuel reduction	Qag woodland with mixed chaparral on hill slopes--Cb, Af, Qd	120	40 to 50 on hill slopes	1280 to 1520	N-S trending canyon	35
Laguna Mountain 2/12 through 5/29/80	Reduce activity fuels, fuelbreak construction	P. jeffreyi--Q. kelloggii woodland, P. coulteri with Ag understory	140	0 to 35	1720 to 1800	Predominantly W-SW	70

[1]Af--Adenostoma fasciculatum, Ag—Arctostaphylos glandulosa, Cb—Cercocarpus betuloides, Cg—Ceanothus greggii, Cl--Ceanothus leucodermis, Qag--Quercus agrifolia, Qd--Quercus dumosa.

Table 2--Burning conditions for four prescribed fires

Project	Air temperature	Relative humidity	Windspeed and direction	Fuel stick	Live fuel moisture	Fraction of chaparral dead
	°C	Percent	km/h	Percent	Percent	Percent
Noble Canyon	15 to 26	28 to 50	5 to 21 NW, morning; SW, afternoon	4.5	75 (Af)	30
Kitchen Creek	12 to 15	21 to 27	Wind run--4.8 gusts to 24; NE	4.5	78 (Qd)	<20
Test fires:						
5/21/79	27	25	<8; NE-SE		130 (Qd)	
7/25/79	30	25 to 30	<13; NE-SE	5.25	100 (Qd)	
8/15/79	24	38 to 42	<6; NE-SE		88 (Qd)	
Troy Canyon	13 to 22	21 to 33	10 to 16 NW	9	80 (Af)	<25
Laguna Mountain	9 to 19	50 to 72 in P. coulteri-A. glandulosa stands	0 to 19 SE-SW	10 to 15+	80 to 110 (Ag)	60 to 70 in P. coulteri-A. glandulosa stands

[1]See footnote 1, table 1, for key to abbreviations.

From the experience gained in this project, it was apparent that the operation could have been improved in two areas. First, the construction of handlines could have been avoided on both the south and northeast perimeters. The fire could have been easily extended on the south to the existing county highway and an abandoned road (fig. 1) without creating traffic control problems. On the northeast, the perimeter could have been extended by firing along the canyon bottom north to the Noble Canyon Road. The existing handline on the northeast proved to be a poor location for firing since the backing fires ignited there progressed only poorly down or along the hill slope and the prevailing wind tended to carry firebrands across the line. Firing from an extended line in the canyon bottom would have been upslope and in the lee side of the hill. Second, the understory of the live oak woodlands could have been burned without the construction of handlines. Burning under relative humidities greater than 35 percent and with higher chaparral live fuel moistures during the early spring would have effectively contained the fire at the woodland perimeter.

The Noble Canyon project successfully demonstrated prescribed burning in old chaparral and rugged terrain. Fire intensities were moderate and there were no serious adverse effects. It provided valuable experience in the planning and execution of a large prescribed fire, and demonstrated the need for complete pretreatment operations, and the effectiveness of late afternoon humidity recovery in controlling fire spread.

Kitchen Creek Research Prescribed Fires

A series of prescribed fires conducted jointly by the Chaparral Research and Development Program of the Pacific Southwest Forest and Range Experiment Station and the Descanso District, Cleveland National Forest, was begun in the summer of 1979. This project was designed to provide replicated fires in mixed chaparral in which fire effects and biological recovery processes could be studied. It was located on east-facing hill slopes above Kitchen Creek on southern Laguna Mountain. The chaparral, last burned in a wildfire in 1944, consisted primarily of scrub oak, chamise, and two species of *Ceanothus*--*C. greggii* and *C. leucodermis* Greene. Standing biomass in stands of scrub oak was 18.5 MT/ha.

Our research needs required strip fires on a uniform slope and aspect, with the strips running perpendicular to the contours so that any sediment movement would be restricted to the strip. Handlines were cut on an intermediate ridge at the top of the slope, and some preparation burning was conducted on the flank of a hanging valley beyond this ridge. In the event of a major escape, containment could be made at the top of the main ridge where there is an age-class boundary with chaparral burned during 1970. Areas 30 m wide were hand cleared on the north and south project boundaries to provide both lateral fire containment and harvested areas for research purposes. Control lines 2 m wide were also cleared on the strip boundaries, and the dried brush was burned under high humidity conditions.

Burning trials conducted throughout the late spring and summer provided an opportunity to observe fire behavior as live fuel moisture in new growth was reduced from 130 to 78 percent under continuously dry weather conditions. These fires showed generally low flame heights and poor rates of spread despite relatively hot and dry weather (table 2), and indicated that relatively hot prescription conditions and mass ignition would be required to achieve the desired fire coverage and fuel reduction.

Three successful prescribed fires were conducted November 14-15, 1979 under relatively severe weather using a helitorch for ignition (table 2) (fig. 2). Strips measuring approximately 30 by 200 m were burned at the north end and center of the project on the first day. These fires were well behaved, showed slow runs with little lateral spread, and partially (60 to 70 percent) burned each strip after several passes of the helitorch.

Wind direction was from the northeast so the southern or leeward edge of each strip was ignited first, with successive passes of the helitorch moving further toward the windward edge. This ignition pattern gave the best possible visibility and minimized the chance of burning areas outside of the intended strip. Several passes of the helitorch were required to build heat and obtain good fire coverage.

Weather conditions during the second day remained similar to those of the first. However,

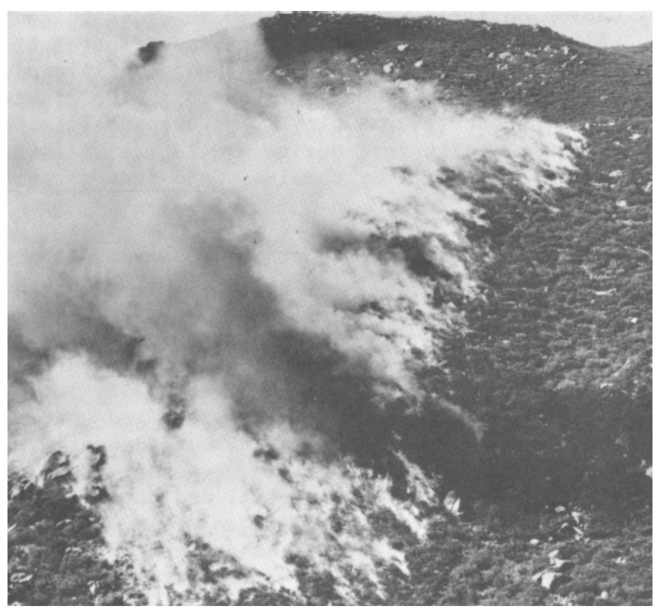

Figure 2--Strip burning with a helitorch in mixed chaparral at Kitchen Creek.

several of the brush piles from the adjacent hand-cleared area were inadvertently ignited by firebrands. Windspeed also increased to 7.5 km/h (gusts to 32 km/h), and fire spread into standing brush outside of the project boundary. During the burning operation, the Laguna Hot Shot crew was strategically located for fire control at the upper end of the project, and the helicopter used for ignition had a water bucket available at the helibase used for the operation. When fire spread beyond the project boundary, burning was suspended and these crews suppressed the out-of-bounds fire. Fire runs outside the project boundary moved slowly upslope and posed no control problems.

Our experiences at Kitchen Creek have demonstrated the importance of site fuel properties. Even though it is fully mature, the mixed chaparral at this site has species with characteristically low dead fuel accumulations and flammability. Windspeeds, humidity, and fuel moisture that might produce severe burning conditions in other chaparral community types are required to propagate fire in these stands. This prescribed fire was successful because we were able to conduct a series of burning trials under successively more severe conditions and refine our prescription. Fire runs did leave the intended project boundary due to spotting and increased windspeed, but we were fully prepared to deal with these. We also knew from past experience in this fuel type that such problems would not produce a large escaped fire. This project also demonstrated that a fire can often propagate in a stand only if a sufficient amount of heat is initially generated by use of natural fine fuels or special ignition techniques such as the helitorch.

Troy Canyon

A prescribed fire was conducted along Troy Canyon on April 9 and 14, 1980 in order to reduce the fine fuels in the understory and forest floor of a California live oak woodland, and to produce a mosaic of different age classes in the adjacent mixed chaparral community. The chaparral in this area was last burned during a wildfire in 1944, and was dominated by chamise, *Ceanothus greggii*, and scrub oak.

From past experience at Noble Canyon, Kitchen Creek, and elsewhere in this area, it was expected that prescription conditions with low humidity and moderate (12 to 20 km/h) winds would produce well-behaved fire runs. Humidity recovery late in the day was also expected to drastically reduce fire activity, especially on north- and east-facing slopes. This area was bounded on the east by areas of low-flammability chaparral and a moist, grass fuelbreak system, and on the west by a highway. These control areas would effectively contain any fire leaving the project area. For these reasons, no control lines were constructed.

The light fuels and forest floor under the oaks were ignited by hand-held drip torches. Approximately 6 km of understory burning was conducted over 2 days using a crew of six persons for ignition and needed suppression activities. Burning was conducted with a relative humidity ranging from 20 to 33 percent and 12 to 20 km/h winds out of the northwest. Live fuel moistures were generally at the lowest point of the year. Flower buds in the *Ceanothus greggii* were beginning to burst; otherwise, there was little new growth or rise in the dormant season fuel moistures apparent.

Good fire behavior and results were achieved. Fire did carry into some oak trees, but it burned in the canopy for less than 10 seconds and little damage was produced. A general pruning of the lower canopies was achieved. A partial reduction of the oak forest floor occurred (fig. 3), but a large input of fresh oak litter from scorched leaves was later observed. A second burn in 1 to 3 years may be desirable to further reduce litter accumulations in the oak woodland.

The understory fires were carried by the wind up the west-facing hill slopes and stopped at the ridge line with little carryover onto the adjacent east-facing slope. The latter slopes were shaded and apparently had higher live fuel moistures. Burning conditions would propagate fire uphill with the wind, but would not allow it to carry down the opposite slope. These chaparral fires achieved good fuels reduction and produced the desired mosaic pattern. Overall, about 30 to 50 percent of the chaparral along the canyon reach was burned. Burning was suspended when weather forecasts indicated developing Santa Ana wind conditions, and patrols were assigned to monitor the burned area for possible outbreaks.

This project successfully used vegetation and fuel differences on different aspects and late afternoon humidity recovery to effectively contain the prescribed fire. A substantial area of oak woodland and adjacent chaparral was burned in

Figure 3--Understory burning and fuels in a California live oak woodland at Troy Canyon.

rough terrain with only a small fire crew and no established control lines.

Laguna Mountain Understory Burns

The conifer—oak woodland found on Laguna Mountain is one of the most important areas for recreation and wildlife habitat in San Diego County. Large areas have no known fire history and support heavy accumulations of forest floor litter and downed woody fuels. The Laguna Mountain area is subject to less than one ignition from lightning each year,[6] but illegal campfires are a problem. Wildfires in this area would be expected to destroy the pine—oak overstory, and result in dense manzanita thickets on some aspects. A second wildfire burning in the regenerated manzanita and young pine could eliminate the pine from the site.

A series of prescribed fires was initiated in the area north of the Mount Laguna Air Force Station in February 1980 in order to reduce the accumulations of forest floor and manzanita fuels in the woodland and encourage regeneration of the forest species. Stand composition varies from an association of. Jeffrey pine and California black oak with some Ceanothus palmeri Trel. in the understory on more mesic slopes to open stands of Coulter pine (Pinus coulteri D. Don) with an Arctostaphylos glandulosa Eastw. understory on the drier west—facing aspects (fig. 4). The manzanita stand is about 2 m high with a biomass of 19 MT/ha. The underlying forest floor averages 8 to 10 cm in depth, and pine needle accumulations in the manzanita contribute to the stand's flammability.

The 185—ha project was subdivided into nine units ranging from 5 to 40 ha in size. Existing roads and trails were used to delineate units where possible, and hand clearing was used to complete the control lines. The most difficult prescribed burning problem in this project was in the areas of. Coulter pine and manzanita; caution was needed to avoid damaging the canopies of the overstory trees.

Firing with hand—held drip torches began with a backing fire ignited along the top of the ridge on the leeward side of a block. Good fire propagation and minimal tree damage in Coulter pine stands were obtained when the relative humidity was above 70 percent. Below this value the fire became too intense, and hose lays and handtool work were necessary to control flame lengths and prevent damage to the tree crowns. Some crown scorch did occur, but less than 5 percent of the trees were badly damaged or killed. Good reduction of fine fuels was achieved in the manzanita and forest floor, but heavy accumulations of the larger size class dead material remain. A second

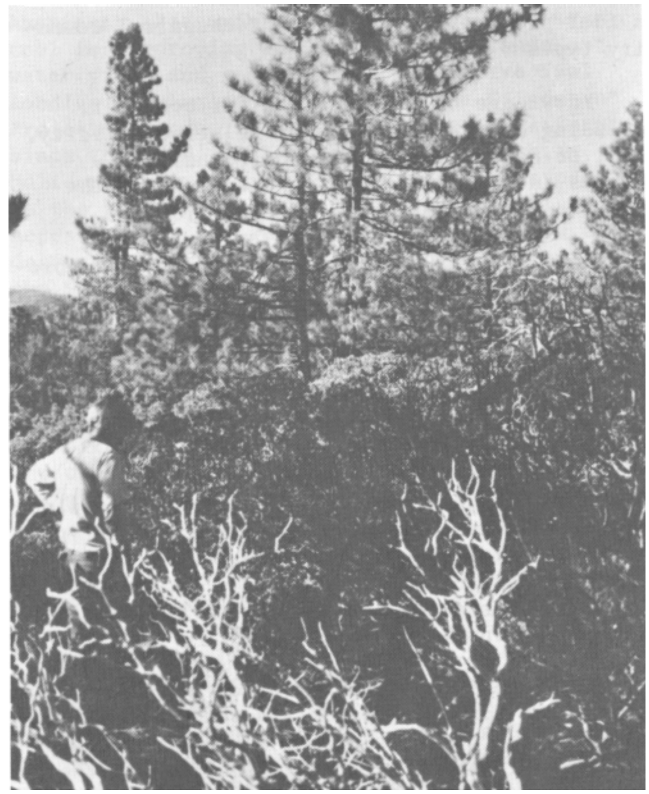

Figure 4--Coulter pine with manzanita understory fuels on Laguna Mountain.

or third fire is needed to further reduce forest floor and standing dead material accumulations, especially after scorched needles fall and provide new ground fuel to carry the fire. The manzanita is also rapidly resprouting, and subsequent fires could reduce its density and growth rates.

High humidity and low windspeeds are required to successfully burn mixed conifer—chaparral stands with heavy fuel loadings, vet good fuel reduction can be obtained in these areas with minimal overstory tree damage. Repeated burns may be necessary to achieve desired fuel reductions and wildfire protection for these valuable areas.

CONCLUSIONS

Prescribed fire is an important chaparral management technique that may be used to meet resource objectives including fire hazard reduction, wildlife habitat improvement, sediment management, and the reduction of adverse wildfire effects. It may be used successfully in a variety of chaparral fuel types and weather conditions. Successful prescribed fires require:

° Management by an experienced fire management officer

° Knowledge of stand fuel characteristics, particularly the proportion of fine dead fuels, total fuel loading, live fuel moisture, and the changes

[6]Personal communication from D. Studebaker, Cleveland National Forest, Alpine, Calif.

in fuel properties in different chaparral community types

° Knowledge of expected weather behavior, including diurnal patterns of relative humidity, onset of desert influence conditions, daily changes in wind direction, and especially the likelihood of severe burning conditions

° Knowledge of differences in fuels and microclimate with terrain, including north- and south-facing slopes or trends with elevation

° Consideration of transient (nonsteady state) fire behavior, including the use of special ignition techniques and light fuels to control fire spread and activity

° Careful planning of fire control lines along natural features such as ridge lines, fuel-type boundaries (for example, conifer-oak woodland or riparian woodland with chaparral), and chaparral age-class boundaries; or the use of weather and fuel conditions to contain the fire

The Laguna-Morena Demonstration has been a focal point for development and refinement of prescribed burning techniques in the chaparral. Careful application of prescribed fire and the knowledge acquired here has the potential for substantial resource benefits in chaparral throughout California.

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