

# Maximizing Vegetation Response on Management Burns by Identifying Fire Regimes<sup>1</sup>

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Abstract: Maintenance of vegetation is a central goal of watershed management. When prescribed burning of chaparral is included in management practice, then it is important for managers to understand and use the natural chaparral fire regime to maximize vegetation response. Variations from the natural fire regime in intensity, frequency, season, and environmental conditions at the time of burning can all have substantial effects. These factors interact differently with the species that comprise chaparral. This paper focusses on the variation in responses of different groups of chaparral species to changes in fire regime.

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Prescribed burning often has been used to reduce fuel loads to meet fire safety objectives. An assumption inherent in this type of management is that prescribed burning reduces the likelihood of a wildfire yet has little net effect on the vegetation, which is basically true for many species and communities. One exception, however, is California chaparral, widely recognized as a fire-type vegetation. Chaparral tolerates burning only under certain conditions at limited times of the year. Under other conditions or times, the recovery of chaparral following prescribed burning can be limited. Particular types of species are most sensitive and several environmental conditions appear to exert the most influence on recovery. My objective in this paper is to illustrate these vegetation and environmental characteristics. Only after a careful consideration of these factors can managers hope to maximize the response of their vegetation.

Overall watershed management involves not only short-term objectives like fuel reduction, but also, the long-term objective of maintaining the health of the vegetation. The health of the vegetation depends upon species diversity as well as ensuring vegetation recovery. Many chaparral dominants in the genera Arctostaphylos and Ceanothus, for example, are usually killed in fires and are greatly reduced in regeneration following most prescribed burns (Parker 1987b). Twenty species of these two genera, furthermore,

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are listed rare and endangered species or under consideration. Chaparral contains a number of additional sensitive species. Most of these rare and endangered chaparral species are vulnerable to management practices like prescribed burning. Protection of rare and endangered species is an issue that will continue to increase in importance.

## INFLUENCES ON RECOVERY OF CHAPARRAL

### Vegetation Characteristics

The diversity of species in chaparral is reflected in the variation in plant response to burning. This diversity can be grouped according to population changes and methods of surviving fire. In this way, four regeneration syndromes can be distinguished. Many chaparral dominant species, for example, are obligate seeders with respect to fire. This means that their populations are killed by fire and require regeneration from dormant seed stored in the soil seed banks. Other dominant species also have soil seed banks, but can also resprout and are termed facultative sprouters. Populations of another group of woody species are called obligate sprouters; they resprout after fire and have no soil seed reserves. A fourth important group of species are post-fire annuals and short-lived perennials that are present only as dormant soil seed banks before a fire. Several recent reviews of these regeneration syndromes exist and should be consulted for more information (Christensen 1985, Keeley and Keeley 1988, Parker and Kelly, in press).

What is apparent is a spectrum of species, some of which sprout and some of which maintain seed banks in the soil. The various combinations establish a spectrum of vulnerability for management practice. Some species are extremely resilient, while others are readily eliminated. To maximize the diversity and rate of vegetation response and to know how careful one must be requires knowledge of what combination of species exists at the site, at least in terms of their regeneration responses.

The rate of chaparral post-fire recovery and the resilience of the vegetation depend in part, therefore, on the combination of species present at a site. If all the woody species are obligate sprouters and a large and diverse seed bank of temporary species exists, then the site will appear to recover rather rapidly. If all the woody species are obligate seeders and few temporary species are in the seed bank, then the

vegetation remains open and appears to recover rather slowly.

### Environmental Variables

Not only are vegetation characteristics important to understand, but so too are environmental characteristics. For example, in Marin County, California, serpentine soil and sandstone soil chaparral occur side by side in many areas, but these two chaparral vegetations respond very differently to fire at any given season or condition. In part the response reflects species differences, but the species in common also respond uniquely, indicating that different phenologies result from soil-influenced moisture and nutrition environments (Parker 1987b). The result is that timing for a prescribed burn that would be effective in one stand would be disastrous in the other.

While soil type is a demonstrably important influence, so too are other environmental conditions. A large proportion of chaparral plant species depend upon soil seed banks for regeneration (Parker and Kelly, in press). To survive the high soil temperatures during fires, many seeds must be dry, while other seeds require relatively high temperatures to break open their seed coats so that germination is stimulated. Soil moisture conditions vary greatly in prescribed burns and will influence survival of certain species whose seed imbibe water, while reducing germination rates of species whose seed are stimulated by higher temperatures. These types of variation in influence on recovery, and their interaction with other vegetation characteristics will be more fully described with reference to the concept of fire regime.

### FIRE REGIME CONCEPT

In the first year or two following a fire, chaparral is a substantially different vegetation from that which was burned. Obligate seeders are present as populations of seedlings lacking a soil seed bank reserve, the facultative sprouters as surviving resprouts and seedlings, the obligate sprouters as surviving resprouts, and the temporary vegetation as reproducing annuals and short-lived perennials with seeds on or close to the soil surface. A second fire in the first several years of recovery has great impact on chaparral. Such a fire eliminates the obligate seeders, kills many of the resprouts, and reduces any seed populations on or near the soil surface (Zedler and others 1983). Species diversity is reduced, cover is reduced, and the vegetation opened up for invasion by species from adjacent habitats.

The effect of a second fire illustrates that chaparral vegetation is not adapted to fire per se, but is adapted to a particular fire regime.

The phrase "fire-adapted" ignores the complexity of the fire regime to which chaparral has adapted. Fire regime is not a new concept, it has been more clearly defined recently, however, as including (1) the type of fire; (2) the intensity of the fire; (3) the season of the fire; and (4) the frequency of fires (Gill 1975, Gill and Groves 1981). When any of these characteristics are at variance with those to which the vegetation is adapted, then recovery may be poor. Two fires in a short period constitute too great a fire frequency for chaparral vegetation to tolerate.

### CHAPARRAL FIRE REGIME AND RESPONSE OF THE VEGETATION TO PRESCRIBED BURNS

Chaparral vegetation has evolved in the context of high-intensity canopy fires that usually come in the late summer or fall every 30 to 100 years (Hanes 1977, Keeley and Keeley 1988). Prescribed burns vary in a number of characteristics from this type of fire regime. In the short term, as we have seen, species differ in their response to these variations. Populations of some species are immediately reduced while others show high survival. Species showing high rates of prescribed burn survival may decline in the long term.

One common difference between prescribed burns and natural fires is in the season of the burn. Many prescribed burns, especially in urban areas, may be conducted in winter or early spring for safety reasons. This can create several problems. A common dominant species, Adenostoma fasciculatum, or chemise, is particularly sensitive to season of burn. Mortality increases in burns from fall to winter to spring (Parker 1986, 1987a, Rogers and others, these Proceedings). This type of response has been known in chemise for several decades and has been used to convert chemise stands to other vegetations in the past (Biswell 1974). A problem for watersheds today, however, is that while chemise may be eliminated, controlling what replaces chemise could be more difficult. For example, invasive species like French or Scotch brooms are expanding and are often minor components of watersheds. Opening up of habitat by prescribed burns provides opportunity for these species to expand their own populations. In contrast to chemise, many resprouting species are less sensitive to season of burn.

Another problem with out-of-season burns is that as the burn occurs later in the winter and spring, fewer and fewer species germinate from dormant seed banks. The consequence is that reestablishment of native chaparral may be delayed into the second year, while a number of other potentially invasive species may establish. Less of the watershed has a cover for the remainder of the growing season and into the next year. The watershed becomes an erosion risk for a longer period of time. Availability of soil nutrients is increased for a short period of time after a fire,

but, if germination is delayed, then opportunity to recover those nutrients is delayed and lost.

As already indicated, frequency of fires is also a great problem, especially if the watershed is being manipulated as a whole for fire safety purposes. When fire safety is the only consideration, maintaining chaparral as a young vegetation is an important consideration. Thus, on first thought, a relatively short fire-free interval would be the best policy for fire safety. But too short a fire-free interval may result in degeneration of the stand in the long run and create large-scale problems. Even an interval as long as 20 years could be too frequent. Species utilizing soil seed banks for regeneration need time for seed production, and time to incorporate sufficient seeds at a depth that can survive a fire. Movement of seeds down to the minimum soil depth required is a process that has not been studied, and probably occurs at different rates in different locations depending on slope, soil texture and structure, rainfall patterns, animal activity, and other factors. Not all individuals survive a fire, even among the most resilient sprouters. A 20-year fire frequency may also be too short for obligate sprouters, which effectively reproduce only in older stands. Such a regular interval may result in loss of their recruitment, and cause a loss in population size as individuals are lost in fires but not replaced. The net result is that while attempting to maintain fire safety, the vegetation loses species diversity, and surviving populations are reduced in density. An opened-up chaparral may allow invasion of species that are more flammable and may decrease fire safety in the long run.

Another consideration in planning a fire management program that includes prescribed burning of chaparral is that a diversity of fire-free intervals for any one site may work better than a regular interval. Recall that there really is a diversity of responses among the species that comprise chaparral. Any consistent fire frequency will favor one set of species over all others.

Previous research has also determined that prescribed burns conducted when soils contain moisture can seriously reduce the response of the seed bank (Kelly and Parker 1984, Parker 1987a, 1987b, Parker and Rogers 1988, Kelly and others, these Proceedings). There are two very different reasons for the reduction in seedling establishment. One is that many species which form persistent seed banks produce seeds that absorb water, but remain dormant unless they have been cued to germinate, usually in response to fire. When seeds have absorbed moisture, their ability to resist heat is greatly reduced (Sweeney 1956, Parker 1987b, Parker and Rogers 1988, Rogers and others, these proceedings). Even though fire intensity is reduced in a prescribed burn, the fatal temperature range for these seeds is reduced to as low as 70 C for less than 30 minutes. Such an intensity and duration in moist soils occurs to

several cm in depth, beyond the depth of most seeds.

The second class of seed response is quite opposite to the one already described. In some types of seeds, the seed coat is thick and water is not absorbed, as in species of the Rhamnaceae, Leguminosae, and Convolvulaceae. Therefore, moist soil during a burn is not fatal for these species (Parker 1987b). The problem is that the intensity and duration of heat is generally too low to stimulate germination. The consequence is a lack of seedling establishment in the first year, and those that germinate in following years are generally not able to compete with the established vegetation. This condition has been observed under field conditions with Ceanothus greggii in San Diego County. In stands burned in early winter, where C. greggii and Adenostoma fasciculatum had shared dominance, chemise now totally dominates (White 1988).

#### IMPORTANCE OF SPECIES DIVERSITY IN CHAPARRAL

The importance of careful management practices is especially clear with respect to species diversity in chaparral. Species that comprise chaparral vegetation have been shown to vary in their regeneration methods. It should come as no surprise that they also differ greatly in a number of other characteristics. Chaparral species flower, fruit, and grow throughout the year. This variation in phenology or timing of activity patterns means that species differ in how much moisture is contained in the aboveground portions of the plants. Those active later in the season maintain higher amounts of moisture in their foliage. Further, species differ in the size and shapes of leaves, in stem structure and diameter classes, indeed, in all the characteristics that influence flammability. Mixtures of species minimize the ignition potential of a stand by providing a mosaic of flammability.

Species diversity in chaparral means a diversity of tolerances and responses. Even when conditions cannot be controlled throughout a prescribed burn, overall, a dense and rapid recovery is still possible if a diversity of species is present. Diversity will maximize the total chaparral cover, and will prevent grasses, brooms, or other invasive species from penetrating chaparral and later acting as sources of flash fuel ignition.

Other issues related to diversity are well known. Species differ in their susceptibilities to a variety of environmental stresses. For example, a pathogenic fungus causes large areas of dieback in Arctostaphylos myrtifolia stands near Ione, California, at the present time (Wood and Parker 1988). Similar diebacks have been observed in other species of chaparral. Predicting such damage is difficult, because it may result from the combination of pathogen source and

environmental stresses. The result is a vegetation that is less resistant to ignition, to invasion of other species, or other problems. Controlling these problems may not be possible, but maintaining a diverse stand of chaparral will reduce the impact of stress-induced dieback of a species on a watershed.

#### CONCLUSIONS

Whether to maintain water quality, to control erosion, or for other objectives, it is important that watershed managers maintain a healthy vegetation cover. When chaparral is one of the components, then particular care must be taken. Chaparral is sensitive to prescribed burns because fires kill a large number of individuals or at least their aboveground parts. Woody chaparral species are slower to regenerate and more susceptible to climatic variation than many other plants, and recovery time is increased. Chaparral should not be considered a fire-adapted vegetation, but rather one adapted to a particular fire regime. Variations from that fire regime can reduce the vegetation response by a variety of mechanisms, from increasing mortality to simply not stimulating germination. The greater the number of fire regime factors that vary from the desirable norm, the greater the impact on the vegetation. The examples provided examined fire season, fire frequency, fire intensity, and other conditions at the time of the fire.

Also important to these responses to a prescribed burn are the types of species. Regeneration characteristics vary among chaparral species. Their sensitivity to changes in season, frequency, and intensity also vary. The response of a particular watershed to a prescribed burn depends upon environmental conditions at the time of the burn and the combination of species present. This uniqueness of response underscores the need to know the species present and to understand the types of functional responses present in those species.

The phrases "fire-adapted" and "chaparral vegetation" hide considerable complexity. Other characteristics that are important sources of variation include soil texture and mineral composition, as in serpentine chaparral. In order to maximize vegetation response to management intervention practices such as prescribed burning, it is necessary that (1) the component species be understood in terms of their types of regeneration modes; (2) seasonal timing be as close to a natural timing (summer-fall) as possible; (3) fire-free intervals be relatively long and variable; and (4) other factors such as soil type and soil moisture at the time of burning be known and controlled.

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