# Effects of Wet-Season Management Burns on Chaparral Vegetation: Implications for Rare Species

V. Thomas Parker [1]

Abstract: Many chaparral species depend upon soil seed banks for recovery after fire, including most rare and endangered chaparral species. Prescribed burns in Marin County on both sandstone and serpentine have been followed for the last three growing seasons. Field and experimental data indicate decreased germination for shrubs and herbaceous post-fire species following burns during winter. Prescribed burns during the moist conditions of winter should be carefully considered with respect to species regeneration.

The reproductive cycles of many chaparral species depend on the frequency of fire. Following wildfire, chaparral regenerates rather quickly with many fire successional species appearing for a few years before the woody shrubs dominate the site again. Prescribed burning, as a consequence, has been adopted as a common and generally well-accepted management treatment because its application mimics nature while achieving other objectives, for example reducing fuel-loads.

Reliable management techniques are critical, however, when maintenance of plant diversity is an objective. Managing the vegetation from a "fuel" perspective, relatively accurate predictions can be made about fire frequency or intensity of a fire, but managing chaparral as a dynamic association of many different species must be considered experimental. While considerable information exists regarding chaparral, present knowledge is still rather fragmentary.

Because of the need for control, prescribed burns usually occur under moist, cool conditions from late fall to spring, especially in the beginning stages of a long-term prescribed burn program. These conditions are probably not historically typical of fires to which chaparral evolved and adapted. As a consequence, many species that could otherwise survive wildfires may have difficulty recovering from prescribed burns.

Wet-season fires can have a number of effects on vegetation response. Seed germination and establishment is a critical stage of regeneration for many chaparral species, especially among those considered rare or endangered. Because many prescribed burns occur after the first fall rains, soil is commonly moist at the time of the fire. I will examine in this paper the influence of moisture on the viability of seeds stored in the soil at the time of a fire.

## VARIATION IN REPRODUCTION IN CHAPARRAL SPECIES

Three different life history reproductive patterns are associated with chaparral response to fire. One pattern is that of sprouting from parts that survive a fire, for example perennial bulbs in *Zigadenis* or the base of the stem in *Quercus*. Other species resprout after a fire, but also have a dormant seed bank that is stimulated by a fire. This is the pattern in chamise, *Adenostoma fasciculatum*, and in many *Arctostaphylos* and *Ceanothus* species. A third pattern can be found among species that only survive fire as seed. These species are completely dependent on the germination of dormant seed to reestablish their populations. Most species within both *Arctostaphylos* and *Ceanothus* follow this pattern as do many of the herbaceous species that appear in the first year after a fire.

Almost all of the rare and endangered chaparral species fall into this last category. Many currently listed species are non-sprouting woody species of the genera *Arctostaphylos* and *Ceanothus* (Table 1). Among the herbaceous species that appear after fire are those that have been or are being considered for rare or endangered status. Evaluation is more difficult for these species because they are normally present at a site only as dormant seed making it difficult to evaluate their locations, size of

[1] Associate Professor of Biology, San Francisco State University, San Francisco, CA.

Table 1--Taxa of Arctostaphylos and Ceanothus that are considered on various rare and endangered species lists within California.

| | Arcto | Ceano |
|---|---|---|
| State and Federally listed R & E | 8 | 4 |
| CNPS-Rare and Endangered (List 1) | 30 | 10 |
| CNPS-Rare only in Calif. (List 2) | 1 | 1 |
| CNPS-Need more inform. on (List 3) | 6 | 0 |
| CNPS-Of limited distr. (List 4) | 11 | 5 |
| CNPS-Considered, not incl. (Appen.) | 14 | 8 |

populations and viability of the populations. Such herbaceous species will increasingly become rare or endangered because of loss of habitat and human manipulation or management. For all of these species, woody and herbaceous, the soil seed bank represents their only opportunity to regenerate a new population following fire.

Formerly, only heat was thought to be required to break dormancy but chaparral species turn out to differ in which conditions will break seed dormancy and stimulate germination. Seeds of Adenostoma fasciculatum and of species of Arctostaphylos can be stimulated to germinate by compounds leached from charred wood with no other treatment, while seeds of Ceanothus require something like heat to break their thick seed coats (Table 2, 3).

Herbaceous species present a large variety of responses, many of which are not known. One large group of fire-response species are also readily stimulated by chemicals extracted from charred wood (Wicklow 1977, Keeley et al. 1985). Another group of herbaceous species have

Table 2. Germination from soil seed banks of two dominant shrubs, Adenostoma fasciculatum and Ceanothus ramulosus. Treatments included 100 C for 1 hr, aqueous leachate of charred wood, and no treatment (control). Data are expressed as numbers per $m^2$.

| Seed Bank Source | Control | 100 C | Charred Wood |
|---|---|---|---|
| A. fasciculatum | 3.0 | 1.5 | 22.0 |
| C. ramulosus | 0 | 13.0 | 0 |

Table 3. Germination of Arctostaphylos canescens seeds in laboratory trials. Treatments include various combinations of aqueous leachate of charred wood (char), a plant hormone, gibberillic acid (GA), high temperature (120 C), and no treament (ctrl). Seeds were of two types, "old seeds" collected from soil seed banks and fresh seed from field collections.

| Seed | Ctrl | Char | Char/GA | 120 | 120/Char | 120/Char/GA |
|---|---|---|---|---|---|---|
| Old | 0 | 14 | 9 | 1 | 1 | 0 |
| Fresh | 0 | 0 | 14 | 0 | 0 | 0 |

rather thick seed coats and rely on the heat pulse from the fire to break open those seed coats (Sweeney 1956). These two groups might be expected to respond differently to prescribed fires under moist soil conditions, particularly if the species responding to chemicals produced in the fire readily absorb moisture.

Within the dormant seed bank of a single species there also can be a variety of responses. For example, within Arctostaphylos canescens, the age of the seed also can influence the response. Seeds long dormant in the soil are more easily stimulated to germinate than those freshly produced (Table 3), thus there can be variability of response within the same population of seeds.

## GERMINATION OF SEEDS IN RELATION TO WET-SEASON BURNS

Seed banks are a significant component of chaparral and important in recovery from fire. Dormant seed banks are formed by a variety of species and by rare and endangered species in particular, as well as more common species. Few chaparral areas are not dominated by some combination of seed bank forming species of Adenostoma, Arctostaphylos, and Ceanothus; any post-fire annual species will be present only as seed in the soil. What effect will prescribed burning have on the soil seed bank? Prescribed fires will heat the soil and cause chemical changes similar to wildfires, but one major difference can be higher soil moisture under prescribed burn conditions. The influence of moisture on soil seed banks during prescribed burns, therefore, must be considered for successful vegetation management.

I have followed the germination response of chaparral species to prescribed burns for the past three years. These burns have occurred in the watershed of the Marin Municipal Water District. This agency has been experimenting with chaparral fires in cooperation with the Marin County Fire Department and the California Department of Forestry to determine if burning can be incorporated into their management policies. These fires have been conducted from October to April and generally under cool conditions with moist soil.

## Shrub response

The germination from seed banks by dominant shrubs following these fires has been rather poor (Kelly and Parker 1984, Parker 1986a, Parker 1986b). The highest density observed for Adenostoma fasciculatum only was 16 seedlings per $m^2$. In response to an April burn, no seedlings germinated at all the first year. This compares poorly with responses to wildfires in other parts of the state where seedling establishment can reach well over 100 seedlings per $m^2$. While considerable mortality of seedlings during the first several years is common, three years after a single fire that occurred in January, almost two-thirds of the total burn area had less than one surviving seedling per $m^2$; thirty percent of the burn area had no surviving seedlings.

Similarly, Arctostaphylos canescens, A. montana, Ceanothus jepsonii, and C. ramulosus all demonstrated poor germination after these prescribed burns; typically less than 1 per $m^2$ were found and no areas with over 8.4 per $m^2$. Similar to Adenostoma, no seedlings appeared the first spring following an April burn but did a year later. The rates of seedling establishment for these species on any site would not result in general in a one-to-one replacement of the preburn adult population. Seedling response in these non-sprouting species to previous wildfires in the same locations has been described as "hosts of seedlings" (Brandegee 1891), "carpets", "flourishing", or "abundantly " established (Howell 1946, 1947), a marked contrast to these prescribed burns (see also Riggan et al. 1986).

## Herbaceous response

The response of herbaceous species after these wet-season fires has also been poor (Kelly and Parker 1984). One burn on sandstone substrates on Pine Mountain showed a good herbaceous cover following a January 1983 fire with Phacelia divaricata, Calandrinia breweri, and Calystegia occidentalis as the common species. All of the other burns, and those on serpentine in particular, have had few species and little cover by herbaceous species. Previous reports of herbaceous response to wildfires in these Marin County locations have described annuals covering the slopes and listed large numbers of species, few of which appeared after these recent prescribed fires (Brandegee 1891, Howell 1946, 1947).

## SEED TOLERANCE TO HEAT UNDER MOIST CONDITIONS IN LABORATORY TESTS

To test these ideas with seeds of species specific to chaparral areas, soil seed banks of dominant shrubs and seeds of post-fire annuals were collected for experiments. When soil seed banks were moistened prior to heating, the germination response of shrubs were inhibited (Table 4). In this particular example, the heat was provided by burning a light cover of wood shavings (excelsior). The heat was variable within each heat treatment and differed somewhat between the moist and dry treatment; the dry treatment experienced a higher range of temperatures. In additional laboratory experiments with the heat applied using controlled ovens, the difference between moist and dry treatments was dramatic using soil from beneath either Adenostoma fasciculatum or Ceanothus jepsonii. In these experiments, no seeds germinated from the soil that was moist before experiencing either 80 C or 100 C for one hour. In the dry soil treatment, seedling numbers averaged from 30-125 per $m^2$ regardless of the temperature treatment.

Of the herbaceous species I collected, some absorbed moisture and the percent moisture uptake ranged between 28-45% of the seed dry weight (e.g., Emmenanthe

Table 4. Average number of Arctostaphylos seedlings ± S.D. in moist (44% & 48%) and dry seed banks experimentally heated by burning excelsior on top of them. Temperature ranges were 31±3 - 190±85 C (moist soil, subsurface to near surface) and 36±6 - 260±76 C (dry soil, subsurface to near surface).

| Source of Soil | No Heat | Excelsior Fire: Moist Soil | Excelsior Fire: Dry Soil |
|---|---|---|---|
| A. canescens | 0.8±1.1 | 11.8±4.3 | 29.6±11.0 |
| A. glandulosa | 0.4±0.5 | 1.6±1.6 | 6.0±5.5 |

penduliflora). The seeds of species requiring heat scarification (e.g., Calystegia macrostegia) absorbed less than 4% of their dry weight in water. Seeds of each species were either presoaked or left dry and subsequently heated to various temperatures for 10-20 minutes depending upon the particular experiment. The response of Emmenanthe penduliflora and Calystegia macrostegia illustrate the two types of responses encountered (Fig. 1).

The upper graph of figure 1 shows the response of Emmenanthe penduliflora and is indicative of the other species whose seeds

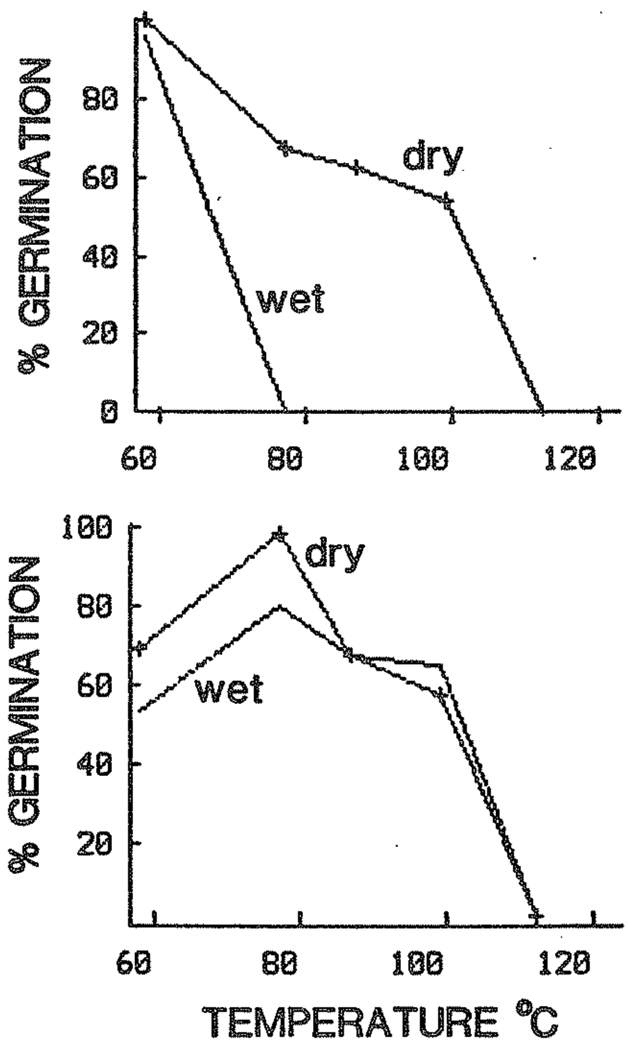


Figure 1--Top: Percent germination of Emmenanthe penduliflora. Bottom: Percent germination of Calystegia macrostegia. In both cases, seeds were dry or presoaked prior to brief heating treatments.

absorb moisture. When moistened prior to heating, the seeds can tolerate temperatures below 70 C but all are killed above 80 C. Under dry conditions these seeds can tolerate temperatures well over 100 C. On the other hand, there is no difference in the response of Calystegia macrostegia seeds to temperature between dry or premoistened treatments.

## CONCLUSIONS

These experiments illustrate a probable cause for the lack of shrub and herbaceous seedling response observed throughout the Marin watershed on areas burned by prescription under cool, moist conditions. The seeds of most of these species become particularly sensitive to heat when moist. Consequently higher mortality occurs with prescribed burns of this type, even though the fires are of generally lower intensity.

Gradually knowledge of the dynamics of chaparral seed banks is increasing. Soil seed banks of chaparral plants survive wildfires to some extent and the wildfires create appropriate conditions for seed germination. Species that make up chaparral respond to a variety of germination stimuli; there is no uniform response. Rare and endangered chaparral species are predominantly those that depend upon dormant seed banks for regeneration of their populations following fire.

Prescribed burns, if under moist soil conditions, do not duplicate the natural conditions that has maintained a great diversity of chaparral species. Prescribed burning under moist conditions will differentially affect these species by influencing seed bank mortality. This can create serious regeneration problems for annuals or shrubs with dormant seed, reducing their populations or in some cases perhaps eliminating them altogether. The loss or depletion of species can disrupt the species balance and perhaps allow invasion by new species, e.g., french broom.

The recovery of vegetation must be of prime consideration if long-term successful management is the goal. Thus the soil seed bank and its condition at the time of a fire must be integrated into management plans. Any management action will differentially favor certain species, even no action. Management plans, therefore, need to consider each species affected and their types of responses. Responses of the same species can differ within the same fire due to changes in soil type or a number of other conditions. Thus every site should be considered unique, and any burn program as experimental for any particular location and combination of species.

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## REFERENCES

Brandegee, T. S. The vegetation of "burns". Zoe 2:118-122; 1891.

Howell, J. T. Carbonated landscape. Sierra Club Bull. 37(7):18-23; 1946.

Howell, J. T. Marin County miscellany - IV. Leaflets Western Bot. 5:41-56; 1947.

Keeley, J. E., B. A. Morton, A. Pedrosa, and P. Trotter. Role of allelopathy, heat, and charred wood in the germination of chaparral herbs and suffrutescents. J. Ecol. 73:445-458; 1985.

Kelly, V. R. and V. T. Parker. The effects of wet season fires on chaparral vegetation in Marin County, California. Technical report submitted to the Marin Municipal Water District, Corte Madera, CA; 1984.

Parker, V. T. Vegetation response to prescribed burning under moist conditions. Technical report submitted to the Marin Municipal Water District, Corte Madera, CA; 1986a.

Parker, V. T. Evaluation of the effect of off-season prescribed burning on chaparral in the Marin Municipal Water District Watershed. Technical report submitted to the Marin Municipal Water District, Corte Madera, CA; 1986b.

Riggan, P. J., S. Franklin, and J. A. Brass. Fire and chaparral management at the chaparral/urban interface. Fremontia 14(3):28-30; 1986.

Sweeney, J. R. Response of vegetation to fire: a study of the herbaceous vegetation following fires. Univ. Calif. Publ. Bot. 28:143-250; 1956.

Wicklow, D. T. Germination response in <u>Emmenanthe penduliflora</u>. Ecology 58:201-205; 1977.

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