Prescribed Mosaic Burning in California Chaparral[1]

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Abstract

In fire-prone ecosystems, knowledge of previous fire history and long-term fire regimes is essential to the establishment of ecologically sound fire management. In the Californian chaparral, fire regimes are determined by the rate of fuel accumulation and previous fire history. The evolution of patch mosaics created by fire is a non-random and self-organizing process because the occurrence of fire events is affected by past events, and in turn affects future events. A strategy that increases the frequency of burns (events/area) on the landscape can reduce the probability of large fires by establishing a highly fragmented patch structure. Baja California's chaparral has a highly fragmented patch structure that is resistant to the spread of large fires. Because it is an example of ecosystems functioning under natural disturbance, it should be used as a model for fire management in California.

In fire-prone ecosystems, knowledge of previous fire history and long-term generic fire regimes (fire intervals, intensities, size, weather) is essential in the evaluation of relationships between fire and vegetation dynamics, as well as in the establishment of ecologically sound fire management. In the California chaparral, the fire regime is characterized by a self-organizing patch dynamics, making the vegetation an ideal setting for proactive broadcast planned burning for fuel management. A strategy that increases the frequency of burns (events/area) on the landscape can reduce the probability of large fires by establishing a high degree of fragmentation in patch structure.

These findings emanate from the profound discontinuity in land-use and fire history along the United States-Mexican boundary (Minnich 1983, Minnich and Chou 1997). In the United States, anthropogenic control of fire has been in place for a century, whereas little or no fire control has occurred in the isolated wildlands of northern Baja California. On the Mexican side of the international boundary, the chaparral appears as a diverse, fine-grained patch mosaic. From any view, a dozen patches of different ages may be seen---from fresh burns, to medium-sized stands, to dense old-growth stands. Beneath distant smoke columns are fires creeping through the brush with discontinuous lines of flames less than 5 m in length. North of the international boundary, however, the mountains support unbroken, dense, old-growth chaparral interspersed by a few extensively denuded watersheds from a fire provoked by a past Santa Ana wind.

This paper discusses the process by which a superior chaparral landscape has developed in Baja California without fire management.

Self-regulating Fire Regime

In the Californian chaparral, the fire regime is constrained in time and space by the rate of fuel accumulation and previous fire history (Minnich and Chou 1997). Although the standing biomass is high (40 to 100 tons per hectare), the flammability of stands remains low during the first decades of succession because of low fuel continuity (stand cover) and biomass, as well as high stand fuel moisture due to low dead-to-live stand fuel ratios. Fuels tend to be moist because the evergreen shrubs have good stomatal controls, and evapotranspiration rates are low despite high evaporative demand. This efficient internal water regulation, coupled with low annual biomass production tend to reduce interannual

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variability of fire hazard and fire recurrence intervals. Because fire hazard develops gradually, preventing the recurrence of fire far into the successional cycle, fire probability is heterogeneous from stand to stand, depending upon the differential fuel build-up related to previous fire history. Thus, the evolution of patch mosaics created by fire is a non-random and self-organizing process because the occurrence of fire events is affected by past events, and in turn affects future events. Fires burn mostly old stands (> 40 years), and the spatial extent of burns is limited by surrounding younger stands that have lower fire probability. The steady fuel build-up also results in temporally uniform, long fire intervals and a steady rate of burning at the scale of the landscape, especially over multiple fire cycles. As a consequence, there is an inverse relationship between fire frequency (events/ area, or event density) and fire size.

Baja California fires have been small because historically high burn densities have resulted in a fragmented patch structure that precludes large fires. Conversely, in California, control of fires has resulted in low fire densities and extensive stands of mature chaparral. Fires are few and large, and they spread at intensities beyond the ability of fire management agencies to suppress them.

Effects of Fire Suppression

Reversing this dilemma of large fires in California requires understanding the specific impacts of suppression. The objective of fire management in chaparral has been to put out all fires as soon as possible. Small fires were extinguished by small fire crews with portable equipment, or so-called "initial attack." Because 99 percent of fires are put out in initial attack (mostly at < 1 hectare), the few fires that do escape this phase of suppression invariably grow into intense fires of enormous size (10,000 to 60,000 hectares). The management objective for large fires is to surround the flame lines with men and equipment. In an intense, fast-moving brushfire, most effort is placed upon the protection of structures in the path of the flames. These costly efforts have little effect on fire spread, as evidenced by the much larger fires in the chaparral of California than Baja California, where large fires are not fought. The efficiency of the "initial attack" practice greatly diminishes the number of moderate sized burns (about 500 to 3,000 hectares), and encourages stand homogenization. Fires can spread as far as the heavy fuels can support them.

The most significant and negative impact of suppression is that efficient "initial attack" selects for large fires to occur during the severe fire weather. In Baja California, fires are temporally random and most events, even moderate-size fires of 500 to 2,000 hectare fires, take place in weather that occurs most frequently within the climatic distribution. The majority of fires burn slowly in summer afternoons with westerly slope winds of 5 to 10 meters sec^{-1}, temperatures of 30 to 35°C, and relative humidity of 20 to 40 percent. Because of the effectiveness of initial attack in suppressing fire starts in normal weather, large fires in California coincide with low relative humidity (≤ 20 percent) and high winds of 35 to 80 kilometers $hour^{-1}$, notably Santa Ana winds and "sundowner" winds, which accelerate flame spread and fuel consumption rates, as well as producing longer flame lengths.

Historically, the development of fire management has been a response to the threat of fire to land-use and watershed. Thus, suppression is fundamentally "reactive" and cannot be reconciled with fire as a natural process. Focussing on extinguishing of burns fails to address the management of regional vegetation and stand homogenization. The concept that surrounding burns can prevent the destruction of infrastructure is illogical when fire suppression forces cannot control large fires. The energy of flame lines is several orders of magnitude greater than the energy expended to put them out, and this overwhelms the ability of fire fighting forces to protect property and resources.

Fire Regime Properties Useful to Management

Examination of the fire history in chaparral of California and Baja California (Minnich and Chou 1997) leads us to several fundamental conclusions that are vital in fire management. First, fire poses only a cyclical threat in space and time. The removal of fuels by fire precludes the occurrence of another fire until there has been sufficient development of vegetation and fuels after fire (plant succession). In addition, at short time scales of days when fires are spreading, only a discrete portion of the vegetation (old stands) is flammable, as defined by a combustion threshold (CT) related to stand age; remaining younger stands are not flammable (Minnich and Chou 1997). The growth of vegetation and fuel production is nearly constant, reflecting the broad-scale climate. Therefore, the spatial extent of burning will approach steady-states averaged over long time scales, and at the scale of the landscape.

Another factor for management is that fire rotation periods in southern California and Mexico are very similar. Hence, suppression has not resulted in excessive regional fuel build-up. As a corollary, suppression will not slow down the pace of burning. In addition, the size of individual fires is inversely related to the density of fire events. Increasing the number of fires will produce smaller fires but not an increase in the area burned. Vegetation cannot be burned at higher rates because the availability of fuels becomes more limiting (an increase in the area of nonflammable vegetation). Finally, without fire control, high fire densities and fine-grained patch mosaics are a spontaneous outcome due to high natural ignition rates. A corollary of this is that the suppression of fires has reduced fire frequencies.

Broadcast Mosaic Burning

Although wildland fires present the greatest threat to communities at the urban-wildland interface, the most intractable problem has been the growth of the dispersed, small land-holdings within wildlands, whose presence complicate broadscale regional fire management. A management solution to this problem permits the development of a strategy that also furnishes protection at the urban-wildland interface.

Instead of encircling fires, an alternative policy is to treat settlement inholdings (ranchsteads, villages, camping facilities) as point features, around which fires can be allowed to pass through in a vast cyclically flammable landscape. For this strategy to work, there must be intense fuel management around local inholdings. In Baja California, local ranches use cattle, goats, or other livestock to remove fuels around buildings. Agricultural zones and cities use livestock, or plow fields in contact with natural vegetation. Similar measures can be undertaken in California, including severe building codes that require the design of fire proof structures. Once inholdings are made "fire safe" with these mitigations, fuel management through maintenance of a patch mosaic in the natural vegetation can be accomplished through the use of planned broadcast burns of moderate size. Patch structure can play the role of an "insurance policy" to plan the location and size of future burns, i.e., flame lines spread across old-growth patches with prevailing winds until they are controlled by young stands down-wind that lack sufficient fuel to sustain flames. Fire fighting personnel need only to check the progress of the fire relative to the preexisting patch mosaic. This strategy can be accomplished by recycling chaparral at intervals of 50 years. This is seen in Baja California where relatively old stands can still restrain fires burning in still older stands due to prevailing low fire intensities. Other advantages of planned broadcast mosaic burning include the proactive selection of appropriate weather and the forewarning of landholders weeks in advance.

To design specific management plans, National Forests and other land management agencies already have fire history databases to reconstruct current patch structure. The primary advantage of prescribed broadcast mosaic burning is that moderate size units of vegetation (about 500 to 2,000 ha) can be burned economically. However, this will be effective only if planned burns remove fuels at the same rate that fuels build up. This requirement is actually modest. For example, in the San Gabriel Mountains of California there are about 250,000 hectares of chaparral. To completely recycle the entire ecosystem at 40-year fire return intervals requires that an average of 6,250 ha are burned each year. This is equivalent to only two or three burns a year.

In California, prescribed burns are mostly small in scale (< 40 hectares). They are used mostly to remove fuels adjacent to structures, or in the urban/wildland interface, and are therefore prohibitively expensive. Moreover, the cumulative area of prescribed burns is perhaps two orders of magnitude below that required to keep up with regional fuel build up.

Planned burns should also be conducted during the summer, which is the primary fire season in Baja California. The weather is fairly constant, dominated by upslope winds in daylight and downslope air drainage at night. Unexpected weather conditions as a result of the jet stream (such as Santa Ana winds) are practically nonexistent, especially in July and August. In our experience of past fires, flames normally spread slowly uphill during afternoons. Flames generally stop during the night, with fires persisting in logs, snags, and root burls. The implementation of planned burns during normal weather reduces the potential for uncontrolled fires in extreme weather.

Conclusion

In fire management, it is perhaps not the best advice to produce a fire management system based on observations of a typical backyard. The fire history in California is a sad story of one conflagration after another. Yet, this has been our entire experience because we know little of the chaparral fire regime before fire control. In establishing a fire management system, it is important to examine the "well-managed" status of chaparral in Baja California as a example of ecosystems functioning under natural disturbance.

References

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