Fire Management Conflict Among Urban and Rural Populations and Fire Related Ecosystems in the Mexico City Forests

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Abstract

The Mexico City territory covers 150 000 ha. 50% is rural, including 35 000 ha with forests (mostly pine forests), with species like *Pinus hartwegi*i, *P. rudis* and *P. montezuma*e, examples of Mexican pines fire-adapted. For instance, *P. hartwegii* exhibits good regeneration on burned sites, young individuals resprout after fire, it has thick bark, restores crown affected by fire and shows more radial growth if only the inferior third of its crown is scorched. This pine ecosystems need low intensity frequent fires. In average 600 forest fires are present annually, mainly originated by cattle growers or farmers for disposing agricultural residues. The root of this problem is poverty and lack of forest culture. This means excess of fire in several localities, facilitating deforestation. In counterpart, the federal and local authorities, plus the inhabitants of Mexico City visualize every fire as negative, and the inhabitants are not aware (like in all the country) of the necessity of appropriate fire for preserving this forests that provide many services to Mexico city. This means fire exclusion in several parts. Other problems here are soil use change, pests and forest decline related to pollution, so smokes are also an issue. In this kaleidoscope, some pine areas are degraded because of the excessive fire, other areas are maintained, and in others the fire exclusion implies fuel accumulations that eventually facilitate intense forest fires, as demonstrated during the historic 1998 season in Mexico. The University of Chapingo proposes to evolve fire management policies and practices, from the fire exclusion stage to a use of fire for preserving the fire-related ecosystems, using techniques, intensities, timing and appropriate seasons for prescribed burning, in order of minimizing negative environmental impacts (pollution, erosion, deforestation), and increasing the positive impacts (regeneration, diversity, fire danger reduction, etc.), plus and appropriate fire use for *campesino*s. In doing so, is necessary to start at small scale, for example with *P. hartwegii* (the best studied in terms of fire ecology), with the participation of the land owners *(comunero*s), the federal and Mexico city firefighting agencies), and research institutions. In this context have been conducted some researches. Season of application of prescribed burn is a crucial issue. During 2002 were performed low intensity prescribed burns and contained forest fires (high intensity) at both March 21 (middle fire season, treatments A and B, respectively), and by May 29 (advanced fire season, treatments C and D), and was evaluated the effect of fire on survival of *P. hartwegii* trees 2-5 m height, resprouting and percent of crown by December 2002. Survival was 98% for control and 91% for A and B, and 86% and 49% for C and D. Resprouting was present in 23% of individuals in A and B, 18% in control, and 0% and 3% in C and D. Percent of crown was 81% for control, 71% and 35% for A and B, and 43% and 12% for C and D, evidencing the advantage of low intensity prescribed burning, applied no later than March.

Introduction

This work presents the results of a project in course, headed by the Universidad Autónoma Chapingo (University of Chapingo), and with the participation of the Consejo Nacional de Ciencia y Tecnología (National Council for Science and Technology), the Comisión Nacional Forestal (National Forest Comission), the Mexico City government, and the campesinos of the community of Ajusco, Distrito Federal. The project is focused on the fire ecology, fire management, conservation and restoration of the *Pinus hartwegii* ecosystem in central Mexico. It is studying the effects of fire on survival, growth, resprouting and vigor of trees; the sinecology of burned and non burned areas; the dynamics of fuels; the smokes; the differences of effects among prescribed burns and fires, and among timing of both of them; and the success of reforestation on burned areas.

The natural scenario.

Most of the Mexico City is include into the Distrito Federal, but part of the city is into the Estado de México state. The Distrito Federal has a surface of 150 000 ha; 70 000 ha are rural. Most of the city is on flat lands, but by the north of it, the mountains Sierra de Guadalupe reach 3 000 m a.s.l., and the climate is temperate and dry (600 mm of precipitation). The vegetation there is shrublands with species such as *Eysenhardtia polystachya*. In the south and southwest,some mounains exceed 3 500 m a.s.l., and the climate is temperate, with precipitation from 800 to 1 200 mm. The rural areas include 35 000 ha with forests over several mountains. 23 000 ha are pine forests, with species such as *Pinus hartwegii, P. montezumae, P. teocote, P. pseudostrobus*, and *P. ayacahuite* var. *veitchii*. There is also fir forests (*Abies religiosa*), oak (*Quercus rugosa, Q. Crassipes*, among other species), and mixed forests, plus grasslands and shrublands. The *Pinus hartwegii* forests reach the highest areas, from some 3 000 m a.s.l. to some more of 4 000 m a.s.l. in some areas of the Estado de México. This pine is the one that reaches the highest altitude in Mexico, forming pure stands on that elevated sites. The Distrito Federal hosts 220 bird, 32 reptile, 15 amphibian, and 84 mammal species. It has plant and animal species considered as endangered or/and endemic.

There is three main types of fire regimes in the area: The surface low intensity frequent fires are present on most of the pine forests, some oak forests and the grasslands. The destructive non frequent crown fires are present in the fir forests, and relatively frequent crown fires affect also the shrublands.

The city

From its evolution from the first human settlements and the establishment of Tenochtitlan (its initial name) in prehispanic times, to the colonial era and to the present time, the Mexico city has increased its population from some thousands to more than 15 million of inhabitants, being one of the most populated and, unfortunately, one of the most polluted cities in the world. Most of the population is urban, but a few millions live on city-forest or city-rural interface areas, plus some tens of thousands of campesinos live in the rural areas.

Stress over the forest

The most important perturbations over the forests in the Distrito Federal are: Change in soil use for agriculture, grasslands or urban settlements, cattle growing, forest declination related to air pollution, clandestine harvests, forest pests, and human caused forest fires.

The forest fires

The fire starts in January and ends in June. Despite the relatively small surface of the Distrito Federal forests, every year an average of 1 026 forest fires occur (including some 400 of very small size), over an area of 2 270 ha. This places the Distrito Federal in the places 3 (for number of fires) and 20 (for affected area) among the 32 states of Mexico. The majority of such fires are originated for agropecuarian activities, campfires and smokers. So a vast part of the problem is related to poverty, lack of economic opportunities, and scarce forest culture, involving both the rural an urban population. The average area affected by fire is low because there is an important and effective force to fight the fires, from the Mexico City and the federal governments, plus the campesinos, and because most of the fires are easily detected and at short distances.

The project

In Mexico, practically all of the population, urban or rural, visualizes only the negative side of the fire. However, people is starting to be more receptive to benefits derived from use of fire, other than those related to cattle growing or cleaning the land. One proof of that is the authorization granted to the Universidad Autónoma Chapingo for conducting experimental prescribed burning and confined forest fires in the communal lands of the Ajusco, where this project is being developed.

The basic idea is to learn about the different ecological impacts of prescribed and wild fires in two different times on the *Pinus hartwegii* ecosystem, in order of setting a basis for an use of fire knowing the conditions in which it must be applied to maximize positive effects, and to minimize negative impacts. This is a firs step, for uses of land (cattle growing, etc.) must be involved in future research, because of their interaction with fire.

On the Ajusco volcano, Distrito Federal, at 3 200 m a.s.l., on southwest aspect and 55% of average slope, in a young *Pinus hartwegii* forest, were compared several effects of fire on trees and forest. The treatments were low intensity prescribed fires (March 21 and May 29, 2002), and confined forest fires (same dates), plus a control. Prescribed burns and confined fires were directed by the author, but with the valuable and indispensable collaboration of two teams of professional firefighters from federal government, and with the participation of graduate students. Each treatment was applied on 1 ha plots, surrounded by wide firebreaks. Into such plots were installed several experimental units for measuring fire behavior, survival, resprouting, growth of trees (as a function of crown scorch), and to determine composition and importance values, among other parameters of herbaceous and woody vegetation. Also the fuel dynamics is being analyzed and a stereoscopic fuel guide is being developed. Part of the plot was planted in July 2002 with container trees of the studied species to evaluate its survival and growth. In nearby areas (Desierto de los Leones and Estación Forestal Experimental Zoquiapan) the effect of crown scorch on radial growth and the smokes were studied. For experimental and statistical analysis details, please see the references provided in this work.

Fire behavior was quite contrasting. During the March 21 prescribed burn, early in the morning, with low temperatures and high humidity, and against wind and slope, propagation rates was < 1m/min, with flame lengths around 0.5 m. In comparison, the confined fire (May 29) conducted at peak hours, with high temperature, low humidity, and in the same direction than slope and wind (reaching 15 km/h), reached in some moments propagation rates >60 m/min and flame length of 6-8 m.

One year after the treatments application, survival of young trees (2-6 m tall) was 95% in the unburned control, 90% in the March prescribed burn area, and 30% in the zone under the May confined fire. The treatments of May and the confined fires, produced higher proportions of trees with high crown scorch, in comparison with March and prescribed burn treatments. González-Rosales and Rodríguez-Trejo (in review, Figure 1) report that light crown scorch (>30%) implied a 32% greater radial growth than an unburned control. Trees with medium crown scorch (30-60%) had a secondary growth similar to the control, while intense crown scorch (>60%) was related to a reduced radial growth. Preliminary results show that height growth by March 2003 was higher in light crown scorched trees (13 cm), in comparison with controls (8 cm).

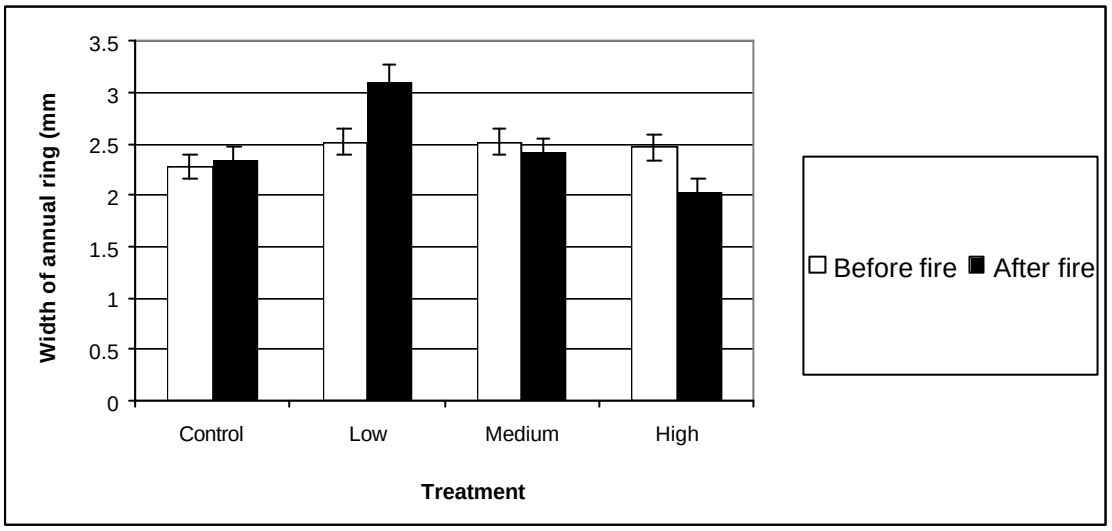

Figure 1. Width of annual ring of *Pinus hartweggi* with across different levels of crown scorch (adapted from Agrociencia, in review). The error bars represent standard error.

Fire in March (both as prescribed fire or wildfire), increases the alpha-diversity, in comparison to control, with 21, 21, and 12 species, respectively. Some of the more typical species on burned areas are: *Senecio cinerarioides, Penstemon gentianoides, Senecio tolucanus*, and *Arenaria* sp. (Martínez-Hernández and Rodríguez-Trejo, in elaboration).

Initial survival of planted trees, at six months from planting, exhibited no significant differences among unburned control, prescribed burn in March and confined fire on March, with 95, 90, and 80%, respectively, but this figures were superior to those from the Mary prescribed fire and confined fire (60% in both cases) (Ortega-Baranda and Rodríguez Trejo, in elaboration). Revegetation was later and slower in May treatments, leaving the planted seedlings more exposed to weather extremes in such altitudes.

In 1998, México had its worst fire season in record. Central Mexico was not the exception. In *P. harwegii, A. religiosa* and other forests intensely burned that year, the shrub Senecio cinerarioides become more abundant. It produces shade, that may be favorable for fir regeneration. However most of pines are intolerant, including *P. hartwegii*, so this shade is non benefic in this case. Moreover, Contreras-Moctezuma et al. (2003) found that such shrub emits more NO_X (7.05 kg/t) and SO_2 (1.98 kg/t) (Figure 2) and as much CO (76.71 kg/t) than the other fuels (grasses, wood, needles, etc.) in this forest. If this areas covered with *S. cinerarioides* burn, they are going to pollute more than the undisturbed forest.

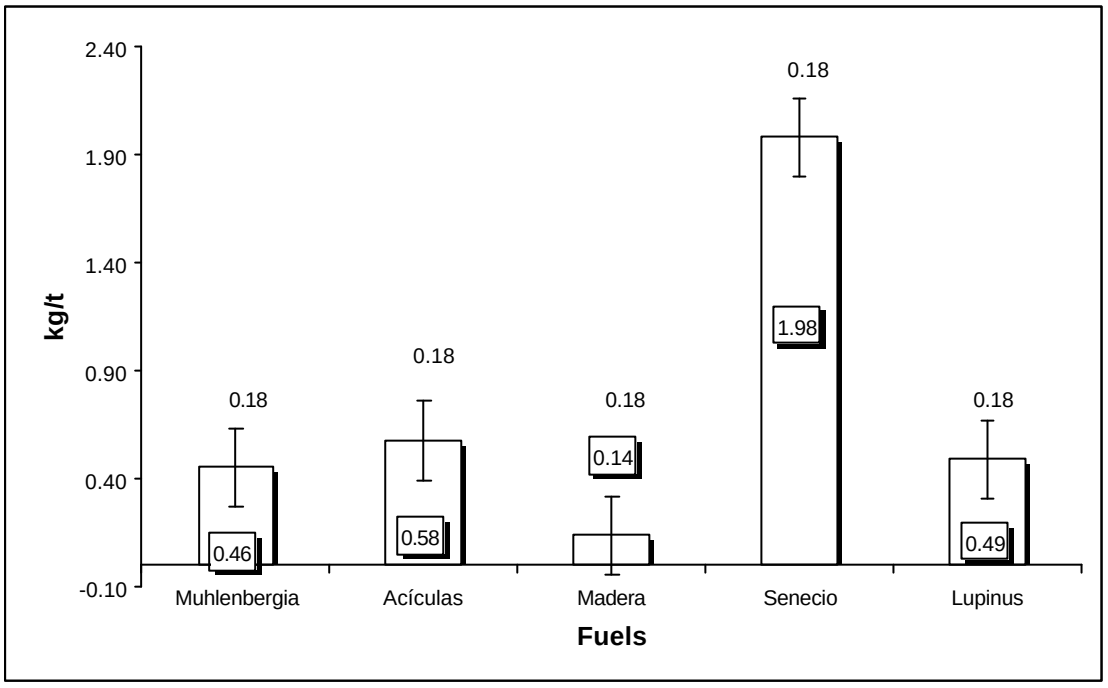

Figure 2. Sulphur Dioxide emissions of the main fuels in the *Pinus hartwegii* forest. Muhlenbergia=dominant grasses, Acículas=pine needles, Madera=wood, Senecio=*Senecio cinerarioides*, Lupinus=*Lupinus montanus*. The error bars, represent standard error.

Pinus hartwegii regenerates well in burned areas (Sarukhán-Kermes and Franco, 1981), emits resprouts, it has a thick bark, tolerates crown scorch, restores it scorched crown (Rodríguez Trejo, 1996; Rodríguez Trejo, 2001; Rodríguez-Trejo and Fulé, 2003) plus in some populations exhibits grass stage, making this species one (if not the most) pine fire adapted in Mexico. The other pines present in the Distrito Federal show fire-traits, as documented by Rodríguez-Trejo and Fulé (2003).

Rzedowski (1978) and Hernández-Xolocotzi (1985) report that very frequent fires will favor grasses to the detriment of *P. hartwegii.* Also is known that lack of fire implies dense grasses that difficult the contact between seed and mineral soil, affecting natural regeneration of this pine.

This ecosystems may be key in terms of fire regimes, plus their location on tops of the mountains make them crucial also in terms of restoration, for is advisable to start it from the tops of mountains.

It is evident the need for fire in the studied ecosystem. However, the excess of fire is quite detrimental, for produces deforestation. The fire exclusion implies more fuel accumulation that eventually burns, producing more negative impacts (pollution, alteration, increases of *S. cinerarioides* that eventually may pollute even more).

Social aspects

The vast majority of urban population see fire only as detrimental. The federal and Distrito Federal authorities are aware of fire as an ecological factor, but are not planning its broad use in the short term, so the policies are to fight every fire and to minimize the number of fires and the surface affected by them. The rural population is aware of negative impacts of fire, but in several cases needs to use it for survival, for complementing its economy. Also observationally in some cases has detected the positive role of fire in the Mexico City ecosystems, which in several cases need an appropriate amount of fire, not in excess not in lack. The opportunity given to the Universidad Autónoma Chapingo for conducting this project, and the participation of several sectors in it, plus the increase in fire-related research across the country. The researches still are not abundant, but they are larger than in previous times.

The next step in the present project is to show the results to campesinos, firefighting, federal and Mexico City authorities, plus citizens, in order of establishing small areas for fire management, using it no later than March, at low intensity, in sites not susceptible to erosion, looking for favoring natural regeneration, reducing fuel load and fire danger, promoting secondary and primary growth in trees, favoring a larger diversity of species, and emitting less smokes in comparison with wildfires. Dendrochronological studies are required to define an interval of fire frequencies.

This strategy may help to use more efficiently fire, coupled with the needs and fire use technologies of the campesino (being required then more research on this interactions). Adding also other productive strategies (such as agroforestry systems, e.g. silvopastoral systems) under a site social and ecological characteristics basis.

Maximizing benefits and minimizing drawbacks of fire trough its management under scientific basis, may help to reduce arson caused fires, to incorporate formally and in a responsible way fire as a tool for land management (traditional uses, silviculture), and help to preserve and restore the forest ecosystems.

The only way is more scientific knowledge to understand impacts and ecology of fire, to can use it as a friend and to reduce its face of foe. Also is indispensable to educate more the society in this issues, including part of the government, and an intense participation of universities and research centers. This steps must be given carefully, gradually, holistically, under the scope of adaptive management.

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