Effect of Wildfires on Woody Species in the Monte Region of Argentina

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Highlight: *Woody vegetation was assessed on two adjacent areas 1 year after the occurrence of wildfires. One area was burned slowly by a backfire that moved mostly through the understory, while the other area was burned by a rapidly-moving headfire that reached into all crowns of trees and shrubs. The six woody species studied exhibited some degree of mortality after both fires, with the headfire causing significantly more mortality than the backfire. The tops of all woody plants were killed by both types of fire, except for caldén, which had considerable new crown growth following the backfire. Significantly greater percentages of plants of all six species were able to sprout following a backfire. Plant ignition and subsequent wood consumption were generally higher when subjected to a headfire than a backfire. The degree of ignition and wood consumption apparently had a direct effect on the ability of the plant to produce sprouts.*

The Monte region of central and western Argentina is a vast, almost continuous area of thorny shrublands encompassing nearly 60,000,000 hectares. This grazing region supports approximately 1,835,000 animal units of cattle, sheep, and goats, thus being one of the major livestock-producing regions of Argentina (Ragonese, 1967). Wildfires, set mostly by lightning during dry summers, are very common throughout the Monte. However, little is known about the effects of these fires on the vegetation.

Several large wildfires occurred in the Monte during the summer of 1971. One front burned for more than 100 kilometers from January 20 to 25, thus providing several thousand hectares for evaluation. A site was selected on the Biondini Estancia, approximately 150 kilometers west of Bahia Blanca, to assess the effects of wildfires on dominant woody species common throughout much of the Monte region.

Study Area and Methods

The area selected for study included a portion burned by a headfire and another by a backfire, thus affording an opportunity for evaluation of the effects of both types of fires within close proximity to each other, as both share a common boundary. No information is available concerning the amount of fuel in the form of grass that was on the area when it burned. However, samples clipped on a nearby unburned area within the same pasture yielded 1470 kg/ha. Thus, it is assumed that a comparable amount of fine fuel was present on the nearby burned areas to carry the fire. The headfire burned with the wind and advanced rapidly as a front often 4m high, while the backfire moved much slower into the wind and remained mostly in the herbaceous layer at an average height of 1m.

The plant community is a dense shrubland dominated by low-growing trees, mainly caldén (*Prosopis caldenia*)[1], algarrobo (*P. flexuosa*), and sombra de toro (*Jodinia rhombifolia*), and an abundance of shrub species, including piquillín (*Condalia microphylla*), molle (*Schinus fasciculatus*), chañar (*Geoffroea decorticans*), jarilla (*Larrea divaricata*), and alpataco (*Prosopis alpataco*). Grasses in the understory include mostly cool-season species such as flechilla (*Stipa tenuis*), paja (*S. tenuissima*), flechilla negra (*Piptochaetium napostaense*) unquillo (*Poa lanuginosa*), and cebadilla pampeana (*Bromus brevis*).

The topography is flat to rolling with slopes of 0 to 5%. Average annual rainfall is about 455mm with the major portion falling during the spring and summer. No precipitation records are available for the study area during the period

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[1]Common and scientific names of Argentine plants follow those of Ragonese (1967).

immediately before and after the occurrence of the wildfire. However, the general area was very dry at the time the fire occurred, while the remainder of the growing season following the fire was much wetter. The fire was terminated by heavy rains.

Soils range in texture from a fine sandy loam to a loamy fine sand with a thick layer of consolidated calcium carbonate at depths varying from 10 to 60 cm.

In January 1972, 1 year after the fire, 100 plants each of jarilla, piquillín, molle, caldén, chañar, and algarrobo were randomly selected for study under each of the two fire conditions. Wood samples were collected for each species present on the area for use in identification of dead plants and those having most of the top consumed by fire. Wood characteristics were sufficiently different among species to allow identification. Other characteristics such as growth form and leaves on live sprouts also were used in species determination.

Each plant was classified according to the following characteristics:

1. Dead or alive
2. Degree of wood consumption by the fire
   a. None—plants were only scorched with no charring
   b. Moderate—only certain portions of the plant were charred or consumed
   c. Heavy—plants severely charred or mostly consumed
3. Sprout production
   a. No sprouts
   b. One or more sprouts
4. Degree of canopy regrowth
   a. None
   b. Partial
   c. Total

Data were statistically analyzed where appropriate by use of a chi-square test (Steel and Torrie, 1960) at the 5% probability level to determine significant differences.

Results and Discussion

Plant Mortality

All six species of woody plants assessed in this study exhibited some degree of mortality 1 year after exposure to a headfire or a backfire. The conditions present during the headfire resulted in a significantly higher percentage of mortality in all species than occurred with the backfire. Fifty-eight percent of all woody plants were killed by the headfire, while 36.5% died in the area burned by the backfire. Mortality ranged from a high of 82% for molle plants to a low of 38% for chañar in the headfire area (Table 1). Molle again had the highest mortality of 55% in the area burned by the backfire, while calden and chanar had the lowest percentages, 18 and 19%, respectively.

These values represent plant mortality 1 year after the fire and may not express the final percentages of mortality attributed to the fire. However, these data indicate that a headfire is more damaging to woody plants than a backfire. Hare (1961) suggested that headfires develop considerably more heat than backfires because the flames are fanned by the wind to ignite new fuel ahead of the flame front. Thus, more fuel burns per unit of time, and more aerial fuels are consumed, resulting in greater crown damage.

Table 1. Percent of plants of six woody species killed by a backfire and a headfire.

Species	Type of fire		Difference
	Backfire	Headfire	
Algarrobo	35	58	23*
Chañar	19	38	19*
Jarilla	42	55	13*
Caldén	18	50	32*
Molle	55	82	27*
Piquillín	50	65	15*

*Significantly different at the 0.05 probability level.

Sprouting

One important variable which determines the relative fire resistance among species is the ability to sprout following a fire. Dormant buds were observed on the root crowns of all six species included in this study, indicating a source of buds for sprouting. These buds were apparently subject to apical dominance which was reduced or removed following fire injury to the aerial plant parts.

Wide variations in ability to sprout following exposure to fire were encountered with the species in this study. For example, the percent of plants sprouting ranged from a low of 18% for molle to a high of 62% for chañar on the headfire area (Table 2). Percentages were also quite variable on the backfire area, ranging from 45% for molle to 82% for chañar and caldén.

Table 2. Percent of plants of six species of shrubs sprouting after exposure to a backfire and a headfire.

Species	Type of fire		Difference
	Backfire	Headfire	
Algarrobo	65	42	23*
Chañar	81	62	19*
Jarilla	58	45	13*
Caldén	82	50	32*
Molle	45	18	27*
Piquillín	50	35	15*

*Significantly different at the 0.05 probability level.

A significantly greater percentage of plants of all six species sprouted following a backfire than after a headfire. Differences in sprouting on the two areas ranged from a low of 13% for jarilla to a high of 32% for caldén (Table 2). Twenty-one percent more of all woody plants sprouted in the area burned by the backfire than in that of the headfire. Thus, the damaging effects of the rapid-moving, hotter headfire were more restrictive to sprouting than those of the cooler-burning backfire, which moved at a slower speed.

Several of the new sprouts on chañar and jarilla plants were observed to be dead or in a weakened condition which would apparently lead to death. Very few herbaceous plants were present near the base of these two woody species 1 year after the fire. Thus, competition by herbaceous plants would not explain the observed sprout mortality. Apparently, more initial sprouts were produced than could be supported by the plant. Competition probably occurs between sprouts, with some having an advantage over others as evidenced by their continued growth. Willard and McKell (1973) reported the same phenomenon in snowberry (*Symphoricarpos vaccinioides*) and little rabbitbrush (*Chrysothamnus viscidiflorus*) in which various amounts of sprout mortality were observed on shrubs which had been clipped to simulate grazing and also on intact plants which had been protected from grazing or other forms of herbage removal. Sprouts on algarrobo, caldén, molle, and piquillín plants were all vigorously growing; thus it is assumed that little if any sprout mortality will occur in these

species.

Plant Combustion

Less plant combustion occurred during the backfire than the headfire, especially in the taller species, which include chañar, algarrobo, jarilla, and caldén (Fig. 1). The taller species and taller individuals had canopies well above the grass layer which carried the fire into the wind, thus escaping ignition of the upper branches and leaves to a greater extent than those plants subjected to the conditions of the headfire. The shorter molle and piquillín plants generally had canopies beginning in the grass layer, thus being more susceptible to ignition.

No chañar plants ignited when exposed to the conditions of the backfire. However, 44% received moderate combustion and 3% heavy combustion in the area burned by the headfire. Chañar plants have a particular type of cork cambium which produces layers or sheets of bark that peel away from the trunk after suberization is complete. This peeled bark appears to be highly susceptible to ignition, but in no instance were plants found with charred or burned bark. Combustion during the headfire occurred only in the canopy, mainly with leaves and smaller limbs.

Eighty percent of the jarilla plants failed to ignite in the backfire area, 15% received moderate fire damage, and only 5% were heavily burned. Conversely, 100% of the plants had heavy combustion when exposed to the conditions present during the headfire. Jarilla plants are several-stemmed, with the leaves and smaller twigs occurring above the grass layer. Thus, a taller flame such as was present during the headfire was necessary to ignite the canopy. Once the foliage caught fire, ignition was almost complete, with most plants being burned to the ground. Heat created by burning jarilla plants

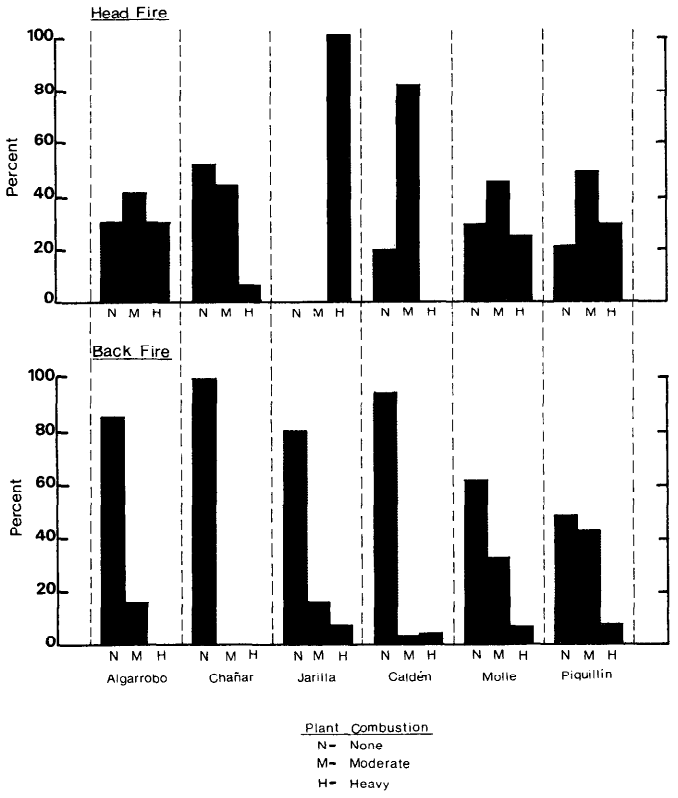

Fig. 1. *Percent of plants receiving various degrees of combustion in six woody species as related to the conditions present during a backfire and a headfire.*

appears to have been more intense than for the other woody species, as evidenced by the almost complete mortality of plants in the understory beneath individual jarilla plants. This condition was observed to a much lesser degree under molle and piquillín plants. but not for the other species. Combustion of a dense stand of jarilla plants might be expected to greatly reduce the desirable grasses and forbs in the understory.

Algarrobo and caldén are of the same genus and have the same general size and shape. Both were highly resistant to ignition from the backfire, as 85% of algarrobo and 94% of caldén plants failed to ignite. However, the degree of combustion during the headfire was quite different between the species. Only 16% of the caldén plants failed to ignite during the headfire, with the remaining 84% having only partial combustion. Almost twice as many algarrobo plants escaped ignition during the headfire, but 30% of those which ignited were heavily burned. Thus, algarrobo appears to be more resistant to ignition than caldén during a headfire, but, once ignited, burns to a greater degree.

The low-growing shrubs, piquillín and molle, exhibited similar degrees of resistance to ignition and combustion. Sixty-two percent of molle plants failed to ignite during the backfire, as compared with 47% of piquillín. Most combustion of plants that did ignite was moderate. Twenty percent of the piquillín plants and 30% of the molle plants failed to ignite during the headfire; approximately one-half of the plants burned only moderately; while 20% of piquillín plants and 25% of those of molle burned heavily, sufficiently to leave only charred stumps.

Fuel conditions on an unburned area in the same pasture as the burned areas were examined in an attempt to determine why certain plants ignited and others did not. As previously mentioned, the four taller species had canopies of mature individuals well above the level of the understory. The height and duration of the flames reaching into the canopy of a particular plant probably explains the variation encountered within a single species. The amount of fuel under a particular plant of the taller species probably had less influence than in the lower-growing species. The amount of grass fuel under piquillín and molle plants and also that reaching into the canopies was variable, and evidently influenced the degree of ignition and combustion of individual plants.

It appears, then, that the amount of fine fuel directly under low-growing shrubs is more important in regulation of ignition and combustion than under taller-growing species. The degree of ignition of plants with canopies above the fuel layer may be more influenced by the total amount of fine fuel in the general vicinity and the action of wind in whipping flames into the canopies.

White (1969) assessed the degree of combustion of six Arizona desert shrub species during a wildfire in relation to plant mortality. He reported that the percentage of survival of plants severely burned was significantly less than for those lightly or moderately damaged. Survival of lightly-burned plants was greater than for those moderately damaged in certain species. Thus, the degree of wood consumption by a fire may be an important variable influencing the plant's ability to sprout.

Britton and Wright (1971) found that 33.6 to 94.9% of individual stems of *Prosopis glandulosa* var. *glandulosa* ignited in areas experimentally burned under a wide range of weather and fuel conditions. However, these values relate to plants having tops previously killed by herbicide application; no

information was available for ignition of live tops. Burndown was also reported to vary from 14.4 to 89.1% for the dead tops. I was unable to find any complete burndown of live tops of *Prosopis* plants following the wildfire in the Monte. The difference in burndown of live tops and dead tops of *Prosopis* is apparently at least partially related to the higher moisture content contributed by sap in live tops.

Sprouting as Related to Plant Combustion

The amount of crown material consumed by fire apparently had a direct effect on the ability of the woody plants to sprout later. Seventy percent of all woody plants which were exposed to fire but failed to ignite were able to produce sprouts the following year. Fifty-three percent of those moderately burned sprouted, while new sprouts appeared on only 14% of plants heavily consumed by fire.

A fire which fails to ignite the canopies of the six species studied will have a limited effect in controlling sprouting. Of those plants failing to ignite, algarrobo had the lowest percentage of plants sprouting (56%), while jarilla and caldén had the most sprouting with 77% and 78% respectively (Table 3). Sprouting of plants moderately burned was reduced below that of those escaping ignition, except for algarrobo, which had an 8% increase. Sprouting was greatly limited in plants heavily consumed by fire, ranging from none for chañar and caldén to a high of 24% for piquillin. The number of plants included in the heavy combustion class is quite low for certain species, especially caldén, but these appears to be a trend toward less sprouting with an increase in combustion.

Table 3. Percent of plants of six woody species sprouting following various degrees of plant combustion.

Species	Combustion class		
	None	Moderate	Heavy
Algarrobo	56	64	23
Chañar	73	72	0
Jarilla	77	58	15
Caldén	78	54	0
Molle	71	38	22
Piquillín	62	31	24

The relationship between sprouting ability and fuel consumption is probably that of increased temperatures at the bud zone when a plant ignites and burns for an extended period. The longer period of exposure to a high temperature may be important in heating the soil to a greater depth.

Canopy Regrowth

Canopies of all woody plants were killed by both the backfire and headfire with the exception of caldén, which had considerable new top growth after the backfire. However, caldén was also vulnerable to the backfire, since 38% of the tops were killed and 57% had partial regrowth (Table 4). Only 5% of the canopies of caldén plants in the backfire area were fully growing the year after the fire.

These data illustrate that heat alone without accompanying ignition can be effective in killing aerial parts of woody plants. Starker (1934) suggested that relative fire resistance includes such characteristics as bark thickness and composition. These variables may help explain the difference in top kill between caldén and the other woody species, as caldén was found to have a thicker bark than the other species. This thick bark apparently served as an insulating deterrent to the heat generated by the fire.

Table 4. Percentage of caldén plants with crown regrowth following a backfire and a headfire.

Degree of crown regrowth	Type of fire		Difference
	Backfire	Headfire	
None	38	100	62*
Partial	57	0	57*
Total	5	0	5

*Significantly different at the 0.05 probability level.

Conclusions

Wildfires are very common throughout the Monte region of Argentina and apparently have had an influence in controlling the density of woody vegetation, as was found in this study. However, uncontrolled fire is a hazard to livestock, wildlife, structures such as fences and houses, and even to man. Therefore, its natural occurrence must be discouraged and cannot be relied upon for controlling woody species. Controlled burning has been used in many parts of the world to suppress woody vegetation. West (1965) reviewed the literature related to the effect of fire on vegetation with special reference to Africa. He concluded that in savannah rangelands and in those types of grazing lands containing thick stands of shrubs, fire can effectively suppress brush and help to maintain open stands. The present study of an area of the Argentine Monte burned by wildfires suggests the feasibility of using prescribed burning in this region also.

Fire is an inexpensive method of controlling brush and reducing the actual numbers of woody plants. One problem encountered in the aerial application of herbicides to sprouting species is the high probability of sprouting following top kill. A second application of the herbicide is necessary to control sprout growth, as is the common practice with various species of *Prosopis* in the southwestern United States. A possibility exists for using controlled burning to kill the tops of woody species, reduce the number of live plants, and initiate growth of dormant buds on the root crowns of plants not killed by the fire. Control of the new sprouts might then be possible by use of a follow-up controlled burn, individual plant treatment by basal application of chemicals, or perhaps aerial application of herbicides. These control methods need to be tested, as no information exists for their use in controlling sprouting of the major woody species on the Monte region of Argentina.

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