Economic Information on the Historical Behavior of Forest Fires in the Forest Lands in the State of Parana, Brazil[1]

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Abstract

It is widely acknowledged that the fires have caused severe impact in the world, and their frequency and intensity tend to increase as a result of ongoing climate changes which have occurred over the past decades. It should be also noted that the urban-rural interface has attracted the attention of governments by the concentration of the number of fire occurrences and their specificities. The study aimed at determining economic indicators from the determination of the profile of forest fires in the study area during the period 1965 to 2009.

Statistical analysis related to the number of fires, the burned areas, the spatial distribution of the occurrence, the distribution through the months of the year, and the identification their main causes have been done. Costs associated with the incidence of fire were calculated as well the benefit-cost ratio related to the actions that have been taken into account for the prevention and control of fires in the area of the study. The results obtained allow indicate suggestions to the administration of the forestry enterprise in terms of the amount of investments that are required to implement activities related to prevention and control of fires, from the perspective of an economic analysis.

Keywords: economic damage valuation, economic return, forest fires.

Introduction

Despite the adoption of protection practices, each year fire damage or destroy each year large extension of forests in the world. In South America it is estimated that in the last three decades have occurred at least 290,000 forest fires, affecting 51.7 million hectares, of which about 300,000 hectares were of forest plantations of *Pinus* and *Eucalyptus* (Global Fire Monitoring Center -

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GFMC, 2007).

The predictions of the consequences of global climate change and particularly in regional basis indicate an increase in forest fires in various parts of the region. Therefore, the countries need, and are obliged to increase their mutual cooperation, in order to be coordinated and prepared to face these challenges related to more severe scenario.

According to the United Nations Food and Agriculture Organization - FAO (2006), in South America, 85.5% of forest fires, on average, are due to human causes, 5.5% to natural causes (lightning) and 9 % to unknown causes. Among the human causes of deforestation are the areas for agro industrial crops, mining activities, construction of road networks, ranching activities and illegal logging. According to FAO (2007), the occurrence of fires near to the urban-rural interface has intensified over the past decade, especially in countries like Argentina, Chile, Ecuador and Uruguay. Pellizzaro and others (2011) also observed in Sardinia, Italy, an increased occurrence of fires in the last three decades, especially in summer, due to the increase of tourists in the region and when weather conditions are more conducive to the initiation and spread of fire. Ribeiro and Viegas (2011) reported an increase in urban-rural interface fires in Portugal and Greece in 2007 and Australia in 2009. Based on its 38 years of fire occurrence in Sydney, Price and Bradstock (2011) identified seasons with more intense fire danger associated with the loss of homes, once or twice per decade.

Vosgerau and others (2006) reported that forest fires in Brazil are concentrated in winter and early spring seasons, by offering lower average rainfall and relative humidity. According to these authors, the normal period of fires in Brazil runs from June to October, when about 69% of fires occur and more than 90% of areas are burned. Soares, Batista and Santos (2006), analyzing the last 20 years the occurrence of forest fires in Brazil, found that the normal fire covers the months from June to November, with a greater number of recorded fires in the period from August to September.

Soares and Batista (1998) indicated that one of the biggest fires in the history occurred in 1963 burning 2 million hectares in the state of Paraná, about 10% of its surface, corresponding to 20,000 ha of forest plantations, 500,000 ha of forests and 1,480.000 ha of natural pastures, secondary forests and scrubs. In this fire, Klabin Paraná, a paper industry, had 85% of the area impacted, and, therefore, was the first to do so, since 1965, the systematic recording of events and worry about the subject (Figure 1).

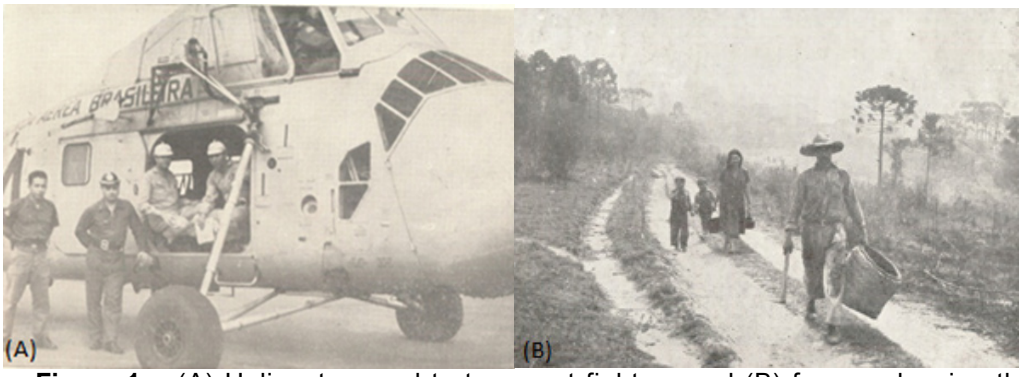

Figure 1— (A) Helicopter used to transport fighters and (B) farmers leaving the region in the fire of 1963
Source: Paraná (1963)

Protective measures against fire should be taken even before the establishment of an area. Decisions related to the preparation of the ground, spacing, area of the stands, silvicultural practices and construction of firebreaks will affect the potential for the occurrence and spread of fire in the future. Annually, the forestry administrator should decide about the resources to be allocated for fire protection in areas that are under his care. Traditionally, this decision has been based on experience and judgment related to success or failure of measures previously adopted in the region. This practice can lead to large disparities in protection between different policy areas and, especially, the administrator makes it difficult to know whether resources are being calculated correctly (Soares 1978, Soares and Batista 2007).

Given the importance of establishing the amount to be appropriated for protection against forest fires, the objective of this study was to estimate the budget for the protection of forest fires in Fazenda Monte Alegre, state of Paraná, Brazil, based on data collected during 45 years, from 1965 to 2009.

Material and Methods

Characterization of the area

The research was conducted at Fazenda Monte Alegre, owned by the company Klabin Paraná, located in the municipality of Telemaco Borba, PR, central region of the State of Paraná, in its the second plateau, approximately between the coordinates 24º 03' and 24º 28' South Latitude and 50º 21' and 50º 43' West Longitude, becoming the largest continuous area of forest plantations in Brazil, with the activity beginning in 1943 (Figure 2).

The topography of the area is gently rolling and the most important geographical feature is the Tibagi River, main tributary of Paranapanema, which in turn is one of the main tributaries of the Paraná River. The average altitude of the study area is 850 m above sea level, with a range from 750 to 868 m (Soares 1972, Nunes and others 2009, Nunes and others 2010).

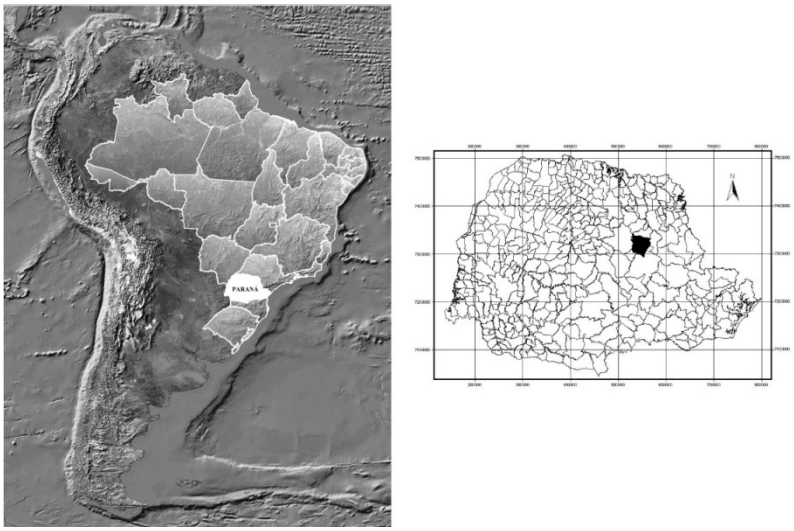

Figure 2—Location of the study area.

According to Köppen climate classification of the region belongs to Cfb, that means, humid temperate, without dry season, with cool summers and regular frosts. According to the classification of life zones of Holdridge, the region is located in the humid temperate forest eco training (Soares 1972)

The average annual rainfall of the region of was 1,608 mm which indicates, according to Nunes and others (2010), a water surplus of 557 mm/year distributed in all months of the year. Nunes and others (2009) analyzed data on monthly rainfall and number of rainy days in the period 1947-2005, and concluded that the wettest months were December, January and February, and the less rainy months were July and August. These results are also according the data generated by the Agronomic Institute of Paraná (IAPAR 2012). The quarter with the lowest number of rainy days was in July, August and September.

The average of the annual temperature was 18.6 ºC and the coldest months are June, July and August, with minimum absolute temperature of -5 °C (June 1978), and the hottest months were December, January and February, with maximum temperature absolute at 38.2 °C (Nov. 2005). The average of the relative humidity of the air was 78.5%, with lower values during September, October and November. The wind has predominant direction southeast, with monthly average wind speed ranging

from 1.4 to 1.8 m/s, which corresponds to the wind classified as "too weak" to "weak" according to the Beaufort scale (Soares and Batista 2004).

Regarding to the natural vegetation, there were three basic formations in the region: *Araucaria angustifolia* forests, secondary forests resulting from the operation of the pine forests and fields with river formations. The cultivation of farm forestry, implanted especially in areas of the natural pastures and to replace the degraded secondary forests has been done mainly with *Eucalyptus* spp, *Pinus taeda*, and to a lesser extent, with *Araucaria angustifolia*. According to Santos (2007), Klabin Paraná is responsible for an area of 259,923 ha, 132,104 ha of those are forest plantations of *Pinus taeda*, *Pinus elliottii* and *Araucaria angustifolia* and *Eucalyptus* spp.

Forestry activities, including planting, harvesting and manufacturing of wood, are the basis of the local economy. Data from the Department of Rural Economy, the Ministry of Agriculture and Supply of the State, show that in 2009 the Gross Value of Production (GVP) in the county was R$ 169.2 million, and the main products were: paper logs and cellulose (61%), pine logs for sawmills (28%), logs for firewood (3%) and pine seedlings (3%) (Paraná 2009a). This represented 5.7% of GVP of the state's forest products in 2009 (Paraná 2009b). The wood produced in the region is critical to supplying the largest producer, exporter and recycler in Brazil, which is located inside the Fazenda Monte Alegre (Klabin 2011).

The Fazenda Monte Alegre has an area of 131214,70 hectares and is divided administratively into 21 forest regions.

Data collection and analysis

The records of fires in the Fazenda Monte Alegre, since 1965 are individual sheets and contain the following information: a) forest region where the fire occurred, b) data c) burned area, d) type of vegetation affected, and) hours of the fire detection; f) hours of the beginning of combat; g) personnel and equipment used in combat; h) time the fire was controlled; i) the probable cause of the fire; j) additional comments; k) identification of the responsible for information.

The data from the questionnaires were tabulated, standardized and analyzed using the programs Visual FoxPro version 9 (Microsoft Corporation 1989 - 1993) and Microsoft Office 2007 (Microsoft Corporation 2006).

The Figure 3 shows schematically the flow chart of the estimated budget for forest fire protection, proposed by Urzua (1967) and modified by Soares (1978).

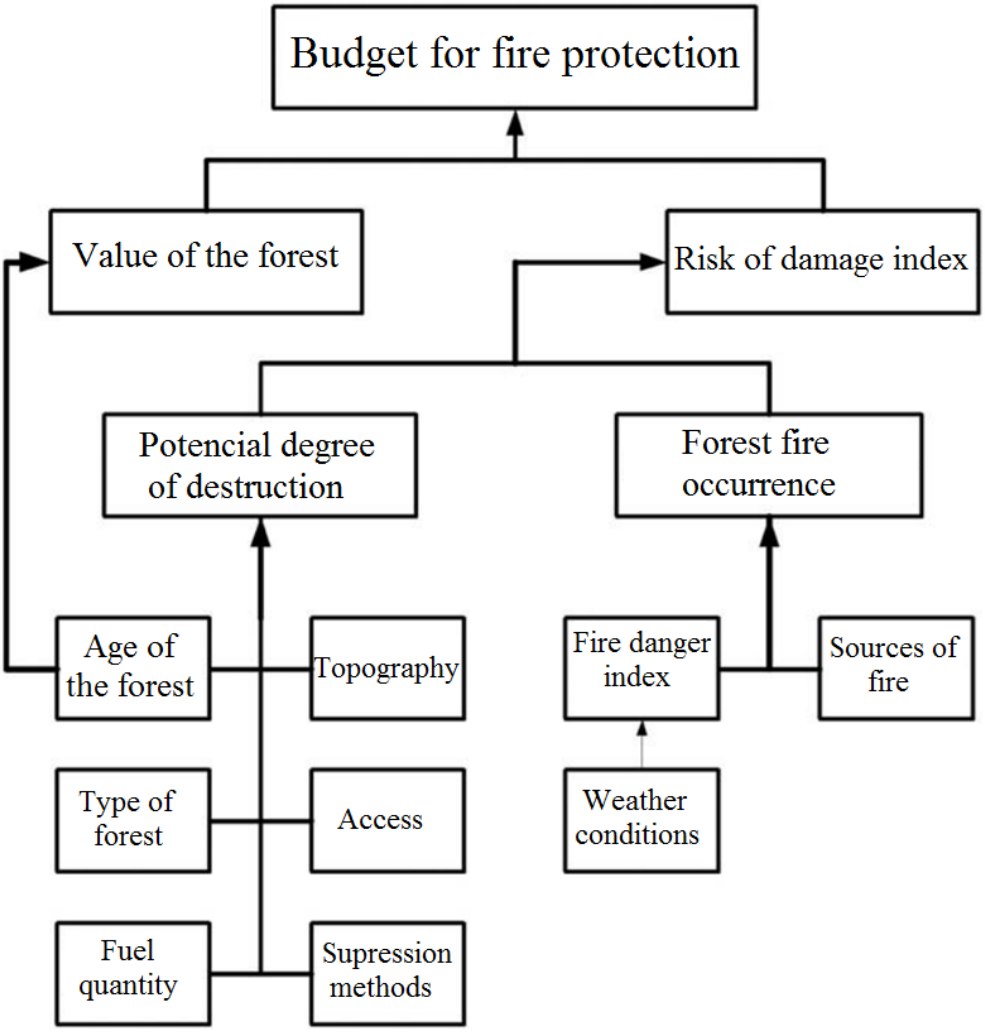

Figure 3—Flow chart of the estimated budget for forest fire protection
Source: Soares (1978)

The main assumption made in this study was that the budget for firefighting should be based on the current value of the forest.

The economic value of forestry production was obtained from estimates analyzed by Cubbage and others (2011). These authors have estimated productivities based on using a common Mean Annual Increment (MAI) for growth rates based on typical or representative stands for each species in the relevant region of the country. Then we estimated typical costs for establishment, stand management, administration, or other factors for each species/region. The authors also used relevant information on timber prices by product size was gathered from available literature or personal contacts with colleagues in the timber sector. These data were then used to calculate timber investment returns for forest landowners based on growing timber for typical rotations and selling stumpage. Common discounted cash

flow analyses including net present value (NPV), such as described in Wagner (2012) for reference, were used for measuring timber investment returns.

The estimated amount to be allocated to fire protection, was calculated based on the information obtained from the technical coordination area of firefighting in the region of study.

Results

In the period 1965 to 2009 were attended by firefighters from Klabin Paraná in, 1676 occurrences of forest fires, which reached an area of 2923.16 ha (Figures 4 and 5).

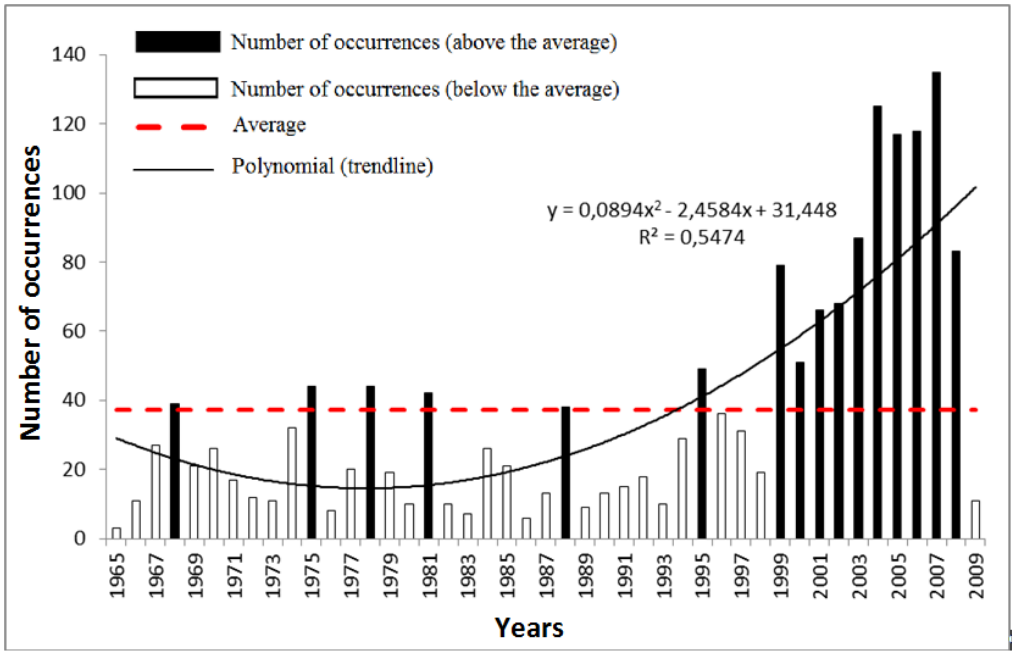

Figure 4—Forest fire occurrences in Fazenda Monte Alegre in the period 1965 – 2009.

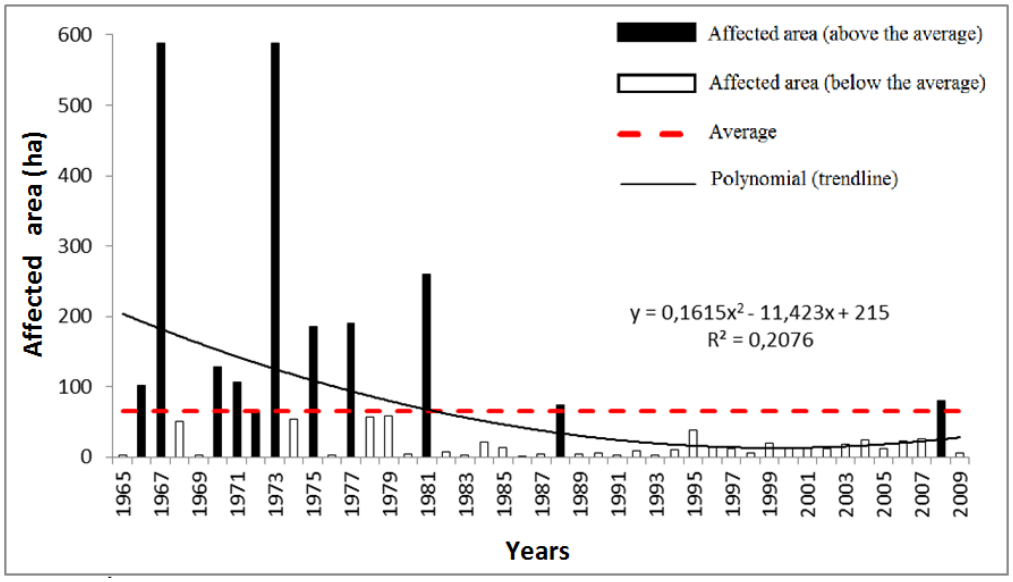

Figure 5—Affected area in the period 1965 to 2009.

It should be noted that the average area affected by fire was 1.74 ha, lower than that found by Soares and Rodriguez (2004) for the period 1998 to 2001, which was 40.34 ha. The average area affected by fire was below the amount cited by Medeiros (2007) that was 4.08 ha in Cenibra (MG) for the period 2002 to 2006, and by Freitas and Vique (2004) ranged from 5.17 to 188.34 hectares per year in V & M (MG) in the period 2000 to 2007.

In the economic analysis were performed considering the costs of actions related to fighting fires that are detailed in Table 1, corresponding to the use of a team of 20 helpers, a charge, a tanker car and a bulldozer.

Table 1—*Composition of average cost per hectare in forest fires supression.*

Costs items	Time required per hectare (h/ha)	Hourly (R$/h)	Total value (R$/ha)[1/]
Firefighters	120	14,00	1.680,00
Tanker car	3	80,00	240,00
Bulldozer	1	100,00	100,00
Total			**2.020,00**

[1/] values prevailing in June 2012
Source: Technical coordination of firefighting

Estimates developed by Cubbage and others (2012) indicated that the net present value of a hectare of *Pinus taeda*, considering a rotation of 15 years and an average annual increment of 30 m^3 per hectare-year, amount equivalent to US$ 4,662.00/ha, (R$ 9,324.00/ha, considering the value of the dollar observed in June/2012).

The estimates indicated that the costs required to fight forest fires correspond for approximately 22% of the net present value of timber production directly affected by the occurrence of the fire.

It is noteworthy that the damage caused by forest fires includes, besides the loss caused directly in terms of timber production, other intangible losses such as the impacts on watersheds, on the socioeconomic and environmental values related to non-timber products and on the conservation of biodiversity.

Considering the occurrence of fire in an area of 2,900 hectares, the losses caused by this action would result in reduction of the revenue of timber production equivalent to approximately US$ 13,519,800.00 and the cost of fighting requires only the amount of US$ 2,929,000.00 indicating that for every dollar invested in non-combat results, under the conditions studied, a loss of at least $ 4.62

Considering, furthermore, that for each hectare devasted by fire the entrepreneur should have an additional hectare to not compromise its industrial process and economic results. That means, that for each every dollar not invested in practices to prevent and combat fires should result a loss of approximately US$ 4.62 and would require also an investment of at least US$ 900.00 for the establishment of an additional hectare of plantation forestry and US$ 4,500.00 representing the cost of a hectare of land.

Given these additional constraints, should be estimated that for each dollar invested in fire fighting and prevention can result in a financial loss of about US$ 10.00 which take into account the loss of revenue of timber and investment in additional area for getting the equivalent forestry production, besides the no tangible losses.

Final Comments

The historical fire occurrences in the study area indicated that forest fires reached an area of over 2,900 ha in the period.

The total loss of production in this area associated would reach the amount of US$ 13,519,800.00 and the cost of fighting would require only the investment of US$ 2,929,000.00, without considering that for each hectare devasted by fire the entrepreneur should have an additional hectare equivalent to not compromise his industrial process and outcome.

The analysis indicated that, under the conditions studied, investing one dollar in prevention and firefighting avoid a direct damage of at least $ 4.62 in the income of the forestry business.

The needs for further acquisition and implementation of one hectare of forest plantation may result in additional financial outcomes of approximately US$ 10.00 in

terms of loss of timber and additional area for investment in production, besides and the no tangible damages.

The analysis subject to the conditions of the study clearly indicate the highly importance of investments and actions in preventing and fighting fires in the conditions prevailing in the study region.

Summary

The study aimed at determining economic indicators of the profile of forest fires in the study area during the period 1965 to 2009. Statistical analysis related to the number of fires, the burned areas, the spatial distribution of the occurrence, the distribution through the months of the year, and the identification their main causes have been done. Costs associated with the incidence of fire were calculated as well the benefit-cost ratio related to the actions that have been taken into account for the prevention and control of fires in the area of the study. The results obtained indicate that, under the conditions studied, investing one dollar in prevention and firefighting avoid a direct damage of at least $ 4.62 in the income of the forestry business. The needs for further acquisition and implementation of one hectare of forest plantation may result in additional financial outcomes of approximately US$ 10.00 in terms of loss of timber and additional area for investment in production, besides and the no tangible damages. The analysis also clearly indicate the highly importance of investments and actions in preventing and fighting fires in the conditions prevailing in the study region.

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