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Original article

Occurrence of forest fires in Santa Ana canton, Manabí province, Ecuador (2012-2018)

Ocurrencia de incendios forestales en el cantón Santa Ana, provincia de Manabí, Ecuador (2012-2018)

Ocorrência de incêndios florestais no cantón Santa Ana, província de Manabí, Equador, (2012-2018)

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ABSTRACT

Analyses of the historical behavior of forest fires provide the basis for effective fire management programs. This descriptive research aimed to analyze when, where and why forest fires occurred in Santa Ana canton, Manabí province, Ecuador, during the period 2012-2018. The data were provided by the Fire Department of that locality. The analysis was carried out considering a spatiotemporal context (years, months, days of the week, localities and vegetation cover). Statistical analyses were carried out with SPSS *Statistics for Windows* (version 22.0). A significance level of 0.05 was used. In the analyzed period, 91 losses were reported, corresponding to the year 2016 the highest percentage (38.46 %). From July to January 94.50 % of the total number of fires were recorded, associated with low rainfall and increased use of fire by farmers to clear the land. During the day, the highest number of events was recorded from 14:00 to 16:00 hours (27.47 %). In cases where the parish and vegetation cover were specified, the highest percentages corresponded to Ayacucho and weeds with 54.05 and 26.37 %, respectively. The work allowed to establish temporal and spatial patterns of fire occurrence and its causality, constituting an important and relevant contribution on when, where and why fires occur in the canton of Santa Ana, information that can be used by decision makers of integrated fire management activities.

Keywords: Vegetation fires; Integrated fire management; Fire prevention.

RESUMEN

Los análisis sobre el comportamiento histórico de los incendios forestales fundamentan programas eficaces de manejo del fuego. Esta investigación de alcance descriptivo tuvo el objetivo de analizar cuándo, dónde y por qué ocurrieron los incendios forestales en el cantón Santa Ana, provincia Manabí, Ecuador, durante el periodo 2012-2018. Los datos fueron facilitados por el Cuerpo de Bomberos de dicha localidad. El análisis se realizó considerando un contexto espacio-temporal (años, meses, días de la semana, localidades y cobertura vegetal). Los análisis estadísticos se realizaron con el programa SPSS *Statistics for Windows* (versión 22.0). Se trabajó con un nivel de significancia del 0,05. En el periodo analizado se reportaron 91 siniestros, correspondiendo al año 2016 el mayor porcentaje (38,46 %). De julio a enero se registró el 94,50 % del total de incendios, asociado esto a pocas precipitaciones y al aumento del uso del fuego por los campesinos para limpiar el terreno. Durante el día la mayor cantidad de eventos se registró desde las 14:00 hasta las 16:00 horas (27,47 %). En los casos en que se especificó la parroquia y la cobertura vegetal, los mayores porcentajes correspondieron a Ayacucho y a las malezas con el 54,05 y el 26,37 %, respectivamente. El trabajo permitió establecer patrones temporales y espaciales de la ocurrencia de incendios y su causalidad, constituyendo esto un aporte importante y relevante sobre cuándo, dónde y por qué ocurren los incendios en el cantón Santa Ana, informaciones que podrán ser utilizadas por los decisores de las actividades de manejo integrado del fuego.

Palabras clave: Incendios de vegetación; Manejo integral del fuego; Prevención de incendios.

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RESUMO

As análises do comportamento histórico dos incêndios florestais apoiam programas eficazes de manejo do fogo. Esta pesquisa descritiva teve como objetivo analisar quando, onde e porque ocorreram os incêndios florestais no cantón Santa Ana, província de Manabí, Equador, durante o período de 2012-2018. Os dados foram fornecidos pelo Corpo de Bombeiros daquela cidade. A análise foi realizada considerando um contexto espaço-temporal (anos, meses, dias da semana, localidades e cobertura vegetal). As análises estatísticas foram realizadas com o programa SPSS Statistics for Windows (versão 22.0). Trabalhamos com nível de significância de 0,05. No período analisado, foram notificadas 91 ocorrências, correspondendo ao ano de 2016 o maior percentual (38,46 %). De julho a janeiro, foram registradas 94,50 % do total de ocorrências, associadas à baixa pluviosidade e ao aumento do uso de fogo pelos agricultores para desmatamento. Durante o dia, o maior número de eventos foi registrado das 14h00 às 16h00 (27,47 %). Nos casos em que se especificou a freguesia e a cobertura vegetal, as percentagens mais elevadas corresponderam a Ayacucho e ervas daninhas com 54,05 e 26,37 %, respetivamente. O trabalho permitiu estabelecer padrões temporais e espaciais de ocorrências de incêndios e sua causalidade, constituindo uma contribuição importante e relevante sobre quando, onde e por que ocorrem incêndios no cantão de Santa Ana, informação que pode ser utilizada pelos tomadores de decisão das atividades de gestão integrada do fogo.

Palavras chave: Incêndios na vegetação; Manejo integrado do fogo; Prevenção do fogo.

INTRODUCTION

Wildfires continue to cause damage to property, livelihoods, and the environment around the world (Mistry *et al*., 2018). Humans and their ancestors are the only fire-producing species, but natural fires, i.e., independent of humans, have an ancient geological history on Earth. Natural fires have influenced biological evolution and global biogeochemical cycles, making fire integral to the functioning of some biomes (Bowman *et al*., 2011).

Analyzing the effects of fire exclusion in the semi-arid savanna ecosystem previously managed with fire, Starns *et al*., (2020) found that the reintroduction of fire in that ecosystem at the estimated mean fire return interval of six years during the summer had substantial positive effects on herbaceous biomass. In stark contrast, re-exclusion of fire for 11 years was associated with a sharp decline in herbaceous biomass. According to the same authors, their results support the findings of other studies that fire exclusion facilitates woody invasion in savanna ecosystems.

Fire is an important land management tool, but careless or criminal use of fire can cause catastrophic impacts. Wildfires can be the leading cause of ecosystem degradation and can result in loss of human life, economic devastation, social disruption, and environmental degradation. Each year fires destroy millions of hectares of valuable timber, other forest products, and environmental services provided by forest ecosystems. However, in fire-adapted ecosystems, fire plays a positive role in ecosystem health and vitality while causing damage in fire-sensitive ecosystems (Heikkilä *et al*., 2010).

Forest fires or vegetation cover fires (LCI) can be considered as ecological disturbances with discrete or diffuse effects, serious or destructive, produced by natural or anthropogenic fires, whose dynamics respond fundamentally to the simultaneous concurrence of three or more conditions in the same place (type of vegetation, amount of fuel, oxygen, meteorological conditions, topography, human activities) which develop without control or pre-established limits on land with some kind of vegetation cover (native, cultivated or induced), using as a source of fuel vegetation (native, cultivated or induced), oxygen, meteorological conditions, topography, human activities) which develop without control or pre-established limits on land with some kind of vegetation cover (native, cultivated or induced), using living or dead vegetation as a fuel source and, due to the risk it represents for natural or social systems, must be prevented and extinguished. LCIs are not a new phenomenon in the Earth's history, nor are their impacts always negative. The problem arises when their recurrence exceeds the resilience capacity of ecosystems and irreversibly alters natural processes that serve as the basis for the production of environmental goods and services. It could be said that today the phenomenon is the expression of the degradation of natural fire regimes in most terrestrial ecosystems. Unfortunately, for decades a vision based on mistaken assumptions prevailed in the imagination of states, governments and the general public in different countries, such as the following: a) considering fires of vegetation cover as a phenomenon of fundamentally natural origin and local impacts restricted to vegetation, b) overestimating the capacity of nature to restore affected ecosystems (Armenteras *et al*., 2011).

Most of the fires are caused by human activities. In addition, with the development of society, the wildland-urban interface area is becoming more and more populated, and wildfire is closely related to urban fire (Wang *et al*., 2010). Vegetation fires are responsible for significant socioeconomic and environmental changes, both positive and negative. Increasing urbanization reduces the distance between urbanized and rural areas, causing living things to adapt to the urban-rural interface, characterized by clusters of buildings in contact with rural spaces (Ferreira *et al*., 2019).

Internationally, according to Van Lierop *et al*., (2015), from 2003 to 2012 approximately 67 million hectares (1.7 %) of forest land burned annually, mainly in the tropical regions of South America and Africa. In South America, an average of 72 million hectares of land area burned each year, of which 35 million hectares were forest land.

In Ecuador, during 2017, up to December 15, forest fires greater than or equal to 2 ha caused the loss of 13 403.78 ha of vegetation cover in 968 registered events. The provinces that reported the highest number of fires were: Guayas with 138, Loja with 132, Santa Elena with 120, Manabí with 107 and Azuay with 98 events each. The provinces that recorded the most damage were: Pichincha with 2 250.60, Loja with 1 762.60, Azuay with 1 523.28, Imbabura with 1 294.04, Chimborazo with 1 087.15, and Santa Elena with 1 055.06 ha burned. In Manabí, 964.00 ha were reported (SGR, 2017).

In order to plan prevention actions, it is first necessary to know the profile or historical behavior of forest fires, which allows us to know where, when and why they occur (Soares *et al*., 2007). According to these authors, knowledge of fire statistics is essential for fire control planning. The lack of information about them can lead to two extremes: very high expenditures in protection, above the potential damage, or very small expenditures, putting the survival of forests at risk.

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In correspondence with all the above, this work whose scope is descriptive, had the objective of analyzing when, where and why forest fires occurred in Santa Ana canton, Manabi province, Ecuador during the period 2012-2018.

MATERIALS AND METHODS

Characterization of the study area

The canton of Santa Ana, with an area of 1,022 km^2, is geographically located in the central east of the province of Manabí, at 1°12¼ south latitude and 80°22¼ west longitude. The canton is bordered to the north by the canton of Portoviejo, to the south by the cantons of 24 de Mayo and Olmedo, to the east by the canton of Pichincha and the canton of Balzar, and to the west by the cantons of Jipijapa, 24 de Mayo and Portoviejo (Figure 1). The average altitude of Santa Ana is 50 meters above sea level, with a maximum altitude of 400 meters above sea level. According to the 2010 census, Santa Ana had a population of 47 385 inhabitants. The occupation variable shows that the branch with the highest concentration in the canton is still agriculture (50.16 %), due to the traditional vocation, followed by trade (8.74 %) generated by the exchange of domestic production (Municipality of Santa Ana, 2015).

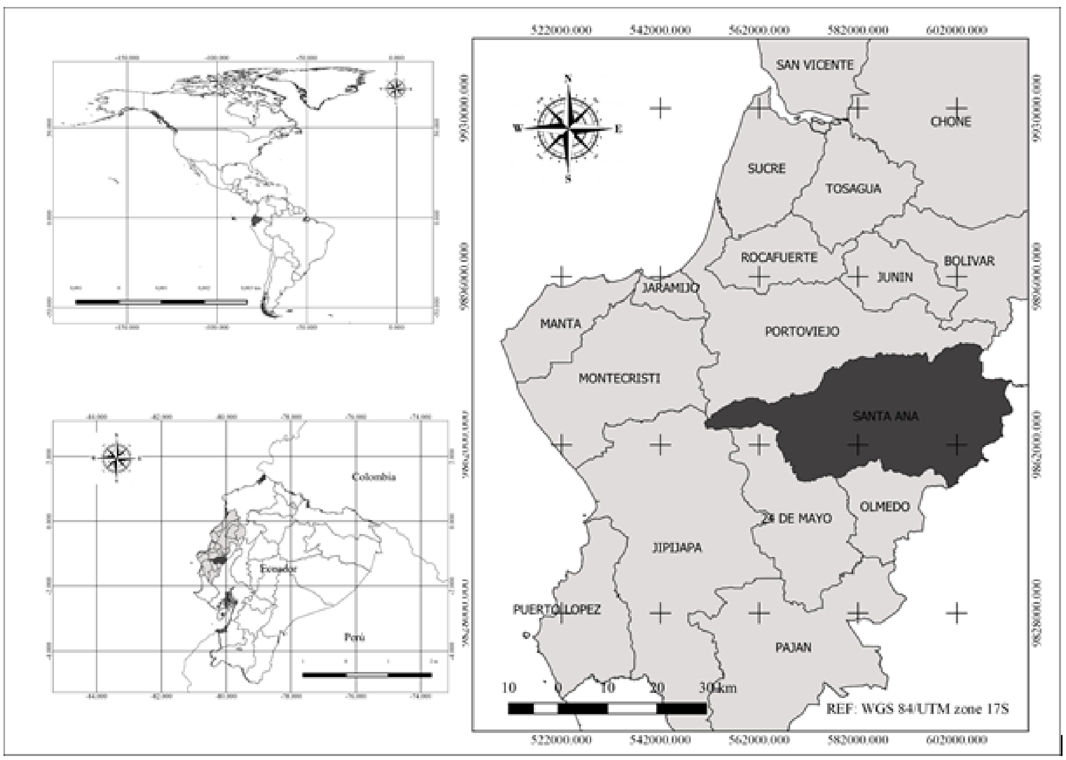

Figure 1. - Location of the study area

Santa Ana is dominated by the local steppe climate. There is little rainfall throughout the year. The climate is classified as BSh by the Köppen-Geiger system. The mean annual temperature is 25.4 °C and the mean annual precipitation is 741 mm. The difference in precipitation between the driest month and the rainiest month is 183 mm. The variation in temperatures over the whole year is 2.1 °C (Figure 2) (Climate-Data.org. 2020).

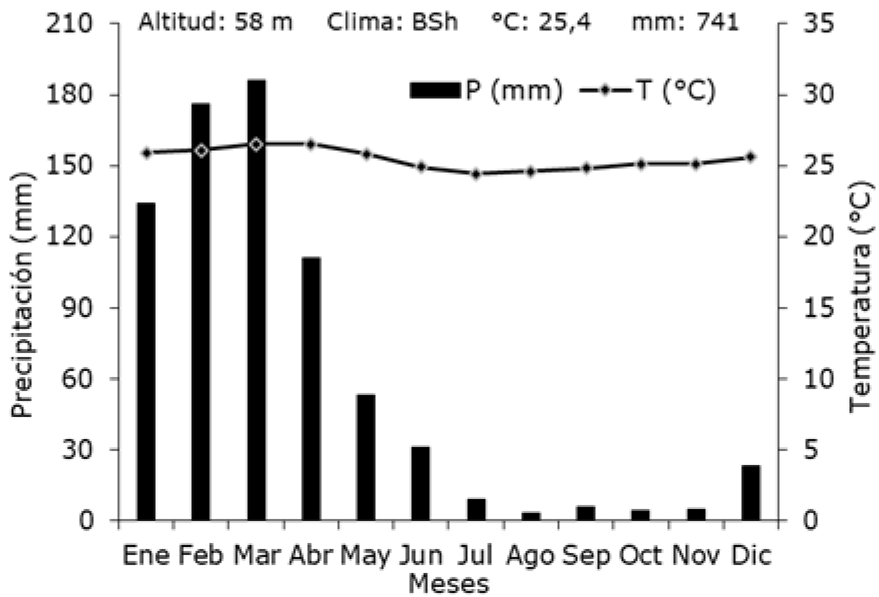

Figure 2. - Climogram of Santa Ana Canton (1982-2012)
Source: Climate-Data.org (2020).

In the canton of Santa Ana, 43,427.00 hectares, equivalent to 42.37% of the cantonal total, are destined to livestock area; 39,198.00 hectares, equivalent to 38.24 % to agricultural area and 14,994.00 hectares, equivalent to 14.63 % to agricultural and livestock area. The three zones total a value of 95.24 % of the cantonal total, dividing the remaining value between the urban area, the area of degraded natural forest, water bodies and eroded soils (Municipality of Santa Ana, 2015).

Data collection and analysis

To develop this descriptive research, a longitudinal non-experimental research design was used. The statistics of forest fires in the canton of Santa Ana were provided by the Fire Department of that locality. All data refer to the period from January 2012 to September 2018, totaling five years and nine months of observation. The database was created with the help of Microsoft Excel and consisted of fields such as fire number, municipality, parroquia, canton, community or site, date, day of the week, time of detection, type of fire, cause, type of negligence, vegetation affected, type of forest (natural or plantation) and area burned.

The analysis of when, where and why forest fires occurred was developed considering their distribution according to variables such as years, months, days of the week, localities, affected vegetation cover and causes, using the classification of Ramos *et al.,* (2000), which classifies the causes as natural (lightning and self-combustion), negligence, intentional, accidents and unknown. The vegetation cover was divided into: a) *Guadua angustifolia* Kunth, a bamboo species widely used by farmers in the province of Manabí, b) Weeds, including herbaceous vegetation accompanied by agricultural crops and sometimes small bushes, c) Degraded natural forests, made up of tree vegetation heavily affected by human activities, d) *Tectona grandis* Linn F.., a tree species used in plantations in the Manabí province and other regions of Ecuador, whose wood is highly valued for its technological characteristics and beauty, and e) Unclassified, which includes fires in which the vegetation affected was not described in the logs.

Statistical analysis was performed with SPSS Statistics for Windows (version 22.0). It was worked with a significance level of 0.05 (P = 0.05). The normality of the data was verified with the Shapiro-Wilks statistical test. The dependent variable number of fires was not normally distributed ($P < 0.05$) in all groups defined by the independent variable or factors such as months of the year, days of the week and hours of the day, so the difference between means was tested with the non-parametric Kruskal-Wallis test, verifying the difference between pairs of means using Dunn's *post hoc* test.

RESULTS AND DISCUSSION

In Santa Ana canton from 2012 to 2018, 91 forest fires occurred, with an annual average of 13 and a variation of ± 10.64 fires. There is no trend, being the number of fires highly variable from one year to another (Table 1). The year 2016 stands out with the highest percentage of events (38.46 %), associated with the earthquake that occurred in April of that year, which had an important impact on the local economy, so more people used fire months later to clear land to plant corn and other crops that would allow them to subsist. The annual average of forest fires for the canton's territory represents a density of 0.17 fires per 1,000 ha. This value is higher than those reported for the Maule Region, Chile, where from 1 986 to 2 012 an average of 378 fires occurred per year for a density of 0.12 fires per 1 000 ha (Díaz-Hormazábal and González 2016). Also during the years 2005 to 2014 in four cities of Londrina, Brazil, an average of 143.5 fires per year and a density of 0.48 fires per 1 000 ha were recorded, however in Pisa, Italy, in the same period an average of 62.9 fires per year occurred with a density of 0.25 fires per 1 000 ha (Santos *et al*., 2019). Ramos *et al*., (2013) from 2002 to 2011 obtained mean annual values of 84.1 fires in Monte Alegre, Brazil and 75.7 fires in Pinar del Rio, Cuba, with densities of 0.42 and 0.06 fires per 1 000 ha, respectively.

Table 1. - Occurrence of fires in the canton of Santa Ana from 2012 to 2018

Years	Fires	
	(No.)	(%)
2012	2	2,20
2013	8	8,79
2014	12	13,19
2015	7	7,69
2016	35	38,46
2017	16	17,58
2018*	11	12,09
Totales	91	100,00

*Information only until September.

The occurrence of fires throughout the months of the year during the analyzed period was variable, which was verified through the non-parametric Kruskal-Wallis statistical test ($\div^2 = 28.105$; $P = 0.003$) (Table 2). Nevertheless, it could be defined that from July to January 94.50 % of the total number of fires were registered with a maximum of 24 (26.37 %) in November, which is associated with the period of greater use of fire by farmers to clear the land for planting maize, which begins with the rainfall that starts in January (Figure 2). During the period under analysis, of the 91 fires reported, in 81 of them (89.01 %) the cause of origin was not identified. The remaining ten fires were caused five by negligence and the same number intentionally (Table 2). According to these results, 80.00 % of the fires originated both by negligence and intentionally, occurred from September to November.

The times of highest fire occurrence during the year can vary considerably between regions, especially in countries with large territorial dimensions, mainly due to climatic variations (Soares *et al*., 2007). The occurrence of forest fires is directly related to the amount and distribution of rainfall (Tetto *et al*., 2012). Liu and Wimberly (2015) analyzing the spatiotemporal patterns of occurrence, size, and severity of large fires (> 405 ha) in the western United States from 1984 to 2010, ranked anomalous precipitation 90 days before fire as the most important climatic variable influencing the percentage of high severity and its effect was greater than the influence of any other climatic or human variable.

In the study area most of the fires occurred from July to January. During these months, with the exception of December and January, the average monthly precipitation is below 10 mm (Figure 2). This situation directly affects the humidity of the combustible material, and there is a large amount of it in a dead state. At the same time, these are the months during which farmers clear the land, mainly with fire, to start planting maize in January, the main agricultural crop in the region. Coinciding with this result, in Monte Alegre, Brazil, in the years from 2002 to 2011 the fire season occurred from August to October, while in Pinar del Rio, Cuba, in the same period, the highest number of fires occurred from March to May (Ramos *et al*., 2013), which does not coincide with what was found in Santa Ana. However, according to the same authors, this distribution is strongly related to the distribution of precipitation throughout the year. In the case of Monte Alegre 45.42 % of the fires occurred during the period from August to October, while in Pinar del Río 56.54 % of the fires occurred in the period from March to May.

In the Maule region, Chile, from 1986 to 2012 the fire season began in late winter (August) culminating in autumn (May). Most of the occurrence of fires (84.00 %) and burned area (87.00 %), occurs in the summer months from December to March. The climate in the region is characterized by a rainy winter period and a dry season of four to six months (between

October and March) (Díaz-Hormazábal and González 2016). In both Londrina, Brazil, and Pisa, Italy, from 2005 to 2014 the fire season was from July to September. In both regions, July and August are at the end of the low rainfall season, which begins in September (Santos *et al*., 2019).

In the State of Paraná, from 2005 to 2010, the highest number of fires occurred from June to September. In the period analyzed, the months with the lowest average rainfall were May, June and August. The Paranavaí meteorological station should be highlighted, with low rainfall from April to August and, consequently, greater danger of forest fires (Tetto *et al*., 2012).

Table 2. - Fire occurrence, mean values ± standard deviation (ds), comparison of means according to Dunn's test (P = 0.05), percentages and causes across months in Santa Ana canton (2012-2018)

Meses	Fires			Negligence		Intentional		Unknown	
	(No.)	(media ± ds)	(%)	(No.)	(%)	(No.)	(%)	(No.)	(%)
January	12	1,71 ± 4,11 ^{d}	13,19	0	0,00	0	0,00	12	14,82
February	1	0,14 ± 0,37 ^{bc}	1,10	0	0,00	0	0,00	1	1,23
March	2	0,29 ± 0,48 ^{cd}	2,20	1	20,00	0	0,00	1	1,23
April	0	0,00 ± 0,00 ^{a}	0,00	0	0,00	0	0,00	0	0,00
May	0	0,00 ± 0,00 ^{ab}	0,00	0	0,00	0	0,00	0	0,00
June	2	0,29 ± 0,75 ^{c}	2,20	0	0,00	0	0,00	2	2,47
July	2	0,29 ± 0,48 ^{d}	2,20	0	0,00	0	0,00	2	2,47
August	4	0,57 ± 1,13 ^{d}	4,40	0	0,00	1	20,00	3	3,70
September	10	1,43 ± 1,39 ^{d}	10,99	1	20,00	1	20,00	8	9,88
October	12	1,71 ± 1,79 ^{d}	13,19	1	20,00	1	20,00	10	12,35
November	24	3,43 ± 3,45 ^{d}	26,37	2	40,00	2	40,00	20	24,69
December	22	3,14 ± 4,52 ^{d}	24,18	0	0,00	0	0,00	22	27,16
Totals	91		100,00	5	100,00	5	100,00	81	100,00

Note: Values with the same letter are statistically equal (P < 0.05).

With respect to the occurrence of fires and their causes during the days of the week, the Kruskal-Wallis non-parametric statistical test showed that there was no statistically significant difference between the number of fires that occurred on each day of the week (÷² = 3.355; P = 0.763). However, the highest number of fires was reported on Thursday (25.93 %). On weekends, no fires were reported, neither due to negligence nor intentionally, which may be related to rest or the development of other activities during those days. Fires due to these causes are distributed from Monday to Friday, coinciding with the working days of the week, although it is likely that fires whose cause is unknown, have also been caused by negligence or intentionally (Table 3). Regarding the distribution of fires during the days of the week, no statistical differences were found in Santa Ana during the period analyzed. This indicates a similar risk of occurrence throughout the week, so prevention measures should be the same every day. Similar results were reported by Ramos *et al*., (2013), during the years 2002 to 2011 in Monte Alegre, Brazil and in Pinar del Rio, Cuba. However, in the Maule region, Chile, (1986 - 2012) the largest burned area on average occurs during weekend days (Friday to Sunday), although the number of fires decreases during that period, with respect to weekdays (Díaz-Hormazábal and González 2016). Also in the Czech Republic from 1992 to 2004 the largest amount of area affected by forest fires originated during weekends (Kula and Jankovská 2013). Environmental factors with high variability over time are often referred to as "temporal" factors and are mainly derived from weather or indices related to drought or vegetation moisture, which influence flammability. However, some temporal variables are related to human ignition pressure, such as the day of the week (Costafreda-Aumedes *et al*., 2017). In some cases, fires during the week are associated with carelessness during the use of fire for land clearing to establish agricultural crops or certain forestry or forest harvesting activities within forested areas, while in other places the highest number of fires are grouped during weekends, related to recreation or rest activities in forested areas.

Table 3. - Fire occurrence, mean values ± standard deviation (ds), percentages and causes across days of the week in Santa Ana canton (2012-2018)

Days	Fires			Negligence		Intentional		Unknown	
	(No.)	(media ± ds)	(%)	(No.)	(%)	(No.)	(%)	(No.)	(%)
Sunday	11	1,57 ± 1,27	12,09	0	0,00	0	0,00	11	13,58
Monday	14	2,00 ± 1,29	15,38	2	40,00	0	0,00	12	14,81
Tuesday	11	1,57 ± 1,51	12,09	1	20,00	1	20,00	9	11,11
Wednesday	9	1,29 ± 1,60	9,89	0	0,00	1	20,00	8	9,88
Thursday	24	3,43 ± 4,11	26,37	1	20,00	2	40,00	21	25,93
Friday	13	1,86 ± 2,19	14,29	1	20,00	1	20,00	11	13,58
Saturday	9	1,29 ± 1,97	9,89	0	0,00	0	0,00	9	11,11
Totals	91		100,00	5	100,00	5	100,00	81	100,00

During the hours of the day the highest number of fires in the canton Santa Ana the years from 2012 to 2018 was reported from 14:00 and until 16:00 hours, in which 27.47 % of the total occurred. Fewer fires were reported during the early morning and early morning hours. The Kruskal-Wallis non-parametric statistical test proved the existence of a significant statistical difference between the means of the number of fires occurring at different times (÷² = 36.042; P = 0.041) (Table 4).

In Santa Ana during the study period, the highest number of fires was recorded in the afternoon hours. This behavior is associated with the daily distribution of air temperature and relative humidity, variables that reach their highest and lowest values, respectively, during the early afternoon, causing the combustible material to lose moisture. Similar results were obtained for Monte Alegre, Brazil and Pinar del Rio, Cuba in the period 2002 to 2011 (Ramos *et al*., 2013) and for the province of Pinar del Rio, Cuba, from 1994 to 2013 (Carrasco *et al*., 2016). The same was reported for the Czech Republic from 1992 to 2004 (Kula and Jankovská 2013). Time of day influences wind, relative humidity and temperature (Heikkilä *et al*., 2010). The above can substantiate prevention measures related to the use of fire in agricultural and forest areas. Burning may be allowed, but at certain times of the day.

Table 4. - Fire occurrence, mean values ± standard deviation (ds), comparison of means according to Dunn's test (P = 0.05) and percentages across hours of the day in Santa Ana canton (2012-2018)

Hours	Fires			Hours	Fires		
	(No.)	(media ± ds)	(%)		(No.)	(media ± ds)	(%)
01:00	0	0,00 ± 0,00 [a]	0,00	13:00	5	0,71 ± 0,75 [b]	5,49
02:00	1	0,14 ± 0,37 [b]	1,10	14:00	10	1,43 ± 1,71 [b]	10,99
03:00	1	0,14 ± 0,37 [b]	1,10	15:00	4	0,57 ± 0,78 [b]	4,40
04:00	1	0,14 ± 0,37 [b]	1,10	16:00	11	1,57 ± 2,07 [b]	12,08
05:00	2	0,29 ± 0,75 [b]	2,20	17:00	4	0,57 ± 1,13 [b]	4,40
06:00	0	0,00 ± 0,00 [a b]	0,00	18:00	3	0,57 ± 0,53 [b]	3,30
07:00	1	0,14 ± 0,37 [b]	1,10	19:00	7	1,00 ± 1,29 [b]	7,69
08:00	6	0,71 ± 1,25 [b]	6,59	20:00	7	1,00 ± 1,00 [b]	7,69
09:00	5	0,71 ± 1,25 [b]	5,49	21:00	3	0,43 ± 0,78 [b]	3,30
10:00	5	0,71 ± 1,25 [b]	5,49	22:00	3	0,43 ± 1,13 [b]	3,30
11:00	9	1,29 ± 1,49 [b]	9,89	23:00	1	0,14 ± 0,37 [b]	1,10
12:00	2	0,29 ± 0,48 [b]	2,20	24:00	0	0,00 ± 0,00 [b]	0,00
				Totales	91		100,00

Values with the same letter are statistically equal (P < 0.05).

Of the 91 fires reported in the logs of the Fire Department of the canton of Santa Ana, the parish and the affected community were not registered in a total of 54 and 27 cases, respectively. In the case of the parroquia, the fires reported were distributed in four of them, corresponding to Ayacucho 20 fires (54.05 %) and Lodana, La Union and Honorato Vasquez 13; 3 and 1 fire, respectively.

The fires reported were distributed in 41 communities, occurring in 27 of them (65.85 %) only one fire. In 10 communities (24.39 %) two fires were reported, while in the communities of Tillal and Bonce 3 and 4 fires were reported, respectively. In the communities El Paraíso and Níspero, 5 fires were reported in each of them. With respect to the causes of the fires in each parish, the logs only reported fires caused by negligence in Lodana and Ayacucho, in addition to a fire caused intentionally in Lodana.

In 55 fires (60.44 %) the vegetation cover affected by the fire was not specified. In the cases where this was done, the greatest number of events was reported in weeds (Table 5). This is due to the large number of farmers who use fire to clear land, and sometimes the fire gets out of control and burns areas that were not intended to be burned. These results do not coincide with those obtained by Ramos *et al*., (2013), for Monte Alegre, Brazil, and Pinar del Río, Cuba (2002 - 2011), locations where the highest number of fires was recorded in plantations of *Pinus* sp. In the Maule region, Chile from 1986 to 2012, fires originated mainly in grassland areas, followed in importance in terms of the origin of the fires, shrublands and plantations of *Pinus radiata* D. Don. (Díaz-Hormazábal and González 2016).

With the growing concern about biodiversity loss, climate change and the chronic shortage of financial and human resources in Brazil's Conservation Units (CUs), it is essential to know the profile of forest fires and the logistics associated with fighting them in order to plan prevention and firefighting actions. For this, the main strategy used by Prevfogo (IBAMA) and currently by CGPro (ICMBio), has been the completion and analysis of the Fire Occurrence Register (ROI) by the CUs (Bontempo *et al*., 2011). In Santa Ana, a model should be used to collect information that allows for a well-founded and complete analysis of forest fires.

This study found that in the great majority of the fires that occurred (89.01 %) the cause of their origin was not identified. However, in the few cases where this was done, half corresponded to negligence and the other half to intentional, both related to human activity. Today, humans have a much greater influence on the landscape fire system than in the past, due to explosive population growth and technological advances. They influence the extent and composition of available fuel, apply (both intentionally and accidentally) and suppress fire, and impact the global climate (Riley *et al*., 2019). Wildfire occurrence is affected by fuel availability, climate, and ignition sources. In China, most forest fires are caused by anthropogenic ignition, which is closely related to residential distribution and production mode (Tian *et al*., 2013). Also most of the fires recorded in the Maule region, Chile, from 1986 to 2012, were human-caused, either accidentally (86.7 %) or intentionally (10.3 %). For unknown causes, the percentage reached 2.8 % and caused naturally, only 0.2 % (Díaz-Hormazábal and González 2016). In the years 2002 to 2011 in Monte Alegre, Brazil, the main cause of occurrence was "incendiary" (71.66 % of the total), while in Pinar del Rio, Cuba, the most important cause was "lightning" (39.26 %) (Ramos *et al*., 2013). In the Czech Republic in the spectrum of forest fire causes (1992-2004), arsonists showed a dominant position followed by smokers, forest management and children under 15 years old. Unknown causes presented a high percentage (Kula and Jankovská 2013).

For the classification of causes some countries adopt the indeterminate group, but this practice can be dangerous, because it can lead to disinterest in the discovery of the true cause, placing most occurrences as undetermined and thus impairing the quality of information. It is very important that the person responsible for firefighting always strives to discover and record the real or most probable cause of the fire (Soares *et al*., 2007).

According to Flannigan *et al*., (2012) if fire activity is determined by fuels, ignitions and weather, this influences our response to the potential impact of climate warming on wildfire activity. We cannot change the weather and we cannot change lightning activity significantly. Our remaining options are to reduce human-caused ignitions and modify fuels. Human-caused ignitions can be reduced by education programs, restricting or excluding the use of fire, and by proper enforcement of existing policies. It is not possible to treat fuels on a global scale, but fuels can be treated on a local scale near high value areas. Several programs already exist that promote the fuel reduction or modification approach as a way to help protect communities and other values at risk.

Table 5. - Fire occurrence according to vegetation cover in the canton of Santa Ana (2012-2018)

Vegetation cover	Fires	
	(No.)	(%)
Guadua angustifolia	2	2,20
Weeds	24	26,37
Degraded natural forest	4	4,40
Tectona grandis	6	6,59
Unclassified	55	60,44
Totales	91	100,00

CONCLUSIONS

The statistics on forest fires in Santa Ana canton during the years from 2012 to 2018, although incomplete, allowed to establish temporal and spatial patterns of their occurrence and causality, which is an important and relevant contribution on when, where and why these fires occur in the locality, a foundation that should be taken into account by decision-makers of integrated fire management activities.

It was possible to define that temporally the fire season is located from July to January and that most of them started during the afternoon hours, which is associated with the annual distribution of rainfall and the daily behavior of air temperature and relative humidity, conditions that favor the increase in the amount of available fuels and in turn the efficiency of the causes of fire, all of anthropogenic origin, to start the fire.

Spatially, it was established that in the period analyzed, more than half of the fires occurred in Ayacucho Parish, and in terms of vegetation cover, in the cases where this was specified in the logs, it was in weeds where the greatest number of fires occurred (26.37 %), which is related to the use of fire by agricultural producers to clear their land in a quick and economical way.

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