

Susceptibility to forest fires in the area, Las Mercedes, Sancán, Cantón Jipijapa

Susceptibilidad a incendios forestales en el recinto, Las Mercedes, comuna Sancán, Cantón Jipijapa

Armando Leonardo Orlando Villacreses*
Luisa Anabel Palacios López*

ABSTRACT

Forest fires are currently an environmental and socioeconomic problem, the frequency and area affected by these events are attributed to intrinsic factors such as the natural characteristics of an ecosystem and extrinsic factors such as indiscriminate agricultural burning, which are developed in areas exposed to this threat. For this reason, our study aims to establish the areas with the highest incidence and susceptibility to forest fires in the area of Las Mercedes, Sancán, canton Jipijapa. The analysis is based on data collected from geospatial sources, in which the methodology proposed in Colombia by the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) was taken as a reference. The results show that the intrinsic and extrinsic characteristics of this ecosystem such as temperature, precipitation, types of plant fuels, topography and accessibility influence the probability of a fire originating in the study area, thus concluding that Las Mercedes has a very high degree of susceptibility to the occurrence of fires, information that serves as a basis for

* Engineer. Master's Program in Environmental Management, Graduate Institute, Universidad Estatal del Sur de Manabí. orlando-armando@unesum.edu.ec
<https://orcid.org/0000-0002-1407-2422>

* Engineer. Master's degree. Master's Program in Environmental Management, Graduate Institute, Universidad Estatal del Sur de Manabí. luisa.palacios@unesum.edu.ec
<https://orcid.org/0000-0002-9257-7557>

REVISTA TECNOLÓGICA
ciencia y educación
Edwards Deming

ISSN: 2600-5867

Atribución/Reconocimiento-NoComercial- CompartirIgual 4.0 Licencia Pública Internacional — CC

BY-NC-SA 4.0

<https://creativecommons.org/licenses/by-nc-sa/4.0/legalcode.es>

Edited by: Tecnológico Superior Corporativo Edwards Deming

January - March Vol. 8 - I - 2024

<https://revista-edwardsdeming.com/index.php/es>

e-ISSN: 2576-0971

Received: July 04, 2023

Approved: October 11, 2023

Page 14-30

decision-making in risk management, risk reduction and territorial planning.

Keywords: risks, threat, prevention, fire

RESUMEN

Los incendios forestales en la actualidad, son un problema ambiental y socioeconómico, la frecuencia y área afectada por estos eventos se atribuyen a factores intrínsecos como las características naturales de un ecosistema y factores extrínsecos como la quema agrícola indiscriminada la misma que se desarrollan en zonas expuestas a esta amenaza. Por esta razón nuestro estudio tiene como objetivo establecer, las zonas con mayor incidencia y susceptibilidad a los incendios forestales en el recinto las Mercedes, comuna Sancán, cantón Jipijapa. El análisis se basa en datos recopilados de fuentes geoespaciales, en la cual se tomó de manera referencial la metodología planteada en Colombia por el Instituto de Hidrología, Meteorología y Estudios Ambientales (IDEAM). Los resultados manifiestan que las características intrínsecas y extrínsecas de este ecosistema tales como temperatura, precipitación, tipos de combustibles vegetales, topografía y accesibilidad influyen en la probabilidad de que se origine un incendio en la zona de estudio, concluyendo de esta manera que en el recinto las Mercedes tiene un grado de susceptibilidad muy alta a la ocurrencia de incendios, información que sirve como base para la toma de decisiones en la gestión y reducción de riesgos y la planificación territorial.

Palabras clave: riesgos, amenaza, prevención, fuego.

INTRODUCTION

Forests are the product of a balance between several ecological factors, including fire, which plays an important role in regulating plant succession (Morales, 2017) However, uncontrolled fire can pose a significant risk to ecosystems, biodiversity and local communities worldwide, due to loss of natural habitats, destruction of forests and vegetation, greenhouse gas releases, soil degradation and risks to human health. Particularly in areas where vegetation and natural resources are abundant, it is critical to understand the susceptibility to wildfires in order to implement preventive measures and mitigate the associated risks.

In the latter part of the 20th century, there have been significant changes in the relationship between human activity and fires, which has led to a worrying situation in tropical rainforests and cloud forests. These regions, which used to be unaffected by large fires, are now being devastated by uncontrolled fires. According to the Committee on Forestry (Agency et al., 2006) more than 350 million hectares of forest were burned worldwide up to the year 2000. In Latin America and the Caribbean, between 2009 and 2019, it is estimated that around 33 million hectares of land are affected annually due to forest fires (Forestry et al., 2006). (Forestal et al., 2006)

In Ecuador, from the end of 2019 to 2021, according to information provided by the National Risk and Emergency Management Service (Servicio Nacional de Gestión de Riesgos y Emergencias) as per (Villacís Guamán et al., 2022)(Villacís Guamán et al., 2022), about 51,600 hectares of forests were affected. Among 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. As of the aforementioned date, a total of 1,406 forest fires had been recorded. In 2022, a total of 994 forest fires have been reported, causing the loss of approximately 5,060.94 hectares of vegetation cover.

According to the Development and Land Use Plan of the Jipijapa canton, the protective forests of Sancán, where the study area is located, and the Montecristi hill, covering an area of 4,947 hectares, are of utmost importance for conservation due to their natural wealth and ecological relevance. However, due to the intense human activity in the area and the characteristics of the forest, there is a high risk of forest fires. According to reports from the control authorities, a total of 23 forest fires have been recorded in the study area during the last 5 years.

Principle of the form

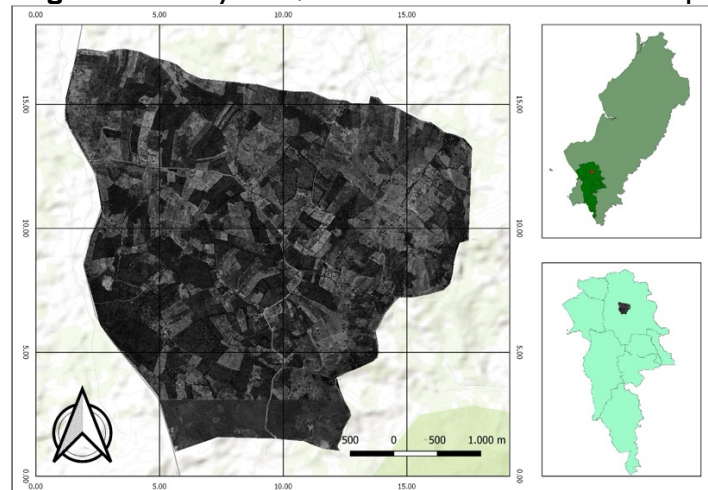
Therefore, it is vitally important to conduct a comprehensive analysis to understand the factors that contribute to this vulnerability in order to develop effective prevention and mitigation strategies. In this sense, the zoning of risk areas becomes essential, as it acts as an essential tool to conserve ecosystems and reduce the incidence of disastrous events. The results of this study have provided a solid base of scientific knowledge to make decisions in the management and prevention of forest fires in the area of Las Mercedes, establishing the areas susceptible to forest fires in the area of Las Mercedes, Sancán commune, Jipijapa canton, which is expected to provide reference in future studies and projects focused on the conservation and protection of natural resources in this specific area.

MATERIALS AND METHODS

The precinct Las Mercedes, located north of the canton Jipijapa, covers an area of 14.10 km². It is bordered to the north by the Sancán commune, to the south by the cantonal capital, to the east by the Secal precinct and to the west by the Santa Rosa precinct. The urban area is easily accessible and is surrounded by several intermittent streams, its

altitudes range between 240 meters above sea level and 508 meters above sea level, with the highest elevation at Cuchilla de Pacheco.

Figure 1. Study area, ESRI satellite 2022 raster map.



Prepared by Wajarai (2023)

For the development of this research, the following steps were taken

1. Planimetry of the study area

- A planimetric survey of the study area was carried out due to the lack of a previous adequate delimitation.

2. Spatial analysis with Arcmap.

- A spatial analysis was carried out using the Arcmap program to process the data and obtain relevant information about the area.

3. Use of 97 geographic points.

- Ninety-seven geographic points were used to perform the specific analysis. These points were strategically selected to obtain an adequate representation of the study area.

4. UTM-WGS17 coordinate register.

- For each of the 97 geographic points, UTM-WGS17 coordinates were recorded, which are a geospatial reference system used to identify the precise location of each point in the study.

Considering that the referent is a fundamental part to carry out the survey and analysis of geospatial data in the research, providing us with accurate and relevant information for the study of the specific area.

The development of the project was carried out using the methodology of the Institute of Hydrology, Meteorology and Environmental Studies of Colombia (IDEAM, 2011). (IDEAM, 2011) This methodology takes into account different risk factors, such as history, climate, vegetation, topography and access. To evaluate the influence of these elements on susceptibility to forest fires, precise statistical analyses were performed. The study of historical forest fires considered the analysis of their annual distribution in the period between 2010 and 2021. The data used for this analysis were obtained from the logs of the Fire Department of Jipijapa canton, which have records available from 2010 onwards. Using the relationship between fires and years, the frequency index was calculated in order to determine the probability of a forest fire occurring in the area. The equation used for this calculation is as follows
Equation 1.

$$F_i = \frac{1}{a} \sum_{1}^a n_i \quad F_i = \frac{1}{12} \sum_{1}^{12} 48$$

Where F_i : Fire frequency; a : Number of years; n_i : Number of fires in each year. To determine the climatic variable, precipitation and temperature records were taken into consideration from the NASA POWER database as well as from the Sancán pluviometric station from the meteorological yearbooks of the National Institute of Meteorology and Hydrology (INAMHI) with a record for the period 2000-2021. The vegetation factor was established taking into account the type of vegetation present, the duration of the predominant fuels and the total amount of fuel in the evaluated area. Subsequently, the coverages were classified according to the dominant fuel, taking into account the physiognomy of each of the vegetation units presented in the vegetation cover map, and then each of the fuel groups, was characterized by the duration and total fuel load (MAE, 2015). The topographic analysis was carried out considering the relief by using the geomorphological map included in the project "Generation of Geoinformation for Land Management at National Level Scale 1:25000", IGM. On the other hand, the evaluation of accessibility, also known as road density, was based on the road map provided by the Ministry of Transportation and Public Works, as well as the project "Generation of Geoinformation for the Management of the National Territory Scale 1:25000, Basic Data and Infrastructure". (Nacional et al., 2020)

RESULTS

Historical Factor

The historical occurrences identified in the study area lead us to analyze the probability of recurrence of forest fires in areas where they have been previously recorded. In the specific case of the Las Mercedes precinct, during the period from 2010 to 2021, a total of 48 forest fires were reported. It was observed that the highest percentages of occurrence were concentrated in the year 2021, resulting in an annual frequency of 3.95

fires. According to the Jipijapa Fire Department report, the cause of all these fires is related to activities associated with agricultural factors such as irresponsible burning to clear the area of underbrush, prepare the land for cultivation or regenerate pastures.

Table 1. *Distribution of fire occurrences across years in the Las Mercedes precinct (2010-2021).*

	Fires		
	(No.)	(%)	
2010	2	4,2	
2011	1	2,1	
2012	5	10,4	
2013	5	10,4	
2014	6	12,5	
2015	4	8,3	
2016	1	2,1	
Climate factor	2017	2	4,2
Climate plays an	2018	1	2,1
the occurrence	2019	6	12,5
forest fires, as it	2020	7	14,6
duration and	2021	8	16,7
and hot seasons	Totals	48	100
region.			

Temperature, precipitation, humidity and wind speed are just some of the climatic factors that can affect the susceptibility of a given area to experience this type of event.

In general terms, the climate of Las Mercedes is tropical megathermal dry, with precipitation ranging between 250 and 450 mm per year. Temperatures vary between 24 and 29 °C, and relative humidity reaches approximately 60%. The average wind speed in Jipijapa presents notable seasonal changes throughout the year. The windiest season extends for 7.8 months, from May 20 to January 14, with average speeds of more than 13.4 kilometers per hour. October is the windiest month in Jipijapa, with winds blowing at an average speed of 16.9 kilometers per hour.

Precipitation

An analysis of the periods of higher and lower rainfall and their respective variations is presented, thus determining the periods of drought and the state of the fuels.

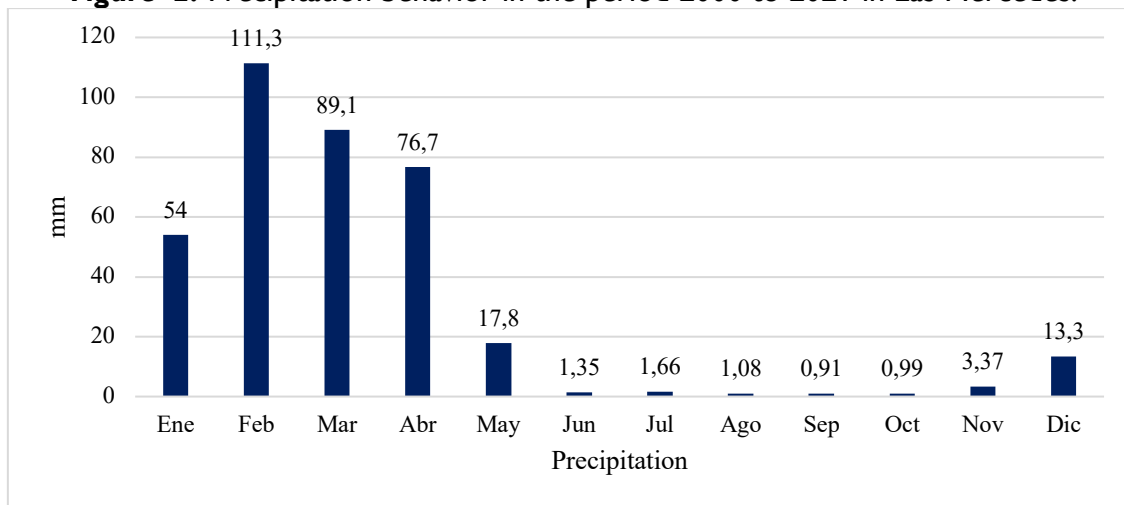
Table 2 (Figure 2) shows the annual and monthly averages of precipitation during the years 2000 to 2021, which records an average annual precipitation of 31 mm and the sum on average was 371.5 mm, while the maximum accumulated annual precipitation was recorded with a value of 768.3 mm in 2002 and a minimum of 148.7 in 2020; The

years 2020 and 2021 are the years with the lowest precipitation averages, 12.4 and 13.3, the same years that show in Table I the increase of fires in the area, this can be attributed to the decrease in precipitation during those years in which the fuels are at low humidity levels and favor fire behavior.

Table 2. *Precipitation for the period 2000 to 2021*

Precipitation														
Year	Jan	Feb	Sea	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	sum	Pre. Prome
2000	37	63,8	101	164	84,3	7,7	1,9	0	1,1	0	2,3	0	462,9	38,6
2001	254	60,8	166	109	30,7	0,8	2,5	2,2	0	0	0,6	4	630,2	52,5
2002	44,7	221	257	156	22,7	0,3	1,9	0,8	0,8	3,6	13,7	45,3	768,3	64,0
2003	65,9	195	38	59,3	32	0,5	0,2	1,7	0	0,6	3,1	16,5	412,5	34,4
2004	17,4	78,4	77,8	7,2	17,9	1,6	3,1	0,2	1,9	2,8	0,2	0,5	209	17,4
2005	13,9	88,8	66,6	160	0,3	0,9	0,4	0,2	0	0	0	16,6	347,6	29,0
2006	50,5	164	79,2	22,7	5,6	0	0	2,8	1,7	0	10,6	10,9	347,6	29,0
2007	28,3	16,1	49,9	116	9,4	0,2	5,4	1,3	0	0	0,3	18,5	244,9	20,4
2008	150	86,4	193	33,4	11,7	5,2	0,4	0,2	3,2	2,2	0,8	0	486,6	40,6
2009	122	84,2	46,2	38,1	12,8	0,8	0	0,9	0	0	0	9,2	314	26,2
2010	65	195	38	59,3	32	0,5	0,2	1,7	0	0,6	3,1	16,5	411,6	34,3
2011	17,4	78,4	77,8	7,2	17,9	1,6	3,1	0,2	1,9	2,8	0,2	0,5	209	17,4
2012	13,4	88,8	66,6	160	0,2	0,9	0,3	0,2	0	0	0	16,6	346,9	28,9
2013	50,6	164	79,2	22,7	5,6	0	0,3	2,8	1,7	0	10,6	10,9	348	29,0
2014	27,3	16,1	49,9	116	9,4	0,2	5,4	1,3	0,2	0	0	18,5	243,8	20,3
2015	43,7	221	257	156	22,7	0,3	1,9	0,8	0,8	3,6	13,7	45,3	767,3	63,9
2016	65	195	38	59,3	32	0,5	0,2	1,7	0	0,6	3,1	16,5	411,6	34,3
2017	17,4	78,4	77,8	7,2	17,9	1,6	3,1	0,2	1,9	2,8	0,2	0,5	209	17,4
2018	12,9	88,8	66,6	160	0,3	0,9	0,4	0,2	0	0	0	16,6	346,6	28,9
2019	49,5	164	79,2	22,7	5,6	0	0	2,8	1,7	0	10,6	10,9	346,6	28,9
2020	28,3	16,1	49,9	19,5	9,4	0	5,4	1,3	0	0	0,3	18,5	148,7	12,4
2021	13,1	86,4	3	33,4	12	5,2	0,4	0,2	3,2	2,2	0,8	0	159,9	13,3
Media	54	111	89	76,7	17,8	1,35	1,66	1,08	0,91	0,99	3,37	13,3	371,5	31,0

Figure 2. Precipitation behavior in the period 2000 to 2021 in Las Mercedes.



Temperature

Table 3 represents the historical record of the average annual temperature during the period 2000 to 2021 with an average of 24.3 °C. In 2015, 25.5°C was recorded, identifying it as the year with a higher temperature than the average (Figure 3); among the monthly averages, February and March are the months with the highest temperature, considering that the temperature in the coastal zone increases during these months (Figure 4).

Table 3. Average temperature for the period 2000 to 2021.

Temperature													
Year	Jan	Feb	Sea	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	□
2000	24,4	24,3	24,0	24,3	22,9	22,5	22,2	22,5	22,5	23,6	23,1	24,4	23,4
2001	24,4	24,6	24,6	24,1	22,8	22,4	22,9	23,2	22,6	22,8	23,4	24,2	23,5
2002	25,1	24,9	24,9	24,3	24,1	23,6	23,7	24,0	24,0	24,6	24,9	25,4	24,5
2003	25,3	25,5	25,7	25,6	25,2	23,7	23,2	24,2	23,0	24,5	24,5	24,7	24,6
2004	24,7	25,6	24,9	25,1	24,7	23,7	23,0	23,3	23,6	24,3	24,4	24,7	24,3
2005	25,7	25,7	25,4	26,6	24,8	23,5	23,4	23,1	23,0	22,4	23,4	24,4	24,3
2006	25,4	25,4	25,1	24,9	24,6	23,9	23,8	23,9	23,9	24,2	24,1	24,9	24,5
2007	25,5	26,1	25,9	26,0	25,4	24,6	23,7	22,6	22,8	22,6	23,3	23,7	24,3

2008	24,3	24,4	24,5	24,1	23,2	23,4	24,0	23,7	23,8	23,3	23,5	24,4	23,9
2009	24,9	24,9	25,0	25,3	25,3	24,8	24,4	24,4	23,5	23,8	24,2	25,3	24,6
2010	25,3	25,9	25,7	25,7	25	24	23,3	23	23	22,9	22,9	23,5	24,2
2011	24,6	25,3	25,5	24,9	25,2	24,4	24,4	23,5	22,9	22,5	22,8	24,2	24,2
2012	24,7	24,9	25,1	24,9	24,7	24,2	23,3	23,1	23,4	23,4	23,8	24,6	24,2
2013	25	25	24,9	24,2	24,7	23,6	23	23	23,4	23,4	23,8	24,3	24,0
2014	25,2	25,2	25,7	26	23,2	25,1	24,7	24,1	23,5	24,2	24	24,7	24,6
2015	25,1	25,5	26	26,1	25,3	26	25,5	24,6	25,1	25	25	26,5	25,5
2016	26	26,2	26,3	25,7	26,2	25,2	24,5	23,9	24	23,3	23,1	24,8	24,9
2017	25,4	25,8	26	25,3	24,9	24,1	23,7	23,5	23,7	23,7	23,3	24,2	24,5
2018	25	25,2	24,9	24,9	25	23,6	23,8	23,8	23,7	23,4	24,4	24,6	24,4
2019	24,4	24,8	25	24,3	23,3	23,4	23,9	23,6	23,4	23,1	23,2	24,2	23,9
2020	24,9	25	25	25	24,9	24,5	24,1	24,1	23,2	23,6	23,9	25	24,4
2021	25	25	24,9	24,9	25	23	23,8	23,8	23	23,4	24	24,6	24,2
Media	25,0	25,2	25,2	25,1	24,6	24,0	23,7	23,6	23,4	23,5	23,8	24,6	24,3

Temperature of the period from 2000 to 2021 (INAMHI, 2022)

Figure 3. Annual temperature behavior in Las Mercedes.

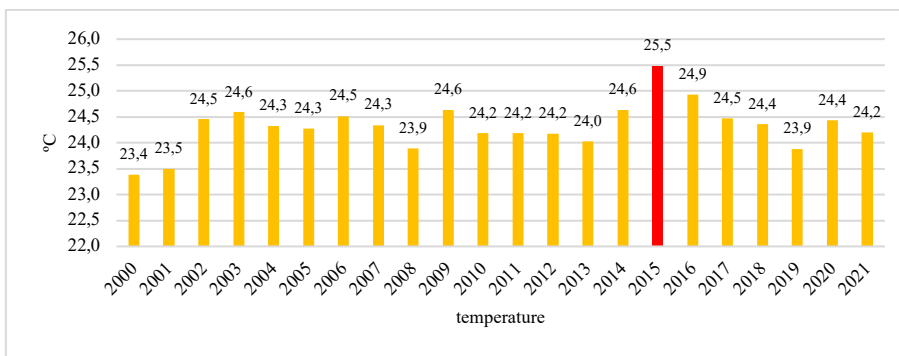
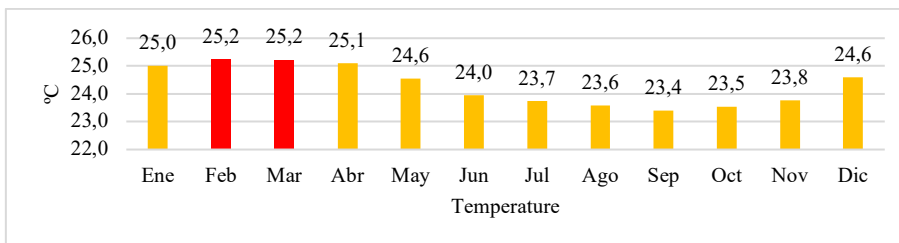
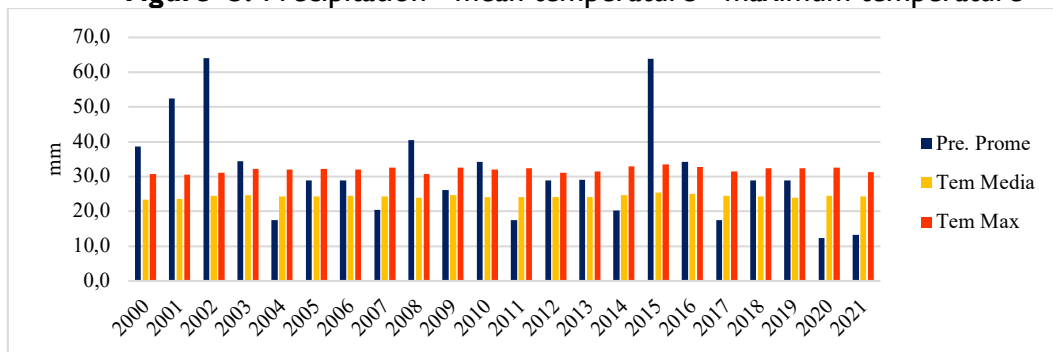


Figure 4. Monthly behavior of the temperature in Las Mercedes from 2000 to 2021.



During the years 2020 and 2021, there has been a notable decrease in precipitation (Figure 5) and a considerable increase in temperature, which has resulted in drought conditions. The lack of rainfall has generated a significant increase in average and maximum temperatures, exceeding the average temperature. The combination of high temperatures and low rainfall considerably increases the likelihood of fires in the area because the vegetation fuels will be drier and with low levels of humidity.

Figure 5. Precipitation - mean temperature - maximum temperature



Vegetation

The regions that have a higher density of trees, shrubs, grasses and other plant elements are those that show a high degree of vulnerability and predisposition to forest fires, in this sense the arboreal composition of the forest has 281 individuals, 22 species and 21 genera, in which 11 families are classified, of which the most representative is the Fabaceae family. The highest concentration of individuals was recorded in the arboreal stratum with 234 trees (Ikhsanto, 2020). (Ikhsanto, 2020)

Table 4. Name of the forest species that inhabit the Las Mercedes site.

NO.	Scientific name	Common name
1	Ximenia americana L.	Alabaricoque
2	Acnitus arborencens (L)Schltdl	Guitite
3	Alvizia multiflora (Kunth) Barneby and J.W. Grimes	Angolo
4	Citharexylum Chartaceum Madenke	Broadleaf
5	Colicodendron scabridum (Kunth) Seem	Sapote
6	Cordia lute Lam	Muyuyo
7	Croton rivinifolius Kunth	Croton
8	Cynophalla didymobotrys (Ruiz and Pav. Ex DC) Cornejo	Senna
9	Eriotheca ruizii (K. Schum) A. Robyns	Pita stick or Borracho
10	Leucaena Trichoides (Jacq.) Benth	Sleepy

11	Machaerium Millei Standl	Screw pole
12	Mimosa pigra L	The pink sleepyhead
13	Muntinguia Calabura L	Cayenne cherry
14	Phyllanthus graveolens (Kunth) Mart	Horsetail
15	Piscidia carthagenensis Jacq.	Jamaica flower
16	Prosopis Padilla (Humb and Bonpl.ex Willd) Kunth	Algarrobo
17	Saptum aff. Marmieri Huber	Knife
18	Senna Mollissima (Humb. And Bonpl. Ex Willd.) H.S. Irwin and Barneby	Yellow carob
19	Varionia macrocephala Desv	Varronia
20	Vasconcellea microcarpa (Jacq) A.DC.	Papayuela
21	Vasconcellea parviflora A.DC	Babaco
22	Zizphus thyriflora Benth	Red sapote

Source Prepared by (Orlando Villacreses, 2020)adapted from (Ikhsanto, 2020)

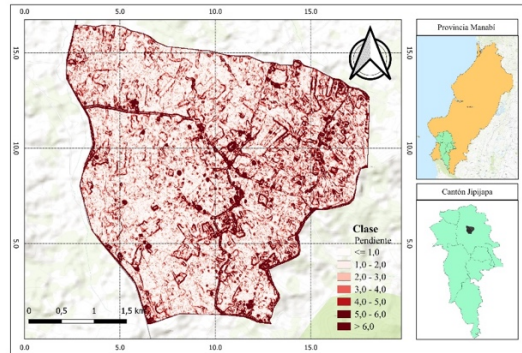
Relief

In the Las Mercedes area, there are two types of relief: high hilly relief and medium hilly relief. The high hilly relief is characterized by sharp peaks that are linked to straight slopes ranging between 250 and 500 meters in length. These units show steep slopes (40-70%) at altitudes above 400 meters above sea level (masl). However, medium to steep slopes (25-40%) are also found in smaller proportions.

The medium hilly relief is located below 400 and 300 meters above sea level, presenting rounded summits associated with convex slopes mostly, although mixed slopes are also present, with a length exceeding 250 m characterized by medium slopes (12-25 %) and medium to steep slopes (25-40 %). (Orlando Villacreses, 2020)

When analyzing terrain slopes using QGIS tools, it can be seen in Figure 6 the classification into three main categories: low slopes range from 0 to 3.0 degrees, while medium slopes are in the range of 3.0 to 5.0 degrees, finally, high slopes are between 5.0 to >6.0 degrees.

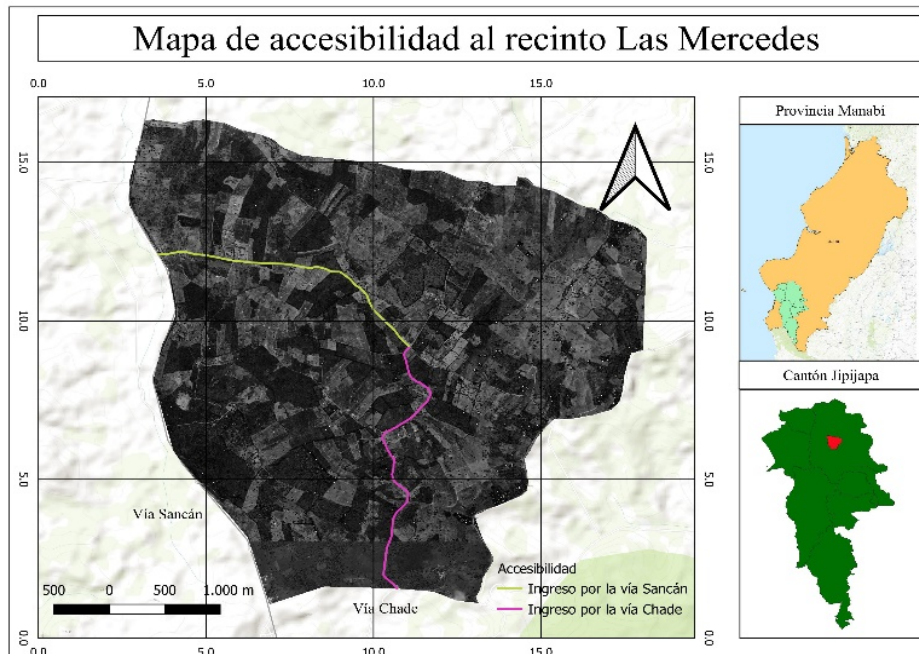
Figure 6. Slope Classification in Las Mercedes



Accessibility

Accessibility is considered part of the threat due to the probability that the population could reach the forested areas of the site to generate fire outbreaks. Based on the difficult access to the different hedges from the main or secondary roads in the precinct, in this context, two access options are presented, the first is to go to the Sancán road located at a distance of 200m from the vegetation cover to the main road, while the second option is the secondary road that goes to Chade.

Figure 7. Map of accessibility to the Las Mercedes site



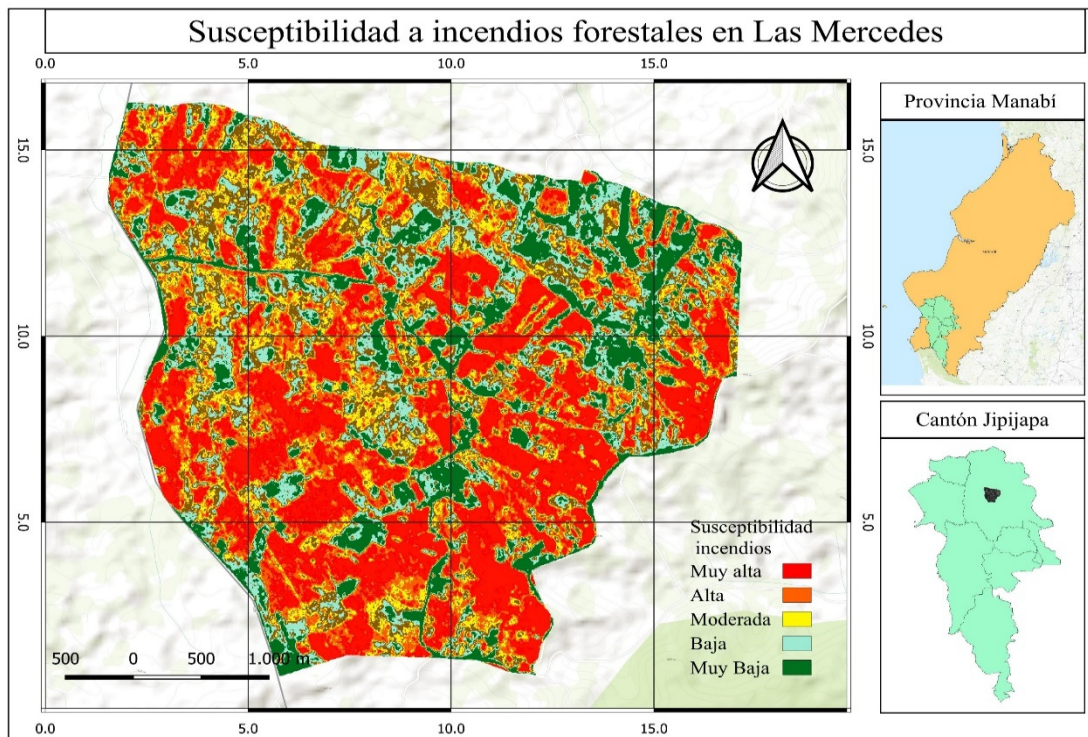
Considering all of the above factors, a susceptibility map was drawn up showing that most of the study area was classified as very highly susceptible (Figure 8), covering an area of 719 ha, equivalent to 49% of the study area.

Table 5. Variables for the elaboration of the forest fire susceptibility map in Las Mercedes.

Variable	Value	IDEAM Range	Rating	Susceptibility
Average annual precipitation	447.4 mm	Aggregate 0 - 500 mm	5	Very high
Average annual temperature	24,4 °C	Warm >24°C	5	Very high
Historical occurrence	# fire 48	Frequency 4	4	High
Vegetation susceptibility	vegetative cover	Fragmented forest	4	High
Earrings	5-6 degrees	12-25%	3	Moderate
	6	25 - 75%	4	High
Accessibility	2000 m	1000 - 2000 m	2	Moderate

Source: IDEAM modified to the result of the Las Mercedes study object.

Figure 8. Location of the area, fire probability significance.



DISCUSSION

The analysis of historical data on fire records reveals the causes of fires, the places where they occur most frequently and the periods of the year in which they are most likely to occur. (Ministry of Environment - Panama, 2015), In the Las Mercedes compound during the years 2010 -2021 according to the reports 48 occurrences were recorded, with a high rate between the years 2020 and 2021, and a frequency rate of 3.95 annual fires, according to, (IDEAM, 2011), this value is considered a high threat due to the occurrence of fires, with respect to this recurrent frequency of fires in this enclosure. (Montiel, 2013)(Montiel, 2013) indicates that this may be associated with the fact that the fire regime, expressed in patterns of occurrence and frequency, has evolved throughout history according to the succession of various environmental changes and socioeconomic and political transformations that have determined a change in the risk of ignition, in the modes of spread and in the territorial and social vulnerability to fires.

Climatic Factor

The climate directly influences the humidity and the amount of fuel available for easy ignition and is directly influenced by precipitation and ambient temperature in this way the data in the study area recorded a value of 371.5 mm although in 2002 it presented 768.3 mm due to torrential rains at the national level causing landslides, and in 2015 with a record of 767.3 because it presented the strongest season of the El Niño phenomenon. (INAMHI, 2016). The temperature factor became a value of 24.3°C reflecting an increase in 2015 due to the fact that it was officially considered the hottest year in history up to that time affecting especially Central America, the northern half of South America, the northern, southern and eastern part of Europe, western Asia, as well as large areas of the northeastern and central Equatorial Pacific (ANNUAL REPORT WHAT ' S APPLIED SCIENCES ?, 2016)In the Litoral region, specifically, there was a thermal increase as an influence of the warming of the tropical Pacific sea surface, which persisted throughout the year, these anomalies fluctuated from 0.5°C to 2.4°C. (INAMHI, 2016)as indicated by the (IDEAM, 2011)These values are considered as a very high threat because the average annual precipitation is in a range between 0 and 1000 (mm) and the average annual temperature exceeds 24° C, in this regard several authors indicate that weather conditions, such as high temperatures and low relative humidity, are determinants for the generation and prolongation of large forest fires. (Moreno Rodríguez, José Manuel; R. Urbieto, Itziar; Bedia, Joaquín; Gutiérrez, 2015)..

Fuels

The area is characterized by a forest, with an abundance of trees and shrubs that are considered as heavy fuels due to their minimum height of 7 meters and diameter greater than 1 cm (Table 4), as indicated by (Myers, 2006)As indicated by (Myers, 2006), these types of fuels have a duration of up to 100 hours and are considered to be in a high threat category due to their persistence and difficult liquidation, in addition, some fuels contain certain volatile materials along with cellulose. These chemical substances, such as oils, waxes and resins, make the fuel containing them available and can affect the linear

intensity of the fire, the difficulty of liquidation and the speed of propagation, for example trees such as muyuyo, carob and cauchillo.

Regarding the type of ecosystem can be considered as influenced by fire due to the range that presents the climatic conditions in this forest and the type of existing species that can respond positively to fire disturbances, example of them are some species of Fabaceae family as stated in a study by (Trejo et al., 2019) in which they determine the effect of fire on the trees of a tropical forest, indicating that some of the species that adapted the most to the presence of fire were those belonging to the Fabaceae family due to the characteristics of the trees that give them greater resistance to fire, such as greater height and diameter; however, as there are less resistant species, they are exposed ecosystems due to excessive burning.

Relief Factor

The topography of the area reflects the existence of a high hilly relief and represents up to 70% of steep slopes, although medium slopes are also present. (IDEAM, 2011) considers a high threat when the percentage of slopes represents values between 25 and 75%, due to the fact that topographic characteristics such as steep slopes and abrupt relief facilitate the spread of fire and hinder the effectiveness of extinguishing tasks. (Ministry of Environment - Panama, 2015)..

Accessibility

Accessibility in this case is expressed as the ease with which the population can access a particular place and generate fire outbreaks; the closer the place is to a road, the higher the level of threat than those where access is more difficult, considering that it has two types of accesses with a main road categorized as a very high threat and a secondary road as a low threat. (IDEAM, 2011) Therefore, adequate management must be carried out to control extrinsic factors derived from anthropic behavior, such as maintenance and cleaning of fine or light combustible material, application of agricultural burning schedules, implementation of conservation agriculture systems, as well as promoting coordination between different entities, such as government agencies, fire departments, agricultural organizations and local communities, to share information, resources and coordinate fire prevention and control actions, among others.

REFERENCES

- Agency, T. C., Consulting, I., DEPARTMENT OF WATER AND SANITATION, Infill, R., Iii, W., June, M. S., Lititz, S., Number, P. P. I. D., Number, P. P. I. D., Owner, P., Address, O., Phone, O., Acreage, T., Coverage, L., Capacity, S., Development, P., Stewart, D., Strictest, I., Confidence, C., ... นครเศรษฐ์ รังควัด. (2006). No Title Πώς Παράγονται και Παρέχονται Αποτελεσματικά Υπηρεσίες Ποιότητας. Transportation, 1 (January), 21-30. <https://doi.org/10.1002/ejoc.201200111>.
- ANNUAL REPORT WHAT ' S APPLIED SCIENCES ? (2016).
- Emergencias, S. N. de G. de R. y. (2020). Situation Report - Forest Fires. Alteraciones Climaticas, 1-6. <http://www.gestionderiesgos.gov.ec/informes-incendios->

forestales-2016/

- Forestal, A., Guillermo, J., & Rodas, F. (2006). Analysis of the processes and main results of the NFP National Forestry Program in Honduras.
- IDEAM. (2011). Protocol for the realization of fire risk zoning maps of vegetation cover SCALE 1:100.00. In Protocolo para la realización de mapas de zonificación de riesgos a incendios de la cobertura vegetal ESCALA 1:100.00.
- Ikhsanto, jurusan teknik mesin L. N. (2020). No 主観的健康感を中心とした在宅高齢者における健康関連指標に関する共分散構造分析{Title}. 21(1), 1-9.
- INAMHI (2016). Annual Climatological Bulletin. 31. http://www.serviciometeorologico.gob.ec/meteorologia/boletines/bol_anu.pdf
- MAE. (2015). Tree and shrub forest species of the montane forests of Ecuador. Ministerio Del Ambiente de Ecuador-MAE, 174. <https://biblio.flacsoandes.edu.ec/libros/digital/55826.pdf>
- Ministry of Environment - Panama (2015). Methodology for the investigation of the causes of forest fires. Government of the Republic of Panama, 114.
- Montiel, C. (2013). The historical presence of fire in the territory. In Ministerio de Agricultura, Alimentación y Medio Ambiente (Issue August). https://www.ucm.es/data/cont/media/www/pag-36030/WEB_Presencia_historica_del_fuego_en_el_territorio.pdf
- Morales, J. A. A. (2017). Actions for the prevention of forest fires in five stands of Lot 7 belonging to the Unidad Empresarial de Base Silvícola Guisa. Revista Cubana de Ciencias Forestales, 5(2), 181-193. <http://cfores.upr.edu.cu/index.php/cfores/article/view/220>
- Moreno Rodríguez, José Manuel; R. Urbieto, Itziar; Bedia, Joaquín; Gutiérrez, J. M. (2015). Forest fires in Spain in the face of climate change. Los Bosques y La Biodiversidad Frente Al Cambio Climático: Impactos, Vulnerabilidad y Adaptación En España, 581-588. <https://ruidera.uclm.es/xmlui/handle/10578/8179>.
- Myers, R. L. (2006). Living with fire.
- National, D., National, C., Geogr, D., Also, P., National, C., Executive, D., Universal, P., National, C., & Executive, D. (2020). Military geographic institute management report. 593.
- Orlando Villacreses, A. L. (2020). Zoning of forest fire susceptibility in the Las Mercedes area, Sancán commune, Jipijapa canton, Ecuador. Journal of Chemical Information and Modeling.
- Trejo, D. A. R., Muñoz, P. M., & Lara, P. J. M. (2019). Fire effects on the trees of a tropical pine forest and a tropical dry forest at villaflores, Chiapas, Mexico. Florestal Science, 29(3), 1033-1047. <https://doi.org/10.5902/1980509833952>.
- Villacís Guamán, F., Lizano Espín, M. K., Toapanta Jaya, E. J., Chango Taraguay, Á., & Miguel (2022). Los Incendios Forestales Y Su Prevención En El Ecuador Forest Fires and Their Prevention in Ecuador. INNDEV - Innovation & Development

Ciencias Del Sur, I(1), I-8. <https://www.itscs-cicc.com/ojs/index.php/inndev/article/view/32>