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Forest Fire Information and Management Systems in Latin America and the Caribbean

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Contact information:
Address: Joint Research Centre, Via Enrico Fermi 2749, TP 261, 21027 Ispra (VA), Italy
E-Mail: JRC-EFFIS@ec.europa.eu
Tel.: +39 0332 78 6138

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Cover image: Latin America and the Caribbean region in the GWIS current situation viewer.

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Abstract

This is the first edition of the Forest Fire Information and Management Systems in Latin America and the Caribbean (LAC) report. This report provides an overview of the efforts made at the national level in each country and at the regional level in the development and use of forest fire information and management systems. The report presents fire information systems at the national level and follows the description of the Global Wildfire Information System (GWIS) where historical and near real-time information on forest fires can be acquired at national, regional (supranational) and global scales. Among the functionalities and features of this common forest fire early warning and monitoring system is its compatibility and interoperability with national LAC systems.

Authors and editors

Bolivia	Franz Callisaya René Cerezo	Ministerio de Medio Ambiente y Agua
	Grover Monasterios Santos Luis Quispe	Viceministerio de Defensa Civil – VIDECI
	Aldo Claure	Autoridad de Fiscalización y Control Social de Bosques y Tierra – ABT
Brasil	Lawrence Nobrega de Oliveira Mariana Senra de Oliveira Govinda Terra	Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis – IBAMA
	Joao Paulo Morita Mauricio Marcon Silva	Instituto Chico Mendes de Conservação da Biodiversidade – ICMBio
	Alberto Setzer Fabiano Morelli	Instituto Nacional de Pesquisas Espaciais – INPE
	Renata Libonati	Universidade Federal do Rio de Janeiro – UFRJ Laboratório de Aplicações de Satélites Ambientais – LASA
	Henrique Bernini	Centro Gestor e Operacional do Sistema de Proteção da Amazônia – CENSIPAM
Chile	Pablo Andrés Lobos Stephani Jorge Andrés Saavedra Saldías Jordi Brull Badía	Corporación Nacional Forestal – CONAF Gerencia de Protección contra Incendios Forestales
Colombia	Néstor Garzón Cadena María Angelica Arenas Aguirre	Ministerio de Ambiente y Desarrollo Sostenible Dirección de Cambio climático y Gestión del Riesgo
	Karen Ávila Luisa Solano Samuel Lancheros	Unidad Nacional para la Gestión del Riesgo de Desastres – UNGRD Subdirección para el Manejo de Desastres Oficina de comunicaciones
	Juan Carlos Puerto Prieto Jhon Jader Ocampo Milton Vargas Hernández	Dirección Nacional de Bomberos de Colombia Sala situacional
	Uriel Gonzalo Murcia Jorge Arias	Instituto Amazónico de Investigaciones Científicas – Sinchi Programa de Investigación
	Amparo Rodríguez león Luis Mario Moreno	Instituto de Hidrología, Meteorología y Estudios Ambientales – IDEAM Subdirección de Ecosistemas e Información Ambiental
Ecuador	Diana Soto Joselyn Pazmiño Sergio Cobos	Ministerio del Ambiente, Agua y Transición Ecológica – MAATE
	Daniel Segura Ximena Herrera	Servicio Nacional de Gestión de Riesgos y Emergencias (SNGRE)
	Carmen Sarango Mariana Quispillo	Instituto Nacional de Meteorología e Hidrología – INAMHI
	Carlos Arreaga Díaz	
México	Eduardo Cruz Tania Salgado	Comisión Nacional Forestal – CONAFOR Gerencia de Manejo del Fuego
Paraguay	Marisa Toffoletti	Instituto Forestal Nacional – INFONA Departamento de Protección Forestal
	Ricardo Pereira Gavilán	Organización de las Naciones Unidas para la Agricultura y la Alimentación – FAO

Peru	Glory Emilsen Alarco Basaldua Tatiana Zarella Pequeño Saco (coord.)	Ministerio del Ambiente – MINAM Dirección de Monitoreo y Evaluación de los Recursos Naturales del Territorio
	José Luis Epiquién Rivera	Centro Nacional de Estimación, Prevención y Reducción del Riesgo de Desastres – CENEPRED Dirección de Gestión de Procesos
	Wilder Lino Canales Campos	Servicio Nacional de Áreas Naturales Protegidas por el Estado - SERNANP Dirección de Gestión de Áreas Naturales Protegidas
	Romina Alejandra Liza Contreras	Servicio Nacional Forestal y de Fauna Silvestre – SERFOR Unidad Funcional de Monitoreo Satelital – UFMS
	César Ricalde Bellido	Ministerio de Cultura Oficina de Defensa Nacional
	Ricardo Zubieta Barragán	Instituto Geofísico del Perú – IGP Subdirección de Ciencias de la Atmósfera e Hidrósfera
	Renzo Manuel Saavedra Estrada Susana Sono Alba Rafael Ramírez Arroyo	Cuerpo General de Bomberos Voluntarios del Perú – CGBVP
	Emma Díaz Escobal Miguel Albornoz Yañez Mario Casaretto Gamonal	Intendencia Nacional de Bomberos-INBP
	Gabriela Rosas Nelson Quispe	Servicio Nacional de Meteorología e Hidrología del Perú – SENAMHI
	Jorge Gonzales Figueroa	Instituto Nacional de Defensa Civil – INDECI Sub Dirección de Gestión Operativa
	Ernesto Luis Cueva Melgar	Comando Conjunto de las Fuerzas Armadas Departamento de Gestión del Riesgo de Desastres
JRC	Jesús San-Miguel-Ayanz[1] María Suárez-Moreno[2] Tracy Durrant[3] Duarte Oom[1] Alfredo Branco[1] Giorgio Liberta[1] Daniele de Rigo[2] Davide Ferrari[3] Elena Roglia[2] Nicola Scionti[2] Pieralberto Maianti[2] Roberto Boca[2] Marco Broglia[2]	1 European Commission, Joint Research Centre (JRC), Directorate for Space, Security and Migration, Disaster Risk Management Unit, Ispra (VA), Italy 2 External consultant for the European Commission (ARCADIA SIT s.r.l) Vigevano (PV), Italy 3 External consultant for the European Commission (Engineering Ingegneria Informatica S.p.A.) Piazzale dell'Agricoltura (RM), Italy
OTCA	Carlos Salinas Isaac Ocampo Mauro Luis Ruffino	Organización del Tratado de Cooperación Amazónica - OTCA

Executive summary

This report provides an overview of forest fire information and management systems in Latin American and Caribbean (LAC) countries. Its preparation and publication aims to disseminate information on the organisation of fire information management in LAC and to improve cooperation among member countries of the Group of Experts of Forest Fire in Latin American and Caribbean (GEFF LAC), particularly with regard to fire prevention, fire mitigation and fire-related climate change adaptation measures.

Our common goal is to maintain and protect our landscapes and natural heritage, to prevent loss of life and to minimise damage to property caused by uncontrolled forest fires. To this end, it is essential to carry out this initial exercise of sharing and comparing, which allows for the identification of opportunities for improvement for each of the countries and for collaboration within the GEFF LAC. This initiative replicates the successful EU work implemented by the Joint Research Centre (JRC) of the European Commission, based on more than 20 years of scientific experience and embodied in the Group of Experts on Forest Fires (GEFF) and the European Forest Fire Information System (EFFIS).

As a background against which the potential of the GEFF LAC can be gauged, the history of EFFIS, originally initiated by the Joint Research Centre in collaboration with the European Commission's Directorate-General for the Environment, can be analysed. Due to the strong support of the Expert Group on Forest Fires (EGFF), which constitutes the network of experts from the countries contributing to EFFIS, the system was developed on an operational level supporting national and European policies and providing the information basis for discussion of forest fire related issues in the European Parliament. EFFIS currently provides operational support to the Directorate General for European Civil Protection and Humanitarian Aid Operations (DG ECHO) in the area of civil protection, to the Directorate General for Defence Industry and Space (DG DEFIS) in the implementation of the Copernicus Regulation, as well as to the Directorate General for Regional and Urban Policy (DG REGIO) in relation to the implementation of the EU Solidarity Fund Regulation for critical fires. In 2015, EFFIS was included as a component of the Emergency Management Services of the EU Copernicus Programme, providing a legal and financial basis for its operation under this framework since then.

More than twenty years after its creation, EFFIS provides an ideal platform for countries to exchange best practices on fire prevention, fire suppression, restoration practices and other fire management related activities, and for the European Commission to update national forest fire services on relevant initiatives at European level. Since its first operation in 2000, the number of countries contributing to and receiving data on forest fires in EFFIS has steadily increased. The EFFIS network currently comprises 43 countries, including 25 EU Member States, 13 non-EU European countries and 5 countries in North Africa and the Middle East. The EFFIS system was used in 2020 by governmental organisations and citizens, with almost 300,000 users from 178 countries.

Seven South American countries (Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay and Peru) and Mexico have contributed to this report, presenting the current status of their forest fire information and management systems. A future update of this report is expected to include an update on the systems presented here as well as a description of the information systems in other countries such as Argentina and Uruguay, which are members of the GEFF LAC. Finally, a description of the Global Wildfire Information System (GWIS), which provides globally standardised data and is therefore of potential use as a regional system in LAC, is included.

All countries have concurrent institutional developments in the field of forest fires from environmental institutions (environmental ministries, forestry services, protected areas systems) and civil defence and disaster risk management, in addition to the participation of fire brigades, which in the region are traditionally a mixed institution, with origins in civil society and volunteers but now partially incorporated into public institutions. In different countries and areas, fire brigades have developed specific capacities to extinguish forest fires.

All reporting countries currently maintain a statistical base in which they record variables related to the number of fires and the area burnt, although these databases differ in their extension (the Chilean one, by far the oldest, contains data from 1964) and quality. All countries contributing to this report maintain and operate, at a minimum, the information provided by NASA's Fire Information for Resource Management System (FIRMS): burned area by MODIS sensor from November 2000 to date, and hot spots by VIIRS sensor from January 2012 to date. Chile, Ecuador and Peru enrich this information with field data, such as field perimeters, confirmation of forest fire classification, probable cause and other data, to varying degrees. In general, there is no specific formal record of loss of life and injury in forest firefighting activity, nor are economic damage assessments recorded, except on an experimental basis in Chile.

Similarly, all participating countries report the availability of meteorological information and forecasts issued by the corresponding national agency; the divergence is in the timing and specificity of these forecasts, as well as in the timeliness of their dissemination for the specific purpose of forest fire prevention and extinguishing. Bolivia issues daily public and officially accessible reports; Chile has a centralised system that provides medium (six and

three months) and short-term (weekly and 3-day) forecasts, as well as twice-weekly "Red Button" reports; the Chilean system is the one that provides the greatest quantity and quality of information for prevention and combating among those reporting. Colombia issues daily alerts through the SIGPI and SIAT-AC systems. In Ecuador there are situation reports (SITREP) which, as in the case of Bolivia, do not allow management teams to anticipate the evolution of the situation. Paraguay has medium-term forecasts, but these are not reported to be disseminated in a usable form from a forest fire perspective. Peru issues central information on conditions favourable to the occurrence of fires (CFOI), which is more useful for planning than for the deployment of firefighting operations. Only Chile reports the use of medium-range forecasts from the European Centre for Medium-Range Weather Forecasts (ECMWF).

The use of hazard indices is not uniform. An important development of its use is found in Chile, where the "Red Button" is applied from both a planning point of view and an operational point of view during fire season. As mentioned, Peru uses a CRT (classification and regression tree) methodology to obtain CFOI maps that are updated during the season.

Similarly, in all cases, reporting countries have developed geomatic capacities for the integration and analysis of data from remote observation and field teams. In several cases, relevant geophysical and space agencies collaborate in these developments.

The recent development of the institutional framework related to forest fires in the countries covered in this report opens opportunities for the participation of organised civil society, particularly the scientific community, both academic and linked to non-governmental organisations. Curiously, the centralisation of knowledge is at its highest in the case of Chile, where the highest levels of capacity among the participating countries are strongly concentrated in the National Forestry Corporation (CONAF), and at its lowest in the countries with the least technical progress in matters of interest, such as Ecuador and Paraguay. Having said that, all countries report open access to available statistical and spatial information, which facilitates investigation, technical development and social participation in combating forest fires.

From a collaborative perspective with the European Union, the GWIS system, initiated within the GEO (Global Earth Observation) Programme, a global institutional programme that includes NASA, as well as other space agencies and the Joint Research Centre (JRC), seeks to provide harmonised information on forest fires and the assessment of their effects worldwide.

The current report is carried out in the context of collaboration between the European Commission's Joint Research Centre (JRC) and the EU-LAC Policy Dialogue Support Facility (EU-LAC Policy Dialogue Support Facility, 2020-2023), funded and managed by the European Union (EU) Foreign Policy Instruments Service (FPI), which aims to deepen the EU's commitment to Latin America and the Caribbean.

National Fire Information Systems

1. Bolivia

1.1. Inter-agency coordination system

The Ministry of the Environment and Water (*Ministerio de Medio Ambiente y Agua*, MMAyA) through the General Directorate of Forest Management and Development (DGGDF, *Dirección General de Gestión y Desarrollo Forestal*) is responsible for managing, supervising and coordinating technical, operational and administrative activities, as well as executing and following up the National Afforestation and Reforestation Programme (PNFR, *Programa Nacional de Forestación y Reforestación*) and the Monitoring and Control of Deforestation and Forest Degradation Programme - *Nuestros Bosques* [Our Forests]. The Forest Information and Monitoring System (SIMB, *Sistema de Información y Monitoreo de Bosques*) is used as a technical tool for both programmes[1].

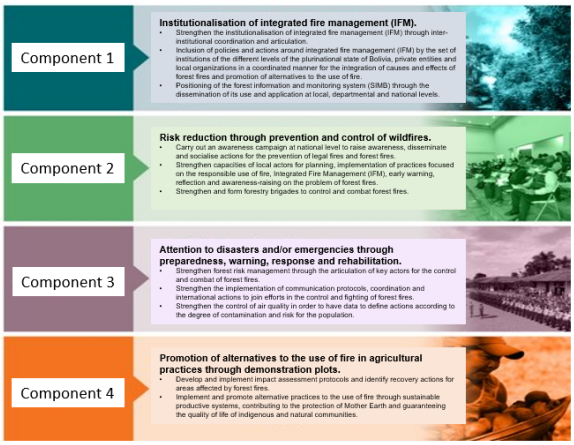


Figure 1. National Strategy for the Prevention, Control and Firefighting of Forest Fires and Post Event.

SIMB is the official forest fire information system, established by law in Bolivia and used by official agencies such as the armed forces, among others.

In terms of risks, there is a regulatory framework for governments, municipalities, the army, the National System of Protected Areas and the departmental and municipal systems, organised by forest type.

Regulatory Framework

Supreme Decree No. 2912

Under Article 17, MMAyA will design and implement the Forest Information and Monitoring System which will articulate all systems and implement the module for monitoring forested and reforested areas.

In addition, SIMB's afforestation and reforestation module has been implemented to evaluate and monitor the compliance with the goals set by the autonomous territorial entities.

Supreme Decree No. 2914

Under Article 8, it is stated that MMAyA, through the Forest Information and Monitoring System (SIMB), will establish a module to monitor deforestation throughout the territory of the Plurinational State of Bolivia.

Similarly, SIMB is the instrument for monitoring hot spots, forest fires and burnings.

SIMB will register the areas that have been authorised for land clearing for food production, which will be publicly accessible.

Ministerial Resolution No. 340/2016

Its purpose is to officially establish the single reporting of hot spots and forest fires, within the framework of SIMB, which will be issued by MMAyA through the DGGDF.

Institutional Competencies

The Authority for Social Control and Auditing of Forests and Land (ABT) supervises and controls burnings at national level (R.M. 131/97); grants permits for controlled burnings; generates information for the detection and monitoring of hot spots; and imposes administrative and criminal sanctions through the administrative sanctioning procedure.

The ABT grants the Controlled Burning Permit through: Land Management Plans; Clearing Plan (PDM) (Plan for non-agricultural clearing; Plan for clearing less than 5 ha; Small clearing up to 20 ha. Plan for land clearing greater than 5 ha.); Burning permits (Controlled burning of pastures; Controlled burning of cordons and stubble; Silvopasture management; and Cleaning of grazing fields).

It is also in charge of control and inspection in the national territory through the National Head Office of Control and Inspection in coordination with the Departmental Directorates and Operational Units.

The ABT issues or resolves administrative penalties in case of burnings (Administrative Disciplinary Process, PAS), which includes an economic penalty plus programmes or projects for reforestation and restoration of affected areas. As for legal proceedings, like any public institution, it can file a complaint with the Public Prosecutor's Office (arson:

[1] https://simb.siarh.gob.bo/

Art. 206 C.P. Penalty of 2 to 6 years imprisonment; burnings Art. 223 C.P. Penalty of 1 to 6 years imprisonment).

1.2. Statistics and historical records

The subsystem of Fire Scars and Forest Fires has the purpose of monitoring the fire-affected areas and automatically generates the same intersections of the previous subsystem; the daily temporal information is made with low spatial resolution images (MODIS Sensor) and monthly with images of medium spatial resolution (Landsat 8), with which the area affected by the fire is determined.

The System, in addition to generating reports with statistical data, allows the information to be visualised in the form of intelligent maps with point and/or polygon coverage.

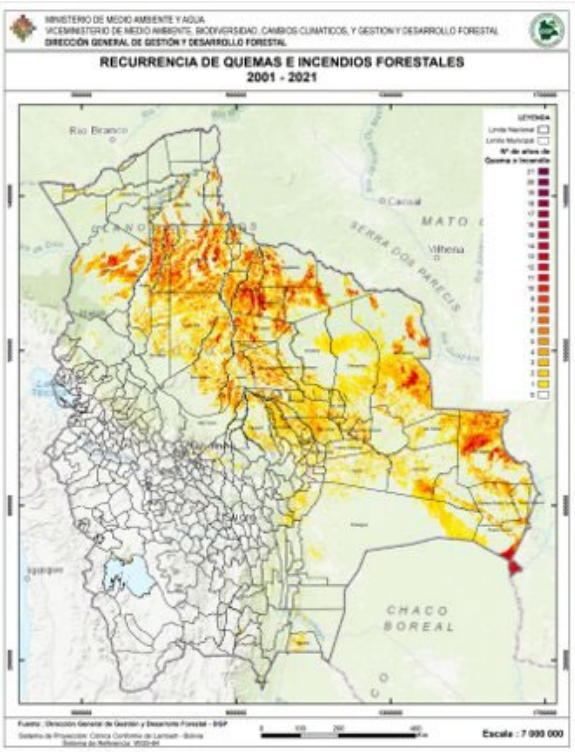


Figure 2. Visualisation of historical information in SIMB, 2001-2021.

The analysis shows a significant reduction in total area burnt for the 2021 management: 1 103 222 hectares less than in 2019; and 819 530 hectares less than in 2020. Similarly to the 2019 and 2020 management, data for 2021 also show a significant reduction in forest burnings (forest fires), showing that 704 792.1 hectares less than the 2019 management and 309 406.9 hectares less than the 2020 management have been burnt.

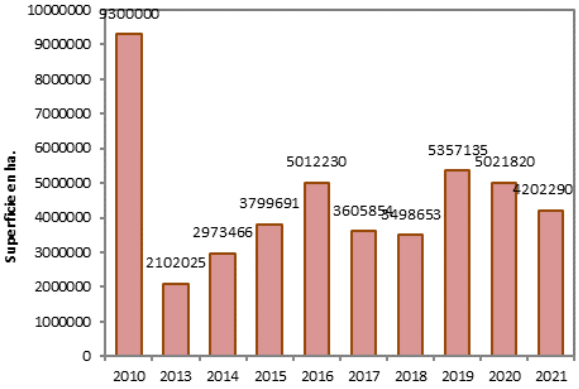


Figure 3. Total area burnt, historical record.

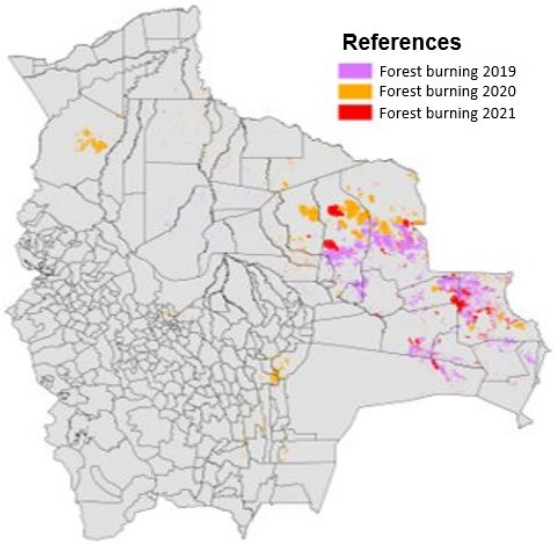


Figure 4. Visualisation of historical information in SIMB, 2019-2021.

Table 1. Area burnt in Protected Areas, 2019-2021

NATIONAL PROTECTED AREAS	2019	2020	2021	Overall Total (ha)
SAN MATIAS	704,320	193,069	787,961	1,685,349
OTUQUIS	301,809	133,468	106,974	542,251
NOEL KEMPFF MERCADO	11	201,032	24,014	225,056
DEPARTMENTAL PROTECTED AREAS	**2019**	**2020**	**2021**	**Overall Total (ha)**
ANMI ITENEZ	21,635	222,267	127,315	371,217
RIOS BLANCO Y NEGRO		183,504	87,589	271,093
KENNETH LEE	11,361	107,094	16,144	134,600
MUNICIPAL PROTECTED AREAS	**2019**	**2020**	**2021**	**Overall Total (ha)**
ACIE ÑEMBI GUAZU	354,993	1,316	196,975	553,284
BAJO MADIDI	216,929	145,781	151,790	514,501
ANMI CHIQUITOS	138,103	2,087	97,479	237,670
BAJO PARAGUA DE SAN IGNACIO DE VELASCO	17,265	160,067	55,082	232,415
RESERVA MUNICIPAL DE COPAIBO	25,397	194,190	929	220,517

1.3. Monitoring system

The Forest Information and Monitoring System (SIMB) has the objective of permanently and systematically monitoring the state of forests at national level, as a technical entity for monitoring and management of official information. The System makes it possible to generate reports (daily, monthly or yearly), monitor and take preventive actions in coordination with various institutions.

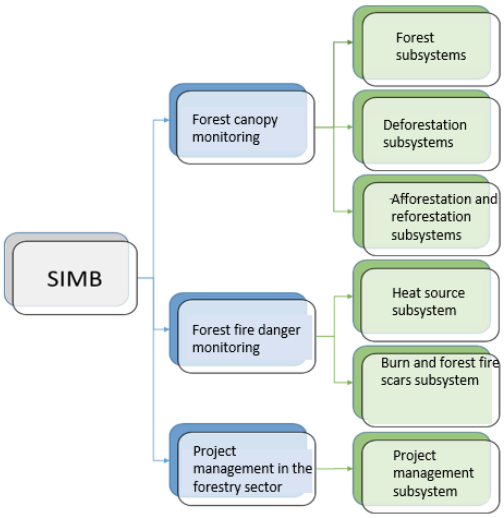


Figure 5. SIMB's structure

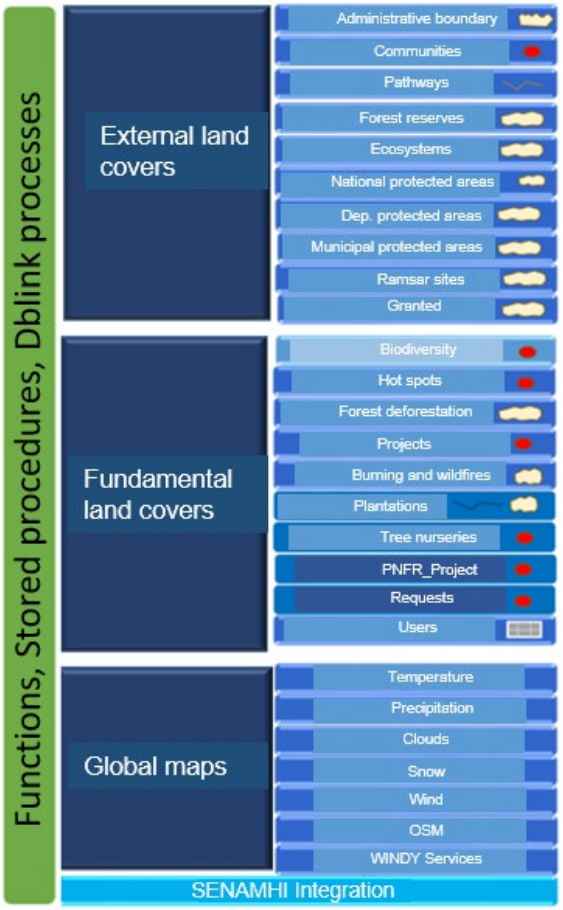


Figure 6. Data integration in SIMB.

SIMB is composed of three modules. The Forest Risk Monitoring is in turn composed of two sub-systems: Hot Spots Sub-system and Burning and Forest Fire Scars Sub-system.

The Hot Spots Subsystem is connected to FIRMS (Aqua, Terra, NPP and SENTINEL sensors) and is therefore updated every 2-3 hours. It automatically generates the intersection of Hot Spots with coverage of Protected Areas and Forest Reserves and forest type, thus providing statistical and geographical data for the prevention of possible forest fires in these areas. It also allows the viewing of data at national, departmental, provincial and municipal levels, which provides data on hot spots in each of these administrative boundaries of the plurinational territory of Bolivia. Daily reports are issued for public use and others with controlled access for official reporting. It is interactive and generates on-demand reports on surface area, historical data, etc.

Table 2. Coverage integration in SIMB

Administrative Boundary	Min. Planning
Protected Areas	DGBAP
Forest Reserves	SERNAP
Forest Type	DGGDF
Temperature	GLOBAL
Precipitation	GLOBAL

1.4. Weather forecast

The National Weather Service Observatory provides online weather data and historical reports. The National Service of Meteorology and Hydrology (SENAMHI) provides one-week forecasts, which are integrated into SIMB.

1.5. Education and prevention

In compliance with the Defence of Life and the Environment Plan, as of May 2021, the Government of the Plurinational State of Bolivia, under the leadership of the Ministry of the Environment and Water, has implemented a National Strategy for the Prevention, Control and Combating of Forest Fires and Post Event. Awareness-raising campaigns, training workshops, the constitution of brigades and platforms are being developed in 7 departments and their municipalities where burnings and fires are recurrent.

Figure 7. Information modules on Hot Spots, Burnings and Fires.

(Source: Bolivian Ministry of Environment and Water).

2. Brazil

2.1. Inter-sectoral coordination system

The inter-sectoral coordination in the management of forest firefighting in Brazil is handled by the Integrated Multi-agency Centre for National Operational Coordination (CIMAN, *Centro Integrado Multiagências de Coordenação Operacional Nacional*). All information management is processed by the tool named CIMAN Virtual[2]. The platform is managed by the National Institute for Space Research (INPE).

CIMAN Virtual is Brasilia Centre's monitoring and support system, integrating satellite-derived data with information, photos and details of the teams in the field fighting the fires, in real time. Data and information are provided by the institutions involved to promote open access and transparency of federal actions implemented in Brazil, especially major firefighting operations. It is possible to exchange information in CIMAN Virtual between brigades and all managers, which allows for greater agility in the exchange of information.

At the end of 2021, IBAMA acquired a geospatial platform on which several modules of the National Fire Information System (Sisfogo) are being developed. Currently, the Fire Occurrence Registry (ROI) modules and the monitoring module are in implementation phase, which will then be used in the 2022 fire season by Prevfogo and the Chico Mendes Institute (ICMBio). Fire events attended by these brigades will be logged via smartphone applications which will also provide data on hot spots and satellite images. Furthermore, teams will be able to consult monitoring panels that present the integration of spatial data from various sources (INPE, CENSIPAM, among others) and web maps with satellite images from different platforms. Some partnerships for the use of the system are in implementation phase, as in the case of some state fire brigades. Modules for recording environmental education activities and the recovery of degraded areas are planned to be developed.

The INPE forest fire programme is one of INPE's four priority activities which has been funded annually since 1998 through a specific and priority task of the federal government. At present, the project team is composed of three staff members and five contracted participants. The programme has four lines of activity: near real-time detection of vegetation fires using geostationary and polar-orbiting satellites; weather fire risk estimation and 5-day numerical forecasting; measurement of burnt areas; and special applications for government sectors, such as platforms for the inter-ministerial forest fire management office, for air pollution mapping using satellite and ground data, as well as for the country's presidential situation room.

Data and products are presented in interactive geographic information systems available on the internet, in daily and monthly newsletters, download platforms, web pages with temporal and spatial statistical summaries and others. It will also create special products for hundreds of protected areas, with animation of the advance of fire fronts and estimates of burnt area within their perimeters.

Users with administrative, technical and scientific needs make extensive use of the information provided, leading to numerous websites and publications based on the INPE forest fire programme; the average number of media articles citing the data is around three per day. In addition, forest fire detections and risk estimates by INPE cover the whole of Latin America. 14 federal agencies (IBAMA, ICMBio, Prevfogo, CIMAN, CENSIPAM, the Fire Brigade and others such as the National Electric System Operator, the National Electric Power Agency, the Ministries of Health, Science and Technology and Justice, and the Presidential Office), dozens of NGOs and thousands of registered individual users are regular users of these services.

The main current limitation is the programme's inadequate budget as a result of general government spending cuts over the last few years.

2.2. Statistics and historical records

Statistics on detection data and hot spots and burnt area data are available on the INPE's Queimadas[3] Programme website, which makes use of around 200 images per day from ten different satellites. For comparative temporal and spatial analyses, only the reference satellite is used.

The monitoring of burnt areas by INPE is carried out using the monthly product AQ1KM1, with a spatial resolution of 30 m[4] (partial coverage) and 1 km[5]. The data maps fire scars detected in Brazil based on a burn-sensitive vegetation index, which is calculated from daily near-infrared reflectance and average MODIS sensor near-infrared reflectance values.

The Queimadas Programme platform of the National Institute of Space Research (INPE) has data on hot spots from 1998 for Brazil and South America[6]. Monthly bulletins are also compiled[7] with data from the monitoring of active fire outbreaks, burnt areas, meteorological conditions, meteorological fire risk, influence of observed ocean temperature conditions, trends for the following month and additional information. The Queimadas Programme also makes

[2] http://queimadas.dgi.inpe.br/queimadas/ciman
[3] www.inpe.br/queimadas
[4] http://www.inpe.br/queimadas/aq30m
[5] http://www.inpe.br/queimadas/aq1km
[6] https://queimadas.dgi.inpe.br/queimadas/portal-static/estatisticas_estados/
[7] https://queimadas.dgi.inpe.br/queimadas/portal/outros-produtos/infoqueima/home

it possible to visualise outbreaks in an Online Geographic Information System (WebGis) with options to filter outbreaks into time periods, regions of interest, satellites, information plans (e.g. deforestation, hydrography, roads), etc., as well as to export the data in csv, shapefile and kml formats[8].

The ALARMES system[9] was developed by the Laboratory for the Application of Environmental Satellites (LASA) of the Federal University of Rio de Janeiro (UFRJ), in collaboration with IDL/ULisboa. ALARMES serves as a rapid and agile warning tool on the progress of the spread of the fire affected area. It offers two types of product: ALARMES-NRT (near real-time mode, with a 1-day delay from the satellite pass), and ALARMES-HIST (historical mode, mapping the area burnt annually, available 2-3 months after the end of each year). The system combines satellite imagery, hot spots and artificial intelligence to identify new areas affected by fire, monitoring the location and extent of burnt areas on a daily basis, which allows, for example, understanding of the increasing speed of these affected areas.

This information is sent to the competent bodies for planning and effective action. Coverage of this system is currently restricted to the Pantanal, Cerrado and Amazon biomes.

2.3. Monitoring system

In addition to the Queimadas Programme platform, which is Brazil's main hot spot monitoring tool, there are other complementary initiatives for specific purposes.

The Platform for Analysis and Geospatial Monitoring of Environmental Information[10] (PAMGIA) centralises and provides in a dynamic and integrated way environmental information of interest to IBAMA and its partners, making it possible for users to visualise thematic data in a statistical and geospatial way.

The Fire Panel[11] (Panorama - Interactive Maps) is a platform launched in 2021 by the Management and Operational Centre of the Amazon Protection System (CENSIPAM), which supports the activation of firefighting teams to combat forest fires in the country. This platform offers, as its main product, a fire monitoring service based on the grouping of hot spots into individual fire events. The system aggregates different geospatial data, satellite imagery and individual event properties which, combined with a severity level indicator, monitor the evolution of events.

2.4. Weather forecast

The weather forecasting used for planning and monitoring forest firefighting operations is carried out by the Weather Forecasting and Climate Studies Centre[12] (CPTEC) of the National Institute for Space Research (INPE). It provides the weather forecast and its variables for the whole of Brazil.

Climate forecasting is also carried out by CPTEC, which runs the Climate Projections Portal in Brazil[13]. The available dataset in the PCBr platform comes from various global and regional climate models: Coupled Model Intercomparison Project Phase 5 (CMIP5), Coupled Model Intercomparison Project Phase 6 (CMIP6), HELIX Project, BESM Project and Eta/CPTEC/INPE. The user can search for further information on the options available in the Portal, such as datasets, climate models, experiments, scenarios, climate variables, climate indices and data frequency.

It is also possible to find the activities developed by the Impacts, Adaptation and Vulnerability Division[14] of INPE.

2.5. Hazard

INPE and the National Institute of Meteorology (INMET)[15] use the weather forecast to calculate the[16] fire hazard. Both of these aim to identify and map fire risk areas in order to provide managers with geo-referenced information.

The Climate Change Impacts Information and Analysis System[17] (AdaptaBrasil MCTI) was created by the Brazilian Ministry of Science, Technology and Innovation (MCTI) in October 2020 to consolidate, integrate and disseminate information that makes it possible to advance in the analysis of the impacts of climate change, observed and projected in the national territory, giving support to the competent authorities for adaptation actions.

AdaptaBrasil MCTI is developed through a partnership between the National Institute of Space Research (INPE) and the National Research and Education Network (RNP) promoted by MCTI. A Steering Committee composed of representatives of these institutions is responsible for its governance.

[8] https://queimadas.dgi.inpe.br/queimadas/bdqueimadas
[9] https://lasa.ufrj.br/alarmes/
[10] https://pamgia.ibama.gov.br/home
[11] https://panorama.sipam.gov.br/painel-do-fogo/
[12] http://tempo.cptec.inpe.br/
[13] https://projeta.cptec.inpe.br/#/dashboard y http://pclima.inpe.br/sobre/
[14] http://www.ccst.inpe.br/
[15] https://queimadas.dgi.inpe.br/queimadas/portal/risco-de-fogo-meteorologia
[16] https://portal.inmet.gov.br/paginas/incendio
[17] https://sistema.adaptabrasil.mcti.gov.br/

2.6. Education and prevention

There is no system in place in Ibama to support environmental education and prevention activities, with data only available for viewing on the PAMGIA dashboard.

2.7. Research and open data

Investigation activities are described in the fire report. There is no system for their management. This information is usually integrated into the specific platforms of research institutions, such as INPE's Queimadas Programme platform and LASA/UFRJ's ALARMES platform.

Open data is also often referenced in platforms, such as:

1. Ibama

   https://dadosabertos.ibama.gov.br/dataset/

2. ICMBio

   https://dados.gov.br/organization/a144dc5c-3a19-4630-a65f-8484dc46e844?license_id=notspecified

3. Queimadas Programme
   https://queimadas.dgi.inpe.br/queimadas/dados-abertos/

(Source: Brazilian Institute of the Environment and Renewable Natural Resources).

3. Chile

3.1. Statistics and historical records

The **Digital Information System for Operations Control (SIDCO,** *Sistema de Información Digital para Control de Operaciones*)[18] records the detection, dispatch, coordination and control of ground and air resources for each forest fire since the 2002-2003 season. Overall, there are about 126 500 recorded forest fires affecting approximately 1 800 000 hectares. It is a platform that is not publicly accessible, and where external users are public institutions of the Civil Protection System for forest fires and private institutions, airlines that provide services to CONAF and the National Emergency Office of the Ministry of the Interior, ONEMI.

Additionally, historical statistics, from 1964 to 2021, are available on the CONAF[19] website in the forest fires section. The CARTO web mapping platform also contains[20] the CONAF forest fire forecast system and nearly 130 000 forest fires from the 2002-2003 season to date, with which dynamic maps have been developed to analyse trends and patterns associated with the problem of forest fires.

3.2. Monitoring system

The fire monitoring system uses information available from NASA's Fire Information for Resource Management System (FIRMS), with hot spots from VIIRS (S-NPP and NOAA-20 satellites) and MODIS (Terra and Aqua satellites) sensors with 375 m and 1 km resolutions, respectively. In addition, Coordination and Observation Aircrafts (ACO) are available for real-time monitoring of the most relevant fires, providing operational perimeters for fire analysis and planning. The perimeters are checked whenever satellite images from the Copernicus system and NASA are available.

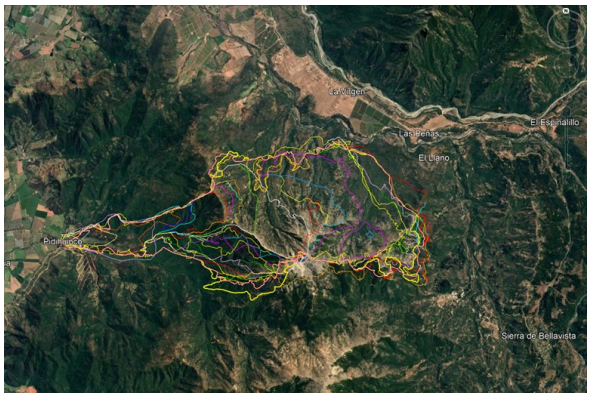


Figure 8. Operational perimeters of the Pidihuinco forest fire, O'Higgins Region.

The Wildfire Analyst™ wildfire simulator is also used as part of analysis and planning, modelling potential fire behaviour based on topography, weather conditions and fuel patterns in the area. These simulations allow the setting and determining of priorities and have also been used to order evacuations.

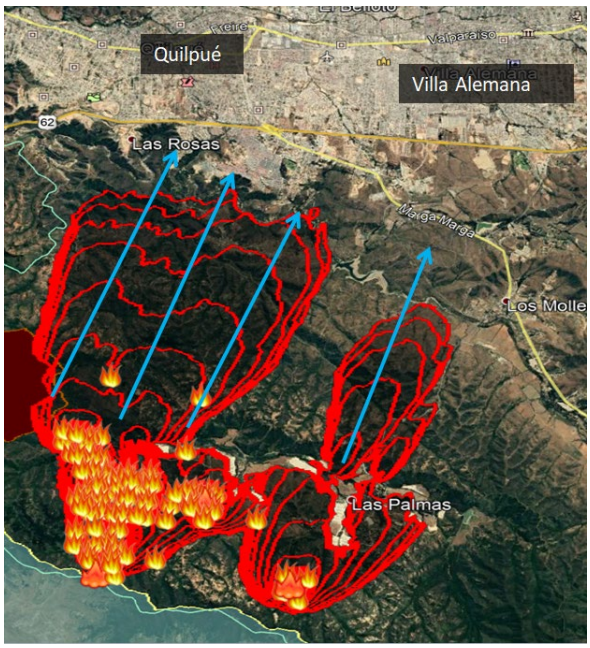


Figure 9. Simulation of the unrestricted spread potential of the La Engorda RNLP fire, Valparaíso Region.

To monitor the condition of vegetation, the system uses data from the MODIS Product MOD13Q1 with a spatial resolution of 250 metres and data from the Soil Moisture Active Passive (SMAP) product with a spatial resolution of 10 km. Through this information, areas with higher anomalies, and therefore higher fire risk due to more stressed vegetation that is more likely to burn, can be identified.

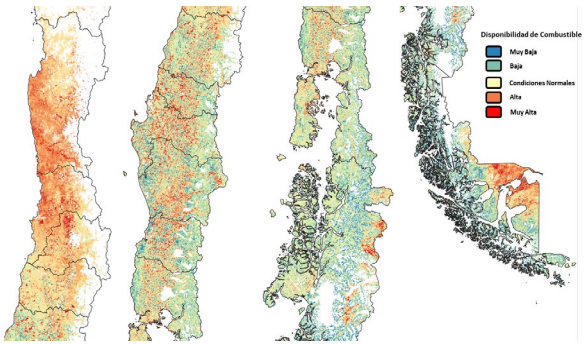


Figure 10. Vegetation health status for the period July 2021 to February 2022

[18] https://sidco.conaf.cl
[19] https://www.conaf.cl
[20] https://conaf.carto.com

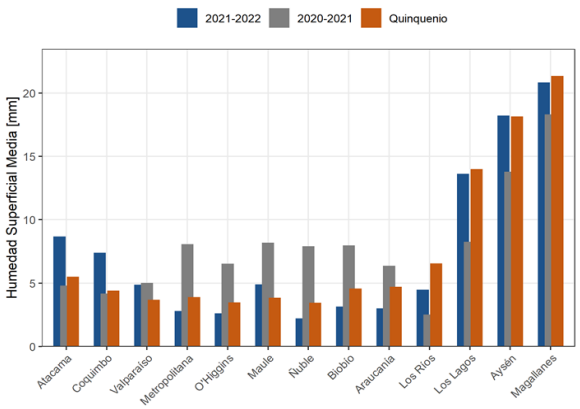


Figure 11. Soil moisture conditions for the month of February and analysed for the 2021-2022 fire season, the previous fire season and the last five years.

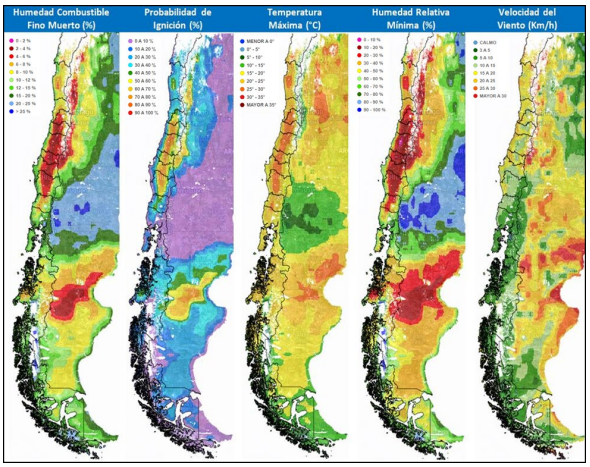


Figure 12. Maps of variables analysed for 19 February 2022.

It has not been possible to incorporate the European model but GWIS has been assessed.

3.3. Weather forecast

The Meteorological Directorate of Chile (DMC) provides CONAF, by agreement, with weather forecasts, Warnings, Alerts or Alarms that are derived from expected weather conditions. These weather forecasts are sent by DMC between September and April, and in the case of Warnings, Alerts or Alarms, they are sent whenever the situation requires it.

For weather forecasting, data from different weather models are used, especially the Global Forecast System (GFS) and the European Centre for Medium-Range Weather Forecasts (ECMWF).

3.4. Hazard

Every Monday, Wednesday and Friday of the year, a 3-day forest fire risk forecast is issued, with maps of the variables Fine Dead Fuel Moisture, probability of ignition, temperature, relative humidity and wind speed. Interactive maps with historical spatial information on forest fires such as frequency, severity and cause, large-scale fire density, intentional cause and fires per week are also included. In addition, every Monday and Thursday of the year, an 8-day fire risk forecast is issued with a medium-term outlook in order to anticipate potential events and be able to make structural decisions such as the movement of resources and measures that may require more time.

When entering the period of highest fire risk conditions, usually from September to April, the "Red Flag Warning" report is issued on Mondays and Thursdays to indicate the areas with the highest probability of simultaneous large-scale forest fires, with this alert being activated when ignition probability conditions exceed 70% and wind speed is 20 km/h or more.

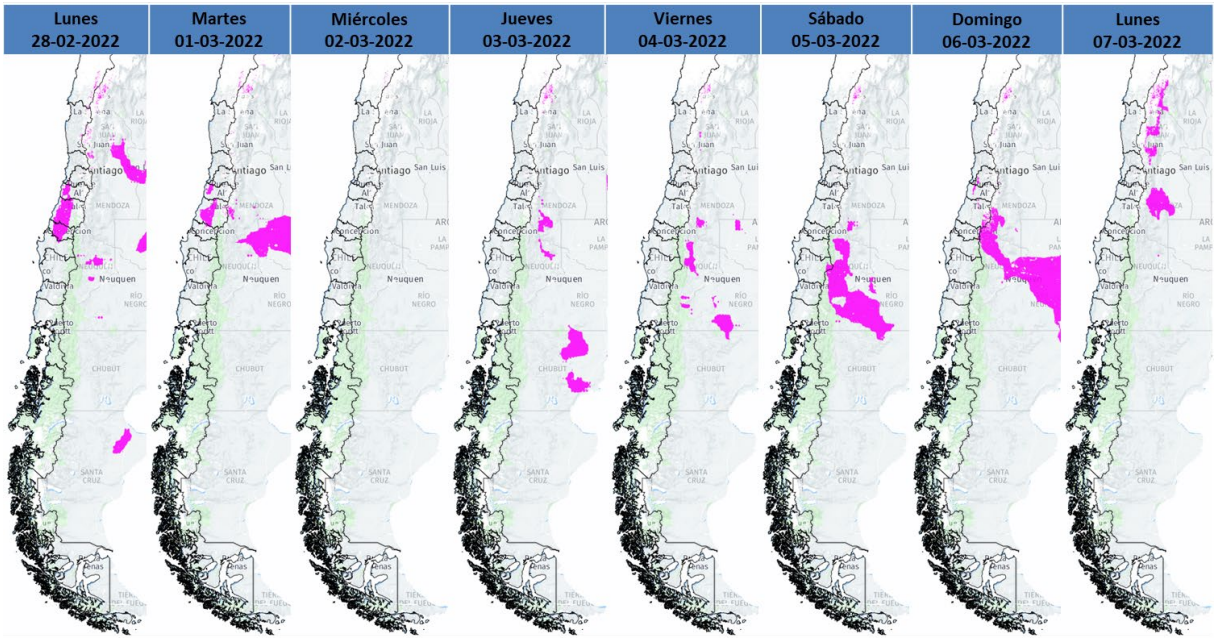


Figure 13. Red Flag Warning Maps for the week of 28-02 to 07-03, 2022.

A quarterly projection report is issued monthly which presents the conditions of the last month, seasonal forecast projections, rainfall analysis, vegetation status and the most relevant fires that have occurred.

Figure 14. Forest Fire Scenario for the Valparaíso Region.

A short- and medium-term forest fire hazard analysis report is also prepared, which provides relevant information for decision-making at the strategic level (Ministries and Services) based on weather conditions, oceanic indices (ENSO) and vegetation status (forest fuel), in order to determine potential scenarios in which the forest fire season may develop. This analysis is based on multiple sources of information such as the Chilean Meteorological Directorate (**DMC**), the National Oceanic & Atmospheric Administration (**NOAA**), the probability climate forecasts of the International Research Institute for Climate and Society (**IRI**) as well as the European Centre for Medium-Range Weather Forecasts (**ECMWF**) and the National Aeronautics and Space Administration (**NASA**) for vegetation and soil information.

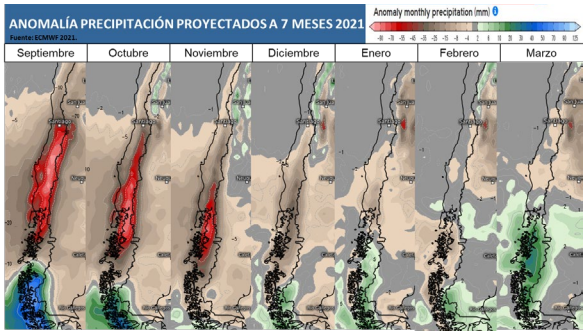


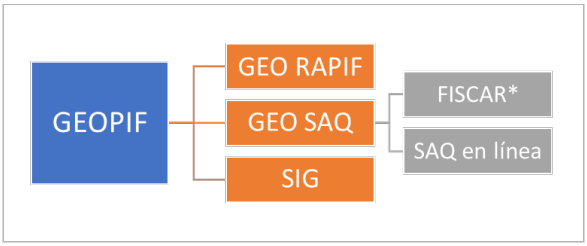
Figure 15. Projected 7-month rainfall anomaly.

3.5. Education and prevention

For the registration and monitoring of forest fire prevention activities, a new IT platform was developed in 2021 to meet the current requirements of this area of work, creating GEOPIF (Georeferencing for the Prevention of Forest Fires).

The GEOPIF platform brings together 2 existing systems, RAPIF (Register of Forest Fire Prevention Activities) and SAQ (Burnings Assistance System), providing an updated version of both systems (GEO RAPIF and GEO SAQ) and including a GIS (Geographic Information System) which allows for spatial location of prevention and mitigation activities, forest and livestock burnings reported to CONAF and support information for the development of preventive and mitigating actions against forest fires.

GEO RAPIF can plan activities supported by a GIS, showing information of interest to prioritise the number and type of activities to be carried out and manage activities, complemented by a calendar and App that allow activities to be recorded in real time. GEO SAQ contains the FISCAR (*Fiscalización Carabineros*) module, which enables the management of information on inspections by the Carabineros de Chile, and the online SAQ module, allowing fire users to manage their burning notifications remotely.



*Carabineros de Chile (former Carabineros de Chile module)

Figure 16. GEOPIF platform diagram

Currently, the GEO RAPIF system is in a six-month run and the transfer of historical information from the old system is in process. Meanwhile, the GEO SAQ system is in the development stage.

3.6. Research and open data

The information and results used by CONAF are fully available to interested parties, researchers and the general public. The main sources are as follows:

- General Forest Fire Statistical Information in https://www.conaf.cl/incendios-forestales/incendios-forestales-en-chile/estadisticas-historicas/
- Information on Carto.com from CONAF's Forest Fire Protection Management (Geprif).

Table 3. Interactive historical forest fire maps available

Variable	**Link Map**
FORECASTING SYSTEM	
Fine Dead Fuel Moisture Index	http://bit.ly/SAPIF_HCFM
Probability of Ignition	http://bit.ly/SAPIF_PROB_IGNICION
RED FLAG WARNING	http://bit.ly/SAPIF_Red_Flag_Warning
Predicted Temperature at 3:00 p.m.	http://bit.ly/SAPIF_TMAX
Relative Humidity (%) Forecast at around 3:00 pm	http://bit.ly/SAPIF_HRMIN
Wind Speed (Km/h) Forecast at around 3:00 pm	http://bit.ly/SAPIF_VV_10M
INTERACTIVE MAPS TO SUPPORT PREVENTION	
Frequency of Forest Fires (2002/2003 to 2020/2021)	http://bit.ly/SAPIF_FRECUENCIA_IIFF
Severity and Cause of Forest Fires (2002/2003 to 2020/2021)	http://bit.ly/SAPIF_GRAVEDAD_CAUSA_IIFF
Forest Fires by Week (2002/2003 to 2020/2021)	http://bit.ly/SAPIF_FRECUENCIA_IIFF_SEMANA
Forest Fires General Intentional Cause (2002/2003 to 2020/2021)	http://bit.ly/SAPIF_CAUSA_INTENCIONAL_IIFF
Forest Fire Density of Size (2002/2003 to 2020/2021)	http://bit.ly/SAPIF_DENSIDAD_IIFF_MAGNITUD

(Source: National Forestry Corporation of Chile).

4. Colombia

4.1. Inter-agency coordination systems

Colombia has different coordination systems. With regard to forest fire management, two systems can be highlighted, namely the National Environmental System (SINA, *Sistema Nacional Ambiental*) and the National Disaster Risk Management System.

The Ministry of the Environment and Sustainable Development was created through Law 99 of 1993, the National Environmental System-SINA was organised, and territorial environmental planning was defined. This ministry is the governing body of the National Environmental System (SINA), and is also responsible for the development of policies and the coordination of environmental management in Colombia.

SINA is composed of five research institutes in charge of executing science, technology and environmental information policies and providing information to the system; 59 national natural parks responsible for managing protected areas; the National Environmental Licensing Authority that manages the environmental permits and procedures of the MADS; 33 Regional Autonomous Corporations (CAR), environmental authorities in charge of policy implementation and regional coordination; 6 Urban Environmental Authorities which have the same functions as CAR within the urban perimeter, executing the urban environmental policies formulated by the Ministry; 32 departments responsible for promoting and executing national, regional and sectoral environmental policies formulated by the Ministry; 1 123 Municipalities in charge of promoting and executing national, regional and sectoral policies related to the environment; Control Bodies and other Public Institutions that provide support and collaboration functions; as well as the private sector and civil society.

Figure 17. National Environmental System (SINA).

The National Disaster Risk Management System, established by Law 1523 of 2012 by presidential sanction, is made up of public, private and community entities that, in coordination with policies, regulations and resources, aims to carry out the social process of Disaster Risk Management with the purpose of offering protection to the population throughout the national territory to improve the quality of life, safety and well-being of all Colombian communities.

Responsibility for Risk Management falls on each and every inhabitant of the Colombian territory, and, in compliance with this responsibility, the entities that belong to the system will execute the Risk Management processes, understood as: Risk Awareness, Risk Mitigation and Disaster Management. In turn, other inhabitants will act with caution and self-protection under the provisions of the corresponding authorities.

The National Disaster Risk Management System is currently made up of 6 guidance and coordination bodies, which optimise the performance and management of the different entities in the execution of actions.

Figure 18. National Disaster Risk Management System.

National Council for Risk Management

This is the highest body in charge of guiding the entire National System, headed by the President of the Republic and followed by ministers, the National Planning Department and the Director of the National Unit for Disaster Risk Management (UNGRD).

National Unit for Disaster Risk Management-UNGRD

This entity is responsible for the coordination of the entire National System and directs the implementation of Risk Management, in accordance with the policies and compliance with internal regulations, as well as the functions established in Decree-Law 4147 of 2011.

National Committee for Risk Awareness

This committee is responsible for advising and planning the ongoing implementation of the risk awareness process.

National Committee for Risk Mitigation

This committee is responsible for advising and planning the implementation of disaster risk mitigation.

National Committee for Disaster Management

This committee is responsible for planning and advising the implementation of disaster management.

National Technical Advisory Commission for Forest Fires

This commission was created by Resolution 373 of 2020 of the National Unit for Risk Management (UNGRD), attached to the National Committee for Disaster Management. It is a permanent commission that focuses its work on advising, proposing and monitoring policies, plans, programmes, projects and activities aimed at strengthening knowledge, prevention, mitigation, preparedness, response and recovery from forest fires in coordination with national committees for knowledge and risk mitigation.

It is made up of 17 entities in charge of functions and commitments related to forest fire risk management, in which UNGRD holds the presidency and Minambiente, the technical secretariat, and has its Action Plan for the 2021-2022 period.

Departmental, district and municipal councils for risk management

These bodies are responsible for coordination, advice, planning and monitoring, and must guarantee the effectiveness and coordination of Risk Management processes in the territorial entity that corresponds to each one of them.

It is noteworthy that cooperation work of all entities within the system is not done independently, but aims at the integrity of communities and their inhabitants, making them responsible for actions to ensure the safety of each and every one of them.

4.2. Statistics and historical records

In Colombia, according to the functions and regulations of entities of the National Disaster Risk Management System, the following three sources are used to record this type of event:

1. The consolidated emergency response system, in which the territorial entities (Departmental and Municipal Risk Management Councils) and the operational entities at national level report to the Information and Telematics Centre - CITEL, part of the UNGRD's Disaster Management Sub-directorate, which monitors, verifies and registers the natural and/or anthropogenic events that occur in the country. This information is compiled in a matrix, which includes, among other characteristics, the type of event and damage in hectares. Since 1998, SNGRD has had a publicly accessible emergency registry[21].

   Based on the information collected by the UNGRD between 2018 and 2021, the year with the highest number of forest fires was 2019, with 2,453 events and an estimated 145,765.48 ha affected.
2. From 2002, resulting from its mission, IDEAM has been monitoring the effects of forest fires on vegetation cover, with information provided by the Environmental Authorities and the National Unit for Disaster Risk Management, generating the annual statistic "Variation in the area of vegetation cover affected by fires", which is also publicly available[22].

Table 4. Vegetation cover affected by fire (2002-2020)

Year	Area of vegetation cover affected by fire (ha)[1]	Absolute annual variation (ha)[2]	Variation (%)[3]
2002	42 282.43		
2003	23 817.59	-18 464.84	-43.67
2004	40 698.91	16 881.32	70.88
2005	22 964.00	-17 734.91	-43.58
2006	13 028.60	-9 935.40	-43.27
2007	187 066.79	174 038.19	1 335.82
2008	4 338.15	-182 728.64	-97.68
2009	32 426.64	28 088.49	647.48
2010	91 298.77	58 872.13	181.55
2011	44 394.61	-46 904.16	-51.37
2012	64 468.66	20 074.05	45.22
2013	59 928.51	-4 540.15	-7.04
2014	98 104.12	38 175.61	63.70
2015	63 760.80	-34 343.32	-35.01
2016	114 131.13	50 370.33	79.00
2017	72 914.90	-41 216.23	-36.11
2018	106 055.92	33 141.02	45.45
2019	168 646.43	62 590.51	59.02
2020	86 802.00	-81 844.43	-48.53

Source: Institute of Hydrology, Meteorology and Environmental Studies - IDEAM. Subdirectorate of Ecosystems and Environmental Information. Forest Group 2021. National Forest Information System SNIF, 2021.

[1] *Corresponds to the area of vegetation cover affected by fires reported by the Environmental Authorities and the National Disaster Risk Management Unit (UNGRD). Fire in vegetation cover is defined as a fire that spreads freely and uncontrolled, whose main fuel is living or dead*

[21] https://portal.gestiondelriesgo.gov.co/Paginas/Consolidado-Atencion-de-Emergencias.aspx

[22] http://www.ideam.gov.co/web/ecosistemas/bosques-y-recurso-forestal

vegetation located in rural, urban or forest areas, which have an environmental function.

[2] *The Difference between the area of vegetation cover affected by fire in a given year and the area of vegetation cover affected by fire in an immediately preceding year, expressed in hectares (ha).*

[3] The indicator corresponds to the difference between the area of vegetation cover affected by fire in two consecutive years (t and t-1), expressed as a percentage of the area of vegetation cover affected by fire in year t-1, where t-1 refers to the year immediately preceding t.

Date of update. July 2021

3. Since 2013, the National Fire Department of Colombia has been recording emergencies responded to by the Colombian fire brigades through a consolidation matrix, and from 2018 they have had a platform of the Single Registry of Statistics of the Colombian Fire Brigades-RUE, which allows the recording of emergencies responded to in real time by fire brigades. Access to the platform is restricted to fire brigades.

To respond to emergencies and disasters, various operational bodies such as the Fire Brigade, Civil Defence, National Army, Colombian Air Force, National Navy, Police, etc., are available. These are coordinated by UNGRD.

According to historical information from the National Fire Department of Colombia, the highest number of forest fire events attended between 2012 and 2022 was in 2020, with 7 510 events, and the lowest number in 2012, with 1 105 events.

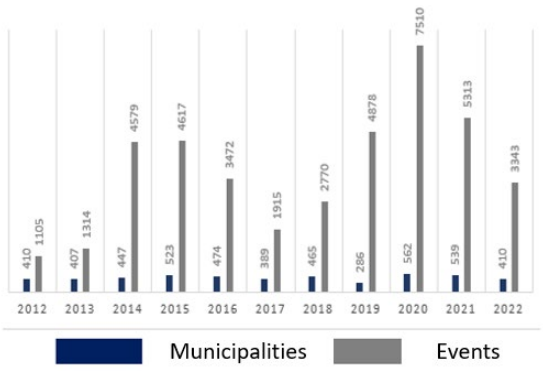


Figure 19. Historical record of events attended by Bomberos.

As can be seen from the information presented, the data does not coincide for each period with the data managed by UNGRD, as the sources differ; the need to consolidate the recording system and protocol is evident.

In turn, the Sinchi Institute generates information on fire scars in the Colombian Amazon, using Landsat 8 and 9 satellite images, updated monthly.

The Territorial Environmental Information System of the Colombian Amazon (SIAT-AC) registers and publishes, from March 2017 to date, information concerning fire scars[23]. Information is generated each month according to the affected cover: forest, secondary vegetation and other cover (mainly grassland). According to data obtained, the year with the highest number of hectares of fire scars was 2018, with a total of 42 ,645 hectares. Conversely, 2021 had the lowest number of hectares with fire scars in the Colombian Amazon with a total of 118 413 hectares (Figure 1).

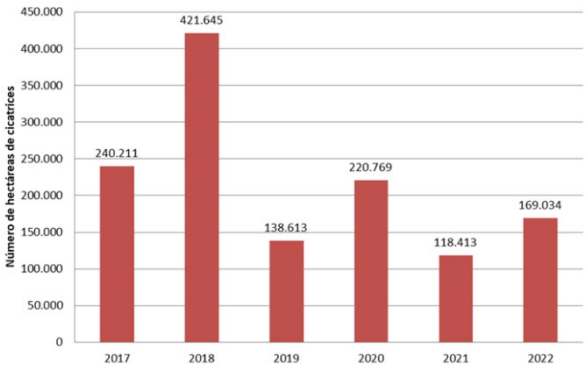


Figure 20. Fire scars in the Colombian Amazon (March 2017-May 2022).

4.3. Weather forecast

The Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) holds a monthly climate forecast committee, from which a bulletin is published on the website. This bulletin, in addition to climate forecasting information, contains predictions on hydrological issues related to flash floods and floods, mass movements (landslides) and the prediction of favourable conditions for the occurrence of fires in vegetation cover caused by meteorological conditions. These monthly bulletins are publicly accessible[24].

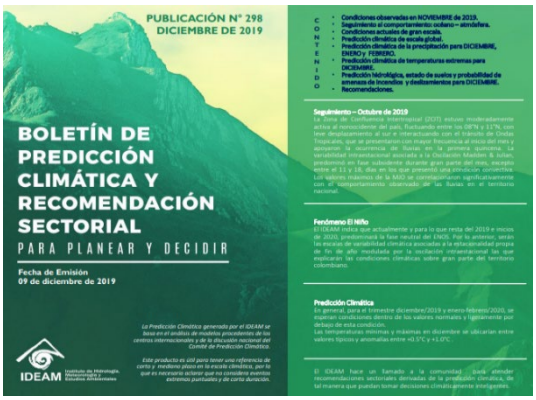


Figure 21. Climate forecast bulletin and sectoral recommendation.

[23] https://siatac.co/cicatrices-de-quema/

[24] https://bit.ly/3QBR1Da

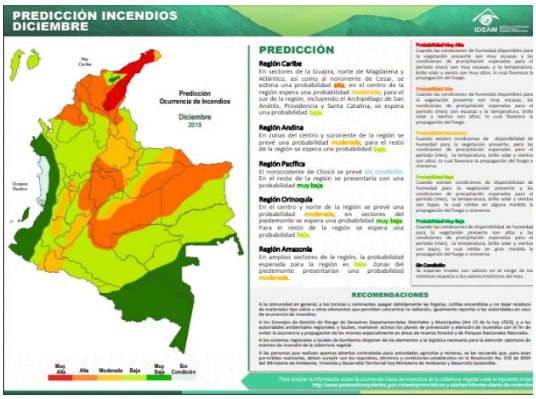


Figure 22. Climate forecast bulletin and sectoral, December 2019.

4.4. Forest fire hazard

IDEAM has two tools to generate alerts for the occurrence of fires in vegetation cover.

1. The objective of the Geographic Information System for Fire Prevention (SIGPI) is to determine the threat and vulnerability due to weather conditions of the occurrence of fires of vegetation cover at municipal level in National Territory, based on meteorological and climatological variables (precipitation and temperature), data from the National network of IDEAM stations and information obtained from the GOES 16 satellite. From the model, a risk map is generated and a daily warning bulletin is published on the official IDEAM website[25].
2. **System for monitoring hot spots.** This system aims to detect thermal anomalies on the Earth's surface in near real time (latency between 1 and 6 hours) using FIRMS data. This information, which is available on a freely accessible web platform, is prepared by IDEAM to identify this information at national, departmental, regional, National Park and Autonomous Corporation levels[26].

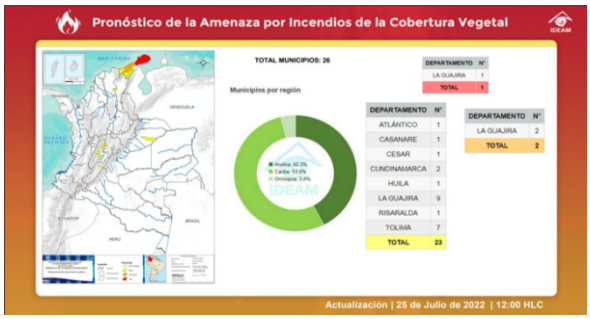


Figure 23. Threat forecast.

In the specific case of the Colombian Amazon, the Amazonian Institute for Scientific Research (SINCHI) is in charge of generating information corresponding to hot spots, starting in November 2000. Reports of these hot spots are generated daily and published through the Territorial Environmental Information System of the Colombian Amazon (SIAT-AC)[27]. According to historical data, the highest number of hot spots occurred in 2020 with 70,857 hot spots and the period from January to 25 July 2022, with 98,267 hot spots in the Colombian Amazon.

4.5. Education and prevention

Colombia has established different regulations related to education and the prevention of forest fires, such as the following:

Law 1523 of 2012 defines the objectives of the National Risk Management System: Develop and maintain the risk reduction process through actions such as prospective intervention through preventive actions to avoid the generation of new risk conditions, corrective intervention through actions to mitigate existing risk conditions and financial protection through risk retention and risk transfer instruments.

Decree 4147 of 2011 establishes the functions of the UNGRD related to risk mitigation:

- To coordinate, promote and strengthen capacity for risk awareness, risk mitigation and disaster management and its articulation with development processes at a national and territorial level of the National System for Disaster Prevention and Response-SNPAD (currently SNGRD).
- To guide and support national and territorial entities in their institutional strengthening for disaster risk management and advise them on the inclusion of disaster risk management policy in territorial plans.

Law 1575 of 2012 General Fire Law of Colombia, in Article 22. Functions, it establishes that fire brigades will have the following functions: to carry out integrated fire risk management, which includes, among others, conducting fire threat analysis and developing all fire prevention programmes.

Decree-Law 2811 of 1974, *which establishes the National Code of Renewable Natural Resources and Environmental Protection,* under Heading IV. On Forest Protection, Articles 241 to 245, allude to the fact that measures to prevent and control forest fires and burnings will be organised throughout the national territory, in collaboration with all public bodies and entities, giving special priority to the work of extinguishing forest fires.

[25] http://www.pronosticosyalertas.gov.co/web/pronosticos-y-alertas/informe-diario-de-incendios

[26] https://bit.ly/3A6HvRB

[27] https://siatac.co/

Resolution 532 of 2005 establishes requirements, terms, conditions and obligations for controlled open burning in rural areas in agricultural and mining activities, through the use of techniques, protocols, permits, meteorological records, restriction areas and protection strips.

Law 99 of 1993 (in Article 31) establishes the functions of the Regional Autonomous Corporations, among which it highlights that they should: promote and develop community participation in activities and programmes for environmental protection, sustainable development and adequate management of renewable natural resources; advise territorial entities in the development of formal environmental education plans and implement non-formal environmental education programmes, following the guidelines of national policy and carry out activities of analysis, monitoring, prevention and control of disasters, in coordination with other competent authorities, and assist them in environmental aspects in the prevention and attention of emergencies and disasters; advance with municipal or district administrations programmes for the adaptation of urban areas in high-risk zones, such as erosion control, riverbed management and reforestation.

Law 2169 of 2021. Promoting low carbon development in the country through the establishment of minimum targets and measures on carbon neutrality and climate resilience and other provisions.

There are two targets associated with forest fires within the framework of this law, corresponding to:

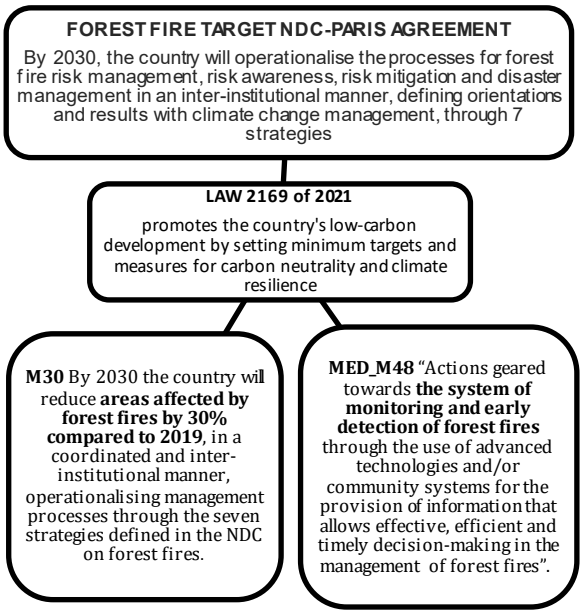


Figure 24. Targets related to forest fires in Law 2169 of 2021.

Target 30: the country will reduce by 30% the areas affected by forest fires by 2030, compared to 2019, in a coordinated and inter-institutional manner, operationalising the processes for the management, knowledge and mitigation of forest fire risk and disaster management, through the seven strategies defined in the NDC on forest fires.

In the framework of these strategies, updating of the social co-responsibility strategy is contemplated, which seeks to activate the participation of sectoral and institutional actors and the community in general, to generate a culture of prevention, raising awareness, training and disseminating information on the causes and consequences of forest fires, while committing to actions that prevent the presence of forest fires, in order to protect natural resources, especially biodiversity, as indicated in state policies.

Target 48: actions towards the monitoring and early detection system for forest fires using advanced technologies and/or community systems for the provision of information to support effective, efficient and timely decision-making on forest fire management.

4.6. Research and open data

As mentioned throughout this report, IDEAM and SINCHI produce and update information that is freely accessible on their respective websites.

(Source: Colombian Ministry of Environment and Sustainable Development).

5. Ecuador

5.1. Inter-sectoral coordination system

The coordination process for forest fire response in Ecuador begins with an alert for a possible forest fire, either through a call, video surveillance from the Integrated Security System ECU 911, or a report from focal points of the National Risk and Emergency Management Service (SNGRE) or the Decentralised National Risk Management System (SNDGRE). This alert is verified and coordination of inter-sectoral response actions is initiated, depending on the level identified by local entities.

The levels are identified according to the complexity of the incident, starting with the initial attack (level 1), which is the response to a fire of low difficulty; if it exceeds local capacities and resources, the need for an extended attack is determined (level 2), where a Unified Command Post (PMU) is established, the Forest Fire Reinforcement Brigades (BRIF, *Brigadas de Refuerzo en Incendios Forestales*) are activated and if the fire is within or in the area of influence of State Protected Areas, the Specialist Brigades in Integrated Fire Management (BREMIF, *Brigadas Especialistas en Manejo Integral del Fuego*) of the Ministry of Environment, Water and Ecological Transition (MAATE, *Ministerio del Ambiente, Agua y Transición Ecológica*) are activated. The large fire (level 3) is activated when coordination is required between different institutions at cantonal, provincial or national level through the PMU and Emergency Operations Committees (COE) to attend to fires of high difficulty.

Similarly, from the moment an alert is issued in the event of a possible forest fire, a flow of information is initiated that allows the compilation and consolidation of the damage, resources and actions carried out, which will be an input for decision-making.

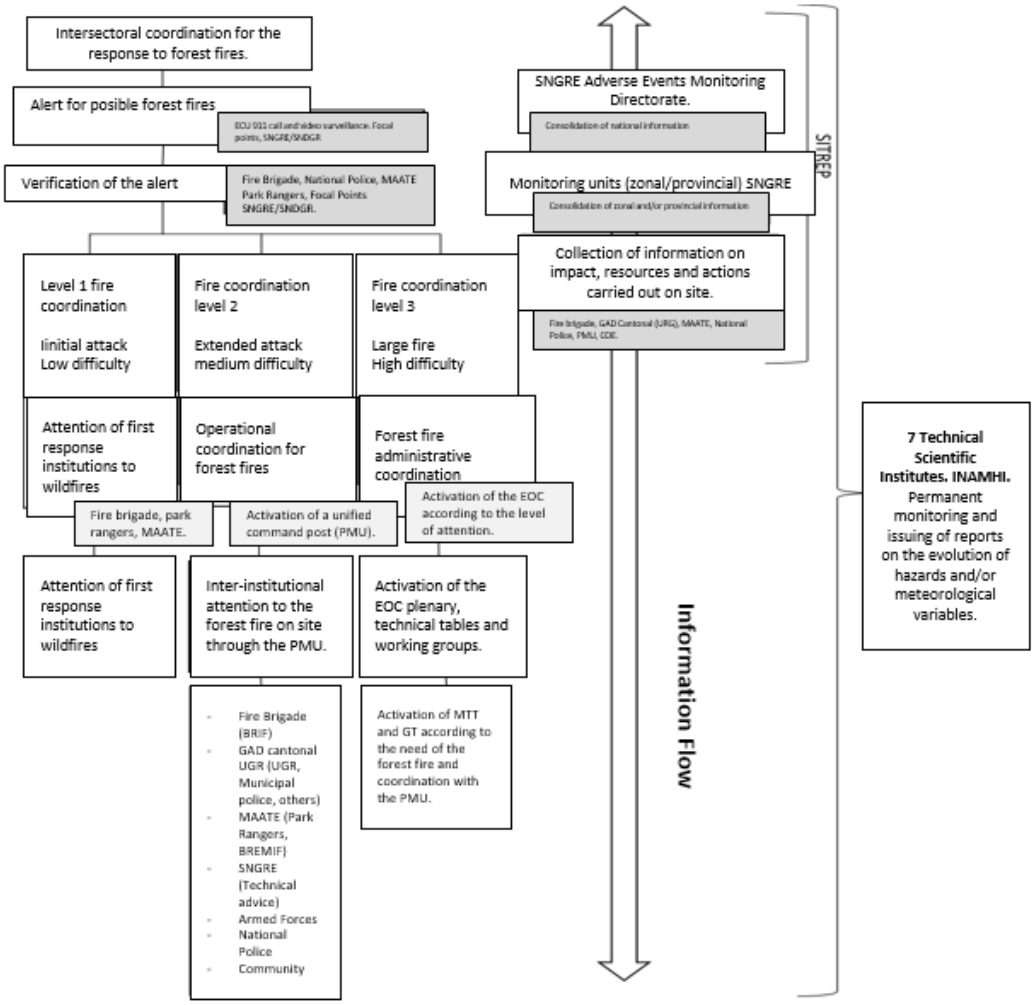


Figure 25. Activation and information flow for forest fires. *(Source: SNGRE/MAATE, 2022)*

5.2. *Statistics and historical records*

From 2010 to 2021 there have been 20 148 forest fires, affecting 202 685.38 hectares of vegetation. The years with the highest number of forest fires are 2012 (3 911 fires) and 2018 (4 304 fires); and the years with the highest vegetation damage are 2012 (31 081.59 ha), 2015 (26 350.36 ha), 2018 (27 686.43 ha) and 2020 (27 904.91 ha) (Figure 26).

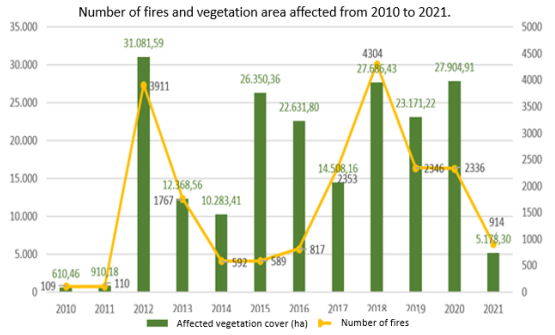


Figure 26. Number of forest fires and affected vegetation area per year *(Source: SNGRE, 2022)*.

The provinces with the highest number of fires in the 2010-2021 period were: Pichincha (4 642 fires), Guayas (2 270 fires), Azuay (2 007 fires) and Loja (1 726 fires) and where the greatest impact on the vegetation surface has been generated are Loja (39 205.38 ha), Pichincha (26 594.70 ha), Imbabura (22 022.21 ha) and Azuay (20 087 ha) (Figure 27).

5.3. *Monitoring* Systems

The Ministry of Environment, Water and Ecological Transition (MAATE) has, since 2014, implemented the National Forest Monitoring System (SNMB) as a harmonised set of actors, components, methodologies and processes which generates, collects, analyses and reports spatial, biophysical and socio-economic information related to forests, other natural ecosystems and their associated biodiversity.

At present, periodic reports on land cover, land use and deforestation are generated, mainly using information from remote sensing and tele-detection. The use of semi-automated algorithms generates biennial monitoring data on land cover and land cover change at national level, and early warnings are generated monthly for forest disturbances and alterations in priority areas such as mangroves, areas under conservation or state management categories.

Information obtained by Fire Brigades at national level on forest fires and compiled by SNGRE was integrated with the type of land cover and land use in 2018[28], showing that the largest area of land affected by fires is agricultural, followed by shrub and herbaceous vegetation.

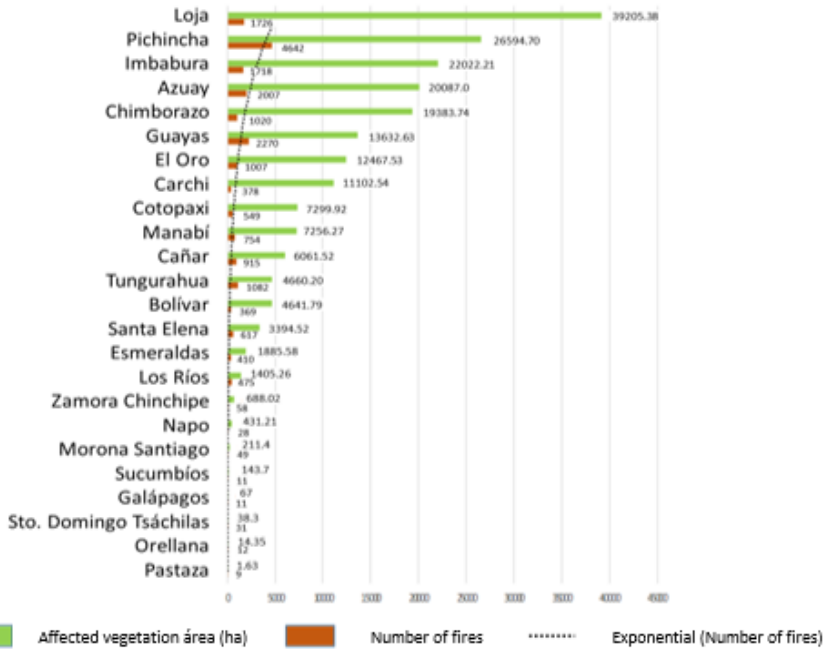


Figure 27. Number of forest fires and affected vegetation area per province (2010 – 2021). *(Source: SNGRE, 2022)*

[28] http://snmb.ambiente.gob.ec/snmb/?page_id=1069

Table 5. No. of fires and area affected by forest fires with historic land cover and land use by year (*Source: SNGRE MAATE, 2022*).

		Agricultural Land	Native forest	Forest Plantation	Shrub and Herbaceous Vegetation	Wasteland	Other Areas	Total
2010	No Fires	78	20	0	2	4	5	**109**
	Area Affected	476.78	83.60	0.00	9.00	41.00	0.08	**610.46**
2011	No Fires	80	21	0	2	1	6	**110**
	Area Affected	651.17	258.01	0.00	0.00	0.00	1.00	**910.18**
2012	No Fires	881	2682	12	133	58	145	**3911**
	Area Affected	16731.38	5084.95	1973.44	6372.90	438.98	434.94	**31036.59**
2013	No Fires	1104	133	27	189	65	247	**1765**
	Area Affected	7047.69	782.21	437.96	1352.28	1633.55	1093.86	**12347.55**
2014	No Fires	297	42	15	85	38	115	**592**
	Area Affected	5240.27	738.70	233.86	1061.57	723.61	2285.40	**10283.41**
2015	No Fires	339	39	24	88	29	70	**589**
	Area Affected	10041.56	1438.00	3564.00	3873.87	5878.93	1554.00	**26350.36**
2016	No Fires	514	91	14	44	38	113	**814**
	Area Affected	13980.17	2175.75	628.00	1601.91	2026.02	2189.95	**22601.80**
2017	No Fires	1162	120	48	227	78	716	**2351**
	Area Affected	5736.27	529.84	161.97	1264.37	3040.06	3766.65	**14499.16**
2018	No Fires	2272	208	104	352	91	1275	**4302**
	Area Affected	13084.53	4569.20	1019.77	3728.18	2817.36	2465.39	**27684.43**
2019	No Fires	1307	78	52	204	76	629	**2346**
	Area Affected	12631.06	1652.59	149.86	3802.30	2862.64	2072.76	**23171.21**
2020	No Fires	1335	107	62	146	88	596	**2334**
	Area Affected	14196.86	1868.75	1713.37	1543.56	4491.50	4085.87	**27899.91**
2021	No Fires	453	60	30	66	29	276	**914**
	Area Affected	2511.27	594.19	34.31	267.87	629.28	1141.39	**5178.31**

5.4. Forecasts of forest fire risk

The National Institute of Meteorology and Hydrology (INAMHI, *Instituto Nacional de Meteorología e Hidrología*), through its Department of Forecasts and Alerts, monitors the weather variables of relative humidity, maximum temperature and winds at 10 metres above the surface on a daily basis. In view of the lack of a high density of observation points in mountainous or forested areas, the Haines index (Lower Atmosphere Severity Index) and the WRF (Weather Research and Forecasting System) weather prediction model are used to monitor the products of the aforementioned variables; the former having a variational 3D data assimilation process which allows for analysis and forecast data with a bias correction for observation data from weather stations distributed throughout the Ecuadorian territory. The resolution grid of the model is 3x3 km, making it possible to obtain forecasts from 72 to 120 hours.

With the information from the weather model, daily forecast charts are obtained for different times of day, from which a hot spot forecast bulletin is prepared for continental Ecuador, and the hot spots or foci obtained from satellite information from VIIRS Suomi NPP (Visible Infrared Imaging Radiometer Suite (VIIRS) - Earthdata) and NOAA 20 are monitored. Information is frequently shared with entities linked at national and local level to the forest fire management. Unfortunately, no automated platform exists in the country to generate periodic information on hazard forecasts and other variables for decision making.

5.5. Education and prevention

The main initiative of MAATE to prevent forest fires is the Amazon Fire-Free Programme (PASF, *Programa Amazonia sin Fuego*). Supported by the governments of Italy, Brazil and the Development Bank of Latin America, this programme promotes integrated fire management as an approach to manage the landscape and reduce the non-technical use of fire, one of the main causes of forest fires in Ecuador.

In the 2017-2021 period, knowledge generation processes aimed at different stakeholders have been implemented, including 38 training actions for forest brigades for the prevention and control of forest fires that linked park rangers, communities, firefighters and technical staff, as well as the installation of 12 field schools for the implementation of alternatives to the use of fire in agricultural and livestock practices directed at 226 families. Furthermore, 369 awareness-raising and dissemination activities have been carried out, such as educational talks, fairs, webinars, and 77 technical workshops on local planning, early warning and introduction to integrated

fire management. This is complemented by forest fire prevention actions on social media at all levels.

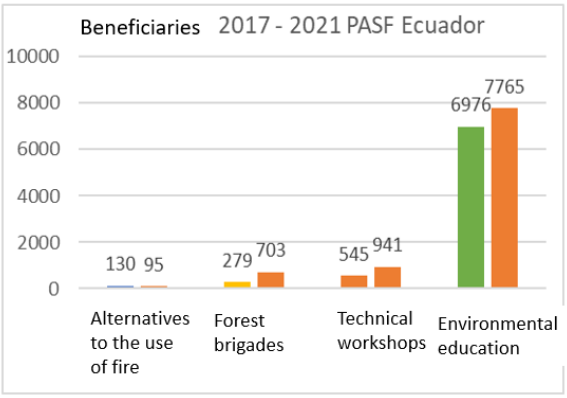


Figure 28. Statistics on forest fire prevention actions. *(Source: Amazon Fire-free Programme, 2022).*

As a complement to this, there have been participatory processes for the elaboration of public policy proposals such as the first National Strategy on Integrated Fire Management 2023-2030 and the National Research Agenda on Integrated Fire Management 2023-2030 (instruments currently in the final phase of construction).

Every year, before the summer season (July - November), with the aim of raising awareness, informing and educating the public about forest fires and their effects on the natural heritage, the campaign "No More Forest Fires" is conducted. This activity is led by MAATE and involves other national and local institutions connected to the subject.

At the same time, SNGRE strengthens the capacities of Decentralised Autonomous Governments and Fire Departments. In 2021, forest fire prevention actions and information campaigns promoted by SNGRE reached a total of 3 933 people made aware of the problem.

5.6. Research, cooperation and open data

During 2020-2022, MAATE together with the support of the German Cooperation GIZ Brazil and Ecuador, the Brazilian Cooperation Agency (ABC), the National Centre for Prevention and Combating of Forest Fires of Brazil (PREVFOGO / IBAMA) and the National System of Conservation Areas (SINAC) of Costa Rica, the trilateral cooperation project "Strengthening of Technical and Institutional Capacities in Ecuador for Integrated Fire Management in Conservation Areas" was implemented.

As part of this initiative, since 2021 the development of the first "National Research Agenda on Integrated Fire Management" has been promoted, a participatory process linked to academia whose objective is to guide the generation of scientific, technological and/or applied innovation research, aimed at producing knowledge on integrated fire management in all its dimensions for the 2023-2030 period. In addition, it will contribute to decision-making to promote and strengthen the public policy of the MIF at the different levels of territorial planning in Ecuador.

More specifically, the Technical University of Loja (UTPL) in liaison with the National University of Loja (UNL) and SNGRE have worked in recent years on the generation and implementation of forest fire probability models for some cantons in the province of Loja. The models were generated using machine learning techniques from anthropic, topographic and vegetation health variables and also using validation techniques from training and validation data, where one of the main features of their implementation is that they can be updated every 5 days using Sentinel 2, generating a single algorithm that is statistically reliable for all the cantons participating in the project.[29]

Other scientific research proposals associated with forest fires have been, and are being, developed in the country with the contribution of the national and international academic sector, tackling issues related to fire ecology, local capacity for training in IFM, ignition techniques and patterns, among others.

(Source: Ministry of Environment, Water and Ecological Transition; National Service for Risk and Emergency Management; National Institute of Meteorology and Hydrology, Ecuador).

[29] https://proyectoincendiosutpl.users.earthengine.app/view/proyecto-de-vinculacin-utpl-incendios-forestales

6. Mexico

6.1. Inter-agency coordination

The Fire Management Programme 2020-2024 aims to reduce the deterioration of forest ecosystems caused by changes in fire regimes. Its inter-institutional coordination components; early warning systems, technological innovation and increased research; promotion of planning instruments, as well as increased infrastructure and response capacity; promotion of physical, cultural and legal prevention actions; development of technical capacities and certification processes; international cooperation; and coordination mechanisms with the Ministry of Agriculture and Rural Development (SADER) and Welfare.

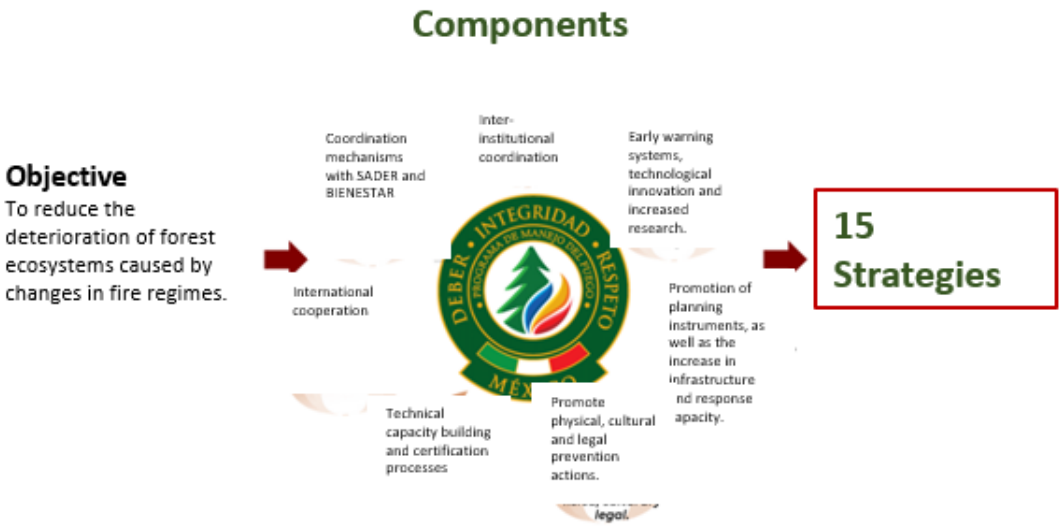


Figure 29. Fire Management Programme 2020-2024.

Regarding inter-institutional coordination, the National Fire Management Programme has 6 Regional Programmes and 32 State Programmes. Every unit participates in the elaboration of planning instruments containing indicators and targets. The Inter-institutional Committee (GTO Nacional), composed of the 6 Regional Centres (CRMF) and the Fire Management Office (GMF), operates at national level. State Fire Management Committees (Steering Group - State GTO), composed of State, Inter-municipal, Municipal Fire Management Centres (Technical Operational Group) operate at state level.

In terms of early warning systems, in the first instance, the State Fire Management Centre (CEMF) monitors and generates specific information. This is followed by the timely analysis and follow-up of incidents, leading in turn to decisions and the prompt dispatch of combat resources. Finally, the Fire Management Office (GMF) in conjunction with the Regional Fire Management Centre (CRMF) proceed to issue alerts to regions and states

Figure 30. Inter-institutional coordination.

6.2. *Statistics and historical records, Monitoring system and Hazard*

The Forest Fire Hazard Prediction System (SPPIF, *Sistema de Predicción de Peligro de Incendios Forestales*) of Mexico, developed in the CONAFOR-CONACYT 2014-2-252620 project by the Juárez University of the State of Durango in coordination with the National Forestry Commission (CONAFOR), and the collaboration of the National Commission for the Knowledge and Use of Biodiversity (CONABIO), National Meteorological Service of the National Water Commission (SMN), University of Washington (USA), USDA Forest Service (USA), National Institute of Space Research (Brazil), University of Santiago de Compostela (Spain), Autonomous University of Chapingo, National Autonomous University of Mexico, University of Guadalajara and the Forestry Research Centre of Lourizán (Spain), is a tool to support decision making for fire management in Mexico.

SPPIF is a technological tool that supports decision-making in the management of the forest fires at national level, since it shows the number of active forest fires with basic data on location, type of vegetation, area by strata and total; as well as allocated resources, hot spots, clusters of hot spots with their preliminary area and their dynamic count; fire hazard indices including dryness of forest fuels, probability of ignition and probability of occurrence of forest fires due to human causes; thematic layers with maps of priority areas for protection against forest fires, risk of occurrence of fires due to human causes or forest biomass, types of forest fuels for Mexico, canopy height, burnt area mapping tool and fire severity, among others.

The System has a direct connection with the National Corporation for Knowledge and Use of Biodiversity (CONABIO) and the National Meteorological System. Hot spot information and Normalised Difference Vegetation Index (NDVI) from CONABIO are complemented with weather data from the National Meteorological System to calculate ignition danger and forest fire hazard indices. The maps used to develop the dryness and hazard prediction indices are integrated from the vegetation greenness inputs (NDVI) from MODIS and meteorological data on temperature, relative humidity and precipitation are provided by SMN. This provides the fuel dryness index, which is the basis for the calculation of ignition hazard and forest fire risk, integrating information on vegetation type, hot spot history, ecoregions, fuel type, roads, localities, agricultural interface and forest biomass.

Furthermore, information on active fires is integrated twice a day by the Fire Management Department of the National Forestry Commission (CONAFOR). The last one distinguishes forest, agricultural, interface and fixed points. With respect to monitoring, the number of active forest fires reported daily at 11:00 am and 8:00 pm by CONAFOR is shown, as well as the historic 2011 values to date of the same. MODIS and VIIRS hotspots are shown, including historical hotspots, providing a day-by-day view of the progress of large fires. Also included are the hot spot cluster perimeters, with preliminary hot spot area and their state and dynamic counts, which are updated in near real time with each satellite pass captured by CONABIO's antenna.

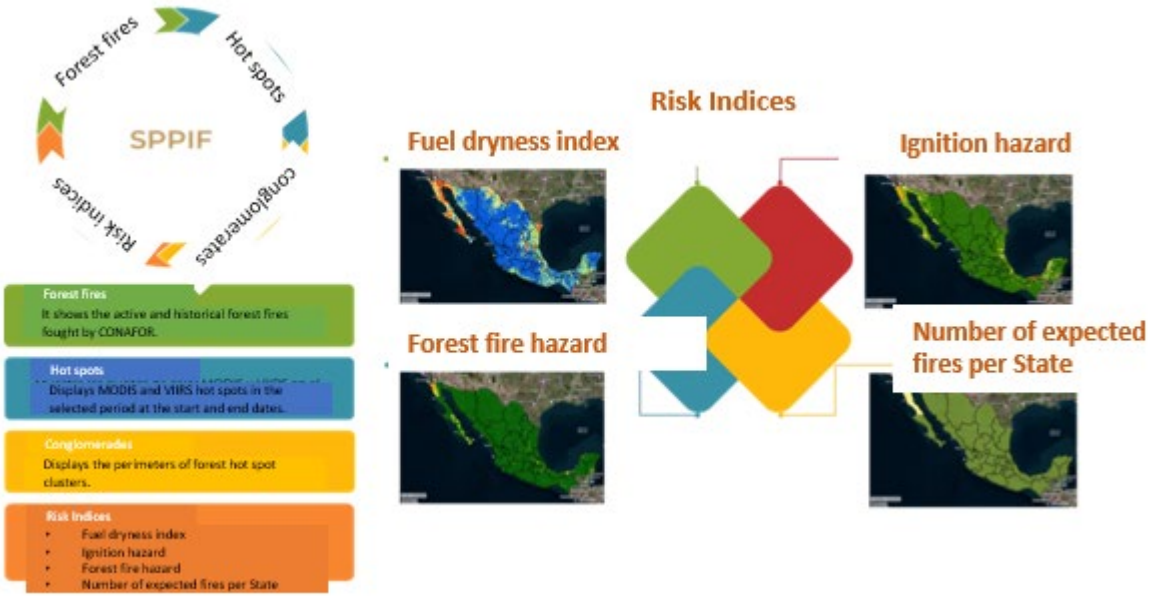


Figure 31. Forest Fire Hazard Prediction System (FDFPS).

Regarding the hazard forecast, it is calculated daily with a resolution of 1 km in the SPPIF:

1. the fuel dryness index (ISC; Mexico calibration of the FPI index), based on the vegetation greenness index (NDVI) from MODIS and weather data on temperature, relative humidity and precipitation provided by CONABIO and the SMN;
2. the risk of ignition which represents the expected hot spot density, calculated from the ISC, fuel type, region, and MODIS and VIIRS hot spots observed in the previous days;
3. the forest fire hazard (expected fire density), calculated from the fire ignition hazard, taking into account the spatial risk of fire occurrence due to human factors and biomass; and
4. the number of expected fires and hot spot clusters per state, supporting decision-making on the mobilisation of available suppression means between and within states, as well as the planning of prevention actions.

6.3. Research and development roadmap

Information on fuel types is currently being integrated and in the short term the incorporation of near real-time fire behaviour and other elements to aid decision making is being sought.

As a future projection, 15 priority objectives are envisaged, among which the following stand out:

- replace MODIS data to update the dead fuel moisture index calculation, as well as the generation of 10-day NDVI composites, with VIIRS data;
- integrate weather forecasts (WRF and/or GFS) for wind and T, P, RH, to map the predicted fuel dryness (H10, H100, H1000);
- integrate information from the National Forestry Information System with that of SPPIF and expand the SPPIF interface to load point or polygon and download by state or area of interest;
- integrate GOES hot spots, including their FRP, as well as observations from NOAA's Aerosol Optical Depth (AOD) Product;

Moreover, there is interest in including visualisation of smoke plume forecasts, projection of GHG emissions, as well as assessing locally adaptive algorithms for assigning burnt area and severity thresholds from Sentinel imagery in near real time. Finally, there is interest in further extending the tool to Central American countries and unifying algorithms with other countries such as the United States and Europe. In this sense, Mexico is interested in the technical exchange between researchers who have developed the different warning systems worldwide, in order to continue strengthening each other's products and, if possible, to interconnect these systems.

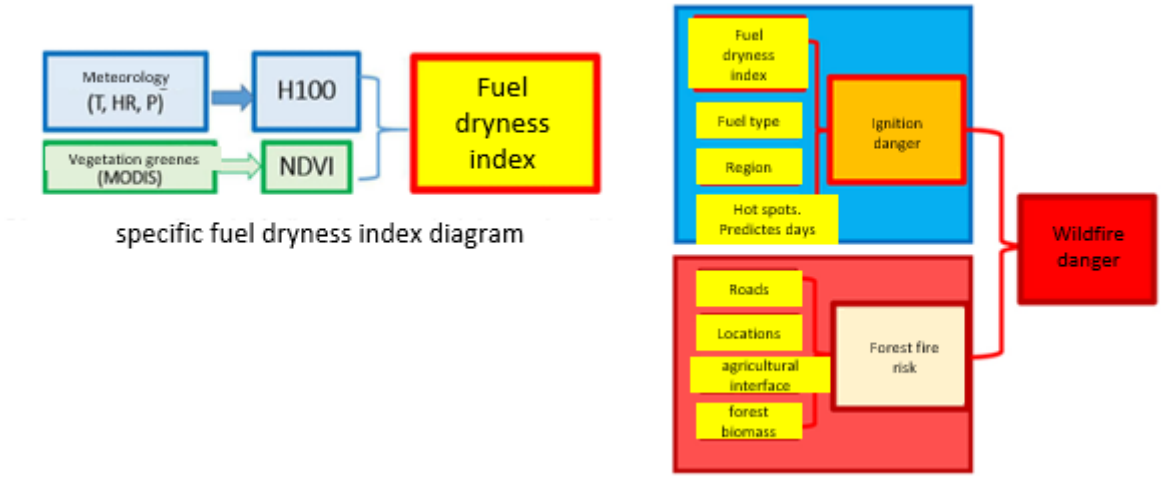


Figure 32. Forest Fire Hazard Index Workflow

(Source: National Forestry Commission of Mexico).

7. Paraguay

7.1. Governance and inter-agency coordination system

Since 2021, when Law No. 6818 on Integrated Fire Management was enacted, the National Forestry Institute (INFONA) has been the national authority for fire management. In 2022, the regulation of the Law was approved, creating the Integral Fire Management Network (REDMIF), made up of 26 governmental, non-governmental and civil society institutions, acting as an advisory body providing technical support to INFONA and its advisory council for compliance with the Integral Fire Management Law.

Table 6. Governance system and conformation of the Integral Fire Management Network of Paraguay.

Sector	Institution
Government	National Forestry Institute - Enforcement Authority
	National Emergency Secretariat
	Ministry of Environment and Sustainable Development
	Ministry of Agriculture and Animal Farming
	Meteorology and Hydrology Directorate
	National Police
	Ministry of Foreign Affairs
	Armed Forces of the Ministry of National Defence
	Paraguayan Space Agency
	National Land Registry Service
	National Institute for Rural and Land Development
	Paraguayan Indigenous Institute
	Ministry of Public Health and Social Welfare
	Paraguayan Organisation for Inter-municipal Cooperation
Fire Brigade	Fire Brigade of Paraguay
	National Board of Voluntary Firefighters of Paraguay
Academy	Forestry Engineering Degree - National University of Asunción
Bi-nationals	Itaipu Bi-national
	Yacyreta Bi-national Entity
Civil society and production associations	WWF Paraguay
	Guyra Paraguay
	Moisés Bertoni Foundation
	Pro Cordillera San Rafael Association
	Rural Association of Paraguay
	Union of Production Associations
	Paraguayan Federation of Timber Companies

7.2. *Monitoring of forest fires through early warning systems*

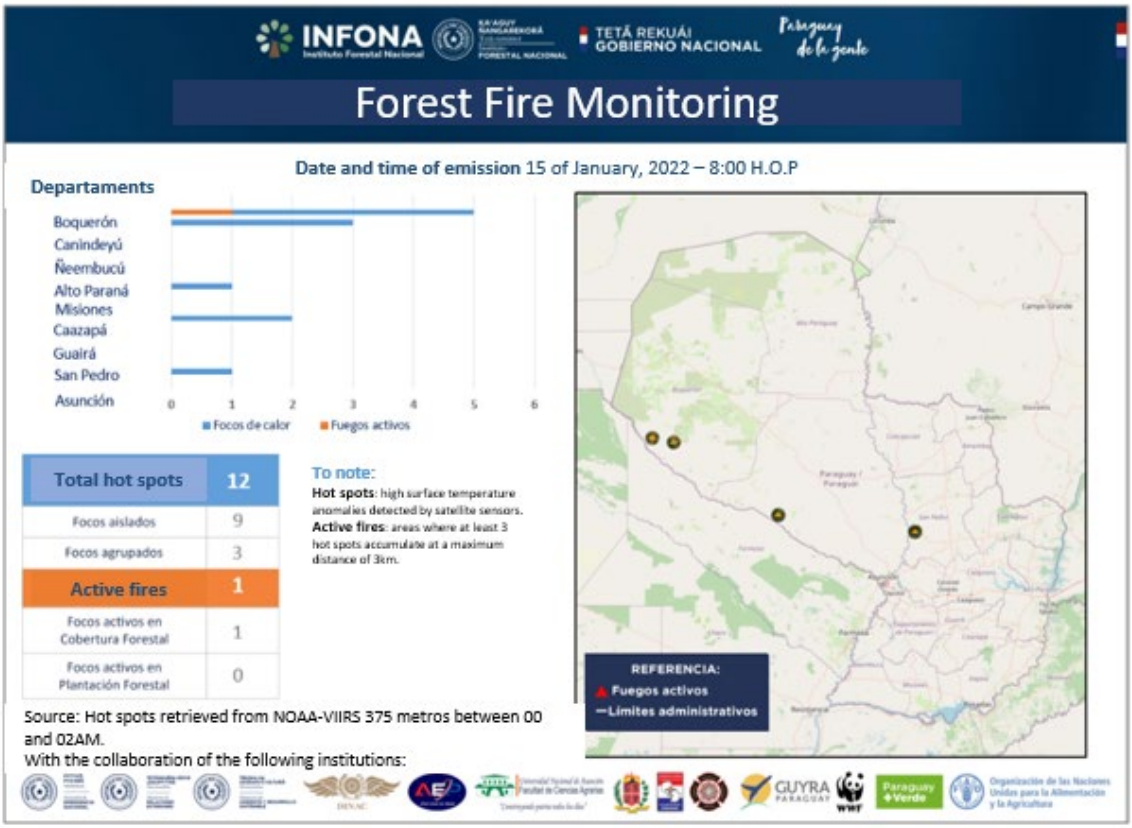
Although fire monitoring has been consolidated at a national level in recent years, INFONA has identified the need to strengthen it in terms of systematisation, in order to have integrated and consistent databases. This systematisation consisted of standardising data and managing processes so that the results collected can strengthen the time series and subsequently obtain efficient and assertive trends and possible scenarios.

INFONA has developed a package of tools for fire management and monitoring, including daily and monthly reporting automation tools, hot spot analysis tools, and fire and burnt area risk estimation tools, that together form part of a platform for monitoring and reporting hot spots, active fires and forest fires.

The forest fire risk estimation tool is a fundamental part of the Early Warning System. This is based on a multi-criteria spatial analysis, where the different layers with geographic information are used as inputs to perform map algebra operations using tools, functions and mathematical expressions, allowing the generation of final risk scenarios that integrate the analysis of all relevant variables, indicators and indices.

7.3. Fire simulation and rapid response platform

The fire simulation and rapid response platform is a very useful tool in fire management and response in forest areas. The main objective of this platform is to simulate forest fire scenarios using models and algorithms based on geospatial, topographic and meteorological data; and to evaluate potential fire risks in different areas and forest zones. Based on the results of fire simulation and risk assessment, the platform will help plan and develop emergency response strategies, optimise the allocation of available resources to fight forest fires, and support informed decision-making by fire managers.



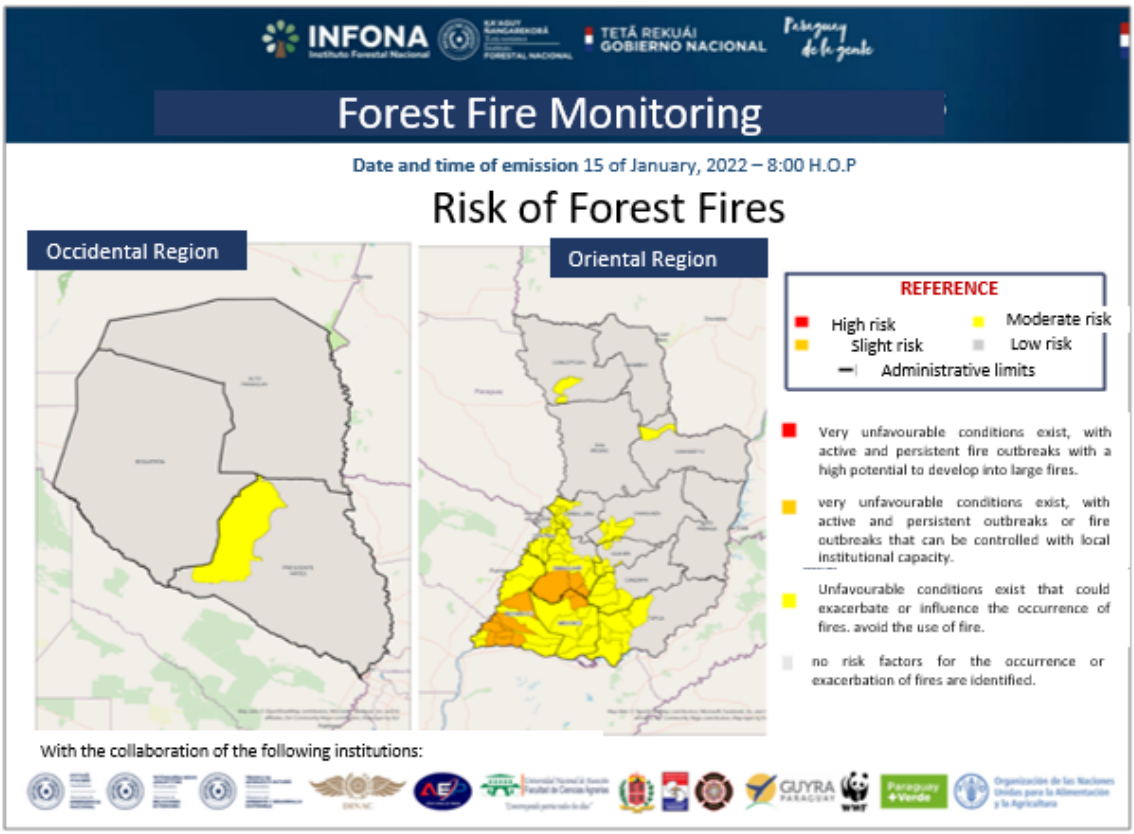


Figure 33. Daily fire and forest fire risk monitoring report.

(Source: National Forestry Institute of Paraguay).

8. Peru

8.1. The Inter-sectoral Coordination System

In 2016, forest fires were brought to light and were considered as one of the dangers that can also affect and cause deterioration of ecosystem services, damage to health, property, the environment and, most importantly, can cause death.

In response to this, various institutions have developed tools, including the Ministry of the Environment, which identifies the territories most prone to the occurrence of fires, the spatial and temporal location of fires and their impact on ecosystems. The National Service of Meteorology and Hydrology (SENAMHI, *Servicio Nacional de Meteorología e Hidrología*) determines atmospheric conditions, the Geophysical Institute of Peru, calculates the normalised difference vegetation index, and the National Forestry and Wildlife Service (SERFOR, *Servicio Nacional Forestal y de Fauna Silvestre*) reports on hot spots, followed by the preparation of forest fire alerts and the analysis of areas affected by fires. Likewise, documents such as the forest fire risk management strategy in the national system of natural protected areas (2018) were generated by the National Service of Natural Areas Protected by the State (SERNANP, *Servicio Nacional de Áreas Naturales Protegidas por el Estado*), by the National Centre for Estimation, Prevention and Reduction of Disaster Risk (CENEPRED, *Centro Nacional de Estimación, Prevención y Reducción del Riesgo de Desastres*) in collaboration with the aforementioned institutions, the National Forest Fire Hazard Characterization at the national level was elaborated and later, by 2020, the National Forest Fire Risk Scenario, followed by closer coordination under the call of the Presidency of the Council of Ministers, where by 2020 the activity of "generation of information and monitoring of forest fires" was created, being SERFOR responsible for it, an activity that brings together five institutions, three of which have been generating information and submitting their respective reports.

Since 2019, upon the proposal of a group of institutions, work meetings were initiated to strengthen inter-institutional coordination, forming the Multisectoral Fire Management Committee (pending formalisation), and in the following years more entities at the national level joined and the formal recognition of this intersectoral group was proposed in 2020. However, as a result of the health emergency caused by COVID-19, this initiative was stopped due to the restrictions for in-person meetings. Virtual meetings were promoted, led by the National Fire Department of Peru (INBP) on this occasion, to promote the multisectoral work team and to address the Forest Fighter Qualification and Certification System within the framework of the 2021 Action Plan.

In 2022, coordination is resumed, this time led by the National Civil Defence Institute (INDECI, *Instituto Nacional de Defensa Civil*), with the aim of continuing the coordinated work of the national institutions, advancing with the approval of a roadmap for 2022 and the establishment of those responsible for the working subgroups.

Inter-institutional coordination is taking place within the framework of the National Disaster Risk Management System (SINAGERD, *Sistema Nacional de Gestión del Riesgo de Desastres*), established by Law No. 29664 and approved by D.S. No. 048-2011-PCM. This system is inter-institutional, synergetic, decentralised, transversal and participative, meaning that the activities related to the danger of forest fires have the participation, continuous collaboration of the sectors, technical and scientific entities towards the executing bodies with the aim of providing knowledge, technical and financial support to avoid the occurrence of this danger, as well as preparedness and response actions in the event of possible disaster situations.

The entities involved in the SINAGERD framework are carrying out their actions within the scope of their roles and functions. (Table 7).

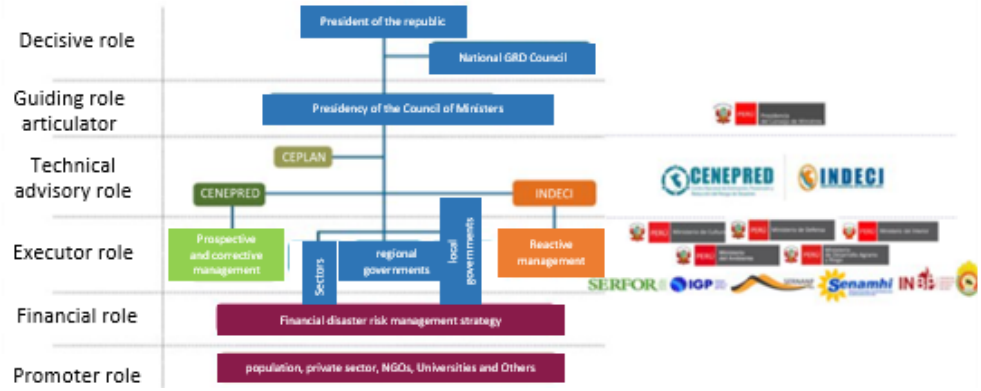


Figure 33. Role of entities in SINAGERD.

Table 7. Institutions related to forest fires.

Sectors and/or Institutions	MAIN FUNCTIONS	ROLE CARRIED OUT	DRM PROCESSES	LEGAL FRAMEWORK
Presidency of the Council of Ministers (PCM)	Coordination and liaison with the SINAGERD entities.	SINAGERD Governing Body	1.Estimation 2.Prevention 3.Mitigation 4.Preparation 5.Response 6.Rehabilitation 7.Reconstruction	Law No. 29664 D.S. No. 048-2011-PCM
National Centre for the Estimation, Prevention and Mitigation of the Risk of Disasters (CENEPRED)	Technician responsible for the estimation, prevention, mitigation and reconstruction processes.	Estimation, prevention, mitigation and reconstruction.	1.Estimation 2.Prevention 3.Mitigation 7.Reconstruction	Law No. 29664 D.S. No. 048-2011-PCM
National Institute of Civil Defence (INDECI)	Technician responsible for the preparation, response and rehabilitation processes.	Preparation, response and rehabilitation.	4.Preparation 5.Response 6.Rehabilitation	Law No. 29664 D.S. No. 048-2011-PCM
Ministry of Environment (MINAM)	MINAM is the agency in charge of conservation and sustainable use of natural resources, enhancement of biodiversity and environmental quality for the benefit of people and the environment in a decentralised and coordinated approach with public and private organisations and civil society, as part of green growth and environmental governance.	Environmental sector governing body	It contributes to the estimation, prevention, mitigation and reconstruction processes.	Law creating MINAM, Legislative Decree 1013. Ministerial Resolution No. 167-2021-MINAM, Text Integrated from the Regulation of Organisation and Functions of the Ministry of the Environment.
Regional Governments (GORE)	Promoting sustainable integrated regional development	Highest authority within its regional jurisdiction	The seven (7) DRM processes	Law No. 27867
Local Governments (GOLO)	Promoters of local development	Highest authority within its district and provincial jurisdiction	The seven (7) DRM processes	Organic Law of Municipalities 27972
National Service of State Protected Areas (SERNANP)	Ensure the conservation of the ecosystems of Natural Protected Areas.	SINANPE governing body	Six (6) DRM processes	D.L. No. 1013-2008-MINAM
Ministry of Culture (MINCUL)	Heritage protection	Cultural sector governing body	Six (6) DRM processes	Law No. 29565
National Forestry and Wildlife Service	Promote the sustainability and competitiveness of the forestry and wildlife sector	SINAGERD Governing body	Seven (7) DRM processes	Law No. 29763 RDE No.284-2018-MINAGRI-SERFOR-DE
National Fire Department of Peru (INBP)	Provides goods and services to the General Body of Voluntary Firefighters of Peru - CGBVP	Governing body for fire prevention, control and extinction (...)	Four (4) DRM processes	Legislative Decree No. 1260
General Body of Firefighters of Peru - CGBVP (CGBVP)	Emergency response and prevention, rescue and firefighting	Provides the public fire service	Four (4) DRM processes	Legislative Decree No. 1260
Joint Command of the Peruvian Armed Forces (CCFFAA)	Emergency and disaster response	Participate in preparedness and response	Two (2) DRM processes	Law No. 29664 D.S. No. 048-2011-PCM
National Police of Peru (PNP)	Emergency and disaster response	Participate in preparedness and response	Two (2) DRM processes	Law No. 29664 D.S. No. 048-2011-PCM
National Meteorological and Hydrological Service (SENAMHI)	Meteorological and hydrological activities	Scientific research	One (1) DRM process	Law No. 27188
Geophysical Institute of Peru (IGP)	Scientific research, teaching, training and conducting studies and projects in various areas of geophysics.	Scientific research	One (1) DRM process	Legislative Decree No. 136

Peru is seeking to migrate towards a policy of integrated fire management. Evidence of this is the fact that in 2020 and 2021, a series of technical meetings were held, convened by the Amazon Cooperation Treaty Organisation (ACTO), with the participation of technical bodies dealing with forest fires, within the framework of their competencies, led by the Peruvian Government Ministry of Foreign Affairs. Finally, in June 2021, the region-wide memorandum of understanding was approved. Likewise, SERFOR is initiating the process of drafting the National Forest Fire Prevention and Control Plan, whose objective is to implement actions to prevent and suppress forest fires, reducing their negative effects, contributing to the well-being of the population and sustainable development, raising the need to address the use and management of fire, considering that integrated fire management is regarded as the best form of governance, ecosystem conservation and forest fire risk management.

8.2. Statistics and historical records

According to information provided by SERFOR during the 2017-2021 period, 2020 recorded the highest number of forest fires, with a total of 14 197 events affecting a total of 537 857.83 hectares, followed by 2019, with 7 133 events affecting 254 189.10 hectares. Meanwhile, 2021 is in third place with 7 104 forest fires, which affected 191 013.79 hectares. In addition, the information provided shows that the months of July, August and September concentrate the highest occurrence of forest fires for the same years.

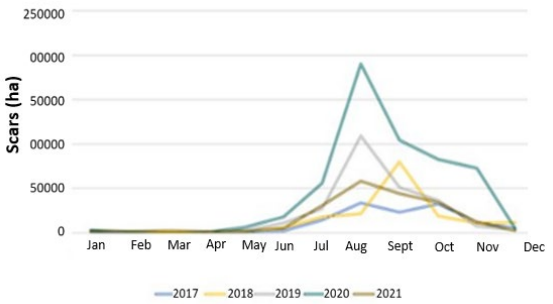


Figure 34. Affected areas (scars) from forest fires at national level by month.

According to the fire database, which is used as input to train the CFOI model, the Ministry of the Environment (MINAM) has information from 2000 to the present, and for this report we will show information from 2000 to 2017, with 3 483 forest fires occurring in the different ecosystems. Some years have higher peaks than others (2000, 2005, 2010 and 2016). The departments with the highest incidence during this period were: Cajamarca (890), Cusco (611), Apurímac (317) and Puno (316).

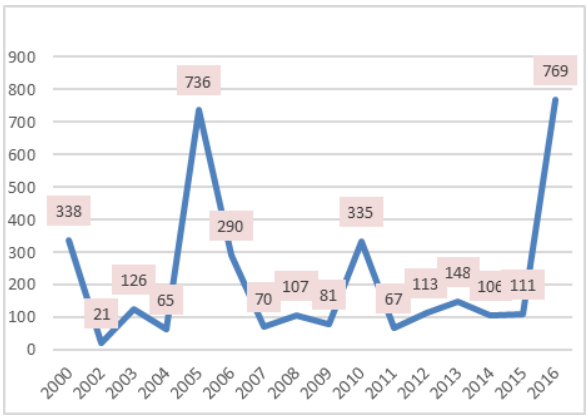


Figure 35. Forest fires over a 17-year period (2000 - 2016).

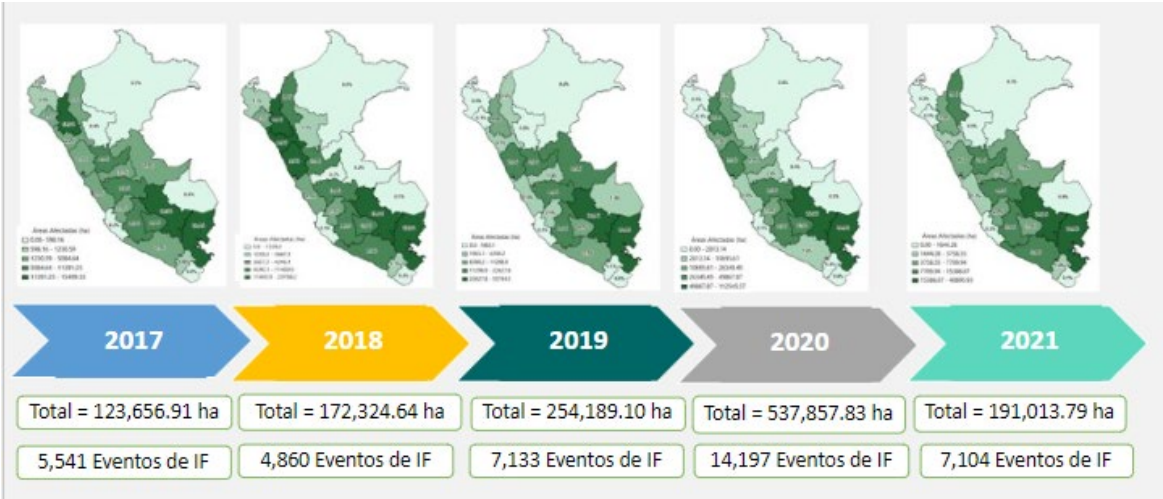


Figure 36. Affected areas (scars) of forest fires at national level.

8.3. Monitoring system

Within the framework of budget programme 068 for the reduction of vulnerability and emergency response to disasters - PREVAED - there is an activity for the generation of information and monitoring of forest fires, which includes the participation of 5 entities: MINAM, SERNANP, SENAMHI, IGP and SERFOR.

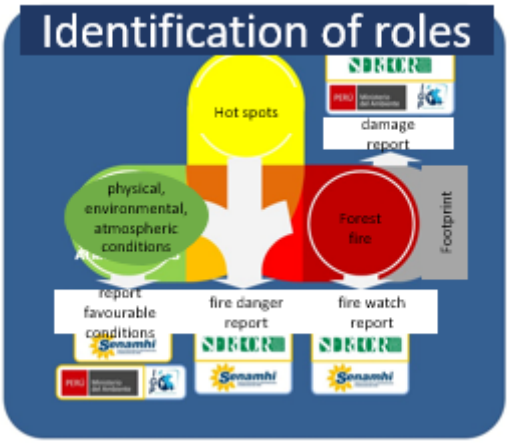


Figure 37. Identification of roles for information generation

The Ministry of the Environment, through the Department of Monitoring and Evaluation of the Territory's Natural Resources (DMERNT, *Dirección de Monitoreo y Evaluación de los Recursos Naturales del Territorio*), monitors the conditions favourable to the occurrence of fires. The information produced by monitoring is being shared through the geographic information system platform of the Ministry of the Environment, Geoservidor, as well as national and departmental reports, on a monthly basis with regional governments and provincial municipalities throughout the country. Through the management of natural resources (or the office in charge), the office of civil defence and/or risk management (or the office in charge), and through interoperability processes, it is being used by SERNANP, the Ministry of Culture, SERFOR, and all national entities through the sectoral module of the National Emergency Operation Centre.

SERFOR, using its Functional Satellite Monitoring Unit (UFMS), monitors forest fires, providing information for the purposes of: prevention, detection and monitoring, and analysis of areas affected by forest fires through the preparation of hot spot reports; surveillance; and analysis of areas affected by forest fires.

This information is used by different State sectors such as: Ministry of the Interior (MININTER), Ministry of Agrarian Development and Irrigation (MIDAGRI), Ministry of the Environment (MINAM), National Service of Protected Areas (SERNANP), National Meteorology and Hydrology Service (SENAMHI) and others such as the National Institute of Civil Defence (INDECI), the Regional Governments (GORES), the National Emergency Operations Centre (COEN) and the Regional Emergency Operations Centres (COER).

Figure 38. Forest Fire Monitoring (Hot Spots)

The National Meteorological and Hydrological Service (SENAMHI), through the Sub-Directorate of Weather Forecasting, issues forecasts and bulletins of favourable atmospheric conditions for forest fires on a daily, weekly and monthly basis, outlining the prevailing conditions in the different regions of the country and delimiting the areas that are most prone to forest fires on a weekly and quarterly scale. These products are available on SENAMHI's forest fire platform, which also provides monitoring and forecasting of meteorological factors that influence the development of forest fires, as well as the Forest Fire Index (FWI). Moreover, SENAMHI issues warnings of favourable weather conditions for forest fires when atmospheric conditions and the danger level is high. Finally, SENAMHI also issues very short-term weather reports for areas where forest fires are developing, in coordination with SERFOR which is notified in a timely manner via email.

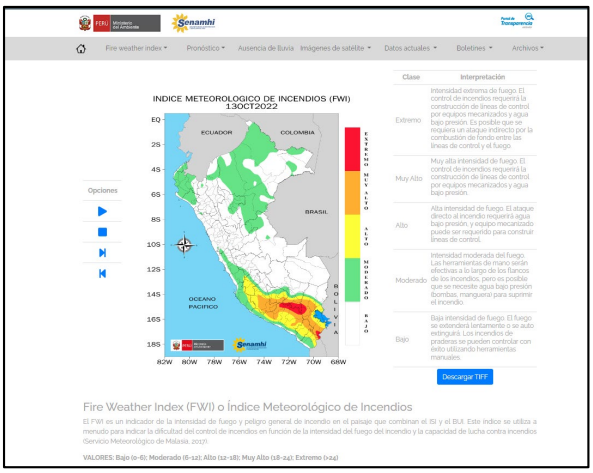


Figure 39. Fire Weather Index

The Geophysical Institute of Peru (IGP) has been preparing the bulletin "Indicators of the Andean Amazonian vegetation for the prevention of forest fires", based on scientific evidence. This Bulletin aims to publish information on vegetation conditions favourable to seasonal fire occurrence, scientific

knowledge, scientific advances and news related to the subject. The aim is to keep the different levels of government (national, regional and local) and the population informed, using scientifically based tools for the optimal use of information in decision-making. Data and information are available on its platform[30] and web map server[31].

Figure 40. Bulletin of Indicators of Andean Amazonian vegetation for forest fire prevention" of the IGP.

8.4. Education and prevention

To carry out actions related to the prevention of this danger, CENEPRED and SERFOR have been promoting the implementation of forest fire prevention and disaster risk reduction plans at departmental and local levels, using risk scenarios as the main input of the territorial diagnosis, which determine and prioritise the areas of intervention with prevention, mitigation and management activities for forest fires.

SERFOR has held several forest fire prevention workshops, including: prevention workshops on alternatives to the use of fire; GRIF workshops on preparedness and response; and forest fire prevention workshops in collaboration with MIDAGRI.

SERNANP, as part of the environmental education strategy, has raised awareness of more than a thousand people established in protected areas in 2021. On that occasion, the "Forest Fire Prevention Backpack", an innovative tool that allows in a participatory and playful way, the elaboration of prevention and awareness-raising messages aimed mainly at the population of native and peasant communities, making use of the objects that exist in the territory.

MINAM has been holding conferences, seminars and training sessions for various stakeholders in the territory, including national entities, regional and local governments, on the use and implementation of information from the Favourable Conditions for the Occurrence of Forest Fires (CFOI) service that affect ecosystems. In this way, it is also strengthening the capacity of managers and decision-makers at different levels of government to implement actions related to the prevention of forest fires and the conservation of ecosystems.

INBP, pursuant to Article 5, paragraph c) of Legislative Decree 1260, is responsible for: "Fighting, controlling and extinguishing fires, rescuing people exposed to danger due to fires, disasters, accidents and incidents involving hazardous materials, and responding to emergencies arising from these, in coordination with the competent State bodies or agencies, as appropriate". In line with this, one of the most important factors in fulfilling this function is the emergency response time. Emergency response time is defined as the period of time between the dispatch of an emergency response from the emergency call centre (116) and the arrival of the first fire brigade unit at the scene of an emergency. This is called activation of the Emergency System (ES). The activation of the Emergency System depends directly on the time it takes for the emergency call centre 116 to validate the emergency call (on average 2 minutes) and dispatch the fire brigade nearest to the place of occurrence. However, if the call does not go directly to the 116 emergency call centre, activation will take much longer, endangering human lives.

Figure 41. In addition to the 116 phone line, the CGBVP now has a mobile phone app called "Bomberos 116" [Firefighters 116].

Therefore, it is important that all households nationwide are aware of both the 116 emergency number and the different types of emergencies that the Peruvian General Voluntary Fire Brigade deals with through this emergency number.

In this regard, the INBP develops capacities for emergency prevention through campaigns, either in-person and/or online, where through playful techniques and the development of case studies, knowledge is conveyed to the population on how to cope with emergencies. The product is delivered either in-person or online. If delivered in-person, it is held where capacity-building events are held for the general population. If the strategy is online, it is carried out through the platform "Lecciones que Salvan Vidas" [Lessons that Save Lives], implemented

[30] https://www.igp.gob.pe/incendios-forestales/

[31] https://ide.igp.gob.pe/portal/apps/webappviewer/index.html?id=2b63791ff92246b18e8fd0a056e897a6

since 2020, where information files (videos, spots, readings, recommendations, etc.) are uploaded by firefighters, so that the population can access this information, emphasising the importance of knowing the 116 emergency number.

Figure 42. "Lecciones que salvan Vidas" [Lessons that save Lives] Platform

8.5. Research and open data

CENEPRED, through its SIGRID platform and as part of its functions, has been publishing geospatial information and administrative records generated by all entities on this hazard, in coordination with the SINAGERD entities that generate information so that in the near future it can work in an interoperable manner and the information will be more fluid and accessible to all.

MINAM, through its Geoserver platform,[32] whose function is to manage the administration of the Ministry's Geographic Information System, offers information on the territories that have a greater propensity for the occurrence of forest fires, and through the CFOI service, access to the information is available in real time through the CFOI viewer, an interactive window for various queries. The information can also be downloaded in different formats, and, through enhanced interoperability, all cartographic information can be accessed.

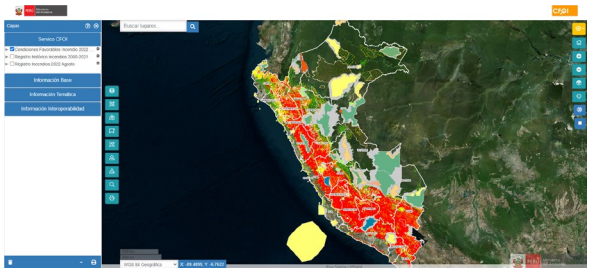


Figure 43. Geoserver - CFOI Service – MINAM.

The impacts of climate variability in the Amazon basin, such as droughts (Espinoza *et al.*, 2016; Marengo and Espinoza, 2016, among others) and a drastic increase in the occurrence of fires in the Andes (Zubieta *et al.*, 2019; Zubieta *et al.*, 2021; Ccanchi, 2021) have been documented by the IGP through the sub-directorate of atmospheric and hydrospheric science. This concludes on the importance of monitoring the dry season (without rainfall) and its impact on the state of vegetation in view of the severe increase in the occurrence of forest fires. Therefore, in support of agroforestry management and within the framework of the Programme Budget for Results No. 68 "Reduction of vulnerability and attention to disaster emergencies", IGP has produced the bulletin, "**Indicators of Andean Amazonian vegetation for forest fire prevention**", which reports on the cumulative frequency of dry days and the state of vegetation[33].

Another area of research addressed in the last year focuses on Andean social perceptions of the occurrence of forest fires. Early results suggest that the COVID-19 pandemic may have played a role in the severe increase of forest fire occurrence through a return to agricultural activities following unemployment. An increase in agricultural activity would have led to increased burning practices and more probable fire conditions during 2020. (IGP, 2021).

SENAMHI, through the sub-directorate of weather forecasting (SPM), has been conducting studies focused on the influence of weather conditions on the occurrence and development of forest fires in Peru, as well as the application and evaluation of forest fire indices in the national territory. In this sense, in March 2018 the "Study of Atmospheric Conditions Favourable to Forest Fires in Peru" was published, and it is also currently conducting research related to the influence and importance of continuous dry days in the occurrence of forest fires.

Additionally, SENAMHI, through the sub-directorate of Atmospheric Environment Assessment (SEA), has carried out the study and monitoring of air quality conditions in areas affected by large-scale forest fires, namely in August 2019, when a large number of forest fires were recorded in the Brazilian, Bolivian and Peruvian Amazon.

All studies carried out and data observed by SENAMHI are available on the SENAMHI Forest Fire platform, and the daily Forest Fire Index (FWI) is available on the IDESEP-SENAMHI platform[34].

[32] https://geoservidor.minam.gob.pe/monitoreo-y-evaluacion/geocfoi/, https://geoservidor.minam.gob.pe/wp-content/uploads/2020/02/Monitoreo-CFOI_CV.pdf

[33] https://www.igp.gob.pe/incendios-forestales/

[34] https://idesep.senamhi.gob.pe/geovisoridesep/go?accion=09.03.285.03.001513.2022.10.12

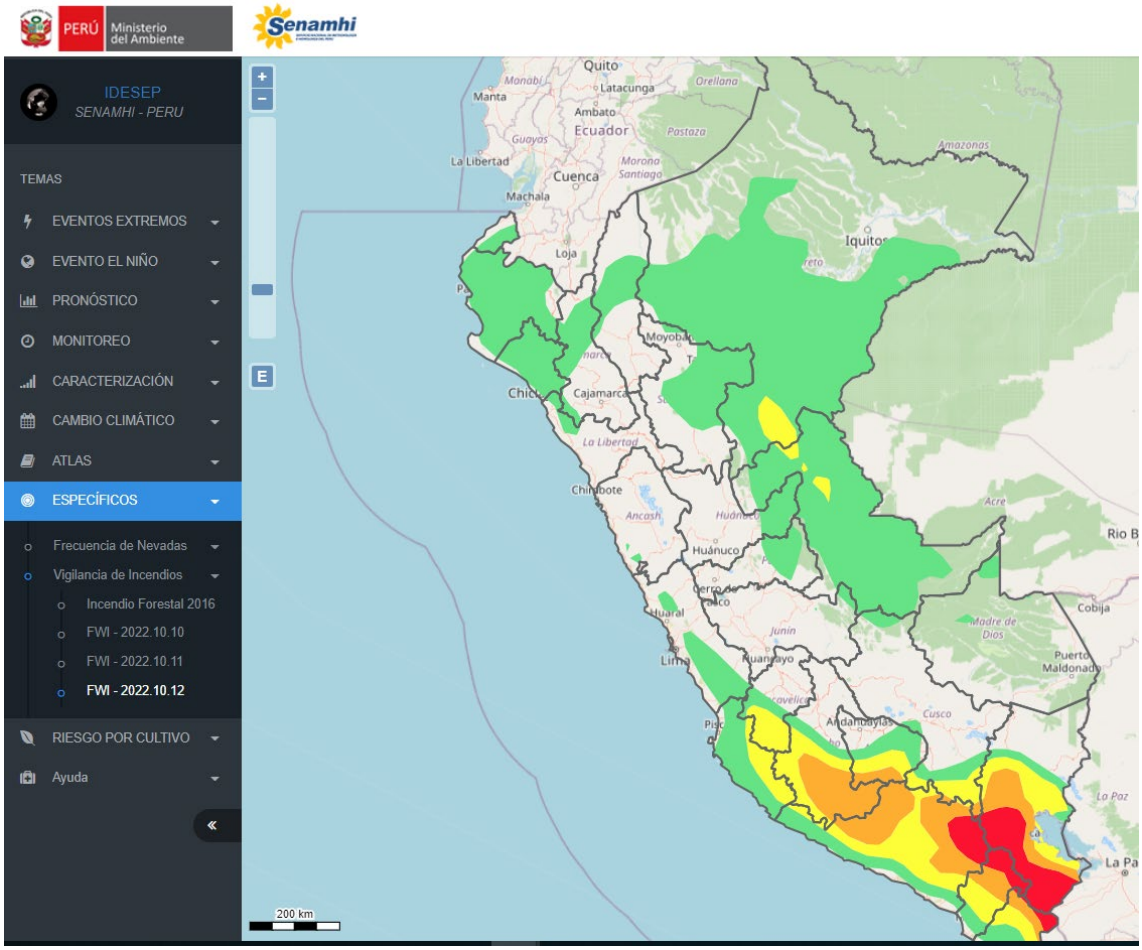


Figure 44. IDESEP-SENAMHI Platform

(Source: Ministry of Environment of Peru).

9. Uruguay

9.1. Inter-sectoral coordination system

The National Emergency System (Sinae) brings together all the actions carried out by the State for emergency and disaster risk management in its different phases: prevention, mitigation, preparedness, response, rehabilitation and recovery. It is a space for vertical and horizontal articulation that develops the practice of intersectorality and integrality. Within the organisational structures, the National Emergency and Risk Reduction Board, the Departmental Emergency Committees and the "Analysis Committees" stand out as cross-cutting inter-institutional spheres of analysis, monitoring and advice on different issues.

Within this framework, several inter-institutional initiatives have been carried out with the participation of public and private sector actors aimed at improving and analysing forest fire statistics, improving the "fire risk index" as well as awareness-raising and promotion of a preventive culture at all levels, through communication campaigns, training courses, workshops in schools, etc.

Thus, within the framework of the Sinae, the "Forest Fire and Open Burning Analysis Board" (MAIF) was created this year. It is chaired by the National Director of Emergencies and is made up of the National Fire Department (DNB), National Defence (DN), the General Forestry Directorate of the MGAP, the National Directorate of Land Management (DINOT) and the Ministry of Environment (MA). The Uruguayan Institute of Meteorology (INUMET), the State Insurance Bank (BSE) and the Society of Forestry Producers (SPF), among others, are also participating. It is worth mentioning that the first work of the MAIF is the updating of the General Action Plan for the prevention, warning and response to forest fires and the analysis of the "National Burning Plan" presented by the National Fire Department is expected to begin.

Other inter-institutional work areas include the Forest Fire Alert and Monitoring System (SAMIF) and the departmental Forest Analysis Board of the Litoral region, which later took on a national character, convened by the Ministry of the Environment, where a report was drawn up with recommendations on the distances of forest plantations from populated centres with the presence of representatives of the National Fire Department, the General Forestry Department of the Ministry of Livestock, Agriculture and Fisheries and the Forest Producers' Society.

9.2. Statistics and historical records

Uruguay does not have a systematised historical record of forest fires, which makes it difficult to manage and plan strategic actions for their prevention. The National Fire Department (DNB) registers in its database all the interventions carried out in the 19 departments throughout the national territory. This survey is distributed to different institutions such as the National Statistics Institute (INE), the General Forestry Directorate (DGF) and the National Emergency Directorate of SINAE (DNE).

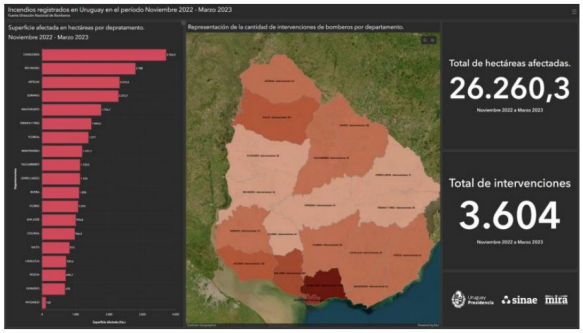


Figure 45. DNB statistics display board.

However, since the creation of the Comprehensive Risk and Affectedness Monitor (MIRA) under the responsibility of the National Emergency System (Sinae), there is now an inter-institutional geographic information system with a national scope that aims to provide information for decision-making in Integrated Risk Management (IRM), record information on adverse events and generate statistics and indicators of aggregated quality at the national level with standard and homogeneous criteria. This IT tool is developed on a GIS (Geographic Information System) platform and the DNE has been using this system to compile the information provided by fire brigades (DNB).

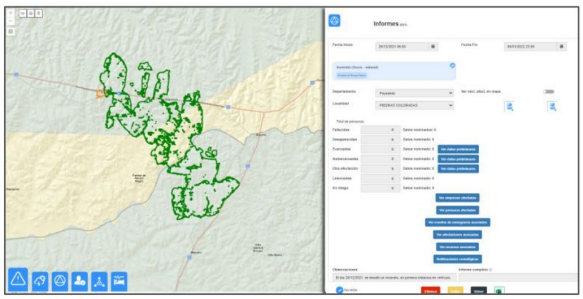


Figure 46. Mira system, example of visualisation of uploaded data.

From each department, the Departmental Emergency Coordination Centre (Ce.Co.E.D.) uploads information on the different emergency events, including forest fires. The National Emergency Directorate (DNE) compiles the data provided from the territory uploaded to MIRA and generates information that is complemented with processed satellite information such as hot spots, detection and determination of burnt area, etc. with freely available products (FIRMS

- NASA, Landsat-8 and Sentinel-2 images, data collection provided by the GWIS platform.

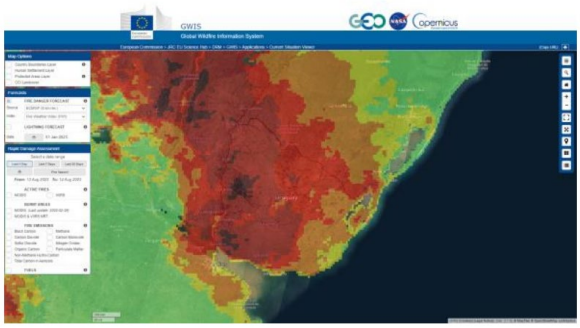


Figure 47. Screenshot of the GWIS platform indicating the fire risk on 1/1/2023.

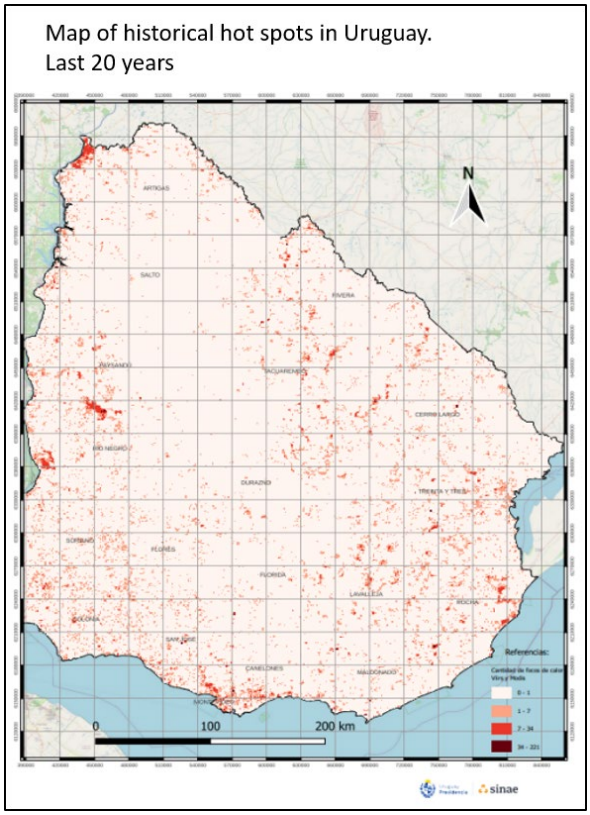


Figure 48. Time series mapping of hot spots from NASA data.

For the most relevant fires, post-event reports are made, where the severity of the fire is mapped, damage and loss analyses are attached, and all possible information provided from the territory is compiled.

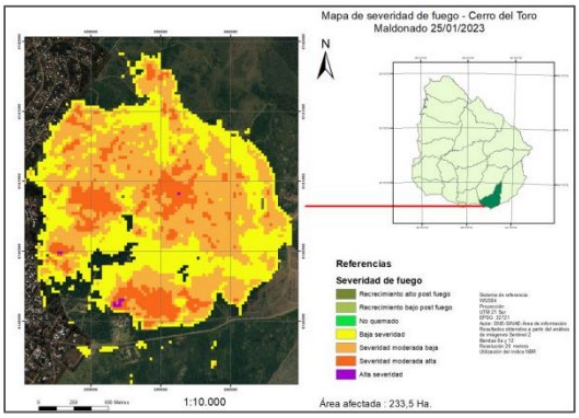


Figure 49. Cartographic representation of severity and calculation of burnt area in a forest fire.

A project is currently being developed to strengthen the firefighters' data registry, which consists of geo-referencing the interventions carried out at national level. It is in the pilot stage for four detachments in the metropolitan area.

Figure 50. Board showing the interventions carried out by the fire brigade.

In particular with regard to the last fire seasons, we can report that during the period November 2021 to March 2022 (inclusive) there were favourable environmental conditions for the occurrence of forest fires with an increase in the number of fires to 1 687 (with more than 100 fires at one time). 687 fires (registering more than 100 fires at the same time) and in terms of area affected, the 2 most extensive fires in the history of Uruguay were recorded, damaging more than 11 000 hectares in each one, registering a total of 38 000 hectares, adding the particularity that fires were recorded in areas where it is not common for fires of that magnitude to be recorded. In the last season, which runs from November 2022 to March 2023 (inclusive), 3 604 fires were recorded, affecting a total of 26 260 hectares of fields and forests.

9.3. Monitoring System

The monitoring of forest fires is one of the main aspects of the action plan, carried out at two levels and in different ways, the first by public institutions and the second by private institutions.

VIDEO SURVEILLANCE CAMERAS

20 multispectral, long range, smoke and heat detection cameras have been installed, with a 360° rotation angle, with a detection radius of more than 10 km, with continuous monitoring 24 hours a day. These cameras are equipped with an artificial intelligence system that makes it possible to analyse the information, detecting the outbreak, issuing a warning to a receiver in a monitoring centre, where the information is analysed and the necessary resources are dispatched.

FLIGHTS

Coordinated and synchronised flights are carried out in order to cover all the country's risk areas. Firefighters together with the Uruguayan Air Force (FAU) and the National Aviation Directorate of the Police, in the period from December to March, make a daily flight along the coast of the Río de la Plata, while the Society of Forestry Producers makes daily flights over areas of forestry plantations in the interior of the country, according to the fire risk index.

WATCHTOWERS

There are forestry enterprises that have watchtowers, in which an official with binoculars and cameras is stationed to detect fire outbreaks within their range, issuing an immediate warning to a monitoring centre.

HEAT MAPS

Occasionally maps of hot spots, recorded on open source satellite monitoring systems, are considered.

9.4. Forest Fire Danger Forecasts

In Uruguay, the Uruguayan Institute of Meteorology (INUMET) is working on the Fire Weather Index (FWI), a forest fire risk index based on the Canadian system, which was recently implemented. It is a meteorological index based on empirical relationships and composed of different codes and sub-indices that take into account the effects of fuel moisture and wind on fire behaviour and fire spread. Higher values of FWI indicate more favourable meteorological conditions to trigger a wildfire. As an index adaptable to different climatic conditions, depending on the region of application, it requires calibration of different fire danger levels. Based on the FWI values, daily risk maps are presented that characterise the danger of forest fires throughout the national territory, with green being low risk, yellow medium risk, orange high risk and red very high risk.

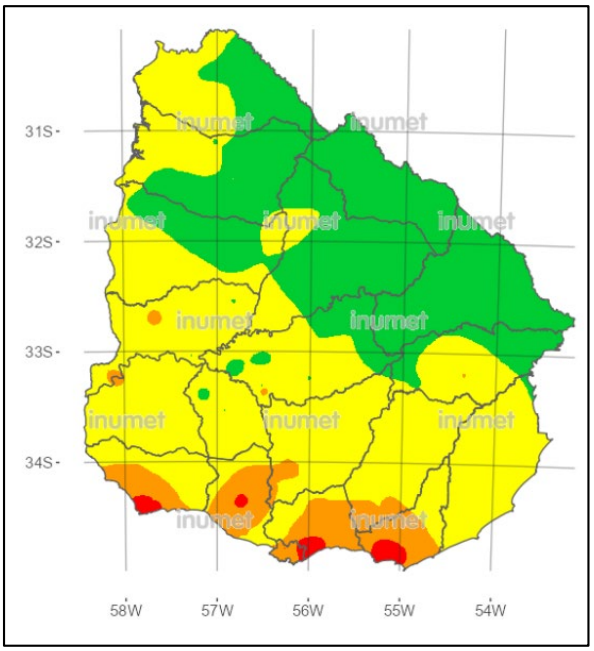


Figure 51. Forest fire risk index (INUMET).

9.5. Education and prevention

In Uruguay, various training, dissemination and monitoring activities are carried out to ensure compliance with current regulations, in pursuit of the development of forest fire prevention programmes, coordinating with other institutions to achieve this. Technical monitoring of compliance with the "Forest Fire Prevention Plans" included as a requirement for the presentation and approval of Forestry Projects at the national level by the General Forestry Directorate is also carried out, as well as attention to complaints in conjunction with the National Fire Department.

In addition, there is training through informative talks on the prevention and extinction of forest fires, prioritising the communities located in the coastal interface zones and raising awareness about the dangers of fires and carrying out the construction of firebreaks, cleaning of land, chipping and destruction of dead vegetation, which have already had favourable results. In addition, prevention and protection measures are being instilled in the population, establishing focal points for detection and risk reduction through neighbourhood groups. The inhabitants of areas at risk of forest fires are also trained on how they should be prepared to face a fire, and how they should act safely.

Within the framework of the "General Action Plan for the Prevention, Warning and Response to Forest Fires", visits are made to rural schools by the National Emergency System (SINAE) in conjunction with the National Fire Department (DNB) and the General Forestry Department as part of the annual dissemination campaign aimed at the protection of forests throughout the national territory. The aim of the workshops is to bring children closer to the importance of valuing the environment and the care

to be taken, from prevention to the occurrence of extreme situations.

The National Emergency System, the National Fire Brigade, the General Forestry Directorate of the MGAP, among other institutions, are participating in a line of emergency prevention work focused on the rural population. To this end, workshops have been held in rural public schools to raise awareness, involving not only children and teachers, but also the rest of the community. Over the years, this mechanism has reached more than 800 rural schools (approximately 80% of the total), more than 14 000 children, 1 460 teachers, and 1 580 family members and neighbours of the community, where one of the priority topics is the prevention of forest fires.

With regard to specific and professional training for firefighting, instructors have been trained in forest firefighting courses and in basic and intermediate level Incident Command Systems, and both courses have been replicated for firefighters, officials from other institutions and forestry companies. These courses are held annually throughout the country.

The aim is also to reach the population through prevention campaigns, carried out by each institution, but coordinated and in inter-institutional cooperation.

9.6. Research, cooperation and open data.

In Uruguay there is little research on integrated fire management and its implications, and this is one of the priority topics for its development to the extent that cooperation projects can be generated at regional and international level.

With regard to links with regional and international organisations, a close relationship has been maintained to date with the "Regional Network on Forest Fires in South America" and the "Group of Experts on Forest Fires in Latin America and the Caribbean" (GEFF LAC) convened by the European Union, with the public institutions through SINAE, DNB and DGF being the focal points for Uruguay. Within the framework of the Regional Disaster Assistance Programme of the United States Agency for International Development (USAID), various activities have been carried out, including the Workshop on "Integrated Fire Management in Latin America and the Caribbean", with the aim of learning and exchanging information on the fire situation in Latin America, focusing on the specific case of the development of knowledge on forest fires in Chile. The Integrated Monitor of Risks and Affectations (MIRA) integrates information on adverse events, generating statistics and quality indicators, ensuring the uniqueness of records, standard and homogeneous criteria and reliability of the information. Forest fire affected areas: Areas affected by forest fires as determined from satellite imagery, UAV flights or GNSS surveys. The Monitor's architecture is web-based, allowing access from any computer, tablet or mobile phone with internet access, without the need to install any software. It is developed on a geographic information platform (GIS) used worldwide by different government agencies related to risk and disaster management (ESRI). As it is developed on this platform, all the information entered can be georeferenced. In addition, it contemplates the current guidelines of the Geoportal of the Spatial Data Infrastructure (SDI). They are also available to the population in the open data catalogue of the Presidency of the Republic.

Among the data available are: - Fire outbreaks registered in the MIRA system: The set has a layer of points containing the fire outbreaks registered in the MIRA system. They are divided into four types of fires: field fires, native forest, planted forest and urban interface. The sources of information for the register are: Departmental Emergency Coordination Centre (CECOED), the Public Security Management System (SGSP) and the press.

Figure 52. Screenshot of the Open Data portal where data published in different formats can be accessed and downloaded.

(Source: Ministry of Interior; Ministry of Livestock, Agriculture and Fisheries; National Emergency System).

Global and Regional Fire Information Systems.

1. Global Wildfire Information System (GWIS)

1.1. Introduction and access to GWIS

The Global Wildfire Information System (GWIS) is a common early warning and monitoring system for forest fires established through a web mapping service. GWIS has been developed by the European Union's Joint Research Centre (JRC) together with the programmes of the Group on Earth Observation (GEO) and the European Union's Copernicus programme. GWIS was developed based on the methodologies in use in the European Forest Fire Information System (EFFIS). It is supported by the Global Terrestrial Observing System (GTOS) GOFC-GOLD Fire Implementation Team together with associated Regional Networks, complementing existing activities being carried out around the world in relation to the collection of forest fire information.

The objective of GWIS is to provide harmonised information on forest fire occurrence and the assessment of its effects worldwide at national and global scales. GWIS is supported by space agencies such as NASA and ESA to use data from MODIS[35], VIIRS [36]and Sentinel-2 sensors, as well as meteorological data from the European Centre for Medium-Range Weather Forecasts (ECMWF), Meteo France and NASA.

Figure 53. GWIS web service portal

The GWIS web service consists of five main applications: (1) a display on the current situation regarding fire and lightning danger forecast, burnt area, number of forest fires, fire emissions, thermal anomalies (hot spots) and evolution of the danger index in the current year (2) a fire statistics portal, (3) a portal for country fire regime profiles, (4) medium and long-term fire weather forecasts and (5) a portal for access to data and services.

1.2. Hazard prediction and fire monitoring system

The current situation viewer provides access to recent information and forest fire forecasts so as to monitor forest fire events at different scales. The data available on this viewer includes the following:

1. **Fire hazard forecasts:** EFFIS adopted the Canadian Forest Fire Weather Index (FWI) system as a method to evaluate the fire danger level in a harmonised way across Europe. Later in 2019, additional indices were added to the GWIS portal in order to compare them with the results of the FWI.

   Three deterministic models are used to assess the forecasts: ECMWF (~8 km) provides forecasts from 1 to 9 days, MeteoFrance (~10 km) provides forecasts up to 3 days and NASA Goes-5 (~30 km) provides forecasts up to 6 days.

Figure 54. Amazon fire hazard forecast on 4 July 2023 using the FWI.

2. **Lightning forecasts:** Monitoring of lightning is important as it can cause considerable damage (e.g. forest fires, disruption of air traffic).

[35] The Moderate Resolution Imaging Spectroradiometer (MODIS) is a key instrument aboard NASA's Terra (previously known as EOS AM-1) and Aqua (previously known as EOS PM-1) satellites.

[36] The Visible Infrared Imaging Radiometer Suite (VIIRS) is a sensor that collects visible and infrared images and global observations of the earth, atmosphere, cryosphere and oceans.

Figure 55. Display of the lightning predicted for 17 May 2023 in northern South America.

Although it is not possible to predict individual lightning strikes, forecasts of average lightning activity provided by the ECMWF can be made up to 9 days in advance.

3. **Active fires:** Through the access to data from NASA's MODIS and VIIRS sensors via the FIRMS system[37], active fires are located in near real time (NRT) using the so-called thermal anomalies (hot spots) that they produce, making it possible to estimate their extent and the areas burnt. In this context, the temperature of a potential fire is compared to the temperature of the surrounding land cover; if the difference in temperature exceeds a certain threshold, the potential fire is confirmed as an active fire or "hot spot".

   The visualisation of active fires is done to provide a clear overview of current fires around the world and to help in the subsequent mapping of the perimeters of the area burned by fires. This information is updated up to 8 times a day and is available in GWIS within around 2 hours after the acquisition of images from the MODIS and VIIRS sensors.

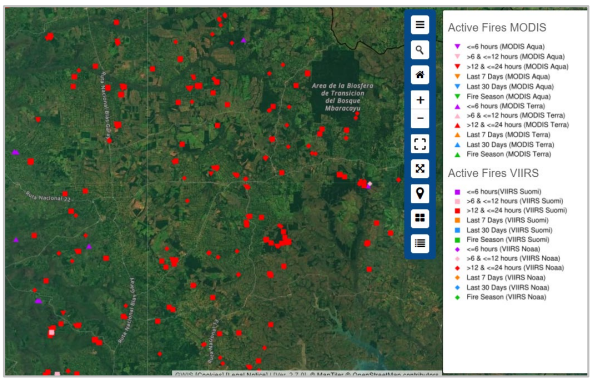


Figure 56. Active forest fires in Latin America between 3 and 4 July 2023.

4. **Maps of burnt areas**: These maps consist of burnt areas delineated by forest fires based on hot spots detected by MODIS and VIIRS satellites. GWIS provides two types of burnt area products: (1) MODIS and (2) MODIS & VIIRS NRT.

(1) MODIS. The MODIS burnt area products, provided by NASA (MCD64A), are not available in near real-time as they are released with a delay of about 2 to 3 months and are updated on a monthly basis. They provide information on spatial and temporal characteristics of all areas affected by fire. However, they do not include information on individual events. This makes it difficult to distinguish certain types of forest fires or to study their behaviour or occurrence.

(2) MODIS & VIIRS NRT. As a result of the circumstances described above, GWIS also distributes information on burnt areas in NRT. This product is a combination of hot spot data provided by MODIS and VIIRS sensors that enable the delineation of individual fire perimeters in Near-Real Time (NRT).

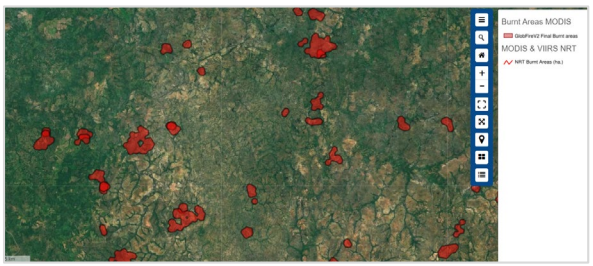


Figure 57. Burnt areas detected from 3 July to 4 July 2023 in the Amazon region.

5. **Atmospheric emissions**: The emission graphs from the Global Fire Assimilation System (GFAS) of the Copernicus Atmospheric Monitoring Service (CAMS), show estimates of daily emissions from forest fires and biomass burning obtained from data on the Fire Radiative Power (FRP) released by the fires.

[37] The Fire Information Resource Management System (FIRMS) distributes near real-time active fire data (NRT) from MODIS and VIIRS.

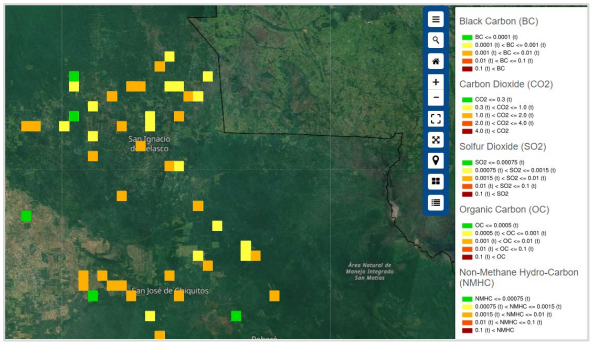


Figure 58. Atmospheric emissions detected from 3 July and 4 July 2023 in the Amazon region.

1.3. Updated fire statistics

The updated fire statistics portal provides information on the evolution of the ongoing fire season as described in the previous section. The graphs titled "GWIS estimates" show annual statistics, and the graphs titled "seasonal trends" show weekly statistics, including weekly cumulative values, the average of the last decades and the maximum and minimum values for that reference period.

GWIS provides data at a national scale and for some areas of special interest, called "regions of interest", including the Brazilian Legal Amazon and the Arctic Monitoring and Assessment Programme (AMAP).

The data available on this portal includes the following:

1. Burnt areas and number of fires.

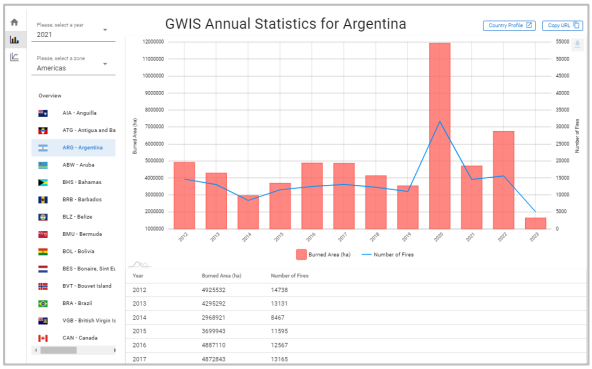


Figure 59. Burnt areas and number of fires in Argentina in 2021.

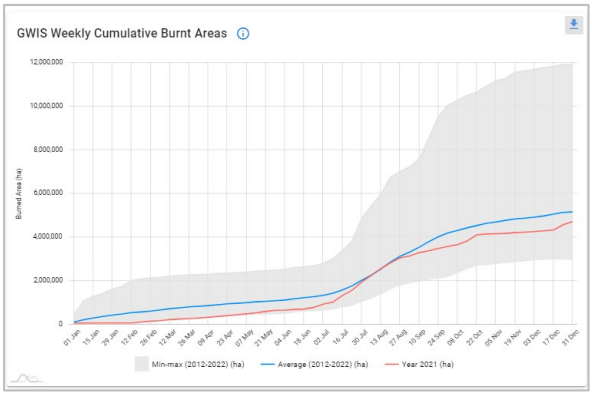


Figure 60. Cumulative burnt areas in Argentina in 2021.

2. Number of thermal anomalies.

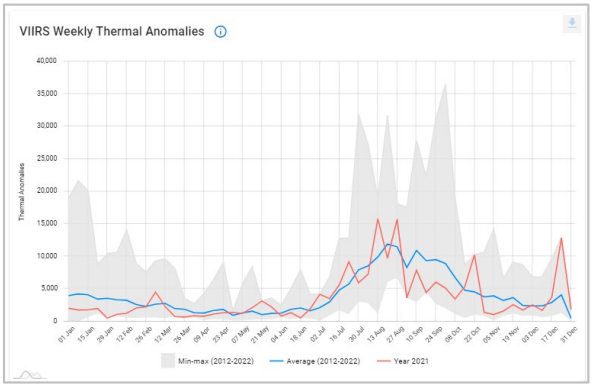


Figure 61. Thermal anomalies detected by the VIIRS sensor for Argentina in 2021.

3. Daily Severity Rating (DSR) DSR is calculated from the FWI so as to provide a measure of the difficulty of fire control. Its average of daily estimates accumulated over a week is called the Weekly Severity Rating (WSR).

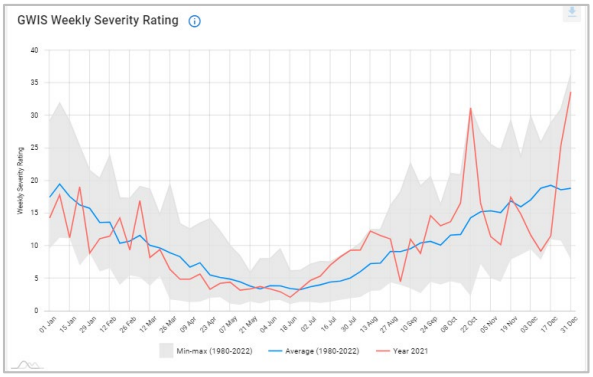


Figure 62. Weekly Severity Rating for Argentina in 2021.

4. Gas emissions. There is a wide range of gases available to be displayed (e.g. carbon dioxide, methane, carbon monoxide).

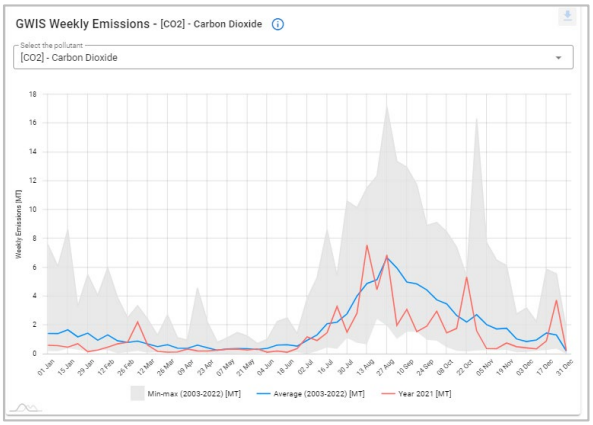


Figure 63. Carbon dioxide emissions in Argentina for 2021.

1.4. Country profiles

As well as the statistics mentioned above, a historical overview of fire regimes at country and sub-country level for the 2002-2019 period is provided in GWIS through a portal called "country profiles". This portal aims to support forest fire risk management at national and regional level. The country profiles provide aggregated data from a historical series of information on fires provided by MODIS data (MCD64A) and GlobFire data.

Information is presented in the form of maps of burnt areas and frequency of fires and graphs of number of fires, burnt areas, frequency of burnt areas, seasonality of fires and emissions produced by them.

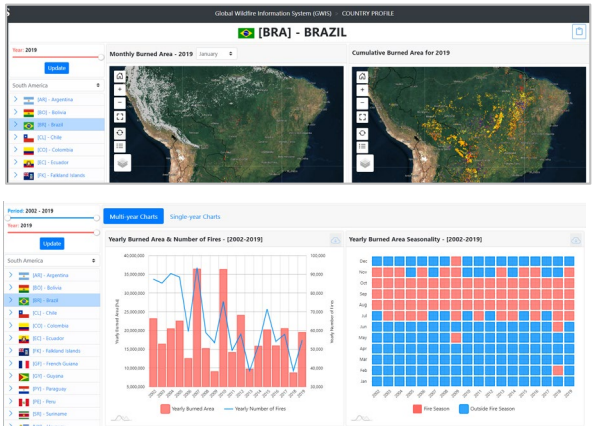


Figure 64. Maps and graphs of burnt areas in Brazil for 2019.

1.5. Medium and long-term weather forecasting

Long-term fire weather forecasts show monthly and seasonal forecasts for temperature and precipitation anomalies in different regions and at a global level. In this section, it is possible to see maps illustrating areas that are expected to be colder or warmer and drier or wetter than usual.

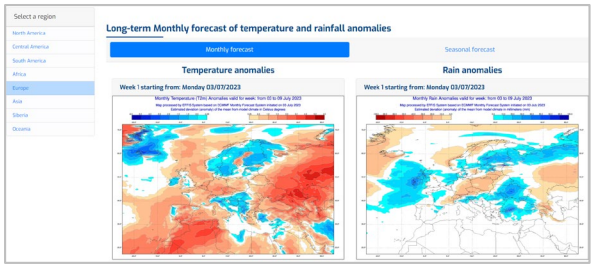


Figure 65. Monthly weather forecasts in Europe.

1.6. Services and access to open data

The development of GWIS has provided a common means for stakeholders and users to collaborate and share information, knowledge and best practices in forest fire management. GWIS services, information and data are fully available to all interested groups as well as to the general public.

The data and services portal allows access to download data used in GWIS applications, such as national boundary layers, urban areas, gas emissions and protected areas.

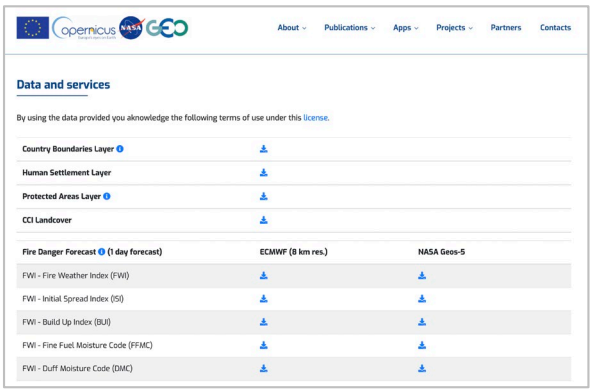


Figure 66. GWIS data and services portal.

1.7. Cooperation and research

As well as the applications described above, GWIS has an information section on the Fire Management Support in Latin America and the Caribbean (LAC) project. This project is developed in collaboration between forest fire management services in Latin America and the Caribbean and the European Union and builds on more than 20 years of collaboration in fire management and the development of fire information systems in the pan-European region. This initiative started in 2020 and contributed to the establishment of the Group of Experts on Forest Fires in Latin America and the Caribbean (GEFF LAC), which aims to facilitate the exchange of knowledge and best practice in forest fire management, and, together with the harmonised information provided by GWIS, could lead to strategic actions to minimise the impact of forest fires in the LAC region.

The Support to Fire Management in Latin America and the Caribbean project has the main objective of collaborating with stakeholders in Latin America and the Caribbean towards a strategic, targeted and comprehensive approach to the management of forest fires in the region.

In this context, it addresses different goals:

- Contribute to the exchange of information on lessons learned in the complete fire cycle, from prevention to restoration, including the discussion and publication of good fire prevention practices.
- Contribute to the harmonisation of data/information in the GWIS database and other national and regional platforms.
- Contribute to the improvement of fire prevention, preparedness and response in the LAC region.
- Contribute to the sustainable management of forests and information exchange to increase forest resilience.

Figure 67. Portal of the Support to Fire Management in Latin America and the Caribbean Project.

In line with the project described above, the EU **Green Pact Programme, which includes specific actions for the Amazon Basin** (Amazon+ Programme), is being implemented as part of the Team Europe Initiative to support the development of environmental measures in the Amazon region in order to reduce forest degradation and deforestation, minimise the environmental impact caused by fires, and integrate indigenous peoples and their knowledge of these issues into environmental management.

The programme seeks to improve the capacity of the eight Amazon basin countries (Colombia, Bolivia, Brazil, Ecuador, Guyana, Peru, Suriname and Venezuela) to mitigate CO2 emissions, adapt to climate change effects and significantly reduce deforestation and damage created by forest fires.

2. Amazon Regional Observatory (ORA)

Reliable and up-to-date data on natural resource conditions are essential for wildfire prevention and extinction planning.

This section describes information systems and tools that are currently used to manage information and monitoring on integrated wildfire management on a regional scale, and to disseminate these data to professionals and the general public.

2.1. *Introduction and access to ORA*

The Amazon Regional Observatory (Observatorio Regional Amazónico, ORA)[38] is a reference centre of information in development on the Amazon that facilitates the flow and exchange of information between institutions, government authorities, the scientific community, academia and civil society of the Amazonian Countries of the Amazon Cooperation Treaty Organisation (ACTO).

The ORA provides information services on the strategic natural resources of the Amazon such as its biodiversity, water resources and forests, offering the possibility for users, through its different tools of geographic analysis, data and indicators, to generate forecasts and identify unfavourable trends in the use of natural resources, promoting the collaboration of researchers and institutions, and contributing to policy formulation and decision-making processes.

2.2. *Monitoring system*

Among the services mentioned, ORA reports on active fire events as well as affected areas (e.g. urban, indigenous, protected natural areas) in the Amazonian territory (Figure 68 and Figure 69). This information is based on satellite detection of variations in land surface temperature, or hot spots, with a high probability of corresponding to fires or burns. These data are obtained from the INPE, CENSIPAM and Global Wildfire Information System (GWIS) portals.

As shown in Table 8, one of the characteristics of these reports is that urban border areas are highlighted.

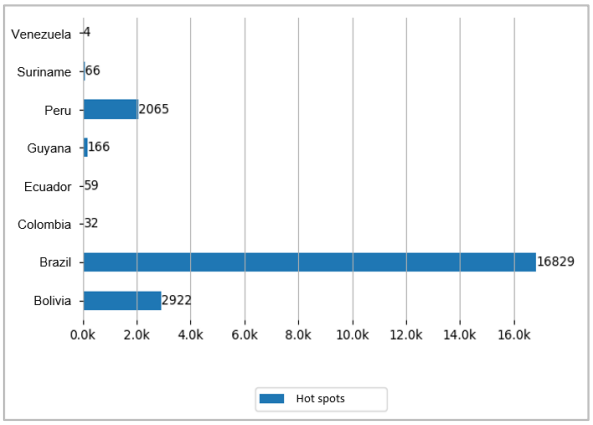


Figure 68. Hot spots by country for the day 03/09/2023

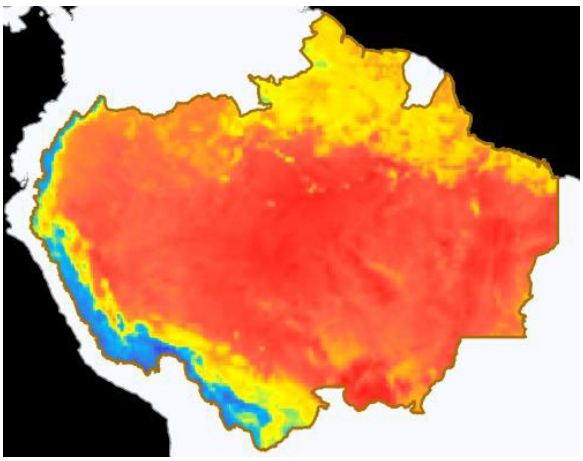


Figure 69. Map of the distribution of hot spots detected in the Amazon region on 03/09/2023

Table 8. Active fire-burn events near the boundary on 04/09/2023 (1 km distance).

Municipality	Nearby country	Approximate distance in km	Area affected approx. in hectares (thousands)	See
Guayaramerín - Boliva	Brazil	0.820	2.25	See
Guayaramerín - Boliva	Brazil	0.740	6.93	See
Guajará-Mirin – Brazil	Boliva	0.140	5.12	See
Guajará-Mirin – Brazil	Boliva	0.360	1.11	See
San Joaquin - Bolivia	Brazil	0.150	12.87	See
San Joaquin - Bolivia	Brazil	0.53 0	2.88	See
Tahuamanu - Perú	Brazil	0.39	7.96	See

[38] ORA is currently (September 2023) in a trial period and is therefore subject to possible adjustments.

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