Forest fire risk assessment and management of forest fires in regions of North Karelia and Republic of Karelia

Information Pack

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Title

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Abstract

This Information Pack was developed in the frame of Karelia CBC -project “Development of forest fire risk assessment capacity and collaboration in the context of climate change – Fire Brake (KA2013)”, which was implemented by Oy Arbonaut Ltd from Joensuu, North Karelia and Vodlozero National Park from Petrozavodsk, Republic of Karelia. During the project, the two partners studied the current situation, available resources and challenges in the field of forest fires in both regions. Some feasible tools and solutions for forest fire risk management were also researched and assessed during the project.

The information on this document was gathered by consulting various stakeholders working with the subject. Information on the available tools and solutions for forest fire risk management was gathered mainly from secondary sources.

The aim of this Information Pack is to disseminate information gathered in the framework of the Karelia CBC project to entities dealing with forest fire management and risk assessment, hopefully facilitating more cooperation in the future between the two regions too.

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Keywords

forest fires, wildfires, wild-urban interface fires, forest fire management, forest fire risk assessment, cross-border cooperation

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TABLE OF CONTENTS

1 INTRODUCTION 4
2 CURRENT SITUATION, NEEDS AND CHALLENGES 5
2.1 Detection and suppression in Russia 5
2.2 Detection and suppression in Finland 6
3 SOLUTIONS FOR FIRE RISK ASSESSMENT AND MANAGEMENT 8
3.1 Closed Circuit Television System 8
3.2 LiDAR technology 9
3.3 Satellites 10
3.4 Aerial data 15
3.5 Integrated forest fires management systems 16
3.6 Fire behaviour tools 17
3.7 Geographic Information Systems (GIS) 20
4 CONCLUSION 23
REFERENCES 24

1 INTRODUCTION

In the Karelia CBC programme region, forest is the dominant ecosystem, covering some 150 000 km² of the total 172 000 km² area of the Republic of Karelia, and 67 500 km² of the 81 320 km² of North-Ostrobothnia, Kainuu and North-Karelia regions. Simultaneously, it is widely accepted that the risk of forest fires will increase in Finland and Russia due to the climate change; together with wind storms, forest fires are one of the largest natural threats that boreal forests have to cope with.

Although Finland and Russia are neighboring countries and hence share similar kind of climate conditions, the situation with forest fires is quite adverse. While Russia is encountering large fires that are often challenging to tackle due to the immense forest lands, Finland is facing a situation where the country has gone through a big decrease in forest fire numbers and sizes in the past 100 years - and according to some research, too few fires leads to a situation where it is impossible to know the effects on biodiversity for example. Hence, there is a need to balance between the benefits of forest fires, while taking into account the risks and public safety.

Many organizations and forest land managers are facing the issue of lack of information regarding forest fire risk. Fire mitigation and monitoring can be expensive, and forest fire response is slowed down by the need of investigating the conditions in the field instead of making good decisions immediately in case of fire. This situation leads to forest fires getting unnecessarily large before they are controlled.

By improving the forest fire monitoring and modelling capacities, forest land managers like national parks or official bodies can mitigate risks more efficiently. The use of modern technologies and more accurate fire fuel information, not to mention combining various methods and means of monitoring and modelling, would allow better planning and faster operations in case of forest- or wild-urban interface fires. Some of the available solutions are recommended in the end of this report.

2 CURRENT SITUATION, NEEDS AND CHALLENGES

Forest fire and wildland-urban interface fire issues are requiring the collaboration of various organizations, service providers and research institutions. This chapter is summarizing the different needs, expectations and capacities regarding forest fires that were identified during consultations with various organizations in Finland and in Russia. While the approach to fire risk assessment and management varies depending on the function of the organization in question, it was evident that in the same time there is a vast network of cooperation and collaboration already existing.

According to officials in both countries, year 2018 was difficult regarding forest fires, mostly because of the weather conditions. High temperatures and dryness raised the risk for fires and made the fire season longer than usually. However, variation between years is quite big; for example, 2017 was a cold year with average temperature of around 13 degrees in the Republic of Karelia, which is why there was nine times less forest fires in number and in 21 times less in area compared to 2018. Hence, it seems to be challenging to make forecast based only on data of previous years and make reliable prediction for following seasons.

One main factor in efficient forest fire detection and suppression is the density of forest road network. Forest roads are not important only when in need of fire suppression, but also in detection, as citizens use the roads to recreational purposes and notice fires when outdoors. In the Republic of Karelia, the most efficient way to detect fires is monitoring by aircraft (around 80 % of forest fires detected by aerial methods), whereas in Finland fires are often detected and reported by citizens too (around half of the fires are detected from the flights, and half by the citizens).

2.1 Detection and suppression in Russia

In the Republic of Karelia, the Ministry issues annually a task for monitoring and protection of forest fires, which the Karelian Centre of Air and Ground Based Forest Protection oversees. The Karelian Centre of Air and Ground Based Forest Protection comprises of seven units located in different municipalities, and the flight plans for aviation monitoring of forest is prepared individually by each unit on annual basis. All of the seven units have a chemical fire station with appropriate equipment and human resources for ground and air-based firefighting. However, the Centre does not have its own aircrafts as the fire season is only part of the year, and it is reasonable to lease the aircraft needed.

All information from pilots, local population, foresters and lease holders is collected and analysed in an information centre, which is operating 24/7. After receiving the information, the risk and further distribution of fire is estimated and evaluation of necessary forces to be taken is chosen. Forecast is done based on information about weather, wind speed, forest type etc. If there are emergency case forces from closest units, they are also involved. In an emergency, all forces of different organisations are involved, such as lease holders, fire departments of urban area, agency for emergency service etc.

In terms of technology, Rosleshoz (Federal Forestry Agency) has developed a system for forest fire monitoring from satellites (description of the program can be found from Aviales.ru). The system has different levels of access depending on organization and the task of employer. Information is provided online and checked on regular basis in the Karelian Centre of Air and Ground Based Forest Protection too. The system is able to identify only big forest fires (ranging from four to five hectares) by presenting high temperature on the map. The main advantage of the programme is that it aids in keeping the information up-to-date and providing reporting for different levels of management.

In terms of planning, forest prevention and suppression plans are developed for one year for each forest district and national park. This plan is developed based on forest inventory and includes all information about the forest and instructions which kind of activities should be done, depend on the scale of forest fire. Fire risk mapping is done based on forest type (site type). Forest fire prevention activities include such as fire breaks, forest roads, thinning of forest, salvage logging, removing forest residuals. All the activities are planned for each year and should be done by the lease holder (if forest area is leased) or by Karelian Center of Air and Ground Based Forest Protection. 80 % of the total forest area is leased in Karelia and hence the responsibility of the activities lies mainly on the lessees.

2.2 Detection and suppression in Finland

Aerial observations are used in Finland for detecting forest fires in the fire season as well, and the routes of the flights (25 in total in the country) are pre-set and optimized to match the possible locations for fire. In the risk season there is at least one flight per day, but when the fire index is high, two flights will be done daily. The control flights are done by local aviation clubs and volunteers, who are trained for the specific task. In case of noticing a forest or wildland fire, the aviators notify the local Emergency Services Department and helps the fire fighters to locate the site.

The rescue officials are using the forest fire index (FFI) counted by the Finnish Meteorological Institute (FMI), and take into consideration also temperature, wind, humidity and biomass of the region. The index determines for example the amount of control flights required per day. FMI has a web service, where notifications are published and can be viewed by the local rescue services and other officials. When conditions are assumed to be favorable for wild fires, announcements to the general public are important too; the FMI together with local rescue officials are giving public warnings to prohibit for example open fires in the nature, to decrease the possibility of accidental fires.

Most of the fires are in the vicinity of cities and habited areas. For example, in the Northern parts of Finland, the amount of fires is a lot smaller. However, the fires around habited areas may be smaller in size, whereas in the more remote areas there is a bigger possibility that the fires will grow large. Natural parks and other nature reserves are more prone to fires, as the canopy in such areas is often multi-layer, and the risk of fire raising to canopy is hence higher too. In Finland, the most important factors in the relatively small fires are dense forest road network, sparse and small-sized forest stands (if forest is like patchwork, fire does not neighbor the next stands so easily), effective prevention of fires and efficient rescue services, in which especially the volunteers play a major part.

In Finland, especially the prescribed burnings are a very important activity that are carried out on a regular basis. These controlled burnings, conducted by for example the state-owned forest administrator Metsähallitus, benefit many other entities too, as the fires enable doing research on the effects of fire for the environment, biodiversity and fire equipment.

3 SOLUTIONS FOR FIRE RISK ASSESSMENT AND MANAGEMENT

This chapter summarizes some of the most important solutions in terms of technology, that could be utilized more commonly for forest and wild-urban interface fire risk assessment. The solutions listed are efficient especially for decision managers that need accurate and reliable data for planning of operations. The sub-chapters below explain in short the input data needed for processing and creating new information to be used in other fire management systems, as well as some of the fire behavior tools.

3.1 Closed Circuit Television System

Closed Circuit Television System is a high-tech automated surveillance network, composed of optronic systems that combine two types of cameras; video and thermal. This novel system allows locating fire sources automatically in isolated environments and away from inhabited areas and in low visibility environmental conditions (National Forest Centre 2012). Apart from the obvious fire detection use, this technology helps also in the subsequent work of extinction thanks to the thermographic real time monitoring of the fire as well as its precise location (Ricardo Vélez Muñoz 2010). In addition to the previous features, the system can be useful in controlling and supporting prevention activities on the field, discard of false smoke alarms such as working farm dust, quarries, chimneys and so on.

Picture 1. Faedo System from Indra. (Source: Digital security magazine.com)

Closed Circuit Television features provide multitude of functions, such as:

- early detection of fires,
- monitoring of fires,
- control of controlled prescribed burnings,
- real-time weather information,
- visualization of the suppression actions,
- vehicle / people tracking,
- dissuading effect,
- and discerning false alarms such as dust or real fireplaces.

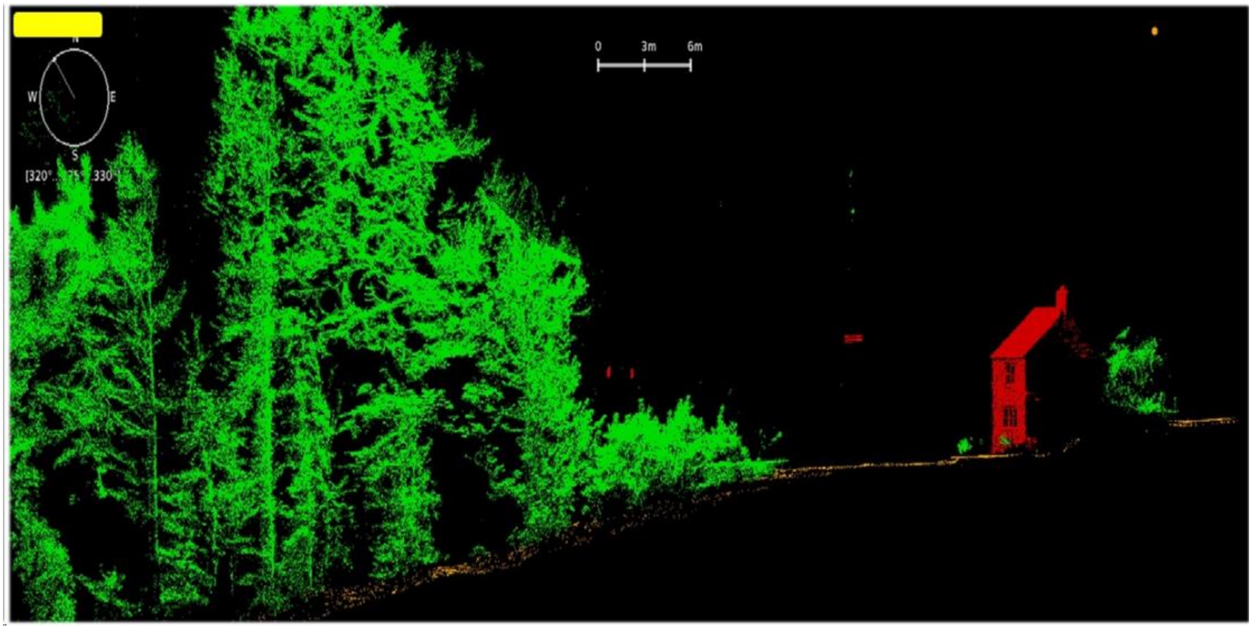
The Monitoring and data analysis system should include the following;

- infrared thermal cameras,
- high performance video cameras,
- geo-referencing system,
- communications equipment,
- computer control equipment,
- and weather stations.

To implement this kind of system, an initial investment is needed, which can be quite significant depending on the area that has to be covered. Nevertheless, it is worth in order to monitor and keep safe important natural areas. (INDRA 2017.)

3.2 LiDAR technology

LiDAR (Light Detection and Ranging) is a laser scanning technology, which generates a 3D point cloud data as an output. This output can be processed to obtain very accurate and valuable 3D information about the scanned area. This technology is at the forefront of forestry technologies but also helps in management of forest fires. LiDAR allows precise mapping of the quantity and distribution of vegetation-based fire fuels. The typical measurements taken with LiDAR include the 3D distribution of the existent fuel (vegetation) and its most relevant characteristics such as density, fuel weight, canopy base height and vegetation distribution, among others.



Picture 2. LiDAR data, presenting vegetation, growth and structures. (Source: ArboFiRM)

Nowadays LiDAR technology is being used to generate new and very precise information about the fuel and the terrain configuration which is crucial for the decision makers at the time of planning their prevention and suppression plans. With this information, both kind of plans are more precise, safe and fast to implement. (Ricardo Vélez Muñoz, 2010.) LiDAR can be combined with other kind of Remote Sensing data to conform a complete Forest Fires Management System to plan, monitor and execute forest fires prevention and suppression actions (SA Forestry 2019).

Usually LiDAR sensors are mounted in planes and helicopters to scan the area of interest, though UAVs can be an option as well. If the area of interest is very small LiDAR sensors may be mounted in drones.

There is an increasing availability of open LiDAR data. There are some countries that have scanned their entire area to have a high-quality base of raw material that can be used freely for any kind of purposes. Thus, there is a need to invest to collect the LiDAR data and it is worth to do it because the quality of the information that can be extracted from it is very high. Due to the great value in many areas of life, it tends to be an excellent investment for a country to collect LiDAR and share it openly as kind of base infrastructure. Countries like Finland and Spain have their entire countries scanned and the data is available for free.

3.3 Satellites

Satellite images are the most common kind of remote sensing data that is used currently for almost any environmental purpose possible. Most of them are open source data (free data) and cover vast areas with only one image. Another characteristic is that they can provide quite a good repeat intensity, which helps the professionals monitoring changes in any area of interest. This is very useful concerning forest fires monitoring for fire detection, fire development and post fire analyses. (Ricardo Vélez Muñoz 2010.)

Multi-spectral satellite data allows analysis of vegetation type and changes in vigor. For example, seasonal grasses that form an easily ignitable fire source, can be detected. However, one of the challenges with satellites images is their inability to measure vertical dimension. When compared to LiDAR, this attribute significantly reduces their usability.

Overall, satellite images are usually free, very easy to access to and can provide the professionals with some usable information. However, if there are adequate resources, LiDAR data is the best investment to be done as it provides the professionals with very high quality 3D information about the area of interest.

Satellites like Landsat 7 and 8 or Sentinel 2 are very common and well known among the professionals, and due to that, those images are among the most used in the world for forestry purposes and hence for forest fires management.

Landsat

NASA’s Landsat program has generated the longest continuous record in the acquisition of satellite imagery of Earth. The first satellite was launched in 1972 under the name Earth Resources Technology Satellite, though this was eventually renamed to Landsat (NASA 2019). Landsat program has collected a huge amount of data on the forests among others like farms, urban areas and freshwater. Freely available Landsat images have been, are and will be used by professionals from all over the world mainly for decision making purposes.

Landsat 7 and 8 have different wavelengths which are very useful for gathering the precise fuel information needed for developing forest fires prevention and suppression plans. Tanks to these images it is possible to calculate several vegetation indexes which will be used to generate new information such as fuel density, quantity of fuel and fire risk maps among others. There are many models that have been developed to generate quite good forestry related (including forest fires) information from satellite images (including Landsat ones).

The following are the eight Landsat 7 spectral bands, including a pan and thermal band;

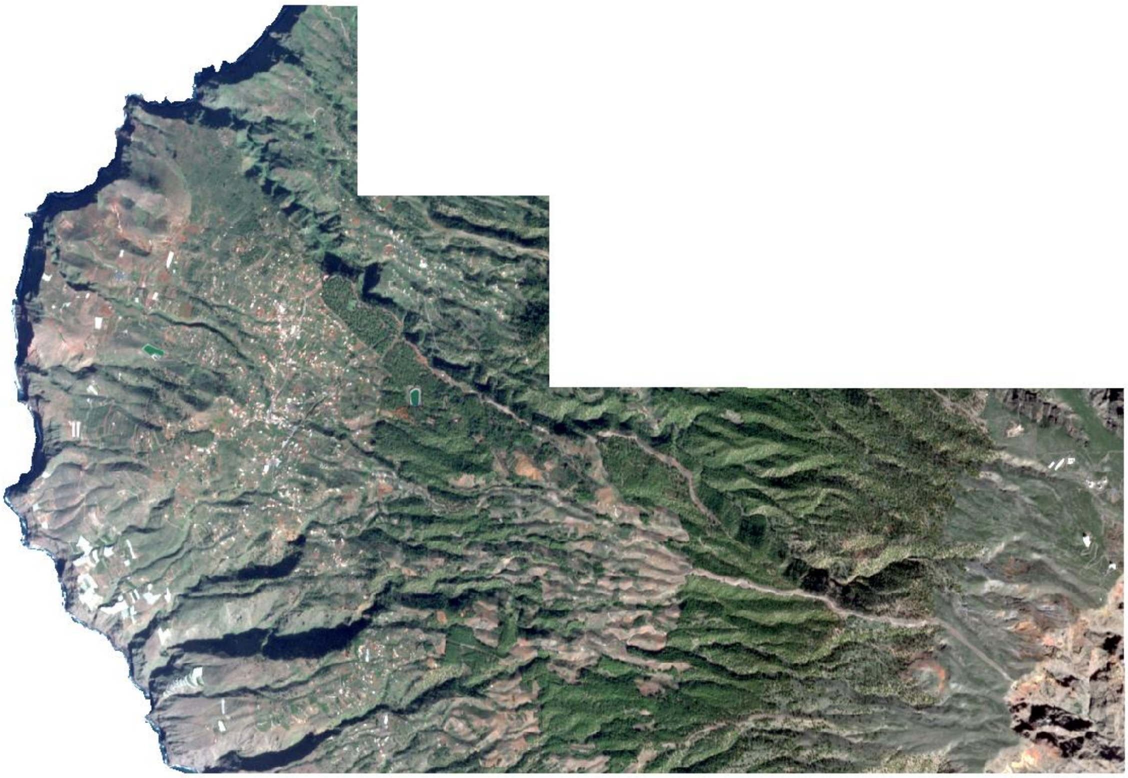
- Band 1 Coastal aerosol (0.4427 - 0.52 µm) 30 m
- Band 2 Visible (0.52 - 0.60 µm) 30 m
- Band 3 Visible (0.63 - 0.69 µm) 30 m
- Band 4 Near-Infrared (0.77 - 0.90 µm) 30 m
- Band 5 Near-Infrared (1.55 - 1.75 µm) 30 m

- Band 6 Thermal (10.40 - 12.50 µm) 60 m Low Gain / High Gain
- Band 7 Mid-Infrared (2.08 - 2.35 µm) 30 m
- Band 8 Panchromatic (PAN) (0.52 - 0.90 µm) 15 m

Sentinel

Sentinel is a multi-satellite project that is being developed by ESA (European Spatial Agency) inside the Copernicus Program (European Space Agency 2019). Six Sentinel missions are being developed at this moment which include radar and super-spectral images satellites for ground, oceanic and atmospheric monitorization.

Sentinel 2 is an Earth observation mission to provide free data for services such as natural disasters monitoring and management and the monitoring of forests evolution, among others (European Space Agency 2019). Among all the Sentinel programs, Sentinel 2 is the most relevant one concerning forest fires monitoring and management as it includes different wave lengths that can be used to calculate several vegetation indexes, such as Normalized Difference Vegetation Index (NDVI), Ratio Vegetation Index (RVI), Green Difference Vegetation Index (GDVI), among others. These indexes are very useful to calculate different vegetation parameters that can be used to develop new information such as fuel volatility which it is used to create forest fires risk maps. Thus, Sentinel 2 obtains very useful data from which professionals can extract crucial vegetation (fuel) information which is the base for developing new specific fire data.



Picture 3. Sentinel 2 Image. (Source: Puntagorda, La Palma, Canary Islands, Spain)

Sentinel 2 has two twin satellites: Sentinel-2A and Sentinel-2B. Sentinel 2 spectral bands include;

- Band 1 Coastal aerosol (0.443 µm) 60 m
- Band 2 Blue (0.490 µm) 10 m
- Band 3 Green (0.560 µm) 10 m
- Band 4 Red (0.665 µm) 10 m
- Band 5 Vegetation Red Edge (0.705 µm) 20 m
- Band 6 Vegetation Red Edge (0.740 µm) 20 m
- Band 7 Vegetation Red Edge (0.783 µm) 20 m
- Band 8 NIR (0.842 µm) 10 m
- Band 8A Vegetation Red Edge (0.865 µm) 20 m
- Band 9 Water vapour (0.945 µm) 60 m
- Band 10 SWIR - Cirrus (1.375 µm) 60 m
- Band 11 SWIR (1.610 µm) 20 m
- Band 12 SWIR (2.190 µm) 20 m

Satellite Active Fire Detection

Nowadays it is possible to detect hotspots from satellites. These hotspots can be active fires or not, thus the data should be checked and filter in order to detect the real active fires out of the initial hotspots. There are many instruments attached to several satellites that are able to detect active fires, and two of the most important ones are the following:

- MODIS;

  The Moderate Resolution Imaging Spectroradiometer (MODIS) is an instrument (sensor) which is on board the multi-national NASA scientific research Terra and Aqua satellites. MODIS sensor identifies hot spots which basically are areas on the ground that present significantly higher temperature than their surroundings and consider them as active fires. The spatial resolution of the active fire detection pixel from MODIS is 1 km.

- VIIRS;

  The Visible Infrared Imaging Radiometer Suite (VIIRS) is an instrument (sensor) which is on board the joint NASA/NOAA Suomi National Polar-orbiting Partnership (Suomi-NPP) satellite. VIIRS and MODIS uses similar algorithms to detect hot spots (active fires).

The spatial resolution of the active fire detection pixel for VIIRS is 375 m and therefore, it provides a greater response over fires of relatively small areas and provides improved mapping and delineation of perimeters of ongoing large fires. Thus, VIIRS complements MODIS very well concerning active fire detection. MODIS and VIIRS data are perfect in support of fire management and in the creation of accurate fire maps (European Commission 2019).

The most important systems using MODIS and VIIRS are:

- FIRMS (Fire Information for Resource Management System);

  a part of NASA's Land, Atmosphere Near real-time Capability for EOS (LANCE). It distributes Near Real-Time active fire data within 3 hours of satellite observation from MODIS and VIIRS. The active fire / hotspot data can be viewed in FIRMS Fire Map or in NASA's Worldview (NASA 2018).

- EFFIS (European Forest Fire Information System);

  a part of the Copernicus Emergency Management Service (EMS) which is a European Union programme managed by the European Commision (EC). EFFIS is a web-based geographic information system that provides fire danger forecasts up to 10 days in advance and near real-time and historical information on forest fires and their regimes in the European, Middle East and North Africa regions.

Picture 4. EFFIS Viewer showing the Fire Danger Forecast, 18 March 2019.

Fire monitoring in EFFIS encompasses the full fire cycle, comprising near-real time information services regarding the current and future fire danger forecast, active fires and burned areas, and post-fire damage assessments. The extension of EFFIS towards a Global Wildfire Information System (GWIS) is underway in collaboration with the Group on Earth Observations (GEO).

EFFIS uses a large variety of data in its assessments, including meteorological information for fire danger forecast, remote sensing satellite imagery for active fire and burnt area mapping as well as information of fuels, topography, soils, etc. to assess environmental damages caused by fires (European Commission 2019).

3.4 Aerial data

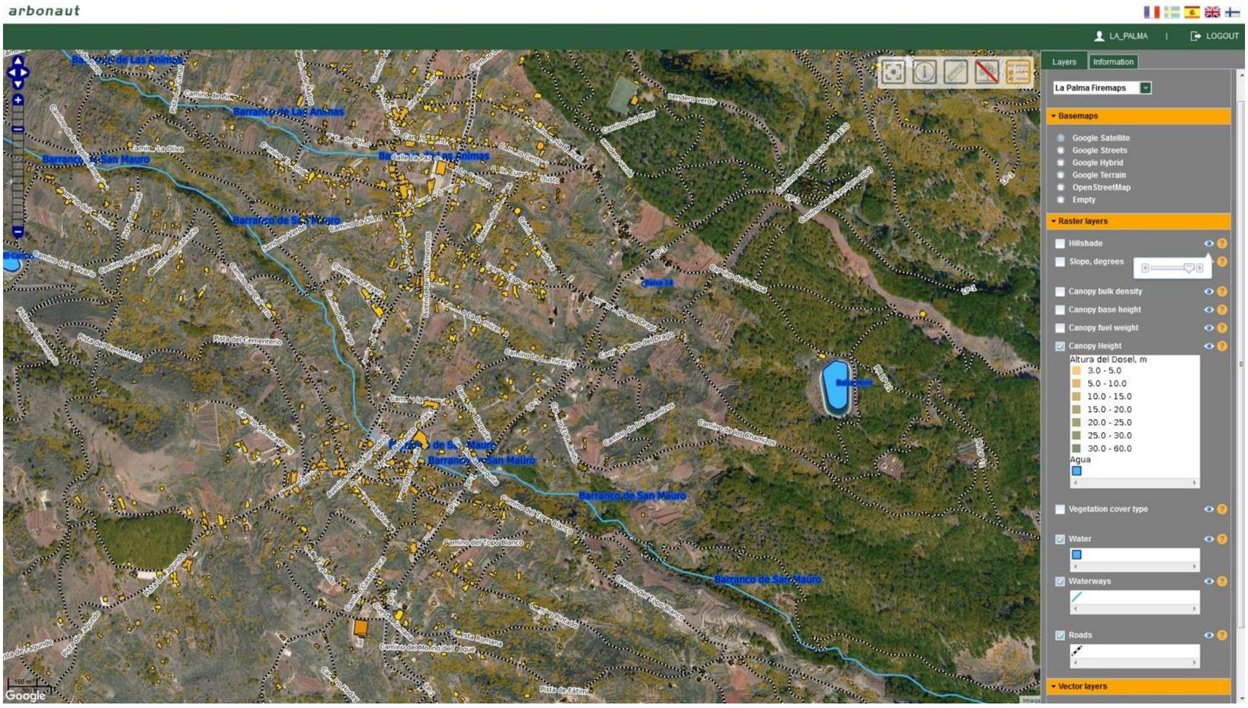
Aerial images have been used for many years as a base remote sensing method. Aerial campaign can cover quite large area with a very high-resolution level. Comparing between satellite images and aerial ones, the biggest difference is the higher resolution of the aerial data.

Nowadays it is possible to extract quite a lot of information from the aerial images thanks to the new data processing tools that geographic information systems have. Technology is being developed and new techniques and tools are coming every now and then. However, aerial images have the same limitations as spectral satellites on the detection of 3D features. Therefore, they are most commonly used as a supporting information with LiDAR.

The availability of aerial data depends on each country and its National Forest Management Planning. There are many countries that have covered their entire areas with aerial images and keep it as open source data (Gobierno de España 2019).

3.5 Integrated forest fires management systems

An integrated forest fires management system is a tool from where it is possible to manage different actions concerning forest fires. It may be possible to plan both prevention and suppression, follow the suppression actions on real time including the tracking of crew members, simulate the progression and much more.



Picture 5. ArboFiRM. Wildland-Urban Interface Area, La Palma (Spain).

This kind of systems use input data from variety of sources, allowing access depending on the rank of the personnel within the team. Systems may include a combination of input data derived from LiDAR, satellites, aerial imagery, weather information and data from other relevant sources.

Countries such as Spain or United States have their own internal fire management systems (Gobierno de España 2019).

3.6 Fire behaviour tools

Fire behavior tools can be used for modelling the behavior of fire, taking into consideration for example the weather and vegetation parameters such as density, moisture etc. In this sub-chapter the most commonly used ones are explained in short.

FARSITE

FARSITE is a fire growth simulation modeling system which uses spatial information on fuels and topography along with weather and wind files to simulate the spread of wildfires. FARSITE simulates wildfire behavior and growth for different time periods under heterogeneous conditions of terrain, fuels, and weather. It simulates, as well, ground and air suppression actions. (U.S. Department of Agriculture 2018.)

Due to the complexity of FARSITE, only users which are familiar with the terminology as well as with the fuels, weather, topography and wildfire situations are in the best position to utilize it.

FARSITE uses the following spatial and tabular data;

- Landscape (.LCP) file,
- Initial Fuel Moistures (.FMS) file,
- Optional Custom Fuel Model (.FMD) files,
- Optional Conversion (.CNV) files,
- Optional Weather (.WTR) files,
- and Optional Wind (.WND) files.

It also incorporates the following fire behavior models;

- Rothermel's (1972) surface fire spread model,
- Van Wagner's (1977) crown fire initiation model,
- Rothermel's (1991) crown fire spread model,
- Albini's (1979) spotting model,
- and Nelson's (2000) dead fuel moisture model.

FARSITE is widely used by the U.S. Forest Service, National Park Service, and other federal and state land management agencies.

FlamMap

The FlamMap fire mapping and analysis system (Finney 2006; Stratton 2006) describes potential fire behavior for constant weather and fuel moisture conditions. Due to the constant landscape conditions, FlamMap does not calculate fire spread across a landscape. As fuel is the only variable that changes, FlamMap is good for the comparison of different kind of fuels placed in different kind of topography, in order to test potential fuel treatment effectiveness.

FlamMap outputs are raster maps of potential fire behavior characteristics (crown fire activity, spread rate etc.) and environmental conditions. The maps can be viewed in FlamMap or in any GIS program, word processor or image viewer software. To sum up, FlamMap is not a complete fire growth simulation model as there is no temporal component. It calculates fire behavior characteristics for certain environmental conditions using spatial information on topography and fuels. (U.S. Department of Agriculture 2017).

As well as FARSITE, FlamMap is widely used by the U.S. Forest Service, National Park Service, and other federal and state land management agencies and it is as well designed for being used by professionals. It uses the same spatial and tabular data and incorporates the same fire behavior models as FARSITE.

BehavePlus

BehavePlus is a Windows® based fire modeling system which models fire behavior and a few fire effects (BehavePlus Fire Modeling System 2019). This fire modeling computer program can simulate rate of fire spread, spotting distance, tree mortality, fuel moisture, wind adjustment factor, and many other variables. Thus, BehavePlus can predict fire behavior in different scenarios (depending on each situation).

As this modeling system is working with models and different variables related to fire modeling, it is a must for the users to have experience and training in fire behavior models in order to know which variables to include and how to interpret them to be able to understand the whole picture and to know which adjustments are needed to model the fire behavior properly.

Some applications include;

- predicting the behavior of an ongoing fire;
- planning fire treatments;
- assessing fuel hazard;
- and understanding fire behavior.

BehavePlus has some fire modeling capabilities, such as;

- SURFACE module
  - Surface fire behavior, including rate of spread and flame length
  - Includes the standard fuel models (13 + 40)
  - Allows for custom fuel model development and use
  - Special case fuel models including palmetto-gallberry, western aspen, and chaparral
- CROWN module
  - Crown fire behavior, including rate of spread and flame length
  - Transition from surface to crown fire
  - Fire type - surface, torching, conditional crown, crowning
  - Flame length and intensity
- SIZE module
  - Assumes a point source fire with steady-state spread
  - Perimeter
  - Shape (length-to-width ratio)
  - Area
- CONTAIN module
  - Fire containment of a point source fire
  - Containment success based on available resources (single or multiple)
  - Final size, fireline constructed
- SPOT module
  - Maximum spotting distance
  - Torching trees
  - Active crown fire
  - Burning pile
  - Wind-driven surface fire
- SCORCH module
  - Crown scorch height from surface fire flame length and flame tilt
- MORTALITY module
  - Tree mortality
  - Probability of mortality from crown scorch
- IGNITE module
  - Probability of ignition from a firebrand

Probability of ignition from lightning

- Fire Characteristics Chart

  Graphical representation of modeled or observed fire behavior for:

  - Surface Fire Behavior
  - Crown Fire Behavior
  - Fire Danger Rating.

3.7 Geographic Information Systems (GIS)

A geographic information system (GIS) is a system created to read, analyze, process, manage and present geographic or spatial data. This systems are able to manage data that is structured in data bases, spatially referenced and that can be graphically shown (maps). The most used ones are ArcGIS (ESRI. ArcGIS Pro. 2019) and QGIS. These systems are very similar in terms of use purposes but not concerning their work environment, some tools and the price (ArcGIS requires a paid license and QGIS is a free system).

The basic functions of GIS systems are:

- A graphic representation system (lines, points, etc.) where the different elements are referenced through geographic or cartesian coordinates.
- A data base able to operate the alphanumeric and graphic data.
- An access system which allows different kind of queries between the alphanumeric and graphic data.
- A system that generates alphanumeric documentation as well as automatic cartography.
- An import and export system which is linked to a language that allows custom programming.

Basically, GIS functions can be sum up in:

- Input data
- Data management
- Transformation and analysis
- Edition

There are two spatial data models:

- Vector model: the representation of reality is made by points and lines. The areas or surfaces are described by the set of border lines that circulate them.

- Raster model: the objects are represented by homogeneous units called cells, which are referenced in lines and columns.

For the vector model the space is continuous and the spatial objects are shown in an explicit way, which concerning physical planification, like forest fires protection planification, is an important aspect, where the exact location and representation of the spatial forest events is an essential condition.

However, satellite images and digital models are better represented in the raster models where the cell is the basic unit and all have the same shape and size and contain a numeric attribute which represent the parameter of interest. Fortunately, there are commercial systems and GIS packages that include both work environments (vector and raster).

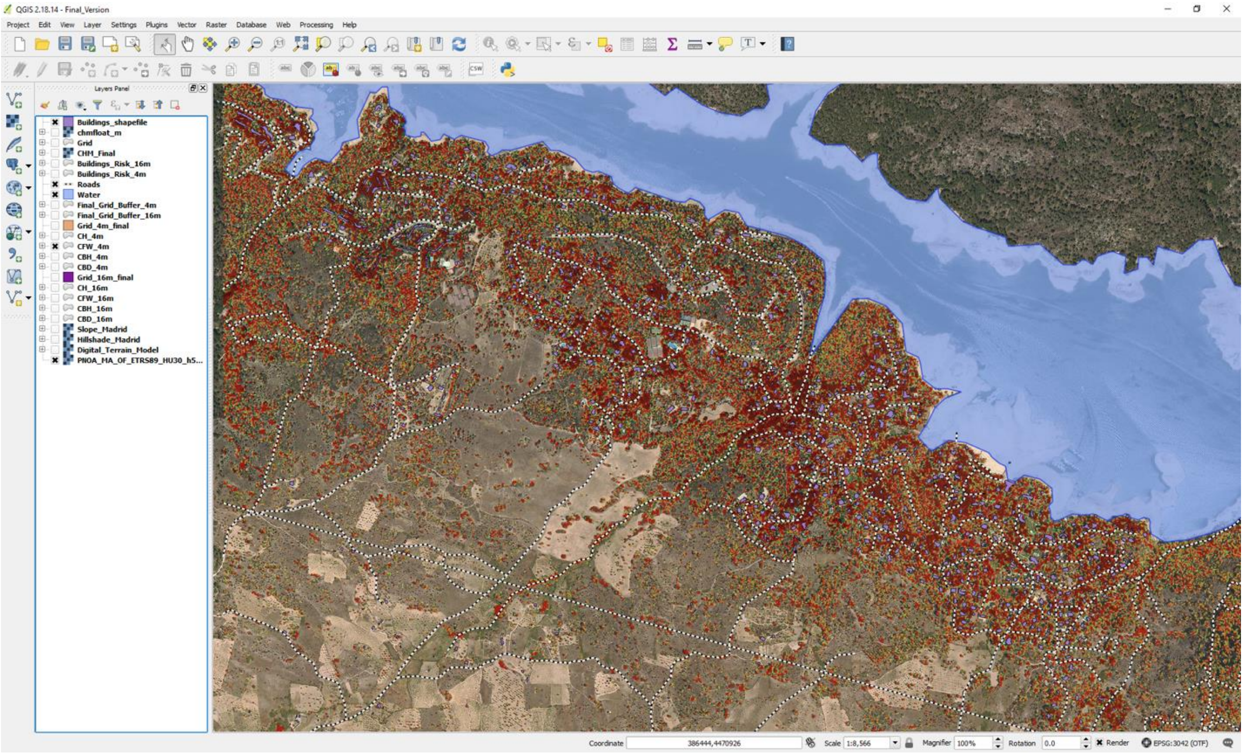
It is possible to affirm that a GIS integrate data and knowledge. The data characterize the studied space or object, while the knowledge represent what it is known about the behavior and the internal and external relationships of the object through rules and models (Ricardo Vélez Muñoz. 2010).

It is important to explain that concerning forest fires GIS systems have very useful and easy to use data processing tools. They bring the proper environment to the users and they are one of the best systems to create new useful and specific data for forest fires from remote sensing data such as satellite or LiDAR based data. Working with GIS systems, it is possible to produce accurate and precise maps for both fire prevention and fire suppression out of raw remote sensing data.

Some of the most common GIS tools used in forest fires management are:

- Analysis Tools
- Cartography tools
- Conversion tools
- Data Management Tools
- Editing Tools
- Spatial Analyst Tools
- Spatial Statistics Tools

Another important characteristic is that it is possible to implement new needed tools to the GIS programs to be able to produce the fire data that we need in the proper time and way (like the forest fires management tools from ArboLiDAR tool package).



Picture 6. Forest fires data processing in QGIS, ArboFiRM tools. Madrid Community, Spain.

In general, every GIS program is compatible with the same kind of data formats such as raster (.tif) or shapefiles (.shp), which helps a lot when using different GIS programs is required to produce certain specific fire data. Thus, it is not necessary to convert the data because it is totally possible to use the same remote sensing data, or even new specific data that has been produced, in different GIS systems at the same time due to the capacity of using the same data formats. However, as it is mentioned before, there are GIS conversion tools that allows the users to work with a huge number of different data formats.

To sum up, GIS systems are the perfect tools to process the remote sensing and spatial data which will allow us to create new and specific forest fires information (usually maps).

4 CONCLUSION

In terms of future development activities in forest fire risk assessment and management, there is some common interest on organizations on both sides of the border. One topic was the use of drones; could they be utilized more in the future for forest fire monitoring, and could drones replace helicopters in forest fire operations in the long run? Drones are a relatively cost-efficient and more effective way for doing forest fire detection and could be utilized simultaneously for monitoring illegal logging and forest inventory activities in some regions. Another valuable subject of study would be creating more advanced forest fire management systems, which could combine information from many different sources and organizations more widely than at present.

The topics of research are expected to be also around forest fires in relation to climate change, as in the future there will probably be higher risk of fires, rising from the Southern Europe to North. In Finland and Russia too, it could lead to bigger number of fires and bigger burned areas. One of the development issues would be take more into account the forest type, stands and other forest information when assessing the risk of forest fires.

Ultimately, it seems to be commonly acknowledged that there could be more cross-border cooperation between the two countries in form of exchanging information of forest fires. Especially with predicting the fire and smoke movements close to the border area would benefit organizations and citizens of Finland and Russia.

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