***Wildfire Hazard plugin*: How to use**

**Instructions for running the forest fire plugin**

1. **Load the input** layers

In QGIS, import the layers (drag and drop) that will be processed by the ***Wildfire Hazard plugin***:

* + **Shapefile** of historical **burned area**
  + List of **raster** file that will be used for creating the dataset (i.e. land cover).

Please note that this step is not mandatory: is possible to load these layers directly from the plugin interface, but in this case they won’t be visible in the QGIS layout.

1. **Open** the ***Wildfire Hazard plugin***

In the main bar click on ***processing 🡪 Toolbox***. The processing toolbox will pop up on the right of the QGIS interface. At this point, if the plugin were installed correctly, search for ***Wildfire Hazard*** and double click on the ***Wildfire Hazard plugin***.

the plugin interface will pop up.

1. **Upload the input data** requested by the plugin following the explanation given in the next paragraph. (for the hazard modules all the files are available at *./data\_for\_testing/input\_hazard*

**Detailed compilation**

1. *Shapefile of study area*: this is an optional file, the country’s administrative level is the domain of our training, If anything is passed, the DEM layer (next input) will be used as reference domain.
2. The next required input data are the *DEM*, *land cover* and *past observed wildfires*: the first input is the elevation raster file, burned areas are in shapefile format, while land cover can be either a shapefile or a raster file. The file names are:

*DEM*: **“dem\_montenegro\_100m.tif”**

*Land cover*: **“veg\_arr.tif”**

*Wildfires*: **“fires\_2009\_2021\_epsg3035”**

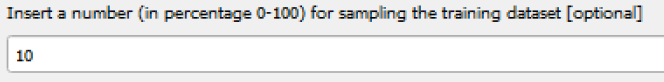
**NOTE:** insert just one file for the *land cover,*if it is provided in shapefile format, please fill in the right place the **field name** that will be used for rasterizing processes.

Graphical user interface, text, application, email

Description automatically generated

Example of compilation

1. At this step a sample *number* between 0 and 100 is required for reducing the training dataset size. The number represents the **percentage of the total burned points** available and they will be used to create the training dataset.



Reducing the number of sample points will reduce the computation speed and will exclude some wildfires from the training phase of the machine learning model.

1. The next input data (optionals) are other *raster files* (e.g. mean annual temperature, distance from roads etc.) that can be included in the machine learning dataset. Each raster file will populate the ML dataset representing a new model feature.

Graphical user interface, text, application, Word

Description automatically generated

1. As additional input file, an *excel table* is required in order to perform the aggregation of the land cover map in fuel type classes.

By default a pre-filled file is shown and it is valid only if CORINE land cover map is selected as vegetation file at step 2.

If users are going to use a different land cover map, they must fill this excel file with the correct mapping.

The first columns on the left contains all the land cover classes of the input file whereas the second column includes the classes of fuel type, where in this case:

1 = grasslands and croplands

2 = low flammable forest (such as broadleaves)

3 = shrublands

4 = high flammable forest (such as conifers)

Finally, a third column is used to define which code is not burnable (e.g. urban area classes) if there is a *y,* (which stands for *yes*) it means that the specific class is not burnable and will be excluded from the computation of the wildfire susceptibility. Depending on the QGIS version the not burnable labels have to be specified (e.g., *no*) instead of leaving the values empty.

1. At this point, it is possible to run the ***Wildfire Hazard plugin*** . Note that the **output files** related to the *wildfire susceptibility\**, *fuel type map* and *hazard\*\** will be saved in a newly directory at the following path:

**“C:\Users\[username] \Downloads\Hazard\_outputs”**

\*two maps will be generated. A continuous map with values from 0 to 1 and a 3-classes map showing low, medium and high susceptibility, which, in turn, is used as input for the hazard map.

\*\* 2 maps are generated, a 6-classes map and a 12-classes map. The first one is used in the IPAFF version for the ***Wildfire Risk plugin*** while the second one for the AAL version. In addition, a probability.tif file will be generated and used as input in the ***Wildfire Risk plugin*** of AAL version.

**Additional notes**

Please note that if the input files were not directly loaded in QGIS, each input should be selected by clicking in the 3 points button and searching for the local file path. In the selection of raster layers, *Add files* button should be clicked in the window that will pop up after hitting the 3 points button.

When the model has finished the run, in the *log window* it is possible to see the performance indicators of the machine learning model and the variable importance:

Graphical user interface, text, application

Description automatically generated

Model performances and feature importances in the plugin output

**Exposed element processing – *Processing Exposure plugin*: How to use**

**Brief description of the plugin**

The ***Processing Exposure plugin*** is a tool that will prepare the data in the correct format for running the ***Wildfire Risk plugin***. The latter, in fact, accepts as input separate files for every exposed element. This, in turn, allows the user to provide some additional data related to each asset, such as its vulnerability curve and value.

For opening the plug-in interface, double click on the ***Processing Exposure plugin*** icon of the QGIS toolbox (as explained in the *MODULE 1: wildfire hazard*) then fill the input boxes as described in the next paragraph.

**Detailed compilation**

1. Load the *dem file*of your study area: this file is necessary for reprojecting some files such as the land cover map.
2. Load the *input land cover map*: The map will be used for extracting exposed land cover types for which the risk will be evaluate.

The user can choose if loading directly a raster file or a shapefile. In case a shapefile is provided, this will be rasterized using the DEM as reference (selecting the name of the field for the rasterization is necessary) and the final geotiff will be saved in a new output folder (*Downloads/Layer\_procesed*)

1. The next input requires an *excel file* mapping the land cover classes with the **fuel types**: the output file will be a different raster for each fuel type defined (to each of these fuel type classes – representing a specific exposed element – the ***Wildfire Risk plugin*** will associate a vulnerability and exposure value). Check the default path to have a sample file.

The last column of this file allows the user to define which class refers to urban areas (put y in correspondence to an urban area class), to evaluate the **urban interface**. The algorithm will select those codes from the land cover map and will provide a raster file of the wildland urban interface (WUI).

**NOTE**: this step is useful in case the user needs to split a unique file in different exposed elements files, as requirement of the ***Wildfire Risk plugin***. If separate files are already available by the user this step can be skipped and the input layer (POI) should be leaved empty.

1. Load the **shapefile** of the *point of interest* (**POI**) (such as buildings, hospitals, schools, etc.). This is optional, in case it is provided, the column (**field name**) for the attributes to be selected has to be defined in the next input parameter.

In this example, *OpenStreetMap* (OSM) data are provided, and point of interest can be found at ***./data\_for\_testing/input\_processing***

Graphical user interface

Description automatically generated with medium confidence

1. Similarly, the same procedure is applied to the *shapefile of roads*, then input path and field name have to be specified.

Graphical user interface

Description automatically generated

**NOTE**: if files are provided in steps 4 and 5 follow this instructions, otherwise skip this step.

The next 2 parameters are *2* *tables*, they give information on how to split *the POI and roads files*, each output will represent a single exposed element with its vulnerability curve and exposure value.

The structure of the table is the following:

Graphical user interface, text, application, email

Description automatically generated

It has **2 columns**, the first one is a user defined **name** for identifying the exposed element, the second column represents the **attribute names** associated to each category under the field defined by the user in the previous step (see point 4 and 5).

For instance, the first row means that I am creating the hospital layer extracted from the general *point of interest file*: the attributes called *clinic*, *hospital* and *nursing\_home* will be selected. These names are present in the OSM POI shapefile under the field *fclass* that has been defined in the previous step (see step 4).

**NOTES**:

* In this example 3 different attributes are selected regarding the *hospital*s category, in this case, the names have to be comma separated, as represented in the picture above.
* Do not put more than 5 rows for each run, the plug-in is configured in a way to accept at maximum 5 categories, if you want to add more, run a second time the tool with different data in the input table.
* If you want to add or delete rows press the **“Add/Remove Row”** in the right side of the table, after compiling the table, press “**ok**” button.

1. Processed files will be automatically saved in “***Dowloads/Layer\_processed”*** directory. Consequently, the output file path in the plugin can be left empty.

Once completed, click the “**Run”** button for starting the processing algorithm.

***Wildfire Risk plugin*: How to use**

**Brief description of the *Wildfire Risk plugin (IPAFF version)***

The tool assesses the wildfire risk taking into account the wildfire hazard and an available set of exposed elements. The following methodology is related to the IPAFF version, while the further inputs and modification for the AAL version are introduced in the last paragraph.

For download install and open the ***Wildfire Risk plugin*** interface please follow the same general steps described in the ***Wildfire Hazard plugin****.*

**Detailed compilation**

1. First input is the *shapefile of the study area*, it is optional, in case it is not provided the vegetation layer will be used as reference raster file representing the domain of the study area.
2. Load the *input land cover map* (output of the ***Processing Exposure plugin***): the raster file will be used as reference file for the other geotiff generation in this tool.

**NOTE**:

The rasterized land cover file is an output of the***Processing Exposure plugin***. The file, together with all the needed input for running the plugin can be found at ***./data\_for\_testing/input\_risk***

1. Load the *hazard layer*, it will be used for building the vulnerability maps. The layer is an output of ***Wildfire Hazard plugin*** *(hazard\_ipaff\_version.tif*).
2. In this step the **file path** in which the exposed elements are stored is required.

The default directory path contains all the single exposed elements necessary to run the plugin.

1. The next 3 parameters represent the **input tables** of the **exposed elements**. The first table identifies the point of interest (POIs), the second one the roads and the third one the vegetation types. Each table has the same structure and the table for the POI is presented as working example in the following picture.

A screenshot of a computer

Description automatically generated

The table contains 8 columns and a number of rows is equal to the number of the files representing different exposed elements.

* The first column contains the information about the **file name** in input and should specify its extension (.shp), for example *hospitals.shp*.
* the next 6 columns (from V1 to V6) represent the **vulnerability curve** of the element.

*They represent the impact (as potential damage from 0 to 1, where 1 is totally destroyed and 0 is not affected) related to each intensity/hazard class (the layer is, in fact, categorized in 6 classes). For instance, V1 is the degree of damage expected for an event of intensity 1, V2 is the degree of damage expected for an event of intensity 2, and so on.*

* The column name “E” refers to the **exposure**, namely the value of the element. For the scope of this training, the value is reduced to an **importance level** from 0 to 100 based on its priority in case it will be affected by a wildfire.

The same procedure is replicated for the *roads* and *vegetation*. After completing the***Processing Exposure plugin***, the input layers will be available in **“Dowloads\** **Layer\_processed”,** otherwise they will be accessible at **./data\_for\_testing/input\_risk.**

1. ***Wildfire Risk plugin*** assesses the risk for 2 more layers:

* the **population** at risk
* the risk in **urban interface**

the *population risk* is evaluated through a contingency matrix between population density and wildfire hazard while the urban interface is evaluated with a maximum sliding (3x3) windows applied on the hazard map. The layer of *population* and *urban interface* has to be loaded in the next 2 parameters of the tool.

The *urban interface layer* comes from the ***Processing Exposure plugin*** while the population layer is retrieved from *GHLS* and it is available at 100m resolution (*pop\_mne\_100m\_3035.tif)*.

**NOTE:** the last parameter is linked with the population file, it is a *multi-selection box* useful for rescaling the *population layer*. This works in case the population is at **1 km resolution**, it will be correctly rescaled at the working resolution.

For the scope of this tutorial, select “**do not rescale”** since the native *GHS population* resolution is already at the working resolution of 100m.

Graphical user interface, text, application, email

Description automatically generated

Example of compilation

1. Finally, define the **output path** for saving the POI risk shapefile, by default it is saved in the newly automatically created output folder **(\Downloads\output\_risk).**

When all the input data are filled in, you can click on “**Run**” button for assessing the wildfire risk.

**Brief description of the *Wildfire Risk plugin V2 (AAL version)***

This version is developed to get a better quantitative estimation of the losses, passing from a qualitative risk level to an Average Annual Losses estimation that can be further aggregated in risk classes. The main difference is that the hazard has now 12 classes and describes the potential behavior of wildfires inside the area of interest considering a worst case scenario. A likelihood term is added to the loss computation based on the average percentage of each hazard class burned in the past. This term is directly combined with the value and vulnerability of each asset. The value of each asset is an average economic value and by default is retrieved by *Global Earthquake Model* data in southern European countries (Croatia, Bulgaria, Romania and Greece).

**Additional/modified inputs**

1. Hazard file: the hazad file is a 12-classes geotiff (*hazard\_12cl\_aal\_version.tif*)
2. A likelihood map is required to have a better understating of the potential frequencies of wildfire occurrences and adjust the limitation due to the worst case scenario computation (probabilities\_aal\_version.tif).
3. The fuel type map (4 classes of fuels, described in the ***Wildfire Hazard plugin*** step 5) is required as input. This is because the potential impact due too the vulnerability of each asset is now linked directly with the fuel type, considered as a proxy for wildfire intensity in a qualitative fashion.
4. The input tables for the assets now changes considering the 4 levels of fuel type/intensity:

A screenshot of a computer

Description automatically generated