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Wildland-Urban Interface (WUI) and forest fire ignition in Alpine conditions (WUI-CH)

Final Report

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1. Introduction

The Wildland-Urban Interface (WUI) is a broadly used term in the context of wild- and forest fires (Stewart et al. 2007) for indicating areas where houses and other human infrastructures meet or intermingle with wildland vegetation, rural areas or forests (Radeloff et al. 2005a,b; Alavalapati et al. 2005; Collins 2005; Theobald and Romme 2007; Guglietta et al. 2010). Many vexing problems are associated with the WUI such as spread of invasive alien or indigenous species, human-wildlife conflicts as well as conflicts between urban people and traditional agricultural activities (Alavalapati et al. 2005; Platt 2009). But, in dense populated areas where the fire regime is dominated by anthropogenic-induced fire ignitions, the problems related to fire hazard and fire management are by far the most relevant in relation to the WUI (Davis 1990; Platt 2009; Lampin-Maillet et al. 2010). In fact the coexistence of urbanization and wildland enhances both the anthropogenic ignition sources and flammable fuels. Furthermore, the growing trend of the WUI in most countries and the expected effects of global change may even worsen the situation in the near future (Theobald and Romme 2007; Zhang et al. 2008; Mell et al. 2010). Most of the research existing on the topic refers to the WUI problem in the United States (Mell et al. 2010), Australia (Gill and Stephens 2009), and Mediterranean Europe (Caballero 2004 in Lampin-Maillet et al. 2010; Eurofirelab 2004). In the Alpine region the WUI may display very specific patterns than those observed in other environments, mainly due to the different general socio-economic and environmental conditions, as well as the related fuel types and fire behavior.

As pointed out by Platt (2009) and Stewart et al. (2007), the WUI assessment and the related fire risk is mainly an issue of definition and parameterization that have be adapted to the local conditions. For this reason the main general objectives of the present study are:

1. The evaluation of the best suited information from GIS and space borne remote sensing sources (RS) for mapping and monitoring the WUI in Alpine regions;

2. The implementation of the obtained results in a WUI model for Alpine region enabling forest managers to implement fuel management programs.

The resulting WUI mapping approach should be semi-automatic and systematic (on large scale) enabling to assess whole administrative units (e.g. cantons) in a work and cost extensive way.

2. Selecting the suitable RS and GIS input data

2.1 Geographic data acquisition

In order to evaluate the most suitable parameters for modeling the geographic location of the anthropogenic fire ignition, available remote sensing and topographic information have been used to generate as much as possible variables to be tested as possible fire ignition predictors.

For this preliminary step, we selected the Canton Ticino as study area, due to the high frequency of anthropogenic fire ignitions. As data sources we selected the VECTOR 25 and DHM25 of the Swisstopo and the USGS online archive of Landsat data covering the whole study area. An additional data source represented by the IKONOS images has been acquired for a subarea of 10 by 10 km around Lugano due to the limited availability and the high costs of the data. Starting from these three different sources, following explanatory variables were created (see table 1).

Table 1. Explanatory variable tested in relation to anthropogenic fire ignition

Short name	Description	
Dis_stb	Distance from closest building or street	Vector 25 DHM25
Dis_vin	Distance from closest vineyard	
Dis_pat	Distance from closest path	
Den_bu	Amount of building area in a radius of 100m	
Mor_ele	Elevation	
Mor_slp	Slope	
Mor_asp	Aspect	
LC_maj	Spectral class assigned to the pixel in the majority of the dates	Landsat
NDVI_me	Median NDVI value 1985 – 2010	
NDBSIme	Median NDBSI value 1985 – 2010	
Bri_me	Median brightness value 1985 – 2010	
Text_NI	Texture homogenity of the IKONOS NIR band	Ikonos
TxtNDVI	Texture homogenity of the NDVI index calculated from IKONOS	

a) Swisstopo data VECTOR 25 and DHM25

Distance from the closest building or street (Dis_stb). As it has been shown in different papers by Lampin-Maillet et al. (2009, 2010) the street's network represent a central element of WUI. At the same time, some of the activities related with dwelling management (for example the garden maintenance, the practice of particular hobbies, etc.) are also expected to represent a potential fire ignition's danger. Initial investigations of the input data showed that both buildings and streets are two very important parameters in the WUI dynamic for the Alpine region. Due to these reasons it is decided to generate a single parameter representing the distance from the closest object of the two mentioned classes (Dis_stb). Only streets belonging to the classes 1-5 are used for the generation of this parameter. Tunnels are removed from the analysis. High- and motorways have not been considered since in the test area their presence is limited to the bottom of the main valleys. Pathways are considered separately in a different parameter. Buildings are all treated in the same way, without any particular building type discrimination. The result consists in a raster-parameter with 5m spatial resolution.

Distance from the closest pathway (Dis_pat). Pathways are substantially different from the other street classes (of the street layer of the VECTOR25 dataset) due to the prohibition to use them by other way than by foot. Due to these reason we decided to consider them as a separate WUI element and therefore to generate a single parameter describing the distance from the closest pathway (Dis_pat).

Distance from the closest vineyard (Dis_vin). Due to the particular vineyard management's activities (e.g. the use of fire for specific tasks) it has been decided to evaluate if also the plays a significant role in the WUI dynamic of the Alpine region. Therefore, a raster with 5m spatial resolution is created adopting the same methodology as described above for streets and railways. The resulting parameter Dis_vin is derived from the vineyards polygons extracted from the Swisstopo 'Primarflächen' dataset (VECTOR25).

Building density (Den_bu). Generally a building does not increase per se the potential danger of fire ignition. The eventual fire danger is rather related to the human activities located in proximity of the buildings. As explained above, only certain human activities are potentially considered as dangerous. We propose to differentiate between different human activities and consequently between different danger levels by looking at the geographical distribution of the buildings. A very dense historical nucleus does not allow a certain type of activities (hobbies in the garden, burning organic rests, etc.; due to the lack of space for doing it). An urban structure constituted for example by villas surrounded by private gardens is probably more suited for practicing potentially dangerous activities. We quantified this aspect by converting the building vector data of the VECTOR25 dataset in raster format and subsequently count for each pixel of the resulting raster, how many building pixels are present in a circular neighborhood of 100 m in radius (Den_bu). This corresponds to the distances adopted also by Lampin-Maillet et al. (2009) in a WUI-related paper. A circular radius is adopted for the moving window (and not a rectangular moving window) in order to equally consider all directions. The adoption of a rectangular moving window, would lead to the generation of an unnatural squared pattern in the resulting parameter. As it is the case for the parameter distance from streets or building buildings are all treated in the same way. In this case the choice is justified by an additional motivation: buildings constitute non-burnable areas. From this point of view an industrial building has the same influence as a school or a private villa. A dense historical nucleus of offices has in this case the same value than a dense nucleus of dwellings or than a huge industrial building.

DHM25 parameters (Mor_ele; Mor_asp; Mor_slp). The influence of morphologic parameters in the fire ignition process is known and has been documented in previous studies (Pezzatti et al., 2009; Conedera et al., 2011). In particular in a highly mountainous region like the Canton Ticino parameters such as elevation, aspect and slope may play a decisive role in the WUI dynamic. Therefore it is proposed to include three different morphological parameters in the analysis: the pure elevation (Mor_ele) extracted from the DHM25 dataset (a simple geographical subset, without further manipulation) as well as the aspect (Mor_asp) and the slope (Mor_slp) directly derived from it using GIS. All three parameters are generated in form of a raster grid with 25m spatial resolution coherently with the input elevation model.

b) Landsat data

The spatial resolution of Landsat images (30m) is not sufficient in order to allow for the identification of linear (railways, streets, pathways) and very small (buildings) features, but may be used to add information concerning the average status of the vegetation in terms of vitality, dryness etc.

To this purpose different Landsat TM including the totality of the test area (Fig. 1) for the period 1984 – 2010 have been obtained from the USGS online archive of Landsat data.

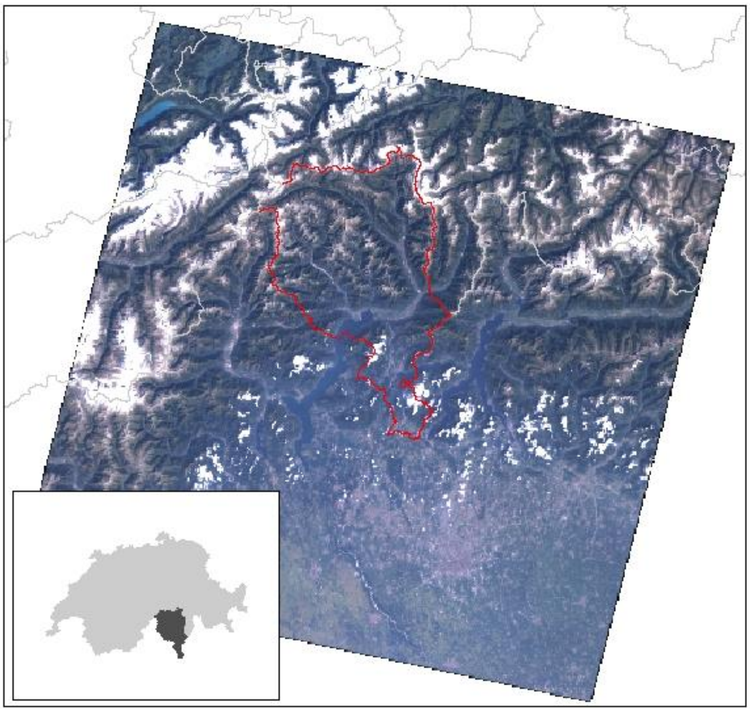


Figure 1: extent of a single Landsat image and borders of the study area of Canton Ticino

In order to keep the influence of the topography-generated shadows at the lowest possible level, only dates between May 21 and July 21 have been selected. This can in fact be quite important in a highly mountainous region as it it’s the Canton Ticino. Concretely it has been observed through visual comparison of different acquisitions, that certain north-facing slopes are already importantly affected by topographic shadows in the month of august (less than 2 months after the solstice).

Furthermore, all the available images for the mentioned months of the considered period have been visually inspected for cloud cover. The acquisition was included in the analysis when at least half of the Canton Ticino appeared to be cloud-free. Using these selection criteria we ended up with 17 images as reported in Table 2.

Table 2: list of all the Landsat acquisitions considered

	Date	Cloud cover
1	14 June 1984	20%
2	30 June 1984	40%
3	19 May 1986	30%
4	22 May 1987	40%
5	23 June 1987	20%
6	9 July 1987	40%
7	7 June 1990	70%
8	23 June 1990	60%
9	9 July 1990	10%
10	16 June 2002	20%
11	5 July 2003	20%
12	21 July 2003	40%
13	5 July 2009	41%
14	21 July 2009	44%
15	6 June 2010	53%
16	22 June 2010	35%
17	8 July 2010	34%

Obtained remote sensing data were first corrected in order to transform the pixel values in Top Of Atmosphere (TOA) radiance. Through this conversion the pixel values are transformed in spectral radiance at the sensor's aperture (in watts/(meter squared * ster * µm)). This corresponds to the apparent radiance as seen by the satellite sensor. This step is necessary in order to further use the information for the calculation of indices or for carrying out a spectral classification (GRASS Wiki, 2011). Atmospheric and topographic corrected remote sensing data were further manipulated in order to obtain WUI-relevant parameters. A SARMAP self-written algorithm based on existing remote sensing literature performs some bands algebra operations in order to derive different vegetation indices.

After attentive evaluation of all the different possibilities for building single values representative for longer periods of time it has been decided to analyze at once the whole time period 1985-2010. We create the parameters to be used in the analysis by looking for every pixel at the temporal sequence of its values, assigning to each pixel the dominant value during the period.

Following parameters were so defined:

Median NDVI (NDVI_me). The Normalized Difference Vegetation Index (NDVI) is calculated by normalizing the difference between the signal registered in band 3 (red wavelength) and 4 (near infrared; NIR). This index is well suited for highlighting changes in the condition of vegetation, and is often used as a simple proxy for changes in ecologically important variables such as the fraction of photosynthetically active radiation (fPAR) and the leaf area index (LAI) (Zaitchick et al. 2006). It is therefore widely used in remote sensing as a monitoring tool for the vegetation health and dynamics. Due to these characteristics this index is used in order to identify an eventual relationship between fire ignition and general forest conditions. After the calculation of five different statistical measures (Max, Mean, Median, Min, Standard deviation) and two further indicators (Range and Difference between highest and lowest value of the temporal span) a visual analysis led to the selection of the median value to be submitted as parameters in the numerical model. Other statistical measures are not considered due to the influence of the clouds despite the masking process described above.

Median NDBSI (NDBSIme). Roy et al. (1997) proposed a Normalized Difference Bare Soil Index with the intent of enhancing the response of Landsat data to land cover such as bare soil areas, fallow lands and vegetation with marked background response. By including this index in the analysis it is expected to detect characteristics of the landscape not represented in the topographic information derived from the VECTOR25 dataset. Concretely the median value of the temporal sequence is adopted, since all the other calculated statistical measures are too strongly influenced by the presence of clouds in the single dates.

Median brightness. (Bri_me). The brightness index is a weighted sum of six Landsat TM band (TM1-5, 7; without the thermal infrared Bad TM6). This index combined the response of the pixels in the different band in order to reflect changes in the total reflectance and in particular variations in the soil reflectance. (Crist & Cicone, 1984)

Long term land cover class (LC_maj). The parameters derived from specific indices presented above are used with the purpose of considering different vegetation conditions principally in forested areas. In particular the adopted automatic spectral classifier is able to group pixels with similar spectral characteristics in corresponding vegetation classes. At the finest possible level the classifier is able to distinguish between 90 different spectral classes (for Landsat images). Such very fine scaled interpretation was then reinterpreted and reduced, trying to preserve as much as possible the original information present in the automatically generated spectral classification (Table 3).

Table 3. **Rules for grouping the original classes from the classification algorithm for Landsat images into the 6 synthetic classes**

intermediate value	New value	Meaning
1	1	Strong vegetation
7	2	Average vegetation
13	3	Weak vegetation
16 – 17	5	Water, clouds, shadows and unknown
18 – 28	4	Shrubland
29 – 84	6	Others
85	5	Water, clouds, shadows and unknown
86 – 89	6	Others
91 – 114	5	Water, clouds, shadows and unknown
117	6	Others
119 - 127	5	Water, clouds, shadows and unknown

The result of this analysis distinguishes between three different kinds of “high” vegetation. For the purposes of the WUI-CH project this distinction is judged to be adequate. Therefore the intermediate classification has been used as a starting point for the spectral class reduction. The three “high” vegetation classes ‘strong-‘ , ‘average-‘ and weak-vegetation have been preserved. A fourth class ‘shrubland’ has been created grouping all the different ‘shrubland’ classes. The remaining 35 classes have been divided into the classes ‘clouds, shadows, water, snow and unknown’ and ‘other’ resulting in totally 6 new classes.

Finally, the most frequent value in the temporal series is selected for every pixel of interest using the ArcGIS cell statistics function. The value of the 17 different dates and of the resulting majority land cover is extracted using the Hawth’s tool *Intersect Points* according to scheme presented in Figure 2.

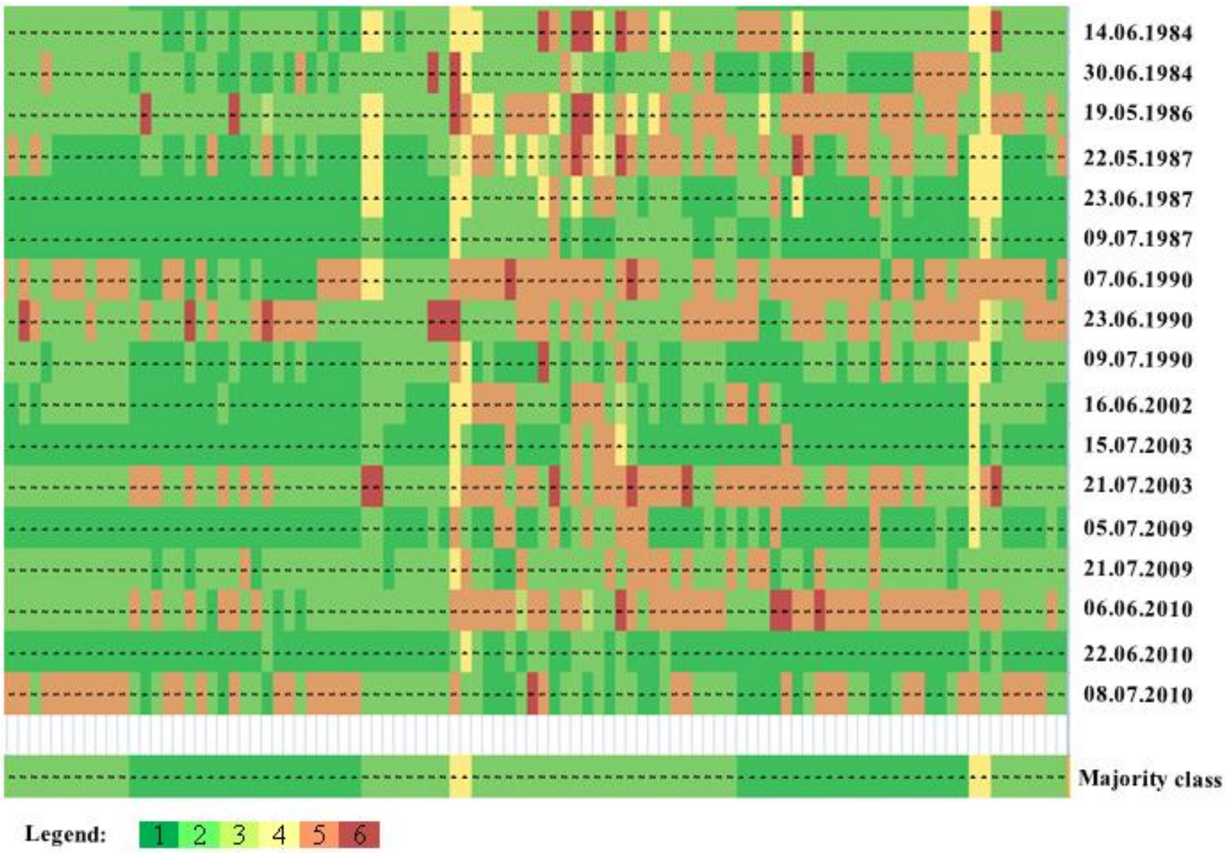


Figure 2:Color-coded excel table illustrating the majority classes assigned to a subset of considered pixels

c) Ikonos data

IKONOS images were provided on 9 July 2008 only for small, single area of about 10 by 10 km around Lugano and acquired from the satellite data reseller GeoEyes (Fig. 3). This area is located in the southern part of the Canton Ticino and is characterized by a relatively extended urban area in the center surrounded by wooden surfaces and agricultural land. The lake of Lugano covers an important part of the area, which includes also some regions above the upper tree level. The area is characterized by a pre-Alpine morphology, without too steep and accentuated valleys, even though the range between the lowest (270 m.a.s.l) and the highest point (ca. 1600 m.a.s.l.) is quite important.

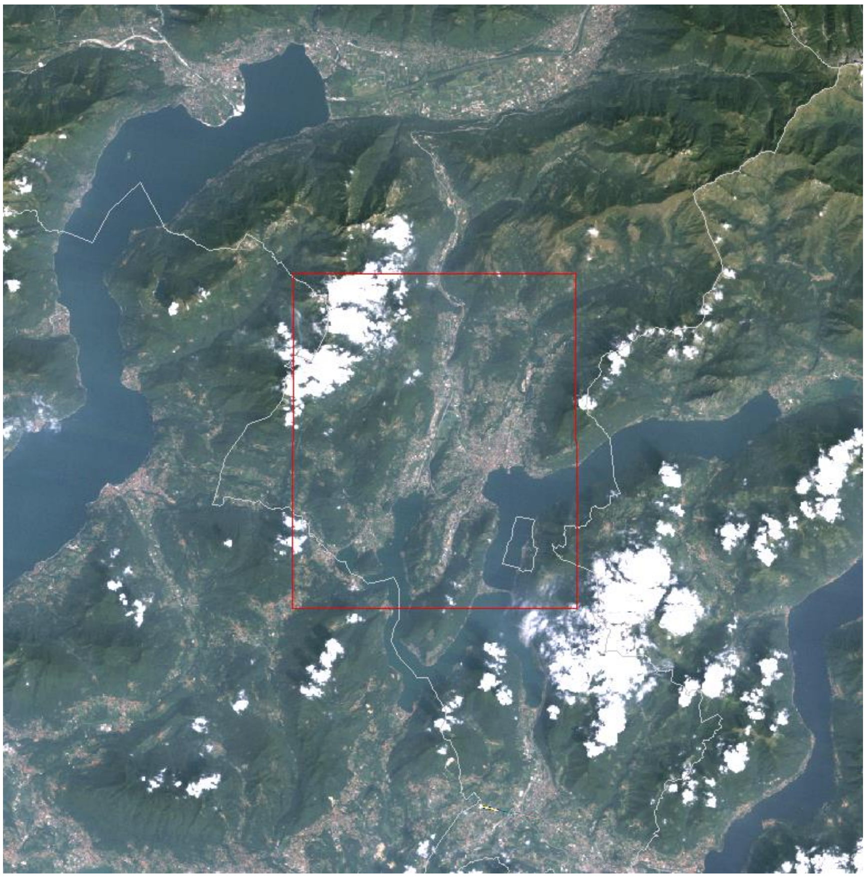


Figure 3. Extent of the available IKONOS image for the area surrounding the city of Lugano.

The high spatial resolution of the IKONOS image (4m) is exploited by looking at particular structures of the forested areas, not represented in the topographic data. By looking at the heterogeneity of the acquired scene in the near infrared (NIR) band and in the Normalized Difference Vegetation Index (NDVI) it is possible to identify areas characterized by different structures such as different tree densities or areas of different vegetation health.

The texture parameters are calculated with the Occurrence Matrix function of the remote sensing image analysis software ENVI. The tool subtracts the lowest from the highest value in a 3x3 rectangular moving window around each pixel. The obtained result is a measure for the texture heterogeneity of the each pixel's neighborhood: the lower the value (i.e. highest and lowest values are similar) the more homogeneous is the area surrounding the pixel. Oppositely, a high value (i.e. highest and lowest values are very different) indicates a heterogeneous pixel's neighborhood. The utilization of bigger rectangular moving windows has been tested, but the result has not been judged to be better suitable than the 3x3 matrix on a visual comparison.

Texture NIR band (Text_Ni). The first proposed texture parameter is calculated from the NIR band of the IKONOS image. Since the NIR band is particularly sensitive to vegetation characteristics it is expected to extract information about structures and distribution of vegetation areas with different traits. The heterogeneity measure has been calculated also for the other three available bands (red, green and blue channels), but the results does not seem to allow the identification of additional WUI-related aspects not already tackled by other parameters.

Texture NDVI index(TxtNDVI). In order to focus more specifically at ecologically important variables the heterogeneity parameter is calculated also from the NDVI index derived from the IKONOS image. Since the IKONOS satellite acquires scenes in only 4 different bands (R, G, B, NIR), it is not possible to apply the texture parameter on other (vegetation) indices, because these cannot be generated from the four bands of the IKONOS data.

2.2 Fire data acquisition

In order to create the link between the proposed WUI parameters and the wildfires, we used the forest fire database of Switzerland Swissfire (http://www.wsl.ch/swissfire/index_EN). A query for non-natural fire ignitions in the Canton Ticino in the period 1985-2009 resulted in a selection of 1073 georeferenced ignition points. The selected period of time corresponds to the period of Landsat data availability.

2.3 Statistical analysis

A logistic regression modeling approach is adopted in order to ascertain the specific influence of the selected single parameters on the anthropogenic fire ignition process what at the end may represent the Alpine WUI area. To this purpose, a binary logistic forward stepwise regression has been carried out using the statistic software SPSS. The selected parameters are stepwise added to the model until a pre-defined threshold is reached. The resulting model is adopted in order to predict the occurrence/non-occurrence of ignitions for the submitted data. The predicted value is then compared with the real value (presence or absence of a real ignition), resulting in the percentage of correct prediction (a goodness-of-classification measure).

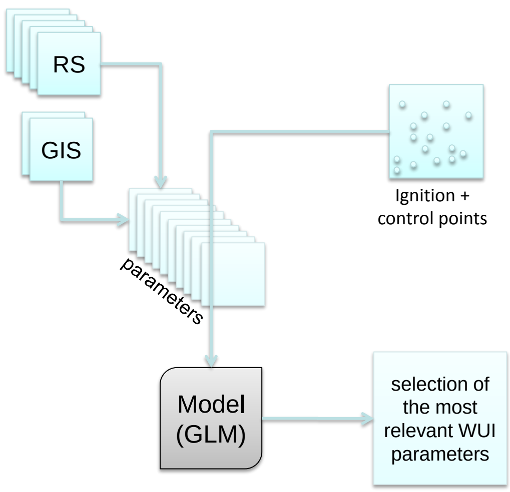


Figure 4: workflow for the selection of the most relevant parameters for the Alpine WUI

Presence values are represented by the fire ignition locations extracted from the database. Absence values are represented by a correspondent number of random generated control points. When generating the random points attention was paid in avoiding non burnable land covers such as glaciers, lakes, urban areas, etc. and sites above 2500 m of elevation. A specific subset of ignition and random points has been generated also for the 10x10 km around Lugano in order to test the possible contribution of the two specific IKONOS parameters texture NIR and texture NDVI.

Figure 4 schematically shows the work flow of the adopted modeling approach.

2.3 *Model results*

Figure 5 shows the results of the logistic regression carried out using the 11 parameters derived from the topographic data or the Landsat images for the Canton Ticino (a) and the region of Lugano (b).

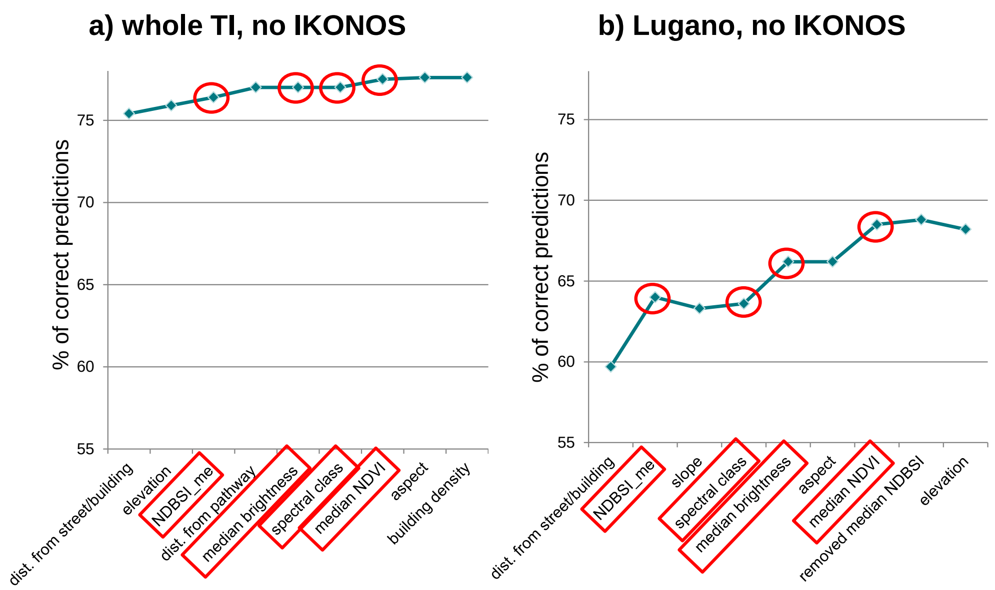


Figure 5: Contribution of single topographic and Landsat parameters to the goodness-of-classification of the anthropogenic ignition points
(in red: Landsat derived parameters)

For the whole Ticino (Fig. 5a), modeling of the ignition points through the single parameter “distance to the next building or road“ resulted to be very efficient giving more than 75% of correct classification. Any additional parameter and the Landsat derived parameters in particular did not contribute to a significant improvement of the goodness of classification in terms of ignition points considered. When restricting the area under study (Fig. 5b), the explanatory power of the single parameter “distance to the next building or road“ slightly diminish (from 70 to 60%) and the contribution of the Landsat-derived structure parameters increases. But also when adding 4 Landsat parameters, the overall % of correct prediction increases of ca. 8% only.

As highlighted in Figure 6, also the inclusion of the Ikonos parameters did not improve such an overall picture.

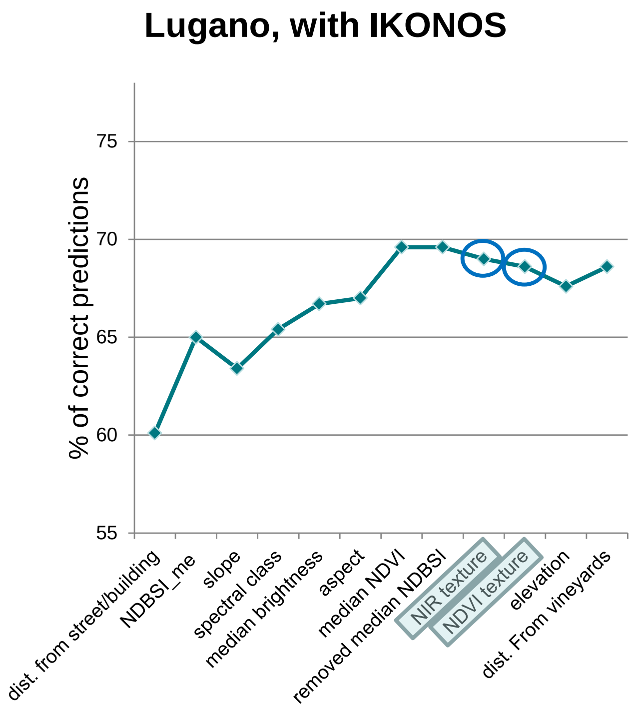


Figure 6: Contribution of single topographic, Landsat and Ikonos parameters to the goodness-of-classification of the anthropogenic ignition points for the Lugano area
(in blue: Ikonos derived parameters)

2.4 Consequences for the WUI definition in the Alpine environment

The modeling approach used in this study clearly demonstrated that the most relevant parameter for defining a WUI in the Alpine environment are the mobility and human activity related parameters distance to the next road and the next building. Work-intensive (Landsat) and also expensive (Ikonos) additional RS information does not contribute to a significant improvement of the WUI characterization.

We therefore decided to focus on the topographic information (Vector25 and DHM25) when trying to defining the three basic component of the WUI as defined by Stewart et al. (2009) and Platt (2010) that is the human infrastructures, the wildland vegetation, and the buffer or the distance representing the potential interaction and feedback effects between them in case of wildfire. Doing so we could also easily extend the Alpine WUI approach to all the Alpine regions displaying a minimum number of fire ignitions that is the whole canton of TI, GR and VS as well as the Alpine part of the Canton BE.

3. Defining the Alpine WUI

3.1 The human infrastructure component

According to the focus of the WUI approach, human infrastructures (houses, roads, etc.) and related human activities may be considered as the ignition source of wildfires in the WUI (Cardille et al. 2001; Lampin-Maillet et al. 2010; Badia et al. 2011) or may represent the residential (infrastructural) fuel at risk of ignition and loss during a wildfire (Cohen 2000). As a consequence, different proxies may be used for characterizing this WUI component: population density, housing density and configuration (see Platt 2010 for details on possible calculation methods), or distance between infrastructures. Resulting settlement distribution may vary from isolated or scattered housing to dense or very dense agglomerations (Lampin-Maillet et al. 2009).

In the Alpine environment human mobility and activity are heavily limited by the access facilities. For this reason we considered in first priority the road net accessible by motor-vehicles (Swisstopo TLM3D-Vector, product "Strasse", including following road types: 10m_Strasse, 6m_Strasse, 4m_Strasse, 3m_Strasse, 2m_Weg).

Other infrastructures related to fire-inducing human activities are houses and their surroundings. In order to avoid selecting all the isolated and hardly accessible cabins, we considered only houses according to the Swisstopo TLM3D-Vector, product "gebaeude_footprint" located at the furthest 100 m to the next drivable road (see Fig. 7 for a details).

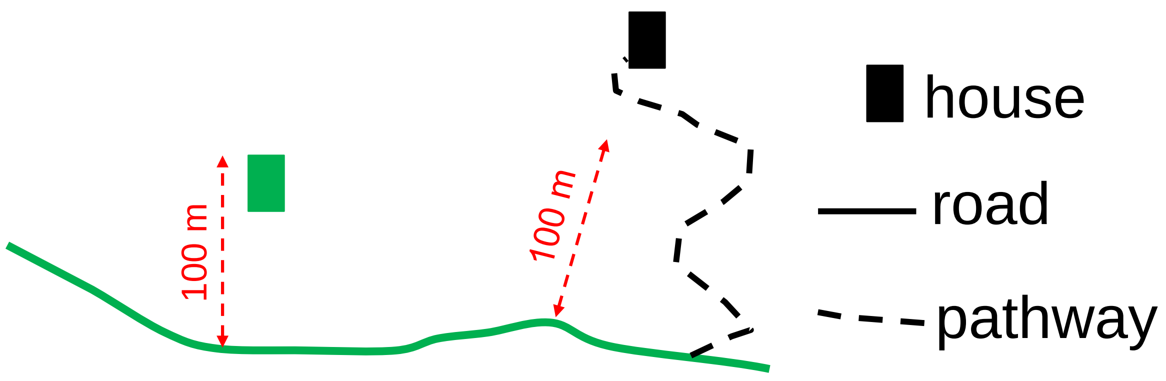


Figure 7: The human infrastructure component of the Alpine WUI
(in green: retained road and houses)

3.2 The burnable component

Wildland vegetation is usually comprehensive of all type of vegetal fuel representing a continuous and dominant land cover and not deriving from cultivation that is excluding urban green, orchards or agricultural activities (Stewart et al. 2007). Depending on the data available, WUI-related wildland vegetation may be just very simply binary classified in wildland and non wildland fuel or may be further distinguished in different categories as function of the potential type and intensity of fire and the related impact on ignition frequency, threat of human structures as well as firefighting options (Theobald and Romme 2007; Platt 2010).

In our case we just selected all the forest-related land covers that is the types “Gebüschwald”, ”Wald”, and “Wald offen” from the Swisstopo TLM3D-Vector product “Bodenbedeckung”.

3.3 The buffer between human infrastructure and burnable vegetation

The last component and most tricky component of the WUI is the buffer that extents from the human structures into the wildland vegetation. Ideally the buffer distances represent the area of active interaction between structures and wildland vegetation with respect to the fire. Buffers usually vary as function of fire characteristics and management objectives such as reducing fire ignition frequency, direct structure protection, protection from or avoiding of flying embers, fire intensity mitigation for allowing save firefighting conditions (Cohen 2000; Theobald and Romme 2007; Platt 2010). As a consequence, no standard or uniform buffer distance can be defined for the WUI.

In the Alpine environment, human infrastructures and the related WUI mostly refer to the fire ignitions (Pezzatti et al. 2013). For this reason we propose to define the buffer distance basing on the percentage of historical ignition points that are included within the buffer. To this purpose, we constructed curves representing the cumulative percentage of ignition points or random forest points located within a given distance from the next human infrastructure as defined in chapter 3.1.

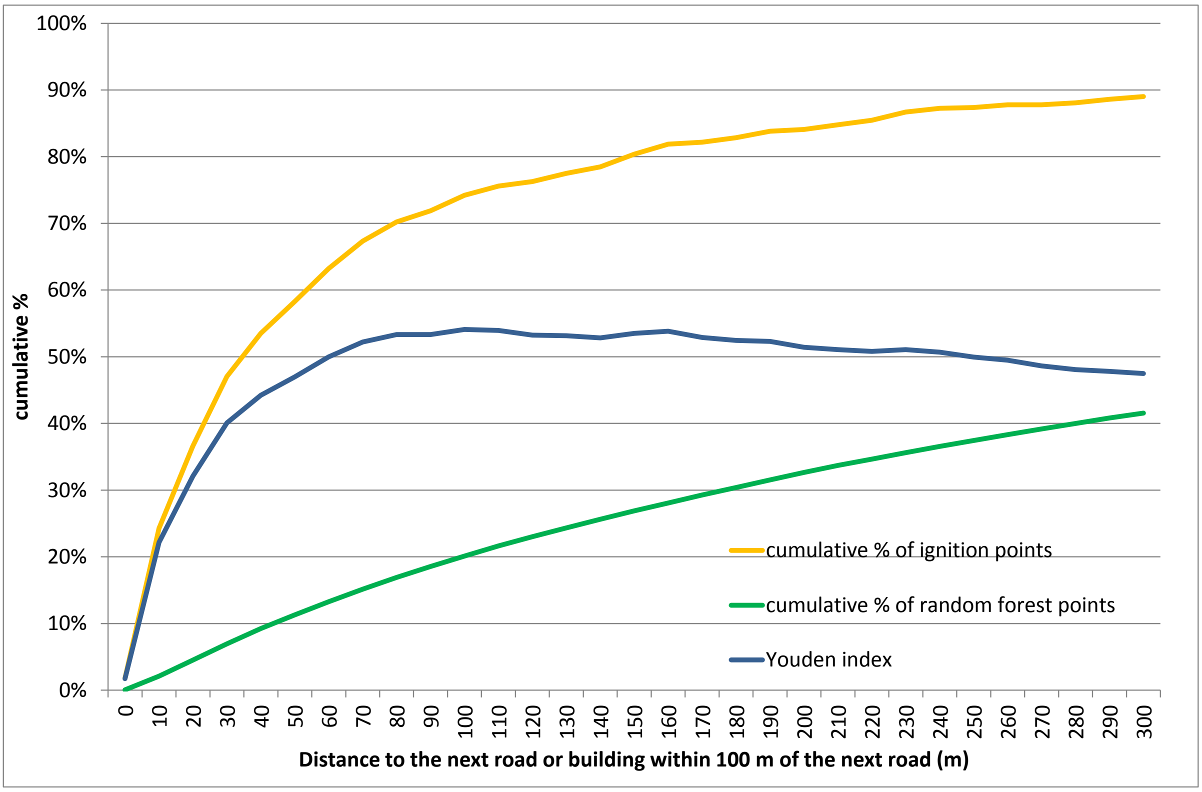
Fire managers may then define the most suitable WUI buffer distance according to the following main criteria:

- Minimum percentage of ignition points included in the buffer distance
- Minimum percentage of forest area included in the buffer distance
- Distance representing the best rate between ignition points considered and forest area covered (Youden Index, Youden 1950).

Figures 8a-d display the result obtained applying this approach to the study areas represented by the Cantons of TI, GR, VS and the Alpine part of the Canton of Berne.

Table 4 offers an overview of the obtained WUI buffer distances when considering the 75% of the ignition points, 20% of the forest area and the related maximum of Youden Index as input parameters.

a) Ticino



b) Grisons

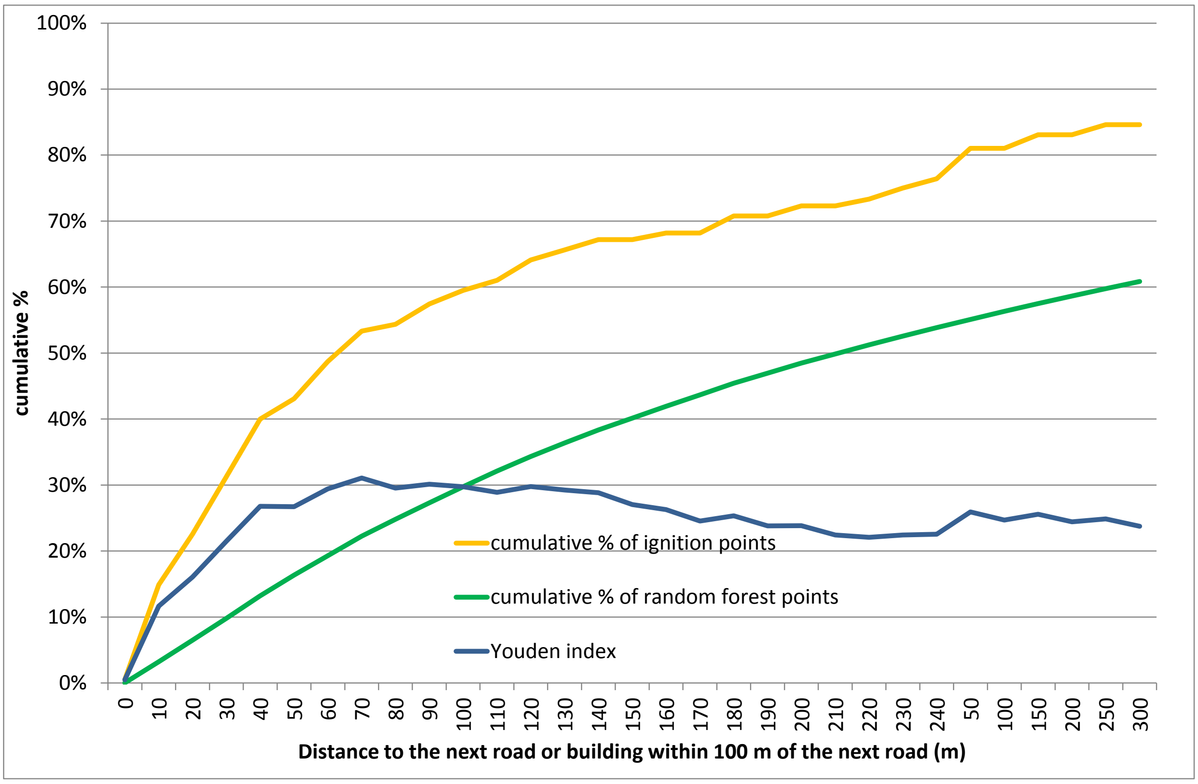
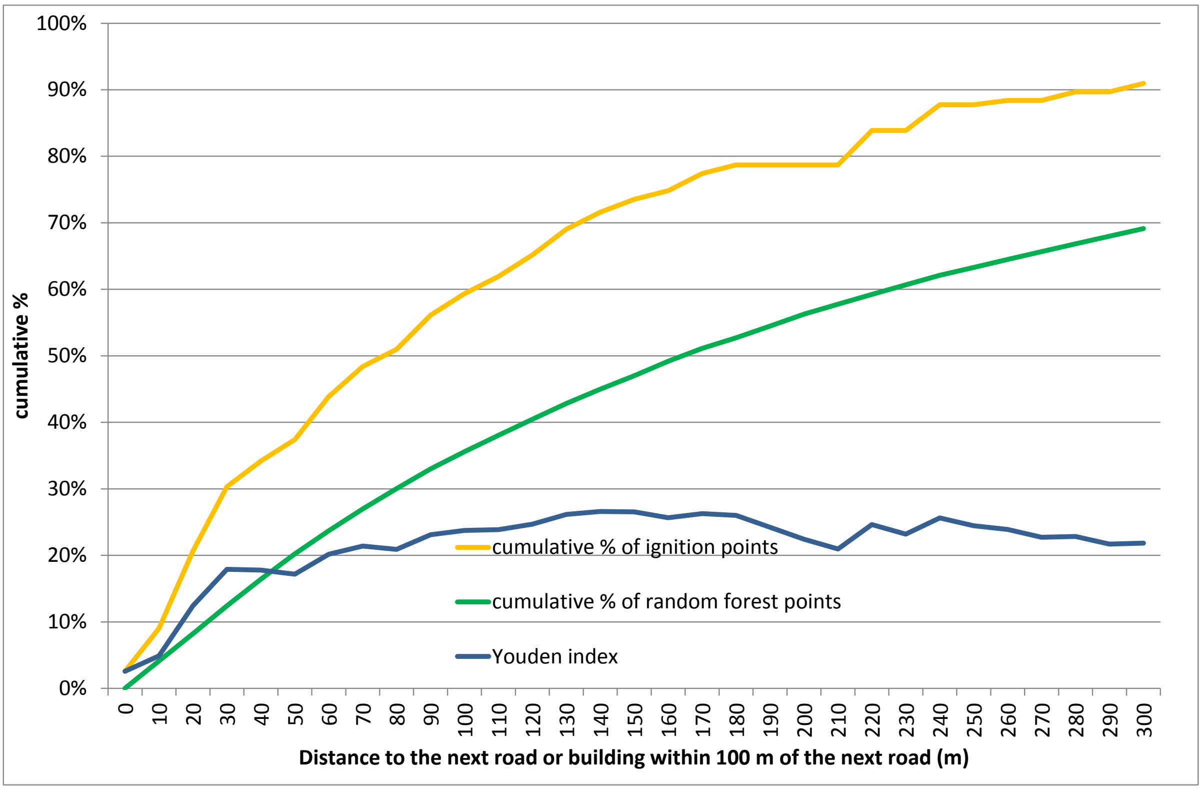


Figure 8: Cumulative curves of the WUI buffer distances as function of the ignition points and forest area covered or Youden Index

(a) Ticino; (b) Grisons

c) Valais



d) Alpine part of Berne

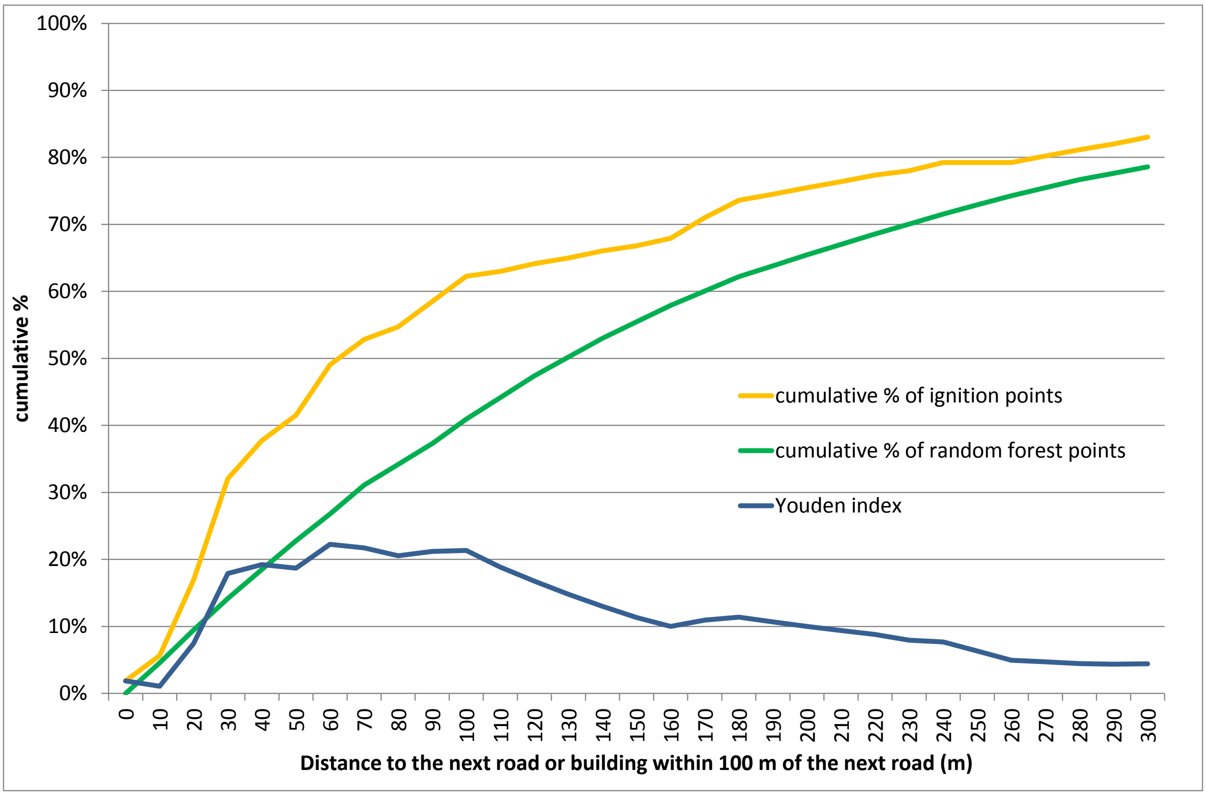


Figure 8: Cumulative curves of the WUI buffer distances as function of the ignition points and forest area covered or Youden Index

(c) Valais; (d) Alpine part of Berne

Table 4. WUI Buffer distances obtained for the different study areas and selection criteria

	TI*	VS*	GR*	BE_Alps*
75% ignitions	100	160	230	200
20% forest	100	50	60	50
Youden index	100	150	70	60

* distance in m

The obtained distances greatly vary according to the region mostly as function of the forest road density (Ticino is the less served region in this respect) and the average steepness of the territory. Again Ticino with only 100 m of buffer distance covering 75% of the ignition points displays the narrowest WUI buffer distance (Conedera et al. 2015.

3.4 Mapping the static WUI

Once defined which criterion and which threshold value should be applied for defining the WUI, the WUI mapping may be performed in GIS following the Model builder presented in Figure 9.

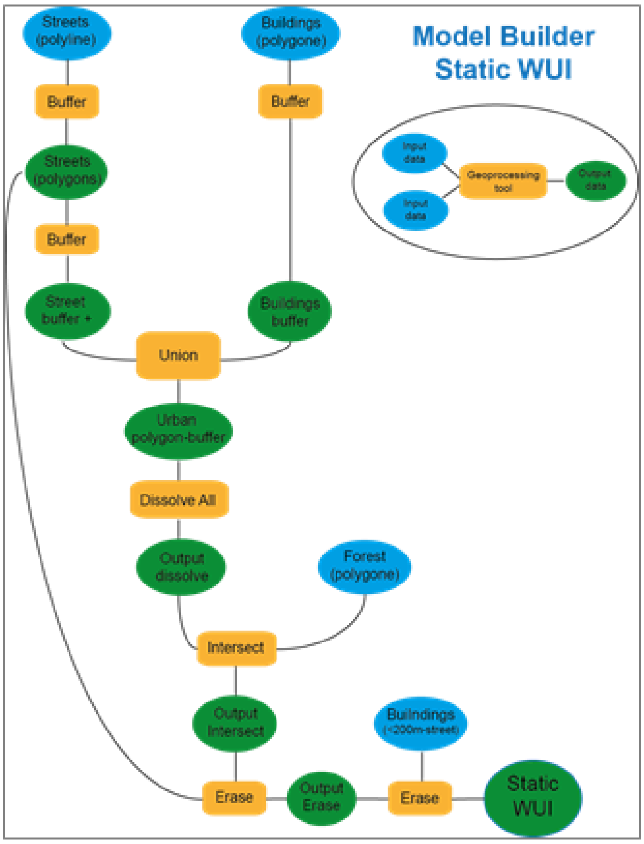


Figure 9: GIS Model builder for mapping the Alpine WUI in Switzerland

Figure 10 shows a selected example of the WUI area resulting when applying the buffer distance of 100 m (corresponding to 75% of ignition points) for Ticino using the Swisstopo vector data of 2010. The final WUI area consists in the forest cover within the buffer distance to the next road or building within 100 m of the next road.

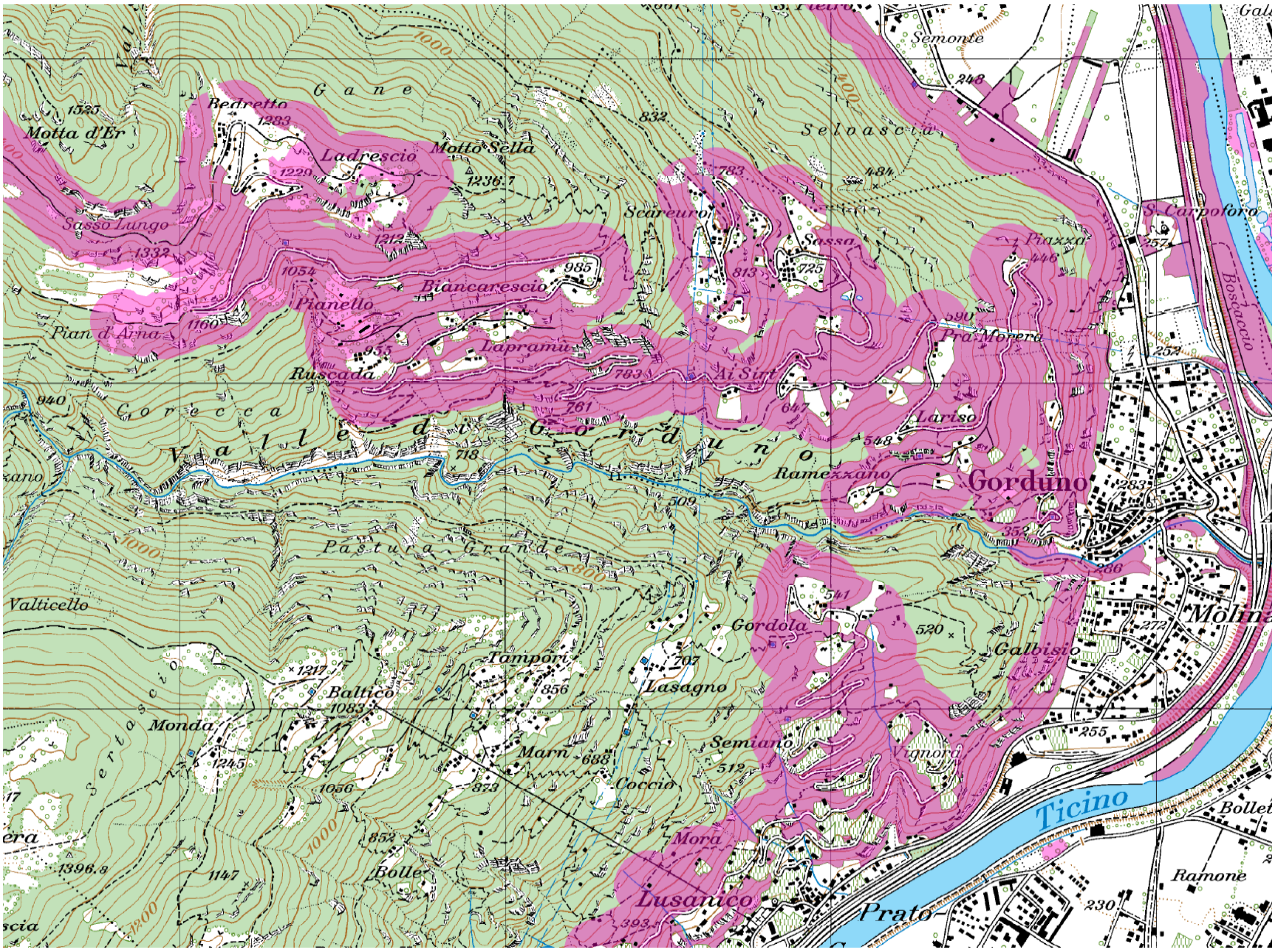


Figure 10: GIS modelled WUI area in the region of Gorduno (TI) when assuming a buffer distance of 100 m to the next WUI relevant human infrastructure

4. Concluding remarks

The Alpine WUI patterns confirmed to be different from the Mediterranean, US or Australian conditions. In particular in the Alps WUI is mostly related to the human mobility and related activities and usually refers therefore to the fire ignition. In very few cases the WUI in the Alps concerns the residential (infrastructural) fuel at risk of ignition and loss during a wildfire.

Unfortunately, due to the difficulties in obtaining information free of shadow effects in the mountain environment spaceborne RS techniques failed to provide useful information for further detailing the WUI conditions in the Alpine region. The additional costs or work for extracting information from the RS sources (e.g. Landsat and Ikonos) are not in balance with the poor gain in information achievable. This is the main reason why we limited the diachronic analysis of the evolution of the WUI as listed under possible additional applications in the project proposal to a preliminary attempt that is not further detailed in this report.

Concerning the static definition of the present WUI in the Alpine environment, we were able to provide a reproducible and simple method for defining the WUI according to the specific needs of the forest and fire managers. The so defined WUI area represents an intermediary step towards fire prevention through silvicultural or technical measures that needs further detailed planning. In particular the defined WUI area according to the method presented here may be further detailed by overlapping the fire ignition probability map (Conedera et al. 2011), the fire risk map (Conedera 2009) or detailed forest and fuel vegetation maps where existing.

Executive summary

The Wildland-Urban Interface (WUI) is a broadly used term in the context of wild- and forest fires for indicating areas where houses and other human infrastructures meet or intermingle with wildland vegetation, rural areas or forests. In the Alpine environment the WUI displays very different characteristics with respect to the Mediterranean, US or Australian ones. In particular in the Alps WUI is mostly connected to the human mobility and related activities and usually refers therefore to the fire ignition. In very few cases the WUI in the Alps concerns the residential (infrastructural) fuel at risk of ignition and loss during a wildfire. Aim of this study is to develop a robust geospatial method for defining and mapping the WUI in the particular conditions of the Alpine environment. We first check for the suitability of using spaceborne RS techniques for acquiring WUI-relevant geographical information. Unfortunately, due to the difficulties in obtaining information free of shadow effects in the mountain environment RS techniques failed to provide useful information for the WUI conditions in the Alpine region. Costs and work for extracting information from the RS sources (e.g. Landsat and Ikonos) are not in balance with the poor gain in information achievable.

We therefore decided to focus on the topographic information (Vector25 and DHM25) when trying to defining the three basic component of the WUI which are the human infrastructures, the wildland vegetation, and the buffer or the distance representing the potential interaction and feedback effects between them in case of wildfire. Doing so we could also easily extend the Alpine WUI approach to all the Alpine regions displaying a minimum number of fire ignitions that is the whole canton of TI, GR and VS as well as the Alpine part of the Canton BE.

The features representing anthropogenic infrastructures (urban or infrastructural components of the WUI) as well as forest cover related features (wildland component of the WUI) were selected from the Swiss Topographic Landscape Model (TLM3D). Georeferenced forest fire occurrences derived from the WSL Swissfire database were used to define suitable WUI interface distances. The Random Forest algorithm was applied to estimate the importance of predictor variables to fire ignition occurrence. This revealed that buildings and drivable roads are the most relevant anthropogenic components with respect to fire ignition. We consequently defined the combination of drivable roads and easily accessible (i.e. 100 m from the next drivable road) buildings as the WUI-relevant infrastructural component. For the definition of the interface (buffer) distance between WUI infrastructural and wildland components, we computed the empirical cumulative distribution functions (ECDF) of the percentage of ignition points arising at increasing distances from the

selected infrastructures. The ECDF facilitates the calculation of both the distance at which a given percentage of ignition points occurred and, in turn, the amount of forest area covered at a given distance. Finally, we developed a GIS ModelBuilder routine to map the WUI for the selected buffer distance.

The developed approach was found to be reproducible, robust (based on statistical analyses for evaluating parameters) and flexible (buffer distances depending on the targeted final area covered) so that fire managers may use it to detect WUI hotspots according to their specific priorities.

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