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Abstract.
Fires in the Wildland-Urban Interface (WUI) areas is a worldwide problem, which is gaining more importance over time due to climate change and constructions in the WUI areas. Standards and guidelines may greatly help the activities of planning, prevention and protection against wildfires. Some countries/States/local communities can already rely on existing standards and guidelines, while other areas, even if potentially subject to wildfires, not. This work presents a systematic review of standards and guidelines belonging to selected countries/States/local communities in the Western world, namely: North American countries (USA, Canada), European countries (France, Italy), Oceanic countries (Australia, New Zealand), and trans-national codes. The main information reviewed includes: hazard definition and severity classes, land factors (vegetation, defensible space and topographic factors), building materials and construction requirements, utilities (resources, firefighters, planning, outreach), fire protection measures, environmental factors (weather, fire history), and access requirements. A comparative analysis regarding the main similarities/differences between all the considered standards and guidelines was performed after the review process. This comparative analysis may be useful for the further development and/or revision of (novel) standards/guidelines for planning, preventing and protecting against fires in WUI areas.

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1. Introduction

Fires in the Wildland-Urban Interface (WUI) have become a global issue, with recent disasters taking place all over the world, including Europe, North/South America and Oceania (Manzello et al., 2017). A WUI fire is a wildland fire, defined as: "unplanned and uncontrolled fire spreading through vegetative fuels, including any structures or other improvements thereon" (National Fire Protection Association, 2013), which develops in a wildfire-prone boundary between structures and vegetation (Mell et al., 2010).

This issue may possibly get even worse in the future, due to climate change (Jolly et al., 2015) and population growth in the WUI areas (Paveglio et al., 2015). In fact, the current situation may evolve towards more dangerous scenarios in areas which have already experienced a long history of fires, such as USA, Canada, Australia, Southern Europe, etc. (Ronchi et al., 2017). However, there are other regions potentially subject to wildfires, which may become more vulnerable in future years, due to climate change and modifications in the location and wildfire intensity, such as South America, Africa and Northern Europe (Jolly et al., 2015). Thus, the phenomenon of fires in WUI areas should be considered from a broad international point of view.

For example, considering only data from Canada, the trend of the number of evacuations caused by wildfires has increased from 1980 to 2014 by about 1.5 evacuations per year, with more than 20 evacuations per year after 2010. The 2016 Fort McMurray fire itself had a cost for the society estimated in over 12 billion US$ of total insured losses (Ronchi et al., 2017). Research has started to address the consequences of the disasters (Caton et al., 2016; Mell et al., 2010), measures to aid evacuation planning (Dennison et al., 2007), and the coupling of fire, traffic and pedestrian models (Ronchi et al., 2017).

For this reason, a set of countries have developed standards concerning measures for response planning, prevention, protection, fighting, etc. of WUI fires. Other countries/states/local communities can rely on guidelines and local provisions, or on provisions which cover the issue of WUI fires, but are included in other general codes (e.g. Building Codes, Environmental Codes, Fire Codes, etc.). An International Code for WUI fires is also currently available (International Code Council (ICC), 2015). The development of standards can be crucial for reducing the negative impacts of WUI fires on the communities through appropriate dedicated measures. This report examines and compares a set of exiting regulatory and guidance documents aimed at addressing some of the WUI issues discussed.

A description of the work and the provisions reviewed are presented in the following sections. Section 1 (*Introduction*) introduces the issues associated with Wildland-Urban Interface (WUI) fires, the overall motivation of the research work and the outline of the present report. Section 2 (*Objectives*) presents the objectives of the research project in relation to the review of existing standards and guidelines on the topic of WUI fires prevention, protection and management. Section 3 (*Method*) describes the methods employed during the project, introducing the template used for the review of standards and guidelines. Section 4 (*Documents reviewed*) introduces all the documents related to WUI fires reviewed during the project. They are listed according to their geographic location. Section 5 (*General WUI-relevant information for the areas considered*) reports some general information about the conditions of the considered areas, which are relevant for the WUI fires. Section 6 (*Comparative analysis*) presents a critical comparison of all the standards and guidelines reviewed, by identifying their underlying common threads and/or main differences. The comparative analysis is conducted by following the main categories of information used in the template for the review. Section 7 (*Conclusions*), provides some general conclusions concerning the work carried out.

2. Objectives

The objective of this work was the review of the provisions and guidelines available worldwide concerning WUI fires. As stated above, this included both documents focused on WUI fires as well as selected documents which are relevant for WUI fires, but are not explicitly dedicated to them. However, additional material relating to WUI fires and WUI areas may be present in general fire codes or other codes.

The choice of the documents to be reviewed is mainly limited to the western world. This includes two North American countries (Canada and USA), two European countries (France and Italy), Australia and New Zealand. The choice of countries was based on their proneness to wildfires, industrial development comparable to Canada, and similarities in the environmental and social conditions. Several trans-national regulations were also considered (International WUI Code and EU Regulations).

The final objective of the research project is the comparison between different types of guidelines/provisions belonging to different parts of the world, in order to highlight commonalities and differences in the provisions made. The work is intended to inform the development of Canadian regulatory and/or guidance documentation that address WUI fires in Canada.

3. Method

The following methodology was used in the present research project to review the current standards and guidelines regarding WUI fires.

Relevant provisions and/or guidelines for WUI fires were collected during the review according to a common template. The information collected are structured in three categorical levels:

- A macro-category (from A to G);
- A second-level sub-category (indicated with a number, e.g. B.1, B.2);
- A third-level sub-category (indicated with a number, e.g. B.1.1, B.1.2, B.1.3).

The macro-categories considered and second-level sub-categories are reported as follows:

- Hazard (1. Definitions)
- Land (1. Vegetation, 2. Topography/Terrain);
- Building Construction (1. General requirements, 2. Roof, 3. Walls and other external coverings, 4 Windows, external doors and vents, 5. Decks and detachments, 6. Floors and interior structures);
- Resources (1. Utilities, 2. Firefighters, 3. Planning, 4. Outreach);
- Fire Protection Measures (1. Measures for water sources, 2. Measures for buildings);
- Environment (1. Weather, 2. Fire history);
- Access (1. Roads)

For some second-level categories further sub-categories (third level) have been considered.

The template used for the information collection is reported in Table 1. The categories are reported in the left column, while the provisions (or guidelines/indications) found in the standards/guidelines are report in the right column. The explanation of the meaning of each category and sub-category (second and third level) is reported in table 1 in italic.

Table 1. Template used for the information collection and its explanation.

Category	**Provision**
A. Hazard	
A.1 Definitions Information concerning the way in which hazard and risk zones are identified and classified.	***1. Destination*** Definition of Wildland-Urban Interface, if relevant. Procedures used for identifying hazards and destining some areas to specific risk zones. ***2. Severity class*** Procedures to define the different risk severity classes. Definition of the thresholds delimiting the different risk categories.
B. Land	
B.1 Vegetation Information concerning the measures to adopt for the vegetation surrounding the structures.	**1. Defensible space** Procedures to create a defensible space around the structures (i.e. fuel modification: removal, reduction or substitution). Definition of the operations to undertake at different distances within the structures, if relevant.

	2. Clearance between/from vegetation Requirements concerning horizontal and vertical clearance between different vegetation types or between vegetation/structures and other objects. **3. Maintenance** Requirements concerning the maintenance procedures to be undertaken for the defensible space and the vegetation present around the structures.
B.2 Topography/ Terrain Information concerning the influence of topography/terrain on the measures to be adopted.	Procedures to consider the influence of terrain (i.e. slopes) and topography on the risk classification or on other protection measures.
C. Building Construction	
C.1 General requirements Information concerning general requirements for buildings and building materials in respect to fire safety.	***1.*** **Classes of ignition resistance** Definition of ignition resistance classes of building materials, if relevant. ***2.*** **Characteristics of ignition resistant materials** Definition of the characteristics required for the ignition resistance building materials or part of structures, if relevant. ***3.*** **Building separation** Requirements concerning the separation between buildings (clearance).
C.2 Roof Information concerning requirements for roofs.	**1. Covering** Requirements concerning the roof coverings. **2. Valley flashings** Requirements concerning the valley flashings. **3. Eaves** Requirements concerning the eaves. **4. Gutters** Requirements concerning the gutters.
C.3 Walls and other external coverings	**1. Exterior walls**

Information concerning requirements for walls and other external coverings.	Requirements concerning the exterior walls. **2. Wall coverings** Requirements concerning the wall coverings.
C.4 Windows, external doors and vents Information concerning requirements for windows (and glazing in general), external doors and vents.	**1. Exterior glazing** Requirements concerning the exterior glazing (mainly windows). **2. External doors** Requirements concerning the external doors. **3. Vents and other openings** Requirements concerning vents and other openings (including chimneys).
C.5 Decks and detachments Information concerning requirements for decks (and other attachments), and detached structures.	**1. Decks and other attachments** Requirements concerning decks and other attachments (such as porches or balconies). **2. Detached structures** Requirements concerning relevant detached structures. .
C.6 Floors and interior structures Information concerning requirements for floors and interior structures.	**1. Floor** Requirements concerning the floors. **2. Underfloor** Requirements concerning the underfloors. **3. Other interior structures** Requirements concerning other interior structures.
D. Resources	
D.1 Utilities Information concerning requirements for water supply and other fire-safety related utilities.	**1. Water supply** Requirements concerning the supply level to be guaranteed for fire suppression, the appropriate water sources, the access to water sources, the standby power to be guaranteed, the fire hydrants (distance and sizes), dry hydrants, if relevant. **2. Other utilities**

	Requirements concerning all other fire-safety related utilities, different than water supply.
D.2 Firefighters Information concerning requirements for firefighters.	Requirements and procedures concerning firefighters, and firefighters' activities before and during the emergency.
D.3 Planning Information concerning the plans which should be adopted for fire protection purposes and other relevant plans.	**1. Fire protection plan** Requirements and procedures concerning the fire protection plans described in the reviewed document. **2. Other plans required/suggested** Requirements and procedures concerning other plans described in the reviewed document, which are relevant to fire safety in case of WUI fires (e.g. emergency plans or development plans).
D.4 Outreach Information concerning the outcomes and the general public to which the reviewed document is dedicated.	
E. Fire Protection Measures	
E.1 Measures for water sources Information concerning the protection measures to be adopted for water sources.	
E.2 Measures for buildings Information concerning the protection measures to be adopted for buildings.	**1. Sprinklers** Requirements concerning the sprinklers in the structures. **2. Manual protection systems** Requirements concerning manual protection systems in/near the structures, such as fire extinguishers (spacing, distance, size, number, etc.). **3. Warning systems** Requirements concerning warning systems in the structures, such as fire alarms. **4. Spark arresters** Requirements concerning spark arresters to be used where needed (such as for chimneys).

	5. Combustible materials Requirements concerning spark combustible materials (such as debris, tanks, or liquefied gas), including their minimum distance from the structures (or their presence not allowed). **6. Private shelters** Requirements concerning private shelters against wildfires near structures.
F. Environment	
F.1 Weather Information concerning the influence of weather on the measures or procedures to be adopted.	
F.2 Fire history Information concerning the influence of weather on the measures or procedures to be adopted.	
G. Access	
G.1 Roads Information concerning the fire-safety requirements for the access to structures.	**1. Type/Number of access roads** Requirements concerning the types of access roads required in the risk areas and/or the minimum number of access roads required. **2. Road standards** Requirements concerning the road geometric standards, the materials to be adopted, parking lots and devoted lanes (e.g. fire lanes). Both main access roads and driveways/dead-end roads are considered. **3. Markings** Requirements concerning the road markings to be used on the access roads and the street and dwellings markers, if relevant. **4. Vegetation clearing** Requirements concerning the vegetation clearing operations to be conducted within the road limits, if relevant.

The complete list of the standards and documents reviewed is provided in Section 4. Moreover, the methods employed for the research project included a general review of the relevant information concerning the Wildland-Urban Interface for each geographic area under consideration. The information collected is reported in Section 5. In addition to a detailed comparison between the provisions/guidelines retrieved from different sources (Section 6), the original completed templates are reported in the Appendix A.

4. Standards and guidelines reviewed

The standards and guidelines reviewed are listed in this section and classified according to the geographic area to which they belong. In addition to the standards/guidelines reviews, other reference sources and relevant documents are identified.

4.1. Canada

In Canada, no standards specifically related to WUI fires were found. However, there are some guidelines concerning wildfire safety in the WUI area. In particular, the FireSmart community program is used across the country, although applied locally. The following document is examined as an example application of the FireSmart program to the Alberta State:

- FireSmart Guidebook for Community Protection (Alberta Government, 2013).

This includes most of the guidance provided in (FireSmart, Protecting Your Community from Wildfire, 2003) and (FireSmart Homeowner's Manual, 2017).

Some guidelines provided by (Shindler et al. 2014) in the TRUST project is also included.

4.2. United States

Four US Standards developed by the National Fire Protection Association (NFPA) have been reviewed, which are relevant for WUI fires:

- NFPA 1141. Standard for Fire Protection Infrastructure for Land Development in Wildland, Rural and Suburban Areas (National Fire Protection Association, 2017);
- NFPA 1142. Standard on Water Supplies for Suburban and Rural Fire Fighting (National Fire Protection Association, 2017);
- NFPA 1143. Standard for Wildland Fire Management (National Fire Protection Association, 2016);
- NFPA 1144. Standard for Reducing Structure Ignition Hazards from Wildland Fire (National Fire Protection Association, 2013).

The NFPA standards give provisions regarding a wide spectrum of features related to WUI fire prevention, protection, mitigation, suppression, hazard definition, and required resources. Several other specific NFPA Codes are referenced in the text of these four standards and listed in this document.

However, together with the standards reviewed, a series of American Federal/State Guidelines were also analysed, given the high number of local programs and guidelines present. Five documents were then reviewed:

- Implementation Guidelines for Executive Order 13728 WUI Federal Risk Management (Obama, B., 2016), providing minimum acceptable standards for Federally-owned buildings or building leased by Federal agencies in risky WUI areas, complying with IWUIC (International Code Council (ICC), 2015);
- Firewise toolkit (National Fire Protection Association, 2016), an informative document, providing guidelines to the general public, encouraged to adopt the proposed measures;

- Colorado WUI Hazard Assessment Methodology (Edel, S., 2002), providing a specific methodology for hazard and risk assessment in the Colorado State;
- Wildfire Hazard Assessment Guide for Florida Homeowners (Florida Department of Agriculture and Consumer Services, 2002), providing guidelines to the general public on different wildfire safety measures, and a very detailed methodology for hazard and risk assessment;
- The Planning for Natural Hazards: Wildfire Technical Resource Guide (Oregon Department of Land Conservation and Development, 2000), providing some guidelines about planning and protection measures.

Given the relevance of the WUI fire issue in the region, the regulatory situation in California has been reviewed as wsell. The main document reviewed, specifically devoted to WUI fire areas is the following:

- California Fire Code (Chapter 49: Requirements for Wildland-Urban Interface Fire Areas (State of California, 2016).

The specific section reviewed is part of the California Fire Code. While a consistent part of the 2016 California Fire Code is taken from the 2015 International Fire Code (International Code Council, 2015), the WUI section is original. This section includes references to other codes (e.g. (California Building Standards Commission, 2016)), regulations (e.g. (California, 2016)), guidelines (e.g. the General Guidelines for Creating Defensible Space (State Board of Forestry and Fire Protection, California Department of Forestry and Fire Protection, 2006)).

4.3. Australia

An Australian code is dedicated to regulate building construction in bushfire-prone areas:

- Construction of buildings in bushfire-prone areas (Australian Standard, 2009).

This code gives provisions about a wide spectrum of features related to WUI fires prevention, protection, mitigation, suppression, hazard definition, and required resources. Several other Australian standards and scientific research articles are referenced in the text.

Complementary guidelines of the States of South Australia (Government of South Australia, 2017) and Tasmania (Government of Tasmania, 2005), providing some standards for vegetation, resources, fire protection measures and access were reviewed and described here.

4.4. New Zealand

The problem of WUI fires is not explicitly treated in New Zealand standards. However, there are several codes that regulate the protection of buildings and the surrounding areas from wildfires, which can be relevant for the WUI fire case. They were reviewed and reported as follows:

- Fire Emergency New Zealand Act (Fire and Emergency New Zealand, 2017);
- New Zealand Building Code, Extract: Clauses C1-C6, A3 (Department of Building and Housing, 2012).

These codes were reviewed, together with the guidelines provided about fire safety in rural homes by the (Fire and Emergency New Zealand, 2017).

4.5. International

The main international code reviewed is the:

- International Wildland-Urban Interface Code -IWUIC 2015- (International Code Council (ICC), 2015).

The IWUIC specifically defines the fire safety provisions to be adopted in the WUI area, including some references to other International Codes (mainly the Building and Fire Codes).

4.6. Europe

No transnational European WUI codes were found. However, the two following EU regulations have been reviewed:

- Council Regulation (EEC) No 2158/92 of 23 July 1992 on protection of the Community's forests against fire (European Commission, 1992);
- EC 2152/2003 concerning the "Monitoring of forests and environmental interactions in the Community" (Forest Focus) (European Council, 2003).

Those regulations provide some directives for the Member States mainly concerning the definition of hazard zones and protection plans concerning forest fires, and do not explicitly mention the WUI fires.

4.7. France

In France, no standards specifically related to WUI fires were found. However, requirements concerning the fire safety of WUI areas are included in the main forest regulations, and in the referenced standards and guidelines, which are also applied locally. The main document reviewed is then the forest law:

- Code Forestier (Francaise, 2017).

Some of the provisions included in this code derive from the Environmental Code (Republic of France, 20107). Specific plans are required for different parts of the territory, according to previously developed (European Commission, 1992). Those plans are named: "Plans de Prevention des Risques Naturels Previsibles" (Plans for preventing predictable natural risks) and a specific plan is devoted to forest fires ("Incendies de foret") -PPRIF-. Guidelines on which features should be included in those plans are given in the official (Plans de prevention des risques naturels (PPR). Risques d'incendies de foret. Guide méthodologique) provided by the involved French Ministries. Some PPRIF plans are currently adopted by local agencies in different French areas.

An example of local PPRIF adopted in a region (Corse) where there is a high percentage of communes exposed to the wildfire risk has been reviewed (Prefet de la Haute-corse, 2011). A local guideline concerning the vegetation clearing was reviewed as well (Département de la Haute-Corse, 2013).

4.8. Italy

The issue of WUI fires is not explicitly treated in Italian fire standards. However, there is a code providing regulations about the activities of forecasting, prevention and fighting of wildfires. This was reviewed and reported as follows:

- "Legge quadro in materia di incendi boschivi" (Framework law concerning wildfires), L. 21.11.2000, n. 353 (Repubblica Italiana, 2000).

Specific reference to Wildland-Urban Interface fires are presented in the "Raccomandazioni per un più efficace contrasto agli incendi boschivi, di interfaccia e ai rischi conseguenti". Allegato (Recommendations for a more efficient fight against wildfires, interface fires and related risks. Attached document) (Presidenza del Consiglio dei Ministri, Italia, 2017).

Moreover, since the Italian law delegates responsibility planning activity with respect to wildfires to the regions, an example of regional plan (Regione Molise. Assessorato Agricoltura, Foreste e Pesca Produttiva, 2004) was reviewed. It includes reference to interface fires. Moreover, guidelines for another region (Piemonte) were reviewed (Bovio et al., 2001), since they include a framework for defining danger zones with respect to structures and wildfires.

5. General WUI-relevant information for the areas considered

In this section, information relevant to WUI fires for the geographical areas considered is reported. Their relevance in respect to the information retrieved for the Canadian context is discussed as well.

5.1. Temperature and rainfall

Both the maximum and minimum average monthly temperature over the period 1901-2015 are reported for all the areas considered (excluding International and EU, which are transnational areas). Maximum and minimum average monthly rainfall over the same period are reported as well. Data were retrieved from: http://sdwebx.worldbank.org/ (Climate Change Knowledge Portal, Data from CRU at University of East Anglia), except for California (which data belong to US Census and US Geological Survey, and are referred to annual averages).

- Canada. Max. Temperature (MT): July, 11.3 °C, min. Temperature (mT): January, -24.3 °C, Max. Rainfall (MR): July, 58.4 mm, min. Rainfall (mR): February, 23.0 mm.
- USA[1]. MT: July, 20.1 °C, mT: January, -5.9 °C, MR: July, 66.0 mm, mR: February, 42.8 mm.
- Australia. MT: January, 27.8 °C, mT: July, 14 °C, MR: January, 78.2 mm, mR: September, 17.0 mm.
- New Zealand. MT: February, 14.7 °C, mT: July, 4.3 °C, MR: October, 160.0 mm, mR: February, 114.0 mm.
- France. MT: July, 18.7 °C, mT: January, 3.7 °C, MR: July, 81.2 mm, mR: February, 59.1 mm.
- Italy. MT: July, 20.8 °C, mT: January, 3.4 °C, MR: November, 108.6 mm, mR: July, 55.6 mm.

Among all the countries considered, Canada has both the lowest maximum average monthly temperature (in July) and the lowest maximum average rainfall (in the same month of the maximum temperature: July).

5.2. Climate

Climates in the different areas considered were assessed based on the Köppen Climate scale. Since in the same country (or even in the same region), climates may greatly vary between zones, the most widespread climatic zone is highlighted, followed by other climates, present in minor areas.

- Canada. Mainly subarctic climate, with presence of warm summer humid continental (South), oceanic (Eastern coast) and other climates in minor areas (such as Mediterranean).
- USA. Several different types of climates: mainly humid subtropical in the South-Eastern States, humid continental in the North-Eastern States, a mix of Mediterranean, semi-arid and desert in the Western States.
- California. Mainly Mediterranean (cold, warm and hot-summer) climate, other relevant climates: cold semi-arid, hot and cold desert.

[1] In California, annual mean daily maximum temperature: 1997-2014, varies between 4.5 °C on mountains to more than 29.5 °C in the desert, while the average precipitation volume per month is 45.4 mm: 1961-1990.

- Australia. Several different types of climates: mainly hot-desert in the Central-Western area, savanna in the north, oceanic and sub-tropical in the Eastern portion, Mediterranean in the South-Western part.
- New Zealand. Mainly oceanic climate.
- France. Mainly oceanic climate, but presence of both mountainous and Mediterranean (in the southern portion) climates.
- Italy. Mainly hot and warm summer Mediterranean climate (South, islands and Western coast) and humid subtropical (North and Eastern coast), but presence also of oceanic (Centre and North), tundra and warm summer humid continental (Alps).

The subarctic climate mainly present in Canada is not shared with relevant climates of other countries. The continental climate is shared with portions of United States, and a very limited portion of Italy, while the oceanic climate is shared with France, New Zealand, some portions of Italy. The Mediterranean climate present in some minor areas (West) is shared with all the other areas (in Canada, it is for warm-summer).

5.3. Population

Population and population density data were reported for each area considered (population is reported in million inhabitants, while density is in inhabitants per square kilometres).

- Canada. Population (P): > 35, Density (D): 3.9.
- USA. P: > 320, D: 32.9.
- California. P: > 39, D: 92.6.
- Australia. P: > 24, D: 2.8.
- New Zealand. P: > 4, D: 17.5.
- France. P: > 67, D: 98.8.
- Italy. P: > 60, D: 201.3.

Canada has a small population compared to the other countries considered, except for Australia and New Zealand. The same is true for the population density, which is the lowest except for Australian data.

5.4. Vegetation (forest)

The forest types are evaluated for all the areas considered, based on the world map retrieved from the Food and Agriculture Organization (FAO) of the United Nations[2]. As for climates, since forest types may greatly vary between zones, the most widespread forest type is highlighted, followed by other types, present in minor areas.

- Canada. Mainly temperate continental forest (East), boreal coniferous forests (Centre-Northern part) and some limited oceanic forests.
- USA. Subtropical forest in the Southern States, temperate continental forest in the Northern States, some limited temperate oceanic forests on the Western coast.
- California. Subtropical forest in the South/Central portion of California, some limited temperate oceanic forest in the North.

[2] http://www.fao.org/forestry/fra/80298/en

- Australia. Tropical dry forest on the Northern coast, tropical shrubland in the North, subtropical dry forest in limited South/South-Western areas, subtropical humid forest on the Eastern coast, temperate oceanic forest on the South-Eastern coast, tropical rainforest (limited North-Eastern coastal areas).
- New Zealand. Subtropical humid forest on the Northern island, temperate oceanic forest on the Southern island.
- France. Mainly temperate oceanic and continental forest (some Central portions), subtropical forest on the Southern coast.
- Italy. Subtropical dry forest (Centre/South), temperate oceanic forest (North).

One of the main forest types present in Canada (temperate continental forest) is shared with a consistent portion of France and the Northern US States. The boreal coniferous forest in the Centre-Northern part is not present in the other areas. The limited portions of temperate oceanic forests are shared with Western US States, France, limited portions of Australia (South-Eastern coast), New Zealand (Southern island) and Northern Italy.

5.5. Wildland-urban Interfaces and related fires

The extent of the Wildland-Urban Interface in the areas considered, together with additional information about fires and other relevant issues, is reported here. Since a common world database with data of equivalent refinement does not exist, the data used are from the local sources.

- Canada. WUI area is 32.3 million ha among the total territory (5.8 %), with largest areas in Quebec (about 6.9 million ha), Ontario (about 5.8 million ha), British Columbia (about 5.5 million ha), but highest percentages of WUI among the total State territory are in Nova Scotia (45.1 %), Prince Edward Island (31.1 %), New Brunswick (30.6 %) (Johnston, L. M., 2016). 5,780 fires/year and > 2.5 million acres (1 million ha) burnt by wildfires (10-years average, up to 2017); with most of the fires per year in Alberta (811), British Columbia (388), Ontario (323), Quebec (318); but largest area burnt per year in Alberta (> 163k ha), Saskatchewan (> 150k ha), Quebec (> 144k ha)[3]
- USA. 46 million total existing homes in the WUI area (2012), with conversion rate from wildlands to WUI estimated in 2 million acres (about 810,000 ha) per year since 1990, and 8 million projected new homes in next 10 years (2012 projection) (International Association of Wildland Fire, 2012). 220 million acres (89,000 ha) designated by different State foresters as at high-risk of WUI fires, with about 100,000 wildfires burning about 7 million acres each year (2,8 million ha), and 2970 homes per year lost on average in the period 2000-2012 (International Association of Wildland Fire, 2012).
- California. WUI interface area is estimated in 746,037 ha, while the estimated number of houses in the WUI area is more than 5 million (Stewart et al., 2003). Average area burned per year by wildfires (period: 2011-2015) is 1272 km^2 (US Department of Agriculture, Forest Service).
- Australia. More than 11,000 houses were lost in Australia in the period 1939-2007; with most of the houses lost in the Victoria State (more than 60 % of losses) (Blanchi et al., 2010).
- New Zealand. The national average annual total area burned in the period 1991-2007 was 5,865 ha, but the average number of wildfires increased from 1,200 to 4,000 annually in

[3] http://cwfis.cfs.nrcan.gc.ca/report

the same period, with the north islands accounting for two thirds of all the wildfires, and grass fires accounting for the majority of area burned (54 %), followed by scrub fires (40 %) (Anderson et al., 2008).

- France. WUI interface particularly developed in some areas (e.g. in the Bouches-du-Rhône, they cover the 15 % of the surface of the Department, with 47 % of fires starting in the WUI) (Ganteaume, 2016). About 4,000 fires per year, with 5.5 million hectares of forests potentially exposed to fire risk, but a limited portion of the French territory severely attacked by fires each year (e.g. Provence-Alpes-Cote d´Azur, with 7000 burnt ha per year) (Ganteaume, 2016), (MeteoFrance).
- Italy. In the first seven months of 2017, 74,965 ha of wildlands are already burned. Regions in which wildfires are mostly developed are Sicily, Calabria and Campania (in terms of ha. burned in the same period) (Legambiente, 2017).

WUI and related fire data for different regions are difficult to compare given differences in the local conditions. However, using the United States as a term of comparison given similar area size, Canada has a comparable number of fires/year and hectares burnt by wildfires, even if United States show somewhat higher values for both measures. Moreover, the phenomenon of WUI fires is strongly location-based, i.e., some states/regions/provinces may be significantly more affected by wildfires than other jurisdictions within the same country/state (Canada, France, Italy, New Zealand).

6. Comparative analysis

In this section, a comparative analysis of the information collected from the different sources is conducted, by highlighting variability in key aspects of standards/guidelines under consideration. The comparative analysis is conducted separately for each macro-category, based on the populated templates for each area considered.

This analysis compares the provisions associated with each category allowing the reader to compare the various approach adopted by different guidance / regulatory provisions for each category described. In Appendices A, the full-set of information for each piece of guidance / regulatory provision is provided in a tabular format, allowing them to be accessed in context.

For each sentence reported, it is indicated if it derives from laws/standards/regulations (Provision = P; Local Provision = LP, if not country/state-based) or guidelines/informative documents (Guidelines = G; Local Guidelines = LG, if not country / state-based).

6.1. Hazard

A definition of risk and hazard zones and the hazard classification are provided in all the standards/guidelines reviewed. A comparison is made considering the sub-category: destination and hazard severity classes.

6.1.1 Destination

Canada. Definition of wildfire risk, hazard level through risk and hazard assessment. Identification of the values at risk. [G]

USA. Definition of the WUI area (interface and intermix) and of the factors to be considered for identifying the values at risk. Definition of the structures considered as hazard-exposed in respect to water supply. [P]
Wildfire risk areas should be assessed considering fuels, fire weather, defensible space, terrain, building construction and water supply. [G]
A map should be made available, showing the WUI areas classified at risk. [G]

California. WUI fire-prone areas (Fire Hazard Severity zones) are defined by the authority. [P]

Australia. Definition of the wildfire risk for structures through the Bushfire Attack Level (BAL), based on surrounding vegetation, heat flux exposure and predicted bushfire attack/exposure. [P]
Different classifications may be given by single Australian States [P].

New Zealand. Not specifically addressed here.

International. Definition of the WUI areas, to be assigned by local appropriate authorities and revised at least on a 3-year basis. [G]

Europe. Risk zones (at least at the NUTS III level) with respect to forest fires should be identified (WUI not mentioned). [P]

France. Definition of the zones subject to forest fire risk (WUI not mentioned) and of the plan dedicated to the individuation of specific risk zones at a local level. [P]

Italy. Definition of the wildfire risk (WUI areas not explicitly mentioned in this definition). [P]

Definition of WUI interfaces. [LP]
Definition of the index to be used for classifying danger zones (Specific Danger Index in Interface Areas) for elementary square areas having side of 200 m. [LG]

Brief summary. Definitions of wildfire risk and hazard levels in all standards/guidelines reviewed, except for New Zealand. The destination of areas to specific risk areas is essentially based on some topographic, vegetation and environmental factors and should be made by the relevant authority. The definition itself of WUI area is slightly different between different standards. In Australia those areas are referred to as Bushfire-prone areas.

6.1.2 Severity class

Canada. A detailed hazard assessment, providing four hazard classes is provided. It is based on sub-ratings given to different indicators (mainly related to building construction, vegetation and fuels in general), which are summed up to obtain the total rating. [G]
An area hazard assessment, providing four hazard classes is provided. It is based on sub- ratings (mainly related to types of vegetation fuels, slopes), which are summed up to obtain the total rating. [G]
An ignition and prevention checklist is provided, for evaluating the ignition potential of site and area, considering fire history and their causes, aspect, chimneys and combustible materials. [G]
A fire suppression checklist is provided, for evaluating the fire suppression capabilities of the site and area, considering access, response time, water supply. [G]

USA. Definition of the occupancy hazard of structures, based on the proneness of structure occupants (people or objects) to develop fire spread and heat release. [P]
Definition of five construction types based on the combustibility of materials used. [P]
Procedure for the structure assessment for the wildfire hazard in the ignition zone of structures, mainly including evaluations concerning surrounding area, roof, exterior structures, vegetative fuels. [P]
A detailed WUI Hazard Assessment based on three categories of information (ignition risk, hazard related to vegetation, aspect and slopes, values) is proposed in the Colorado documentation. The ratings for each of these sub-categories is then converted into a total rating through an equation. Five hazard classes are defined based on the total rating [G].
A very detailed hazard and risk assessment proposed in the Florida State is reported, mainly based on the identification of risk areas, wildfire risk, fuel hazard type, access features, fire protection measures, utilities, defensible space, buildings construction, critical facilities. The ratings for each of these sub-categories is then converted into a total rating by summing partial values. Five hazard classes are defined based on the total rating [G].

California. Three risk classes are considered depending on environmental and physical factors. [P]

Australia. Definition of six Bushfire Attack Levels (BAL) based on surrounding vegetation, heat flux exposure and predicted bushfire attack/exposure. Both a simplified and a detailed procedure (based on equations deriving from previous research) for the definition of the BAL level are provided. Main factors considered are the fire danger index, vegetation type, distance from vegetation, slopes. The final BAL level is assigned through a summarizing input/output table in the simplified procedure, through equations in the detailed procedure. [P]

New Zealand. Five classes of building types are provided, defined considering the risk posed for human life and environment in case of their failure. [P]

International. Three classes of fire hazard severity are defined in the WUI area, depending on a fuel model (vegetation type in the area), the critical fire weather frequency (set of weather-related variables negatively affecting fire behaviour) and the slopes. [G]

Europe. Specific high-risk zones are identified in the European territory: Portugal, Spain, some regions of France, some regions of Italy, Greece. Risk assessments should be constantly conducted for them. [P]

France. Two main hazard zones are defined in the area inquired (high-risk zone and moderate/low-risk zone). In the highest risk area, new constructions should be generally not allowed [P].
Detailed methodologies are provided on how to define the danger areas and which measures should be prescribed in them. [G]

Italy. Interface areas are considered as the areas where fire safety interventions should be prioritized. [LP]
Four danger zones are identified based on the Specific Danger Index in Interface area, a system assigning partial ratings mainly on fuel, slope, structure, defensible space and access characteristics and after obtaining a final rating through an equation. [LG]

Brief summary. Methods for identifying and classifying severity in the interface areas were found in all the standards/guidelines reviewed, with different levels of detail. In the more detailed provisions/guidelines, the severity class is assigned based on a rating obtained as a sum of partial ratings related to different factors (e.g. Canada, USA, Australia, International). In the EU Guidelines it is essentially based on geographic considerations, based on fire history.

6.2 Land

Provisions/indications about the influence of land characteristics on the measures and procedures to be adopted in wildfire-prone areas are provided in all the standards/guidelines reviewed, except for the EU Regulations. A detailed comparison is made considering the sub-category: vegetation and topography/terrain.

6.2.1 Vegetation

Canada

- *Defensible space*. Definition of vegetation management strategies applied around buildings by providing guidelines for fuel removal, reduction and conversion of plant variety. The guidelines differ according to zones (within 10 m of the structure, within 10-30 m and in the area distant more than 30 m from the structure). Fuel removal should be mainly conducted in the area within 30 m. [G]
- *Clearance between/from vegetation*. Prescribed clearance between chimneys, power lines and vegetation. [G]
- *Maintenance*. Prescribed removal of ladder fuels and yearly assessment of grass, surface vegetation and debris accumulation. [G]

USA

- *Defensible space*. Buildings located within 30 feet (9 m) from vegetated slopes require mitigation measures. Vegetation within the same distance from structures should be modified, or a non-combustible barrier required [P]

Additional distance for the defensible space (generally until 100 feet, about 30.5 m), with related provisions for fuel modifications are provided in other guidelines (e.g. for Florida State). [G]

- *Clearance between/from vegetation*. Prescribed clearance between chimneys and vegetation, between tree crowns and vertical clearance between tree crowns and ground vegetation. [P]
- *Maintenance*. Prescribed removal of dead vegetation within 30 feet (9 m) from the structure, ground fuels, also from parking areas. Pruning procedure in accordance with the specific mitigation plan [P/G]

California

- *Defensible space*. Buildings located in the defined high-risk areas should be provided with fuel modified defensible space of 100 feet (30.5). Single specimens or well-pruned and maintained trees are allowed in the space within 30-100 feet (9-30.5 m). Prescriptions for minor vegetation objects and large trees with continuous crowns and definitions of the exceptions. [P]
- *Clearance between/from vegetation*. Prescribed clearance from structures and vegetation and vertical clearance between tree crowns and ground vegetation. [P]
- *Maintenance*. Prescribed removal of dead vegetation, ground fuels, and pruning procedures. [P]

Australia

- *Defensible space*. Prescribed defensible space of at least 10 m in extreme risk areas. [P]
  Additional prescriptions for removing trees are provided within 20 m from dwellings (South Australia). [P]
  Guidelines for the creation of the defensible space (Building Protection Zone) and a buffer zone between the defensible space and the vegetation (Fuel Modified Buffer Zone) are given in the Tasmania state. [G]
- *Clearance between/from vegetation*. General indications provided in local guidelines (Tasmania). [G]
- *Maintenance*. General indications provided in local guidelines (Tasmania). [G]

New Zealand

- *Defensible space*. Firebreaks should be cleared from vegetation if required by the authority. No quantitative indications found about defensible space. [P]
- *Clearance between/from vegetation*. Clearance between trees and power lines. [G]
- *Maintenance*. Indications about paddocks, lawns and hay. [G]

International

- *Defensible space*. The creation of the defensible space depends on an area hazard assessment. Fuel reduction is prescribed from within 30 to 100 feet (9 to 30.5 m) depending on the hazard classification. A minimum defensible space of 30 feet (9 m), provided with fuel modification is required. [G]
- *Clearance between/from vegetation*. Clearance between trees and power lines, structures, chimneys and other tree crowns. [G]
- *Maintenance*. Prescribed removal of dead vegetation, ground fuels (except ornamental and cultivated fuels), and pruning procedures. [G]

Europe. Not specifically addressed here

France.

- *Defensible space*. Authorities can require vegetation removal to within 50 m of the structures, including also other properties, if relevant. For constructions placed to within 200 m of the forest, the space within 50 to 200 m of the structure should be maintained cleared. [P] Planting some vegetation species in the WUI areas is discouraged. [G]
- *Clearance between/from vegetation*. Very detailed provisions on horizontal and vertical clearance between vegetation (trees and bushes) and other plants (e.g. vertical distance between the lower boundary of a tree crown and the top of a bush should be high ≥ 2 times the height of the bush, but anyway > 2 m); between vegetation and structures (e.g. trees should be at least 3 m from structures); road surfaces (e.g. the clearing of vegetation should be conducted on the two sides of a paved public road for a width ≤ 20 m); power lines (e.g. high voltage lines ≥ 1000 V should be at least three meters from the vegetation). [LP]
- *Maintenance*. Prescriptions about pruning of maintained trees. [P]

Italy.

- *Defensible space*. Area of 10 m within the structure should be deprive of vegetation, except for short mowed grass. Dense fuel vegetation in the area included within 10-20 m of the structure should be treated with a removal, reduction or substitution technique. [LG] Defensible space can be increased to up to 50 m for preventing crown fires. [LP]
- *Clearance between/from vegetation*. Tree crowns should be spaced a given distance apart. The same is valid for the distance between chimneys and vegetation. [LG]
- *Maintenance*. Prescriptions about pruning of trees in the defensible space and debris and dead vegetation removal. [LG]

Brief summary. Even with different quantitative provisions, the concept of defensible space is present in all the standards/guidelines reviewed, except for EU Regulations. The same is valid for the prescriptions/guidelines about clearance between vegetation and structures and/or between different types of vegetation; and the prescriptions/guidelines about maintenance (pruning, removal of dead vegetation, etc.)

6.2.2 Topography/Terrain

Canada. Indications about the relative position of the building/slope: single buildings should be placed at least 10 m beyond the slope crest or on the bottom of the hill. More aggressive fuel modification to be conducted on slopes > 10 % or gullied. [G]

USA. Topography and terrain factors included in the structure assessment, determining the wildfire hazards: flat open areas, ridges, saddles, steep slopes, natural chimneys, small canyons. Terrain slopes considered for the wildfire risk evaluation. [P]
Characteristics of slopes and terrain generally considered in risk assessments procedures. [G]
Single-family forestland dwellings (forest and mixed agricultural/forest use) should be built on slopes ≤ 40 % (Oregon State provision). [P]

California. The terrain slopes influence the width of the defensible space. It could be increased to up to 30 feet (about 9 m) for slopes > 40 %. Pruning procedures should be influenced as well. [G]

Australia. Terrain factors (slope in particular) are considered in the definition of Bushfire Attack risk Levels, then influencing the building requirements. [P]
Slopes influencing the required width of defensible space (Tasmania) [G].

New Zealand. Not specifically addressed here.

International. Terrain slopes considered in the definition of the hazard severity classes and in the prescriptions for decks and detached structures. Elevation, ridges, drainages, escarpments, grades, roads, bridges, railroads, exposure should be considered in the definition of WUI areas. [P]

Europe. Not specifically addressed here.

France. Topographic data concerning slope, orientation, exposure to sunlight, should be considered while defining risk areas. [G]

Italy. Extension of the total defensible space in case of structures upon slopes: up to 60 meters for slopes > 40 %. [LG]
Structures are identified as exposed to greater risks if placed upon slopes > 20 %. [LP/LG].

Brief summary. Topographic and terrain factors are considered in all the standards/guidelines reviewed, except for EU Regulations and New Zealand standards. Those factors can affect the definition of risk areas and/or the defensible space for standards/guidelines belonging to USA, California, Australia, International, France, Italy. In Canadian guidelines, the relative position between houses and slopes is considered.

6.3 Building construction

Provisions/indications about the buildings materials and structures to be adopted in wildfire-prone areas are provided in all the standards/guidelines reviewed, except for the EU Regulations. The level of detail of the provisions/guidelines is extremely variable across the different locations / jurisdictions considered. A comparison is made considering the following sub-categories: general requirements; roofs; walls and other external coverings; windows; external doors and vents; decks and detachments; floors and interior structures. Where appropriate, these categories are also broken down into further sub-categories.

6.3.1 General requirements

Canada.

- *Classes of ignition resistance*. Not specifically addressed here.
- *Characteristics of ignition resistant materials*. Not specifically addressed here.
- *Building separation*. Separation ≥ 9 m between structures in high-density dwellings. [G]

USA. Existing/planned properties in WUI areas should be subject to hazard assessment of ignition zones. [P] Specific building requirements provided by local governments. [G]

- *Classes of ignition resistance*. Not specifically addressed here.
- *Characteristics of ignition resistant materials*. Flame spread index ≤ 25 in a 30-minutes burning test for building materials, showing no significant progressive combustion and a flame-front progression ≤ 10.5 feet (3.2 m) beyond the burner center-line during the test. Features to be conserved over time. [P]

- *Building separation*. Minimum distance between buildings included between 15 and 50 feet (4.5 m-15.2 m), depending on the building height, type of building and presence of automated sprinkler systems. [P]

California.

- *Classes of ignition resistance*. Not specifically addressed here.
- *Characteristics of ignition resistant materials*. Building material resistant to ignition or sustained combustion sufficient to reduce losses from WUI conflagrations under worst cases of weather and fuel conditions (including embers and small flames). [P]
- *Building separation*. Not specifically addressed here.

Australia. Specific construction requirements for bushfire-prone areas are defined for all the BALs (Bushfire Attack Levels), except for the BAL-LOW level, for which the other applicable building standards are sufficient. The building elements of the structure should be appropriate for the defined BAL level or a higher level, with some exceptions. [P]

- *Classes of ignition resistance*. Fire Resistance Level (FRL) of building elements is determined through three ratings (in minutes) representing the three resistance levels, by submitting specimens to a standard test: structural adequacy, integrity and insulation. [P]
- *Characteristics of ignition resistant materials*. Definition of non-combustibility should be in accordance with the Building Code of Australia or other relevant standards. [P]
  Bushfire-resisting timber should be (among other requirements) tested according to specific standards, have a maximum heat release rate ≤ 100 kW/m^2, and an average heat release rate ≤ 60 kW/ m^2 for 10 minutes following ignition after exposure to irradiance level of 60 kW/ m^2. [P]
- *Building separation*. Not specifically addressed here.

New Zealand. Buildings with height > 10 m, in which sleeping areas or other properties (land or building not in the same allotment or ownership) are present in the upper floors, should be designed in order to impede external vertical fire spread to upper floors (except BIL 1). Maximum limit requirements for fire spread to other properties (vertically/horizontally, radiation). [P]

- *Classes of ignition resistance*. Not specifically addressed here.
- *Characteristics of ignition resistant materials*. Maximum surface temperature ≤ 90 °C of combustible building materials located close to fixed appliances using controlled combustion and other fixed equipment. Structural stability must be guaranteed during and after fire, considering all the conditions. [P]
- *Building separation*. Not specifically addressed here.

International. Ancillary structures (< 120 ft^2, 11 m^2) and agricultural buildings located ≥ 50 feet (15.24 m) from populated buildings may not comply with the IWUIC Code. [G]

- *Classes of ignition resistance*. Classes of ignition resistance are defined according to the combination of fire hazard severity (moderate, high, extreme), water supply (conforming, non-conforming), defensible space (non-conforming, conforming, 1.5xconforming requirements). Three classes are defined (IR1, IR2, IR3). Non-conforming water supply and defensible spaces in extreme hazard WUI areas are not allowed. [G]
- *Characteristics of ignition resistant materials*. Ignition resistant building materials in WUI areas should be specifically tested on all sides according to specific procedures and standards and meet requirements e.g. for flame spread. [G]

The so-defined non-combustible materials should comply with requirements set in other standards. Materials with a structural non-combustible base and an appropriate covering can be considered as non-combustible as well. [G]
Fire-retardant-treated wood is defined in the International Building Code. [G]

- *Building separation*. Not specifically addressed here.

Europe.

- *Classes of ignition resistance*. Not specifically addressed here.
- *Characteristics of ignition resistant materials*. Not specifically addressed here.
- *Building separation*. Not specifically addressed here.

France.

- *Classes of ignition resistance*. Not specifically addressed here.
- *Characteristics of ignition resistant materials*. Not specifically addressed here.
- *Building separation*. Not specifically addressed here.

Italy. The construction of public buildings necessary for public and environmental safety may be allowed on wildlands previously subject to fires where regulatory plans are absent, while other constructions is forbidden for 10 years. Plantation of new vegetation and public environmental interventions are not allowed for 5 years, unless in specific situations. [LG]

- *Classes of ignition resistance*. Not specifically addressed here.
- *Characteristics of ignition resistant materials*. Not specifically addressed here.
- *Building separation*. Clearance between structures/infrastructures should be ≥ 10 m. [LG]

Brief summary. General requirements about construction materials and ignition resistance were found in all standards/guidelines except for EU and French Regulations and for Canadian guidelines (where only building separation is considered). Some generic requirements were found in Californian and Italian standards. Detailed requirements and classification of ignition resistance can be found in standards/guidelines reviewed from USA, Australia and International standard.

6.3.2 Roof

Canada.

- *Covering*. Fire-retardant assemblies, avoiding the entry of flames, embers and the accumulation of debris should be used. [G]
- *Valley flashings*. Not specifically addressed here.
- *Eaves*. Avoid open eaves, provide undersides of overhangs with sheathing. [G]
- *Gutters*. Not specifically addressed here.

USA.

- *Covering*. Specific fire-resistance class coherent with the wildfire assessment. Spaces between covering and decking fire-stopped. [P/G]
  Openings on roof edges should be caulked. [G]
- *Valley flashings*. Not specifically addressed here.
- *Eaves*. Sheathing, non-combustible materials or solid blocking on eaves. [P/G]
- *Gutters*. Non-combustible. Avoid debris accumulation. [P/G]

California.

- *Covering*. Firestop spaces between roof covering and decking, or put a specific layer on decking. [P]
- *Valley flashings*. Made of corrosion-resistant metal sheets, compliant with other specific details. [P]
- *Eaves*. Exposed roof eaves, exposed undersides of enclosed roof eaves and of other soffits or projections should be made of a material: non-combustible, ignition-resistant, covered with gypsum sheathing, being the exterior part of a fire-resistive wall assembly, or compatible with other specific performance criteria. [P]
- *Gutters*. Impede accumulation of debris. [P]

Australia. Roofs should be non-combustible. Junctions with walls should be sealed. Roof ventilation openings should be fitted with ember guards or screened. Veranda, awning roofs or similar should be built as roofs. [P]

- *Covering*. Different requirements for different BALs. The requirements for tiled and sheet roofs (concerning flammability, gaps, except for the extreme risk level) and roof penetrations (e.g. sealing, gaps) are mentioned. [P]
- *Valley flashings*. Valley leaf guards and flashing between box gutters and roofs: non-combustible for all BAL levels. [P]
- *Eaves*. Different requirements for different BALs. The requirements for gables (assimilated to external walls), eaves penetrations (as roof penetrations), ventilation openings (as roof ventilation openings) and joints (to be sealed) are mentioned for lower BAL levels (12.5-19). Other requirements for higher BALs for fascias, bargeboards, eaves linings. [P]
- *Gutters*. Gutters should be non-combustible, with some other requirements for some BALs. [P]

New Zealand.

- *Covering*. Not specifically addressed here.
- *Valley flashings*. Not specifically addressed here.
- *Eaves*. Not specifically addressed here.
- *Gutters*. Not specifically addressed here.

International.

- *Covering*. Different requirements for roof coverings for different ignition resistance (IR) class. For all classes, spaces between covering and decking should be fire-stopped or have a specific layer over the combustible decking. [G]
- *Valley flashings*. Made of corrosion-resistant metal sheet with prescribed thickness, over a specific layer for all the valley length. [G]
- *Eaves*. Underside of eaves and soffits protected with materials having different requirements for different IR classes (no prescriptions for IR 3 class, enclosing prescriptions for IR 2 class and stricter requirements for IR 1 class). [G]
- *Gutters*. Gutters and downspouts made of non-combustible materials. Avoid leaves/debris accumulation. [G}

Europe.

- *Covering*. Not specifically addressed here.

- *Valley flashings*. Not specifically addressed here.
- *Eaves*. Not specifically addressed here.
- *Gutters*. Not specifically addressed here.

France.
- *Covering*. Made of material with calorific value of 2.5 MJ/kg or with lower requirements if placed upon an incombustible material or other material equally resistant to fire. [LG]
- *Valley flashings*. Not specifically addressed here.
- *Eaves*. Awnings made of materials not flammable (not producing notable heat). They should not cross exterior walls. [LG]
- *Gutters*. Same material indicated for eaves. [LG]

Italy.
- *Covering*. Not specifically addressed here.
- *Valley flashings*. Not specifically addressed here.
- *Eaves*. Not specifically addressed here.
- *Gutters*. Not specifically addressed here.

Brief summary. Requirements concerning roofs were found in all standards/guidelines reviewed except for New Zealand, EU and Italy. Provisions about roof covering, eaves and gutters given in all the remaining standards/guidelines (except for gutters in Canadian guidelines). Provisions about valley flashing given in the Australian, Californian and International standards/guidelines. Generally, provisions concerning roof covering and eaves consist in defining materials to be used and their ignition resistance.

6.3.3 Walls and other external coverings

Canada.
- *Exterior walls*. Non-combustible sidings should be used. [G]
- *Wall coverings*. Not specifically addressed here.

USA.
- *Exterior walls*. Made of heavy-timber construction, ignition-resistant material, fire-retardant treated wood or minimum 20-minute fire-rated assembly. Higher requirements if walls exposed to wildfires. Solid blockings to be used between exposed rafters at roof overhangs, under exterior wall covering, where exposed to vegetation. [P]
- *Wall coverings*. Not specifically addressed here.

California.
- *Exterior walls*. Except for specific gypsum assemblies, they should be made of a material: non-combustible, ignition-resistant, heavy timber, log wall, or other appropriate wall assemblies. [P]
- *Wall coverings*. Extend from roof to foundations, terminating in some specific prescribed ways. [P]

Australia.
- *Exterior walls*. Non-combustible, bushfire resisting-timber, fibre-cement cladding, or specific timber species for BALs 12-5-19 (parts located either ≥ 0.4 m from the ground

and ≤ 0.4 m). Non-combustible material (valid also for FZ) or timber/steel-framed walls sarked with fibre-cement cladding or similar material for BALs 29-40. Other systems and combination of different systems for BALs 40-FZ.
- *Wall coverings*. Not specifically addressed here.

New Zealand.
- *Exterior walls*. If < 1 from the lot limit, must be non-combustible or not igniting for 30 minutes if subject to radiant flux of 30 kW/m^2 (BIL 3-4)/15 minutes for BIL 1-2. [P]
- *Wall coverings*. Not specifically addressed here.

International.
- *Exterior walls*. Made (from the top of foundation to the underside of roofs) of materials approved for 1-hour maximum fire-resistance rating, non-combustible materials, heavy timber/log wall, fire-retardant-treated wood, or ignition-resistant materials for exteriors (only for IR 1-2 classes). [G]
- *Wall coverings*. Not specifically addressed here.

Europe.
- *Exterior walls*. Not specifically addressed here.
- *Wall coverings*. Not specifically addressed here.

France.
- *Exterior walls*. Fire resistance of 30 minutes. Combustible parts avoided at roof/wall junctions. [LG]
- *Wall coverings*. Made of material having calorific value of 2.5 MJ/kg. [LG]

Italy.
- *Exterior walls*. Not specifically addressed here.
- *Wall coverings*. Not specifically addressed here.

Brief summary. Requirements concerning walls and other external coverings were found in all standards/guidelines reviewed except for EU and Italy. Provisions about exterior walls given in all the remaining standards/guidelines. Provisions about wall coverings only in French and Californian standards/guidelines reviewed. Generally, provisions concerning exterior walls consist in defining materials to be used and their ignition resistance.

6.3.4 Windows, external doors and vents

Canada.
- *Exterior glazing*. Avoid vegetative fuels within 10 m of glazing. Prefer small/multi-pane windows. [G]
- *External doors*. Not specifically addressed here.
- *Vents and other openings*. Screen openings with corrosion-resistant and provide appropriate spacing for soffit vents and openings. Place chimney outlets at appropriate distance from other items. [G]

USA.

- *Exterior glazing*. Made of tempered glass, glazed multi-pane, glass block or at least 20 minutes fire resistant material. Screen windows with non-combustible mesh. [P]
- *External doors*. Made of solid-core wood, non-combustible construction or at least 20 minutes fire resistant material. [P]
  Exterior glass doors made of double-pane tempered glass. [G]
- *Vents and other openings*. Screened with corrosion-resistant non-combustible mesh (metal mesh for ventilation openings). Avoid ventilation openings at specific locations. Provide appropriate ventilation to attic spaces. [P/G]

California.

- *Exterior glazing*. Made of multi-pane with at least a tempered pane, glass block, specific fire-resistant material or specifically tested material. [P]
- *External doors*. Made of material: non-combustible, ignition-resistant, solid wood, specific fire-resistant material, or specifically tester material. [P]
- *Vents and other openings*. Covered with metal wire mesh, acceptable vent or non-combustible corrosion-resistant vent. Not placed in specific locations. [P]

Australia.

- *Exterior glazing*. Different requirements for different BALs. Requirements concerning window assemblies, sash, glazing, screening, annealed glass, openings, toughened glass, frame, openable/fixed parts, seals, are mentioned. For BAL FZ, they should be protected with bushfire shutters, or having the openable/fixed parts screened. [P]
- *External doors*. Different requirements for different BALs. Requirements concerning external doors (material, door assemblies, glazing, fitting, bushfire shutters, screens, base of doors, seals), sliding doors (material, bushfire shutters, glazing, screens, fitting, doorframes, panels), garage doors (material, panels, guide tracks), are mentioned. [P]
- *Vents and other openings*. Vents in walls should be screened with corrosion-resistant metal mesh (with some exceptions), for all BALs. [P]

New Zealand.

- *Exterior glazing*. Not specifically addressed here.
- *External doors*. Not specifically addressed here.
- *Vents and other openings*. Not specifically addressed here.

International.

- *Exterior glazing*. Made of tempered glass, multi-layer glazed panels, glass block, or having a minimum fire protection rating of 20 minutes (only for IR 1-2 classes). [G]
- *External doors*. Made of non-combustible materials, solid core wood with prescribed thickness, or having a minimum fire protection rating of 20 minutes (only for IR 1-2 classes). [G]
- *Vents and other openings*. Not exceeding 144 square inches (0.093 square meters) and covered with non-combustible corrosion-resistant metal grid. Some locations not indicated for hosting vents (only for IR 1-2 classes). [G]

Europe.

- *Exterior glazing*. Not specifically addressed here.
- *External doors*. Not specifically addressed here.
- *Vents and other openings*. Not specifically addressed here.

France.

- *Exterior glazing*. Not specifically addressed here.
- *External doors*. Not specifically addressed here.
- *Vents and other openings*. Openings covered with 30 minutes fire-resistant tools, with airtight joints. Ventilation of attics protected with metal grids.
  Chimney stacks externally covered with material having calorific value of 2.5 MJ/kg; internally provided with fire-protection valve and spark protection; provided with closing device of chimney stacks. [LG]

Italy.

- *Exterior glazing*. Not specifically addressed here.
- *External doors*. Not specifically addressed here.
- *Vents and other openings*. Not specifically addressed here.

Brief summary. Requirements concerning windows, external doors and vents were found in all standards/guidelines reviewed except for New Zealand, EU and Italy. Provisions about exterior glazing, external doors and vents given in all the remaining standards/guidelines (except for exterior glazing and doors in French documents reviewed, and Canada for doors). Generally, provisions concerning glazing and doors consist in defining materials to be used and their ignition resistance. Prescriptions/guidelines concerning vents and other openings are related to their corrosion-resistance and to the openings in the metal grid.

6.3.5 Decks and detachments

Canada.

- *Decks and other attachments*. Balconies and decks should be closed with flame-resistant material. Debris and combustibles should be not stored under the overhang of stilt construction. Spaces in slotted decks should be accessible in order to allow cleaning. [G]
- *Detached structures*. Not specifically addressed here.

USA.

- *Decks and other attachments*. Made of heavy-timber construction (non-combustible, fire-retardant or other ignition-resistant material) or 1-hour fire-rated assembly. Appendages and projections should not affect the wall fire resistance. [P]
  Enclose underneath deck above ground and balconies with lattice reinforced with non-combustible corrosion-resistant mesh, and remove items under decks and porches. [G]
- *Detached structures*. Minimum 30 feet (9 m) clearance between structure and accessory structures, or accessory structures having the same requirements of structures. Avoid incinerators, fireplaces, barbecues and grills, unless approved. Specific prescriptions for mobile and manufactured homes. [P]

California.

- *Decks and other attachments.* The portion which is at a distance ≤ 10 feet (3.05 m) should be made of material: specific ignition-resistant material, fire-retardant wood, non-combustible, or other appropriate material. Other attached structures should be made of non-combustible/ignition-resistant material. [P]
- *Detached structures.* Not specifically addressed here.

Australia.

- *Decks and other attachments.* Veranda, carports, awning roofs should be separated from main roofs by external walls, and have specific requirements of non-combustibility. The same is valid for attached structures (or they should comply with building standards for the related class). [P]
  Different requirements for different BALs concerning decking, enclosed and unenclosed subfloor spaces, support, framing and barriers of unenclosed subfloor spaces, are mentioned. [P]
- *Detached structures.* Detached structures should comply with the same requirements for buildings or being ≥ 6 m from the building, or being separated from buildings with a wall having the same requirements for attached structures. [P]

New Zealand.

- *Decks and other attachments.* Not specifically addressed here.
- *Detached structures.* Not specifically addressed here.

International.

- *Decks and other attachments.* Made of 1-hour fire-resistance rated material, heavy timber, non-combustible material, fire-retardant-treated wood, or ignition-resistant building material (only for IR1-2 classes). [G]
- *Detached structures.* If < 50 feet (15.24 m) from populated buildings should mostly comply with same requirements for exterior walls (only for IR1-2 classes). [G]

Europe.

- *Decks and other attachments.* Not specifically addressed here.
- *Detached structures.* Not specifically addressed here.

France.

- *Decks and other attachments.* Not specifically addressed here.
- *Detached structures.* Fixed barbecues protected from sparks, provided with ashtrays, quick fire suppression system. Pipes and external channels having fire resistance of 30 minutes. [LG]

Italy.

- *Decks and other attachments.* Not specifically addressed here.
- *Detached structures.* Not specifically addressed here.

Brief summary. Requirements concerning decks and detachments were found in all standards/guidelines reviewed except for New Zealand, EU and Italy. Provisions about decks and other attachments in all the remaining standards/guidelines (except for France). Provisions about

detached structures given in the documents reviewed for USA, Australia, International, France. Generally, provisions concerning decks and other attachments consist in defining materials to be used and their ignition resistance. Provisions/guidelines concerning detachments include also other information such as the distance from main structures.

6.3.6 Floor and interior structures

Canada. Not specifically addressed here.

USA.

- *Floor.* Not specifically addressed here.
- *Underfloor.* Underfloor areas made of the same materials of decks. [P]
- *Other interior structures.* Not specifically addressed here.

California.

- *Floor.* Not specifically addressed here.
- *Underfloor.* Underfloor areas should have the same requirements of eaves. [P]
- *Other interior structures.* Not specifically addressed here.

Australia.

- *Floor.* No requirements for concrete slabs on the ground. Requirements for elevated floors, flooring materials differentiated for the BAL levels. No requirements for elevated floors if subfloor space is enclosed with walls complying with requirements for other structures, depending on the BAL. [P]
- *Underfloor.* No requirements for subfloor supports if subfloor space is enclosed with specific structures; otherwise support posts, columns, stumps, piers and poles should be made of specific materials. [P]
- *Other interior structures.* Not specifically addressed here.

New Zealand.

- *Floor.* Floor surface materials in sleeping areas and exit ways, fire-cells and other occupied spaces different than household units should meet specific requirements concerning minimum critical radiant flux (e.g. 4.5 kW/m^2 for sleeping areas and exit areas of care/detention facilities not protected with automated sprinkler systems). [P]
- *Underfloor.* Not specifically addressed here.
- *Other interior structures.* Specific requirements for materials composing walls and ceiling materials in sleeping areas, crowded areas, exit ways, occupied spaces; composing internal/external surfaces of ducts for HVAC systems, and other structures (excluding household multi-units and detached dwellings, ancillary buildings), also depending on BIL level. [P]

  Fire-cells (inside spaces, enclosed by a combination of fire separations, external walls, roofs and floors) < 15 m of lot limit of buildings not protected by automated sprinkler systems, should comply with specific requirements. [P]

International.

- *Floor.* Not specifically addressed here.
- *Underfloor.* Underfloor enclosure provided with exterior walls mostly complying with the requirements for exterior walls (only for IR 1-2 classes). [G]
- *Other interior structures.* Not specifically addressed here.

Europe.

- *Floor*. Not specifically addressed here.
- *Underfloor*. Not specifically addressed here.
- *Other interior structures*. Not specifically addressed here.

France.

- *Floor*. Not specifically addressed here.
- *Underfloor*. Not specifically addressed here.
- *Other interior structures*. Not specifically addressed here.

Italy.

- *Floor*. Not specifically addressed here.
- *Underfloor*. Not specifically addressed here.
- *Other interior structures*. Not specifically addressed here.

Brief summary. Requirements concerning floors and interior structures were found in all standards/guidelines reviewed except for EU, France and Italy. Provisions about under-floors in all the other documents reviewed, except for New Zealand. Provisions about floors only in Australian and New Zealand standards. Provisions about other interior structures only in New Zealand standards (definition of fire-cells). Generally, provisions concerning floors consist in defining materials to be used and their ignition resistance.

6.4 Resources

Provisions/indications about resources in wildfire-prone areas are provided in all the standards/guidelines reviewed, except for the EU Regulations, Californian and Italian standards. The level of detail of the provisions/guidelines varies between the different jurisdictions/areas considered. For the United States, Australia and in the International standard, the provisions are more quantitative and detailed. A comparison is made considering the sub-categories: utilities, firefighters, planning, outreach.

6.4.1 Utilities

Canada.

- *Water supply*. The use of large diameters (> 0.025 m) for water supply mains is encouraged. [G]
  A water source can be considered as available if it can serve for all the fire seasons, even with power outage. High-volume wells, irrigation systems considered as well if quickly accessible. [G]
  Fire hydrants near buildings complying with given provisions can be considered as water supply. [G]
- *Other utilities*. Not specifically addressed here.

USA.

- *Water supply*. Detailed calculation available, with equations specifically provided for defining the minimum water supply as a function of the total volume of the structure, the occupancy hazard classification and the construction classification, the exposure to hazard. Depending on the calculated water supply level, the water delivery rate to the fire scene is determined as well. Required levels can be decreased/increased under different conditions.

The fire flow should be provided at the same level for at least 1 hour at 20 psi (138 kPa) or 2 hours for fire flows > 1,500 gpm (5700 l/min). [P]
Water source containing ≥ 4,000 gallons (about 15 cubic meters) or water stream having flow ≥ 1 ft^3/s (28.3 l/s) for single-family forestland dwellings (Oregon). [P]
Water sources should be determined such that the required fire flow is achieved within 5 minutes. They should be maintained, accessible and they should guarantee the same capacity and delivery on a 1-year basis. Provisions for levels of the water sources and connections with the fire apparatus. [P]
Single-family forestland dwellings provided with water supply from authorized swimming pool, pond, lake or similar water source (Oregon). [P]
Specific standards for roads which have to provide access to water sources, concerning lane width, curve radius, grade, slopes, bridges or culverts and similar crossings, turnarounds, loading capacity, signs, road surface. [P]
Access for water supply for single-family forestland dwellings ≤ 15 feet (4.572 m) of the water's edge for firefighting pumping units and include a turnaround (Oregon). [P]
Specific standards for fire hydrants are provided concerning markings, location (within 6 feet, 1.8 m from the pavement edge, and within 500 feet, 150 m of points of entry), spacing (different provisions according to population density), pipe diameters, dead-end pipes. [P]
Specific standards for dry hydrants for non-pressurized water supply (to be always accessible and visible) are provided, concerning minimum flow (1,000 gpm, 3,800 l/min), pipes, slopes, protection from corrosion and deterioration, connections, strainers, appropriate materials for installation and covering. [P]

- *Other utilities*. Not specifically addressed here.

California.

- *Water supply*. Not specifically addressed here.
- *Other utilities*. Not specifically addressed here.

Australia.

- *Water supply*. Supply flow rate ≥ 600 l/minute in reticulated areas. In not reticulated areas, minimum stored water between 10,000 and 20,000 l depending on the property to be served. Inaccessible storage should have accessible delivery ≥ 270 l/min. (Tasmania) [G]
  Static and always accessible water supply (dams, tanks, swimming pools) in case of areas not serviced by reticular water mains or where flow rate is insufficient. (Tasmania) [G]
  Access provided within 3 m from water supply for trucks. Storage within 5 m from buildings. Above ground storage should be accessible (Tasmania). [G]
  Fire hydrants > 120 m from all building envelopes, in reticulated areas (Tasmania). [G]
- *Other utilities*. Not specifically addressed here.

New Zealand.

- *Water supply*. (A novel code for water supply should be developed in accordance with local authorities and advisory committees, to be further reviewed every 3 years. The current one available is transitory). [P]
  Water for firefighting should be marked, delivered and accessible in all building parts. [G]
- *Other utilities*. Escape routes and means of escape should be provided in each building. Generally, evacuation times should allow that occupants will be not exposed to: fractional effective dose of carbon monoxide and thermal effects > 0.3; visibility < 10 m except in rooms < 100 m^2 wide (visibility < 5 m). [P]

International.

- *Water supply*. New buildings in WUI areas (except some minor cases) should have a minimum water supply between 1,000 and 1,500 gallons/min. (63-95 l/s) for 30 minutes-2 hours, depending on the floor area and the number of families in the dwellings. The flow is reduced of 50 % if buildings are provided with approved sprinkler systems. [G]
  Approved water source should be ≤ 1,000 feet (305 m) far from the building. It should be fed with rainfall, pumped, hauled from natural sources or tanks. Natural water sources should have a minimum water level complying with requirements for water supply, and equipped with hydrant or a draft site. [G]
  Draft sites and pumper access points should have emergency vehicle access. [G]
  A standby power (of at least 2 hours) should be provided to the water supply system. [G]
- *Other utilities*. Not specifically addressed here.

Europe.

- *Water supply*. Not specifically addressed here.
- *Other utilities*. Not specifically addressed here.

France.

- *Water supply*. The defensible space should be provided with water supply points for all vehicles in the zone. [G]
  Water supply resources for at least 60 m^3/h for minimum 2 hours. A water tank for fire suppression, containing water between 30 and 120 m^3 should be built. All new constructions should be within 150 m of a main road and a water supply. [LP]
- *Other utilities*. Not specifically addressed here.

Italy.

- *Water supply*. Not specifically addressed here.
- *Other utilities*. Not specifically addressed here.

Brief summary. Requirements concerning water supply and other utilities were found in all standards/guidelines reviewed except for California, EU and Italy. Provisions about water supply are made in all the remaining standards/guidelines. Provisions about other utilities only in New Zealand standards (concerning evacuation routes). Generally, provisions/guidelines concerning supply level, water sources, access for water sources and hydrants are given for water supply. A very detailed definition of water supply was found in the US standards. Other detailed definitions were found in the International and Australian standards/guidelines.

6.4.2 Firefighters

Canada. Interagency cooperation (between partner agencies of the same fire protection programs), cross training (for emergency crews) should be promoted. Table-top and mock disaster exercises should be organized. Trust-building processes (including the three qualities: ability, goodwill and integrity) should be promoted at both the involved agency and the practitioner levels. [G]

USA. Assessments concerning the required number of firefighters, considering land use changes. Safety requirements for firefighters and about the procedures to be followed by the incident commander once arrived in place in case of wildfire are described. File incident reports should be prepared after the accident, to report accident causes, actions, procedures undertaken. [P]

California. Not specifically addressed here.

Australia. Not specifically addressed here.

New Zealand. Buildings should be designed in order to allow firefighters to reach fires at each floor and protect the means of egress. [P]

International. Not specifically addressed here.

Europe. Not specifically addressed here.

France. Fire-fighting equipment should be stored near hazard zones in dedicated places, providing right of way to them. [P]

Italy. Firefighters are authorized to remove trees surrounding structures, evacuate not defendable buildings, and take all the necessary protection measures (including evacuation), in case of interface fires. [LP]

Brief summary. Requirements concerning firefighters were found in standards/guidelines from Canada, USA, New Zealand, France and Italy. In this case, the provisions/guidelines found are not homogeneous and scarce.

6.4.3 Planning

Canada.

- *Fire protection plan*. The plans in use (adopting the FireSmart approach) are the Wildfire Preparedness Guide (operational guide dedicated to communities at risk from wildfires, containing a local area description, the individuation of values at risk and the fire operations); the Wildfire Mitigation Strategy (a list of possible activities for reducing the impact of wildfires on important values, including the indication of planning area, stakeholders and the hazard and risk assessment). Possible activities included in the mitigation strategy are: increase public participation, reduce wildfire threat and increase suppression capability. Both these plans should be necessary for high wildfire hazard and risk zones. [G]
- *Other plans required/suggested*. Sprinkler development plan (location of sprinklers during wildfire); municipal development plan (future land use in the municipality considering wildfire risk assessments); land use bylaws (dividing areas into land use districts: high danger areas should be indicated in them); municipal emergency management program guide (outlining response of municipalities to emergency). [G]

USA.

- *Fire protection plan*. Submitted and approved by the authority having jurisdiction. Based on the ignition risk assessment, a mitigation plan including: prevention activities, fuel modifications, hazard mitigation for structures, public information, infrastructures, is prepared. If provisions are not followed, construction/occupancy cannot be permitted. [P]
- *Other plans required/suggested*. Other plans required are: fire lane plan, wintertime access maintenance plan (access through gates and along fire lanes), multi-agency operational plan (for protecting lives and properties during incidents in communities), minimum water supply plan, dry hydrant planning, fire response planning (capabilities/limitations of existing fire service), preparedness planning (resources, activities, training, objectives for

safety and response times), incident action plan (for management of wildfire incidents), plan of containment and control (safety of firefighters, fire-fighting guidelines), construction plan (for compliance with wildfire safety requirements). [P]
Fuel reduction techniques considered in plans can be effective for 3-5 years (Florida). [G]
Firewise Communities/USA Recognition program encourage residents to promote activities for prevention, planning, education and protection against wildfires, through the organization of local committees. [G]

California.

- *Fire protection plan*. Fire protection plans for projects, developments or modifications in WUI areas, including measures for minimizing and mitigating loss from wildfires. [P]
- *Other plans required/suggested*. Not specifically addressed here.

Australia.

- *Fire protection plan*. Bushfire hazard management plans can be developed, also as part of development plans, including minimum requirements for fire protection (Tasmania). [G]
- *Other plans required/suggested*. Local area planning can integrate bushfire hazard management plans at local levels (Tasmania). [G]

New Zealand.

- *Fire protection plan*. Not specifically addressed here.
- *Other plans required/suggested*. Evacuation plans should be developed by owners of relevant buildings (complying with specific requirements, e.g. gathering together ≥ 100 persons or hosting a high quantity of hazardous materials), indicating evacuation procedures. [P]

International.

- *Fire protection plan*. A fire protection plan (concerning water supply, access, building features, equipment, defensible space, etc.) should be developed for the WUI area, based on the wildfire risk assessment. [G]
- *Other plans required/suggested*. Site plans should be developed in the WUI areas, including information about features influential on wildfire risk (topography, vegetation, buildings, ignition resistance, water supply, etc.). Specific information about structures, land, fuel breaks, water supply, access within 300 feet (91 m) from the lot line are required.
  Vegetation management plans including methods and time schedules for interventions, control and maintenance are required. [G]

Europe.

- *Fire protection plan*. Fire protection plans for the forests in high/medium risk zones. In the high-risk zone, they include the description of the existing situation, fire history, the aims of the plan, measures to be used, partners associated in forest protection. The same information are necessary for medium-risk zone, except for fire history and measures. [G]
- *Other plans required/suggested*. A scheme for each country for providing data about European forest risks, including collection, handling, assessment, improvement of data, causes and impacts of forest fires, development of forest risk indicators. [G]

France.

- *Fire protection plan*. Regions interested in establishing forest fire risk according to its national definition require a plan developed by the relevant local authority. This plan should include information concerning an assessment of the forest area, including protection, prevention and suppression current activities, fire history, objectives for eliminations of causes, actions to be undertaken, territory and actors involved, assessment criteria. [P]
- *Other plans required/suggested*. Not specifically addressed here.

Italy.

- *Fire protection plan*. Italian regions should approve the regional plan for forecasting, preventing and fight wildfires including individuation of causes of fires, fire history, risk areas, vegetation, fire factors, planning of interventions and prevention against wildfires, assess access and water supply, planning of maintenance and education activities. Specific plans should be provided for protected regional areas. [P]
  Recommendations are specifically provided for planning, monitoring, preparing, rationalising, promoting firefighting activities in the interface areas. [P]
  Planning in the interface areas should be based on information concerning topography, risk areas, interface areas. [LP]
- *Other plans required/suggested*. Modality of evacuations, evacuation times, shelters, first-aid should be defined in evacuation plans. [LP]

Brief summary. Requirements concerning planning were found in all standards/guidelines reviewed. Provisions about fire protection plans in all the other documents reviewed, except for New Zealand. Provisions about other plans in all the other documents reviewed, except for California and France. The more detailed provisions about required plans were found in the US standards/guidelines and the Canadian guidelines reviewed.

6.4.4 Outreach

Canada. Guidelines reviewed are dedicated to all stakeholders involved in wildfire management, prevention and protection, including residents, firefighters, authorities and communities.

USA. NFPA Codes are national codes, reaching different audiences. Some of their parts can be adapted, by considering local standards and regulations (and the local authority having jurisdiction).
Other guidelines reviewed are mainly dedicated to the general public (single residents/communities), who should follow the recommendations.

California. Guidelines for property owners containing practical rules and recommendations are available, since people must comply with standards for areas around homes.

Australia. Country and local standards are provided for bushfire-prone areas.

New Zealand. Standards are provided for protecting buildings and surrounding areas from wildfires and some guidelines are specifically devoted to rural home owners against wildfires.

International. The IWUIC Code can be adopted by other countries/States/local authorities, as it is, or with modifications according to specific local standards.

Europe. EU Regulations adopted in each European community country, by transferring provisions at the European level to each country.

France. Guidelines for the local authorities on how plans and specific measures should be developed and implemented are provided.

Italy. The relevant Italian law transfers to regions planning activities for forecasting, preventing and fighting wildfires.

Brief summary. The outreach of standards/guidelines is variable, depending on the type of document reviewed. Generally, guidelines for creating defensible space, clear and maintain vegetation or similar activities is dedicated to the general public. Some regulations can be implemented at a local level with modifications allowed.

6.5 Fire Protection Measures

Provisions/indications about fire protection measures to be adopted in wildfire-prone areas are provided in all the standards/guidelines reviewed, except for the EU Regulations and the French Standards. The level of detail of the provisions/guidelines varies between the different areas considered. In fact, the level of detail of Canadian, Californian and Italian standards is limited. A detailed comparison is made considering the sub-categories: measures for water sources, measures for buildings.

6.5.1 Measures for water sources

Canada. Not specifically addressed here.

USA. Fire department connections for sprinkler systems should be < 100 feet (30.5) far from fire hydrants. If water systems are not available, locate connections in order to provide continuous water supply. [P]
Space around fire hydrants should be cleared. Fire hydrants protected by barriers. [P]
Specific requirements for dry hydrant protection (clear zone of 3 feet, 0.9 m, hard suction hose, distance from structures of at least 100 feet, 30 m, no parking within 20 feet, 6 m, protection against damages and UV degradation, seasonal testing). [P]
Helicopter dip spots should have ≥ 4 feet (1.2 m) water depth with 45 feet (13.7 m) clearance from obstructions and 75 feet (22.9 m) clearance in approach at least from one direction (Florida). [G]

California. Not specifically addressed here (general provisions in the general Fire Code).

Australia. Storage tanks made of non-combustible and non-rust materials or protected in the lowest 0.4 m from the ground. (Tasmania) [G]

New Zealand. Not specifically addressed here.

International. Water tanks and pumps with electrical equipment in WUI areas should be protected with an appropriate defensible space. [G]

Europe. Not specifically addressed here.

France. Not specifically addressed here.

Italy. Not specifically addressed here.

Brief summary. Requirements concerning measures for water sources were found only in US, Australian and International standards/guidelines reviewed. Generally, provisions consist in defining clearing, defensible space, materials, protection and connections for water sources. The American provisions/guidelines reviewed are the most detailed.

6.5.2 Measures for buildings

Canada.

- *Sprinklers*. Included in the minimum tools composing an available suppression equipment. [G]
- *Manual protection systems*. Hand tools, garden hose to reach roof tops, ladder and sprinklers should be available and accessible, composing a suitable suppression equipment. [G]
- *Warning systems*. Not specifically addressed here.
- *Spark arresters*. Chimneys used with fuels should have spark arresters complying with rules. [G]
- *Combustible materials*. Firewood, building materials, combustible debris, wooden storage, propane tanks and neighbouring buildings should be at least placed > 10 m from buildings (≥ 3 m from all vegetation for tanks). Burning barrels and fire pits should be screened and surrounded with specific materials. [G]
- *Private shelters*. Not specifically addressed here.

USA.

- *Sprinklers*. All residential buildings and all the buildings with > 2 stories or > 30 feet (9.1 m) tall (with some exceptions) should be provided with automated sprinkler systems. [P]
  Provide sprinklers to single-family forestland dwellings if they are not within a fire protection district or do not have a fire protection by contract (Oregon). [P]
- *Manual protection systems*. Standpipe systems with specific fire department connections (at indicated distances) for new buildings and other specific buildings in case of available municipal water system. Class I standpipe system for new buildings and other specific buildings in case of unavailable municipal water system. Approved fire extinguishers should be installed. [P]
- *Warning systems*. Automatic fire warning systems, with different prescriptions for residential and non-residential structures. [P]
- *Spark arresters*. Screened spark arresters for chimneys, fireplaces, incinerators or similar. [P]
- *Combustible materials*. Avoid combustible material, unprotected heat and flame sources, within 30 feet (about 9 m) of the structure. Appropriate measures for storage of liquefied petroleum gas are provided. [P]
  Flammable materials avoided within 5 feet (1.5 m) of foundations, roof eave lines, gutters, decks and porch surface [G].
  Firewood storage and liquefied petroleum gas ≥ 50 feet (15.2 m) from structures, with cleared space ≥ 15 feet (4.6 m) (Florida). [G]
- *Private shelters*. Not specifically addressed here.

California.

- *Sprinklers*. Not specifically addressed here (general provisions in the general Fire Code).
- *Manual protection systems*. Not specifically addressed here.
- *Warning systems*. Not specifically addressed here.

- *Spark arresters*. Not specifically addressed here (general provisions in the general Fire Code).
- *Combustible materials*. Combustible materials should not be stored/placed within 10 feet (9.1 m) from structures. [P]
- *Private shelters*. Not specifically addressed here.

Australia.

- *Sprinklers*. Not specifically addressed here.
- *Manual protection systems*. Not specifically addressed here.
- *Warning systems*. Not specifically addressed here.
- *Spark arresters*. Not specifically addressed here.
- *Combustible materials*. Not specifically addressed here.
- *Private shelters*. Possibility of building private bushfire shelters in front of the building line, within 0.9 m of a boundary of the land with a secondary street, within 6 m of the intersection of 2 land boundaries facing a road (South Australia). [P]

New Zealand.

- *Sprinklers*. The presence of automated sprinklers is considered in the classification of buildings for fire safety purposes and in setting requirements. [P]
- *Manual protection systems*. Suitable and quickly accessible fire extinguishers are recommended in places where fires may break out. [G]
- *Warning systems*. Buildings should be provided with effective fire warning systems. [P]
  Smoke alarms in bedrooms, living areas, hallways of each floor are recommended. [G]
- *Spark arresters*. Not specifically addressed here.
- *Combustible materials*. Lighting of fires and some other open-air activities may be prohibited/restricted, including access to risky areas. [P]
  Fuel, rubbish, firewood should be stored in dedicated places; machinery should be cleaned from oil, dust or similar material; firewood should not be stacked near buildings. [G]
- *Private shelters*. Not specifically addressed here.

International.

- *Sprinklers*. IR class 1-buildings in WUI areas should be provided with sprinklers. [G]
- *Manual protection systems*. Not specifically addressed here.
- *Warning systems*. Not specifically addressed here.
- *Spark arresters*. Chimneys, incinerators or heating instruments should be provided with screened spark arresters, with defined free areas. [G]
- *Combustible materials*. Combustible materials stored in the defensible space (minimum 20 feet, 6 m from structures and 15 feet, 4.6 m from tree crowns). [G]
- *Private shelters*. Not specifically addressed here.

Europe.

- *Sprinklers*. Not specifically addressed here.
- *Manual protection systems*. Not specifically addressed here.
- *Warning systems*. Not specifically addressed here.
- *Spark arresters*. Not specifically addressed here.
- *Combustible materials*. Not specifically addressed here.

- *Private shelters*. Not specifically addressed here.

France.
- *Sprinklers*. Not specifically addressed here.
- *Manual protection systems*. Not specifically addressed here.
- *Warning systems*. Not specifically addressed here.
- *Spark arresters*. Not specifically addressed here.
- *Combustible materials*. Not specifically addressed here.
- *Private shelters*. Not specifically addressed here.

Italy.
- *Sprinklers*. Not specifically addressed here.
- *Manual protection systems*. Not specifically addressed here.
- *Warning systems*. Not specifically addressed here.
- *Spark arresters*. Not specifically addressed here.
- *Combustible materials*. Combustible and explosive materials indicated as specific risk factors in the interface areas. [LP]
- *Private shelters*. Population should be informed about the possibility of staying in the houses and how to behave when the evacuation is not possible. [LP]

Brief summary. Requirements concerning measures for buildings were found in all standards/guidelines reviewed except for EU and France. Only some provisions/guidelines in Californian standard (for combustible materials), in Australian standard (for private shelters), in Italian local standards (for combustible materials and private shelters). Generally, provisions/guidelines concerning sprinklers, protection and warning systems consist in setting the conditions where they are needed and the tools needed.

6.6 Environment

Provisions/indications about the environmental factors related to wildfire-prone areas are provided only in some of the standards/guidelines reviewed: American standards and guidelines (only for weather in California), Australian standard (only for weather), IWUIC Code, French provisions and guidelines, EU Regulations (only for fire history). Environmental factors are consistently used for risk assessments and definition of hazard zones. A detailed comparison is made considering the sub-categories: weather, fire history.

6.6.1 Weather

Canada. Not specifically addressed here.

USA. Wind, humidity, temperature, fine fuel moisture content are included in the wildfire risk definition. [P]
Critical fire weather generally considered in risk assessment procedures. [G]

California. Weather and winds considered (together with fuel loading, slopes, etc.) in the definition of fire hazard severity zones. [P]

Australia. Environmental factors as input in the calculation of the index for defining the risk areas. [P]

New Zealand. Not specifically addressed here.

International. Climatic factors considered in the definition of WUI areas, including temperature, relative humidity, precipitation, flooding, wind speed, duration of high wind speeds, wind direction, fog and other atmospheric conditions. [G]

Europe. Not specifically addressed here.

France. Climate, intensity of winds, amount of combustible vegetation among the total, presence of dead vegetation, current state of forests/woods, to be considered for developing fire protection plans. [P]
Other factors mentioned: speed and direction of winds, temperature, humidity. [G]

Italy. Not specifically addressed here.

Brief summary. Requirements concerning weather were found in all standards/guidelines reviewed except for Canada, New Zealand, EU and Italy. Weather factors considered in the standards/guidelines from other areas mainly for defining risk areas or severity zones; or for developing fire protection plans (France).

6.6.2 Fire history

Canada. Fire history considered while defining hazards. [G]

USA. Fire history considered in the assessment of ignition sources and in the estimation of values at risk. [P]
Fire history generally considered in risk assessment procedures. [G]

California. Not specifically addressed here.

Australia. Not specifically addressed here.

New Zealand. Not specifically addressed here.

International. Fire history explicitly included in the factors considered for wildfire risk assessments and fire protection plan development. [G]

Europe. Fire history data should be part of the fire protection plan in high risk zones. [P]

France. Fire history explicitly included in the factors for delimiting danger zones. [P]

Italy. Not specifically addressed here.

Brief summary. Requirements concerning fire history were found in all standards/guidelines reviewed except for California, Australia, New Zealand and Italy. Fire history factors considered in the standards/guidelines from other areas mainly for defining risk areas or severity zones; or for developing fire protection plans (International).

6.7 Access

Provisions/indications regarding accessibility and road standards to be adopted in wildfire-prone areas are provided in all the standards/guidelines reviewed, except for the EU Regulations (in the section of California Fire Code concerning WUI fires, access is not mentioned too). The level of

detail of the provisions/guidelines varies between the different areas considered. A detailed comparison is made considering the sub-categories: type/number of access roads, road standards, markings, vegetation clearing.

Canada. Access is adequate if tank truck access can be within 100 m of fire locations (besides other recommendations). If more than 20 % of the area is inaccessible, the access is inadequate. [G]

- *Type/number of access roads.* Access routes for both emergency vehicles and public, serving also as firebreaks. Access routes for interface fire protection are: roadways and fire service access routes. [G]
- *Road standards.* Full tank trucks may require grades ≤ 15 %, radii of curvature ≥ 30 m, curves on gradient ≤ 10 %, adequate bridge/pipeline crossing. Standards applicable if access routes serve ≥ 3 dwellings. [G]
  No standards for driveways/dead-ends. [G]
  If access routes serving building are > 45 m from a roadway, a well-designed fire service access route should be provided. [G]
  No standards for parking. [G]
- *Markings.* Not specifically addressed here.
- *Vegetation clearing.* Not specifically addressed here.

USA. Access provided for all buildings with ground floor area ≥ 400 ft^2 (37 m^2) and all public structures. Approved access for fire apparatus generally within 150 feet (45 m) of the exterior building walls. Other minimum distances are set with respect to access doors, wall perimeters, tall and protected buildings. [P]

- *Type/number of access roads.* The number of access routes required (up to 3) depends on the number of households or parking spaces (e.g. 3 for > 600 households or > 3000 parking spaces (in case of mixed areas). If multiple routes (which should be not close one with each other) are present, one of them should be reserved for emergency use. [P]
- *Road standards.* Specific detailed prescriptions (see Appendix A.2) for main roads concerning materials, minimum clear width, minimum vertical clearance, minimum curve radius, intersection control, traffic calming measures, hydraulic calculations for bridges and culverts, grades, emergency pull-offs, maximum angles of approach and departure. [P]
  Specific detailed prescriptions for turnarounds in case of dead-end/cul-de-sac roads (see Appendix A.2). Max. distance of 30 feet (9.1 m) between gates (with minimum clear width of 2 feet, 0.6 m) and intersections. [P]
  Maximum distance between gates (≥ 2 feet, 0.6 m wide) and roads, minimum length of driveways (12 feet, 3.7 m) and vertical clearance. [G]
  Specific detailed prescriptions for driveways and similar roads if used as fire lanes, concerning materials, curb cuts, maximum grade, minimum lane width, minimum curve radius, bridge loads (see Appendix A.2). [P]
  Specific parking standards provided in terms of angle between curb/limit line and parking slot, minimum stall length, minimum aisle width (for one and two-way roads). [P]
- *Markings.* Addresses consistently assigned. Emergency water source indicators near water points. [P]
  Street numbers at each driveway: non-combustible, visible from each direction, reflectorized and ≥ 4 inches (0.1 m) high. [G]
- *Vegetation clearing.* Vegetation clearing on the roadsides should be eased and permitted. [P]

California.

- *Type/number of access roads.* Not specifically addressed in the specific part of the code reviewed. General requirements in the general Fire Code.
- *Road standards.* Not specifically addressed in the specific part of the code reviewed. General requirements in the general Fire Code.
- *Markings.* Not specifically addressed here.
- *Vegetation clearing.* Not specifically addressed here.

Australia.

- *Type/number of access roads.* Main roads, access roads, fire trails are mentioned as access routes. [P]
- *Road standards.* Standard for main roads concerning pavement, design speed, bridge loads, lane width, curves, dips, turning areas, passing bays. [LG]
  Standards for access roads, concerning width, passing bays. Driveways used by firefighting vehicles must comply with the standards. Access should be provided to within 30 m of buildings. [LG]
  Strategic fire trails should be built if perimeter roads are not available near bushlands. Some general guidelines provided for fire trails design. [LG]
  Suitable and sufficient parking, for avoiding parking on passing bays, roads, fire trails. [LG]
- *Markings.* Not specifically addressed here.
- *Vegetation clearing.* Clearance ≥ 2 m on each side of the carriageway, for a height of 4 m. [LG]

New Zealand. Generic prescriptions for hard-standing for fire service vehicles at within 20 m of building access or sprinkler/hydrant inlets. Access for fire service vehicles provided to ≥ 1 side of fire-cells with floor area ≥ 5,000 m^2, not protected by automated sprinkler systems. Requirements for access not applied to detached dwellings, ancillary buildings and single units in multi-dwellings. [P]

- *Type/number of access roads.* Not specifically addressed here.
- *Road standards.* Not specifically addressed here.
- *Markings.* Building provided with means of information for firefighters mainly concerning fire systems available and the presence of hazardous materials. [P]
  Rural property identification system should be visible to emergency vehicles. [G]
- *Vegetation clearing.* Not specifically addressed here.

International.

- *Type/number of access roads.* Fire apparatus access roads for new buildings in WUI areas. Buildings > 150 feet (45.7 m) far from access roads, should be provided with driveways. [G]
- *Road standards.* Standards for roads in WUI areas which should be travelled by fire-fighters (and be open all year) concerning minimum width, clear height. Structure, curve radii, gradient, pavement should be designed considering fire apparatus loads. [G]
  Standards for driveways in WUI areas concerning the number of dwelling units served, minimum width and vertical clearance, turnarounds and turnouts (also for dead-end roads), turning radii (inside/outside), surface, bridge loads, grades. [G]
- *Markings.* Signs for access/driveways in WUI areas should be non-combustible, at a height of 7 feet (2.1 m) from the road surface, and have defined characteristics for contrast, height of characters and reflective letters. [G]

Markings for fire protection equipment and hydrants. Address markers should be at each driveway, visible from both directions, repeated in case of driveways division, provided at existing roads. [G]

- *Markings.* Not specifically addressed here.

Europe.

- *Type/number of access roads.* Not specifically addressed here.
- *Road standards.* Not specifically addressed here.
- *Markings.* Not specifically addressed here.
- *Vegetation clearing.* Not specifically addressed here.

France.

- *Type/number of access roads.* Design standards of roads should be locally defined in different risk zones. [G]
  Roads can be divided into three classes: main and secondary service roads, driveways. [P]
- *Road standards.* Standards for main roads (to be always practicable) are provided concerning width, vertical clearance, maximum gradients, double-exit paths from dead-end roads. [LP]
  Secondary service roads should have same standards of main roads, except for road width. [LP]
  Group of houses and public structures should be served by a main service road or secondary (if < 6 houses). If the secondary road is < 20 m from the house, a driveway is not needed, but a pedestrian path should be built. Standards for roads internal to the group of houses are provided, concerning cul-de-sacs, curve radii, gradients, width. [LP]
  Standards are provided concerning width, vertical clearance, gradients. [LP]
  All individual houses should be
- *Markings.* Not specifically addressed here.
- *Vegetation clearing.* Both sides of public roads in hazard zones should be cleared within 20 meters. Additional clearance required may not exceed an area within 100 m of the road. Driveways of structures < 200 m from the forest, should be cleared from vegetation for a distance of 10 m. [P]

Italy. The absence of evacuation routes and presence of only one-way out are risk factors in interfaces. [LP]

- *Type/number of access roads.* Not specifically addressed here.
- *Road standards.* Criteria can be provided for main roads concerning width, maximum grade, curve radii, diameter of roundabouts, cross slopes. [LG]
- *Markings.* Not specifically addressed here.
- *Vegetation clearing.* Not specifically addressed here.

Brief summary. Requirements concerning access were found in all standards/guidelines reviewed except for California (retrievable in the general Fire Code) and EU. Provisions about type/number of access roads, and road standards in all the other documents reviewed, except for New Zealand and Italy (only for type/number of roads). Provisions about other markings only in US, International and New Zealand standards. Generally, provisions/guidelines concerning road standards include geometric standards, pavements, turnarounds, clearance, loads. Generally, provisions/guidelines concerning markings concern visibility, location and text on markings. Very detailed prescriptions about access were found in the US standards.

7. Conclusions

This work presents a review of selected international standards and guidelines concerning fires in Wildland-Urban Interface areas. A template was developed and used to consistently present the information regarding hazard, land, building construction, utilities, fire protection measures, environment and access from the review of several regulatory / guidance documents. The main objective was to document the provisions and enable a comparison between the regulations/guidance examined, in order to identify underlying common themes and/or highlight the main differences. This comparison is summarized in Table 2. In some locations, provisions for WUI fires are included in general Fire Codes (see the case of California); elsewhere, requirements are delegated and implemented at local levels (see the case of France and Italy). Some countries have standards specifically dedicated to the issue of WUI fires (see e.g. USA and Australia).

Provisions/guidelines vary between different countries in the quantitative assessments of various parameters, and in the methods used for defining measures and indicators. However, some common approaches were found, such as some methods for assessing the wildfire risk based on several factors and partial ratings; or the concept of defensible space and vegetation clearing.

The commonalities found in the different standards/guidelines reviewed are listed as follows, divided according to the factors considered:

Hazard

- Destination. Definitions of wildfire risk and hazard levels in all standards/guidelines reviewed (except for New Zealand), mainly based on topographic, vegetation and environmental factors.
- Severity class. Methods for identifying and classifying severity in WUI areas in all the standards/guidelines reviewed, with different refinement (a sum of partial ratings based on different factors; or on fire history, such as EU Guidelines).

Land

- Vegetation. Concept of defensible space present in all standards/guidelines reviewed (except for EU regulations). Prescriptions/guidelines for vegetation clearance and distance between vegetation and other vegetation/structures.
- Topography/Terrain. Topographic and terrain factors considered in all standards/guidelines reviewed (except for EU and New Zealand). Those factors generally affect the definition of risk areas (and/or defensible space), or the position between houses and slopes (Canada).

Building construction

- General requirements. General requirements for construction materials and ignition resistance found in all standards/guidelines (except for EU, France, Canada). Only generic requirements in Californian and Italian standards.
- Roof. Provisions abut roof covering, eaves (by defining materials to be used and their ignition resistance) and gutters found in all standards/guidelines (except for New Zealand, EU, Italy, California only for gutters). Provisions about valley flashing in Australian, Californian and International standards/guidelines.
- Walls and other external coverings. Requirements for walls and other external coverings (by defining materials to be used and their ignition resistance) found in all standards/guidelines (except for EU and Italy). Wall coverings considered only in French and Californian standards/guidelines reviewed.
- Windows, external doors and vents. Requirements for exterior glazing, external doors (by defining materials to be used and their ignition resistance) and vents and other openings (by considering corrosion-resistance and grid openings) found in all standards/guidelines (except for New Zealand, EU, Italy, France for glazing and doors, Canada for doors).

- Decks and detachments. Requirements concerning decks and other attachments (by defining materials to be used and their ignition resistance) found in all standards/guidelines reviewed (except for New Zealand, EU and Italy, France only for decks and attachments). Provisions about detachments (by defining their distance from main structures) in the documents reviewed for USA, Australia, International, France.
- Floor and interior structures. Requirements concerning under-floors found in all standards/guidelines reviewed (except for EU, France, Italy and New Zealand). Provisions about floors (by defining materials to be used and their ignition resistance) only in Australian and New Zealand standards (including here also provisions about other interior structures).

Resources

- Utilities. Requirements concerning water supply (supply level, water sources, access, hydrants) found in all standards/guidelines (except for California, EU, Italy). Provisions about other utilities only in New Zealand standards (concerning evacuation routes). Detailed definition of water supply found in US, International, Australian standards/guidelines.
- Firefighters. Not homogeneous and scarce requirements concerning firefighters found in standards/guidelines from Canada, USA, New Zealand, France and Italy.
- Planning. Requirements concerning fire protection plans (detailed for USA and Canada) found in all standards/guidelines reviewed (except for New Zealand). Provisions about other plans in all the other documents reviewed, except for California and France.
- Outreach. The outreach is variable, depending on the type of document reviewed. Generally, guidelines for creating defensible space, clear and maintain vegetation are dedicated to the general public (which may be homeowners, communities and/or planners). Some regulations can be implemented at a local level with modifications allowed.

Fire protection measures

- Measures for water sources. Requirements concerning measures for water sources (clearing, defensible space, materials, protection, connections for water sources) found only in US, Australian and International standards/guidelines reviewed.
- Measures for buildings. Requirements concerning measures for buildings (sprinklers, protection and warning systems) found in all standards/guidelines (except for EU and France). Only some indications in Californian standard (for combustible materials), in Australian standard (for private shelters), in Italian local standards (for combustible materials and private shelters).

Environment

- Weather. Requirements concerning weather (mainly for defining risk areas or severity zones, or for fire protection plans) found in all standards/guidelines (except for Canada, New Zealand, EU and Italy).
- Fire history. Requirements concerning fire history (for defining risk areas or severity zones, or for fire protection plans) found in all standards/guidelines (except for California, Australia, New Zealand and Italy).

Access

Requirements concerning access found in all standards/guidelines (except for California, retrievable in the general Fire Code) and EU. Provisions about type/number of access roads, and road standards (geometry, pavements, turnarounds, clearance, loads) in all the other documents reviewed (except for New Zealand and Italy, only for type/number of roads). Provisions about other markings (visibility, location, text) only in US, International and New Zealand standards.

In conclusion, the work carried out may be useful for the development or revision of novel standards/guidelines concerning WUI fires prevention, protection, planning and management.

Table 2. Comparison of WUI fire design guidance

ID	Indications/ Provisions/ Level	Type of Hazard Definition	Buffer Zone (vegetation)	Influence of terrain?	Specific prescriptions for structural elements (list)	Specific prescription for utilities	Specific prescription for firefighters	Type of plans required	Specific fire protection measures provided	Influence of environment/ fire history?	Specific prescriptions for access
1	Guidelines (Canada/Canadian provinces), dedicated to both communities and homeowners	Four different hazard levels for structures and sites (low, moderate, high and extreme). The same levels are used for the hazard assessment of the surrounding areas of sites.	Three priority zones are identified with respect to vegetation management (priority 1: < 10 m, priority 2: 10-30 m, priority 3: > 30 m). Fuel removal should be conducted in the priority zone 1 at least. Removal, reduction and species conversion can be conducted in the other zones.	Factors addressed: Slopes. Some guidelines are given for the relative position building/ slope: building should be at least 10 m beyond the crest of the slope, or on the bottom of the hill. Fuels on slopes (especially > 10 %) should be modified more aggressively.	Roof (including covering and eaves), exterior walls, glazing, vents and other openings, decks and attachments. Guidelines are not detailed. Minimum separation between structures is considered.	Guidance on water source (qualitative) and fire hydrants.	Guidance on firefighters: cooperation, training and trust-building principles (agencies / practitioners).	*Wildfire Preparedness Guide* (for protecting values at risk, dedicated to emergency response personnel); *Wildfire Mitigation Strategy* (activities for reducing the impact of wildfires on values). Other plans considered are the *Sprinkler Deployment*, *Municipal Development*, *Municipal Emergency Management* plans and the *Land Use Bylaws*.	Buildings, in particular involving / including combustible materials (debris, firewood etc., propane tanks, burning barrels and fire pits) and spark arresters.	Fire history affects hazard definition and assessment.	Definition of adequate access, road standards and fire service access routes.
2	Provisions (American Standards)	The definition the hazard exposure of structures is given. Structures are classified into five classes of occupancy hazard and five classes of construction types, with respect to wildfire risk. A structure assessment is needed to provide a hazard	Buildings located ≤ 30 feet (9 m) from vegetated slopes should require special mitigation measures. If a sufficient space is not present between structures and vegetation, a non-combustible barrier should be created. The fire mitigation plan should include detailed	Factors addressed: slopes, topographical factors (flat areas, ridges, saddles, natural chimneys, canyons). Topography and terrain are included in the structure assessment, with respect to the wildfire risk.	Roofs (covering, eaves, gutters), exterior walls, exterior glazing and doors, vents and other openings, decks, attachments and detached structures. Specific provisions are given concerning the building separation and the characteristics of	Water supply level, providing specific detailed guidance on how to calculate the minimum water supply. It depends on the occupancy hazard, construction type, dimensions and exposures. Other provisions concern water sources, access, hydrants (fire and dry).	Specific provisions are given concerning the activities to be undertaken for planning, managing and assessing the firefighting activity in case of a wildfire disaster.	*Fire protection plan, Mitigation plan* (including fuel modification provisions), and the other following *plans* concerning: *fire lanes, winter access maintenance, multi-agency operation* (not specific to wildfires), *minimum water supply, dry hydrant, fire response, preparedness, incident action,*	Measures for water sources: connections for sprinkler systems, fire hydrant and dry hydrants. Measures for buildings: sprinklers, standpipe systems and fire extinguishers (manual protection), spark arresters and provisions concerning the	Fire history considered in the assessment of ignition sources.	Provisions about the number of access routes to the area to be provided, depending of the number of households. Detailed standards for main roads, dead-end roads, fire lanes, parking, road signs and markers. Geometric and construction

		rating of the structure considering a broad list of elements.	provisions about fuel modification.		ignition resistant materials.			*containment and control, construction.*	storage of combustible materials (including liquid storage).		requirements are listed. Vegetation clearing on the roadsides should be permitted.
2b	Guidelines (American Guidelines, including Colorado, Florida and Oregon), dedicated to communities, planners and homeowners	Different methods for assessing risks and hazards in the WUI areas (highly detailed guidelines in the Florida document). A common approach used is the definition of partial scores for different features (i.e., vegetation, buildings, values, access, etc.) and after the computation of the total hazard score by summing up partial ratings.	Slightly different prescriptions between states. A common essential requirement for the defensible space is to have a first area surrounding the building with heavily reduced fuel of 30 feet (about 9 m).	Factors addressed: slopes, terrain. Characteristics of slopes and terrain generally considered in the risk assessment. Specific requirements only in Oregon guidelines.	Some building construction guidelines, especially for roof covering and eaves, exterior walls, glazing, vents and other openings, decks.	Some guidelines concerning supply level, water source and access to water sources in the Oregon guidelines.	Not specifically addressed	General guidelines on how to develop mitigation and response plans (Florida) and how to adhere to the *Firewise Communities Program.*	Some generic measures for water sources (helicopter dip spots, Florida) and buildings (sprinklers, spark arresters and combustible materials).	Influence of some environmental factors in the hazard and risk assessment.	Influence of some access factors in the hazard and risk assessment. Specific provisions for driveways and street markers (mainly Florida).
3	Provisions (California Code)/ Indications (Guidelines) for homeowners	Three risk levels (medium, high and very high risk) defined by the State and by local authorities (additional very high-risk area)	Up to 100 feet (30.5 meters) for brush, flammable vegetation and other combustible growth (except for some specific cases).	Factors addressed: slopes. Yes. Different horizontal and vertical clearance between vegetation as a function of terrain slopes.	Roof (including valley flashings, eaves and gutters), exterior walls and coverings (including roof eaves, ceilings and appendages), exterior glazing and doors, vents, decks and attachments, underfloor areas. Ignition resistant material are defined.	Not in the specific WUI part of the Fire Code.	Not in the specific WUI part of the Fire Code.	*Fire Protection Plan* for new constructions and modifications	Not in the specific WUI part of the Fire Code	Influence of environmental factors in the definition of the hazard zones.	Not in the specific WUI part of the Fire Code
4	Provisions (Australian standards)	The definition of the hazard exposure of structures is	In the extreme bushfire risk area, a distance of at least 10	Factors addressed: slopes.	Roof (including valley flashings, eaves and gutters), exterior	Not specifically addressed in the reviewed standard.	Not specifically addressed	Local guidelines require some types of protection plans	Local guidelines require some fire protection measures	Influence of some environmental factors in the	Provisions for main, access roads and fire trails are given in

		given. Structures are classified into seven classes of Bushfire Hazard Level (BAL), from a very low level of hazard to an extreme risk level. Detailed guidance is provided on how to define those areas, based on several factors.	meters should exist between structures and vegetation. Otherwise, structures within this distance should comply with specific requirements. Local regulations and guidelines give specific guidance on how to conduct fuel reduction and protection around structures.	Terrain slopes are considered in the computation of Bushfire Hazard Levels. They are considered also by local guidelines for defining the width of protection areas around structures.	walls and coverings, exterior glazing and doors, vents, decks, attachments and detachments, floors and subfloors. The characteristics of some ignition resistant materials are defined. Particular emphasis is provided in defining the detailed characteristics of external glazing and doors.	Guidelines about supply level, water sources, access and fire hydrants are provided in local documents.			(including water sources and private shelters)	definition of the hazard zones.	local guidelines (including e.g. vegetation clearing for a width of 2 m on each side and for a height of 4 meters).
5	Provisions (New Zealand regulations)	A classification of the types of structures with respect to fire and the related risk for their occupants is provided. Five levels of building types are defined (Building Importance Levels, BIL): from BIL 1 (low risk for human life or low cost in case of building fail) to BIL 5 (extreme risk to large area or large population).	Firebreaks should be cleared from vegetation (qualitative indications, not providing specific measures).	Not specifically addressed	Exterior walls, floors, other interior structures (walls and ceiling materials, firecells). Specific provisions about the maximum surface temperature of combustible building materials and the fire spread to other property.	A future plan is in progress for water supply. Provisions about escape routes are given.	Some qualitative indication.	Provisions about *evacuation plans* are given (and the types of structures which need them).	Some indications about combustible materials and warning systems (mainly from additional guidelines reviewed).	Not specifically addressed	Some provisions and guidelines for markings, general provisions for access from roads to buildings.
6	Provisions (International code)	Three classes of fire hazard severity are defined (Moderate	Fuel modification (reducing/alterin g the non-fire resistive	Factors addressed: slopes, topographic factors	Roof (including valley flashings, eaves and gutters), exterior walls, exterior	Water supply points, including prescriptions about supply level, water	Not specifically addressed	*Fire protection plan, Site plan* including specific information about wildfire	Measures for the protection of water sources, sprinklers, spark arresters and the	Influence of environmental factors and fire history in the definition of	Specific prescriptions for standards of main roads and driveways, road

		Hazard -M-, High Hazard, -H-, Extreme Hazard, -E-), depending on a combination of fuel models, critical fire weather frequency, terrain slopes	vegetation) should be conducted within a distance of: -30 feet (9.14 m) for the moderate hazard area, -50 feet (15.24 m) for the high hazard area, -100 feet (30.48 m) for the extreme hazard area. Greater site-specific distances.	(elevation, ridges, drainages, roads, exposure, etc.), interactions between man-made infrastructures and geography. Terrain slopes are considered in the definition of the hazard severity classes and in the prescription for decks and detached structures.	glazing and doors, vents and other openings, decks and other attachments, detached structures, underfloor areas. Definitions of ignition resistant classes (from 1 to 3), based on defensible space, fire hazard severity and water supply; and of the characteristics of ignition resistant materials.	sources, access and supply power.		exposure, *vegetation management plan* (not mandatory)	storage of combustible materials	wildfire risk, hazard zones, and fire protection plans (fire history)	signs and markers.
7	Provisions (European code)	Three risk zones should be individuated in the territory of the European Union with respect to forest fires: high risk (exposed to permanent or cyclic forest fire risks), medium (fire risk not permanent or cyclic, but endangering the forest ecosystem) risk, low risk (all other zones). The WUI fires are not explicitly mentioned.	Not specifically addressed	Not specifically addressed	Not specifically addressed	Not specifically addressed	Not specifically addressed	*Fire protection plan* and a scheme for promoting, improving, and evaluating data about forest risks.	Not specifically addressed	Fire history of the previous 5 years should be considered in defining fire protection plans in the high-risk areas.	Not specifically addressed
8	Provisions (French Law/local)	Two main risk areas (one where it is possible to build new structures under given conditions	Vegetation clearing up to 50 meters. A buffer distance of 200 m should be maintained between new	Factors addressed: slopes, orientation (e.g. with respect to wind), sunlight exposure.	Roof (including eaves and gutters), exterior walls and coverings, vents, detached structures. All	Water supply points. Specific local prescriptions (plans) for their characteristics	Storage of material for firefighting in designated places in the hazard zones.	Local Plan for preventing predictable natural risk – forest fire (including the definition of the	Not specifically addressed	Influence of environmental factors and fire history in the definition of the hazard zones.	Roadsides in the hazard zones should be cleared up to 20 meters (both sides, 10 meters for driveways).

		and the other not). Regions defined as subject to forest fire risk: Aquitaine, Corse, Languedoc-Roussillon, Midi-Pyrénées, Poitou-Charentes, Provence-Alpes-Cote d'Azur	constructions and the forest. Specific local prescriptions (plans) for vegetation clearing.	Influence of terrain in the definition of risk areas. Not considered for setting vegetation clearing criteria.	those information included in local guidelines.	and distance from structures.		hazard zones and the specific prescription for them).			Specific prescriptions about geometric features are given in local plans.
9	Provisions (Italian Law)/Guidelines (regional), dedicated to planners	Definition of interfaces and danger zones (regional guidelines) based on several characteristics. Four danger zones identified (regional guidelines).	Two areas of defensible space identified (within 10 m and 10-20 m of the structure), with different indications about fuel removal, reduction and substitution, clearance between vegetation and maintenance (regional guidelines). Different prescriptions for defensible space are given in different regions (based on the two documents reviewed).	Factors addressed: slopes. Extension of the defensible space in case of high values of slopes (regional guidelines).	Building construction, change of land use destination, planting of new vegetation are activities not allowed for defined periods of time in areas which were recently subject to fires.	Not specifically addressed	Definition of some possible activities to be conducted by firefighters in case of interface fires (regional plan).	Regional plan for forecasting, preventing and fight wildfires, including a list of requirements, recommendations indicated by the President of Ministry Council, evacuation plan (regional)	Some qualitative measures about combustible materials and private shelters (regional plan).	Not specifically addressed	Some qualitative and more specific requirements for road standards of main roads (regional plan and guidelines)

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Appendix A – Filled review templates on WUI fires design guidance

A.1 Canada: Guidelines

In Canada, there are some guidelines concerning wildfire safety in the wildland-urban-interface. In particular, the use of the FireSmart community program is widely applied to local communities across the country. An example of application of the FireSmart guidelines: Guidebook for Community Protection of the Alberta State has been reviewed. It includes most of the indications given in the (FireSmart, Protecting Your Community from Wildfire, 2003) and (FireSmart Homeowner's Manual, 2017). Some additional features included in the baseline document (FireSmart, Protecting Your Community from Wildfire, 2003), which are referenced in the reviewed Guidelines have been considered and summarized below.

Detailed guidelines are provided on how to identify hazard types, risks and categories of hazard for structures and surrounding areas, vegetation, planning. Indications and guidelines concerning topography and terrain, building construction, water supply, firefighters (including also guidelines from TRUST project), fire protection measures for buildings, access.

All the information in the following table refer to the FireSmart Guidebook for Community Protection (Alberta Government), unless otherwise stated.

Table A.1 Canada Guidelines – Guide/Code: FireSmart Guidebook for Community Protection (Alberta)	
Category	**Provision**
A. Hazard	
A.1 Definitions	***1. Destination*** The wildfire hazard level in a given area is determined through wildfire factors: kind, arrangement, volume, condition and location of wildland fuels. The wildfire risk is related to the likelihood of a wildfire starting, in terms of probability and consequences. The community protection areas and their priorities are identified through hazard and risk assessment, in order to quantify the level of risk. Values at risk. Defined based on field observations, provincial GIS data, and development data. Hazard assessment. Defines the wildfire threat potential, based on building materials, landscaping, topography and fire behavior potential for the identified values at risk. Two tools are used: • For individual sites: FireSmart Structure and Site Hazard Assessments (FireSmart, Partners in Protection, 2003) (for the structures and the area around 30 meters from the structures), FireSmart Area Hazard Assessments (for the zone > 30 m away from a structure). The distance measures are modified based on fuels and topography of the area.

- For the community: Wildfire Threat Assessment Model (ArcGIS application combining different data layers into a wildfire threat rating layer). The inputs to this model are: fire behavior potential, fire occurrence risk, values at risk and suppression capability.

Additional available assessment tools are:

- Prometheus (Canadian Wildland Fire Growth Model), a modelling tool able to predict the real-time growth of wildfires and the potential threat to values at risk, and able to assess the effectiveness of wildfire management strategies and potential loss on landscapes altered by those strategies.
- FireWeb, providing real-time information about Alberta wildfires and resources to support wildfire management, prevention and operation.

Risk assessment. Essentially based on wildfire causes, frequency (considering historical data) and threat to values at risk. Tools used are should be municipal incidents report, fire ignition, prevention and suppression checklist, FireWeb mapping, ESRD historical wildfire database (including GIS wildfires polygons for wildfires > 200 ha since 1931 and an electronic database of Alberta wildfires since 1961).

2. Severity class

The Structure and Site Hazard Assessment Form (FireSmart, Partners in Protection, 2003) is used for defining an overall building and site hazard level, considering the area around 30 m from the structures. The factors considered are reported below. For each factor, a rating is given based on the potential wildfire hazard. All the individual scores are then summed up in order to obtain the overall score. By comparing the overall score with predefined ranges, divided into four hazard classes:

- Low (< 21 total points);
- Moderate (21-29 total points);
- High (30-35 total points),
- Extreme (> 35 total points).

The ratings for each factor are reported as follows:

- *Roofing material*.
  - Metal, tile, asphalt, ULC-rated shakes, non-combustible materials - 0;
  - unrated wood shakes - 30.
- *Roof cleanliness*.
  - Noncombustible materials – 0;
  - scattered combustible materials < 0.01 m thick – 2;
  - clogged gutter, combustible material <0.01 m thick – 3.
- *Building exterior*.
  - Noncombustible stucco, metal, bricks, cement, concrete, rock – 0;
  - Log walls, heavy timbers – 1;
  - Wood or vinyl siding, wood shakes – 6.
- *Eaves, vents and openings*.
  - Closed eaves, accessible vents screened with a 0.003 m mesh – 0;

	○ Closed eaves, vents not screened with a 0.003 m mesh – 1; ○ Open eaves, vents not screened – 6. • *Balcony, deck or porch*. ○ Noncombustible material, or sheathed with fire-resistance materials – 0; ○ Made of combustible materials, sheathed – 2; ○ Made of combustible materials, not sheathed – 6. • *Window and door glazing*. ○ Tempered – 0; ○ Double (thermal) pane, less than 1 x 1 m – 1; ○ Double (thermal) pane, 1 x 1 m – 2; ○ Single pane glass, less than 1 x 1 m – 2; ○ Single pane glass, 1 x 1 m – 4. • *Location of nearby combustibles*. ○ None or more than 10 m from buildings – 0; ○ < 10 m from buildings – 6. • *Setback from edge of slope*. ○ Adequate (building on the slope bottom, or slope top with setback) – 0; ○ Inadequate (building on the mid to upper portion of a hill) – 6. • *Overstory of forest vegetation*. ○ > 90 % deciduous vegetation within 30 m of structure – 0; ○ > 50 % deciduous and < 50 % coniferous at 10-30 m of structure – 10; ○ > 50 % coniferous and < 50 % deciduous separated vegetation (low density, crowns not touching each other) at 10-30 m of structure – 10; ○ > 50 % deciduous and < 50 % coniferous within 10 m of structure – 30; ○ > 50 % coniferous and < 50 % deciduous within 10 m of structure – 30; ○ > 50 % coniferous and < 50 % deciduous continuous vegetation (high density, crowns touching each other) at 10-30 m of structure – 30. • *Surface vegetation*. ○ Lawn or noncombustible materials – 0; ○ Wild grass or shrubs at 10-30 m of building – 5; ○ Scattered (groups widely spaced, ≥ 3-5 m) dead and down woody material at 10-30 m of building – 5; ○ Wild grass or shrubs within 10 m of building – 30; ○ Dead and down woody materials within 10 m of building – 30; ○ Abundant (continuous groups) dead and down woody material at 10-30 m of building – 30. • *Ladder fuels (within 10-30 m of building)*. ○ Absent (< 25 % of trees with ladder fuels < 2 m to the ground) – 0; ○ Scattered (25-75 % of trees with ladder fuels < 2 m to the ground) – 5;

	o Abundant (> 75 % of trees with ladder fuels < 2 m to the ground) – 10. The Area Hazard Assessment Form (FireSmart, Partners in Protection, 2003) is used for defining an overall hazard level of the area beyond 30 m from the structures. The factors considered are reported below. For each factor, a rating is given based on the potential wildfire hazard. All the individual scores are then summed up in order to obtain the overall score. By comparing the overall score with predefined ranges (equal to those defined for the Structure and Site Hazard Assessment), divided into four hazard classes: Low, Moderate, High, Extreme. The ratings for each factor are reported as follows (for the definitions of scattered, abundant, absent, continuous, separated, see the above reported Structure and Site Hazard Assessment Form): • *Overstory of forest vegetation*. o > 90 % deciduous vegetation – 0; o > 50 % deciduous and < 50 % coniferous vegetation – 15; o > 50 % coniferous and < 50 % deciduous, separated vegetation – 15; o > 50 % coniferous and < 50 % deciduous, continuous vegetation – 30. • *Surface vegetation*. o Lawn or noncombustible materials – 0; o Wild grass or shrubs – 5; o Scattered dead and down woody materials – 5; o Abundant dead and down woody materials – 15. • *Ladder fuels*. o Absent – 0; o Scattered – 5; o Continuous – 10. • *Slope*. o 0-10 % – 0; o 10-25 % even (smooth or rolling texture) slope – 4; o 10-25 % gullied (with cuts running up) slope – 5; o > 25 % even slope – 8; o > 25 % gullied slope – 10. • *Position on slope*. o Valley bottom or lower portion of the slope – 0; o Mid portion of the slope – 3; o Upper portion of the slope – 5. According to the (FireSmart, Partners in Protection, 2003), the Fire Ignition and Prevention Checklist provides assessment about the ignition potential of the site and the area. Some factors are considered, which are listed as follows. A Yes (contribution to hazard) or No (contribution to lowering the hazard) answer is given for each factor considered in the checklist. The factors related to the *ignition potential of the area* are the following: • *Frequent lighting fires*: areas with high frequency of lightning-caused fires; • *Frequent human-caused fires*: o areas within 1 km from parks recreation site,

	○ areas within 1 km of high-use roads/trails frequently used by humans, ○ areas within 1 km of areas with historic recreational fires starting, ○ areas within 1 km of areas with high accumulation of litter/garbage, ○ areas within 0.5 km of the sites, including dumps/industrial sources, ○ infrequent-use areas with no regular access by humans (low-risk areas). • *Aspect*: if the slope faces to south direction, the best conditions for fires are present, the opposite condition exists for north direction. Eastern and western exposures can provide good conditions for fires only during some hours. The factors related to the *ignition potential of the structure and site* are the following: • *Chimneys*: unscreened chimney openings can contribute to roof ignitions in case of combustible roofs. The distance between chimneys and overhanging branches, the type of screening and the clearance between chimney outlets and roofs should be adequate. Standards about clearance are reported in the appropriate section B.1.2 (for clearance from vegetation) and C.4.3 (for prescriptions about chimney openings). • *Burning barrels or fire pits*: if the appropriate measures are not taken for the protection of burning barrels or fire pits, they could be an ignition cause (see E.2.5). • *Overhead powerlines near vegetation*: if the appropriate clearance is not ensured, they could be an ignition cause (see B.1.2). • *Propane tanks* near vegetation: if the appropriate measures are not taken, they could be an ignition cause (see E.2.5). According to the (FireSmart, Partners in Protection, 2003), the Fire Suppression Checklist provides assessment about the fire suppression capabilities of the site and the area. Some factors are considered, which are listed as follows. A Yes (low suppression capabilities) or No (acceptable capabilities) answer is given for each factor considered in the checklist. The factors related to the *fire service* are the following: • *Response times > 10 minutes:* if this is the case, a yes answer is marked. • *Access to area for emergency vehicles*: if inadequate, a yes answer is marked (see G.1.2 for a definition of adequate access). • *Access to structure*: if inadequate, a yes answer is marked (see G.1.2 for a definition of adequate access). The factors related to *water supply* are the following: • *Municipal water supply:* if unavailable, a yes answer is marked (see D.1.1 for characteristics of adequate water supply). • *On-site water supply*: if unavailable, a yes answer is marked (see D.1.1 for characteristics of adequate water supply). • *Suppression equipment on site*: if unavailable, a yes answer is marked (see E.2.2 for characteristics of adequate equipment).

B. Land	
B.1 Vegetation	***1. Defensible space*** According to (FireSmart, Partners in Protection, 2003), crown fires poses significant hazards for adjacent buildings. Crown fires may spread more rapidly in dense coniferous forests than in mixed wood (coniferous and deciduous forests), while the fire spread in deciduous forests is very unlikely. For this reason, these are preferred near buildings, while mixed wood and coniferous forests should be distant at least 10 m of the structure (better 30 m for coniferous forests). Surface fuels (grass, herbs, shrubs, dead and down woody debris), small tress < 2.5 m in height, should be removed and replaced with noncombustible materials or trimmed lawns within at least 10 m from the structure. The treatment consisting in removing most of the understory vegetation or ground fuels in the area within 30 m is also important. A vegetation management strategy should be conducted around homes and buildings, by differentiating the intervention of: • *Fuel removal* (remove fuel adjacent to high priority areas such as homes, buildings, important infrastructures; by harvesting, mowing or using prescribed burning programs; in order to create fire barriers); • *Fuel reduction* (remove fuel in areas having high hazard vegetation inside; by pruning or reducing surface and ground fuels; in order to reduce fire behavior potential); • *Species conversion* (remove flammable vegetation and replace them with less flammable species, irrigate and maintain grass and deciduous trees near structures; throughout all the community areas; in order to reduce flammability of surrounding vegetation); in the three different following zones: • *Priority zone 1*, most critical, within 10 m of the structure. Fuel removal should be essentially conducted in this area; • *Priority zone 2*, from 10 to 30 m from the structure. A combination of fuel removal, reduction and conversion should be conducted in this area; • *Priority zone 3*, > 30 m from the structure (until 100 m, according to (FireSmart Homeowner's Manual, 2017)). A combination of fuel removal, reduction and conversion should be conducted in this area. Vegetation management strategies should be implement through different methods, explained as follows. • *Site treatments*: through tactical lines (fuel free corridor to base wildfire operations or slowing fire spread), pruning (remove low branches and burnable debris), thinning (increase clearance between trees, see B.1.2), mulching. • *Timber harvest*: harvesting or thinning for commercial/industrial purposes as a tool managing vegetation against wildfires. • *Prescribed or controlled fires*. • *Grazing*.

	2. Clearance between/from vegetation Horizontal clearance. According to (FireSmart, Partners in Protection, 2003), chimney outlets should have clearance of ≥ 3 m from vegetation and obstructions. The same recommendation is included in the FireSmart Guidebook. Vertical clearance. According to (FireSmart, Partners in Protection, 2003), overhead distribution power lines should have adequate clearance from vegetation. ***3. Maintenance*** Removal of ladder fuels (shrubs, immature trees < 2.5 m in height, branches near the ground within 2 m, should be conducted in the area within 10 to 30 m of the building. The following assessment should be conducted annually: • Amount of grass on tactical lines and in hazard reduction burn sites; • Growth of surface vegetation on previously thinned or converted areas; • Accumulation of combustible debris in fuel-breaks and forests to be converted.
B.2 Topography/ Terrain	According to (FireSmart, Partners in Protection, 2003), the relative position building/slope affects the wildfire hazard. Structures on slopes must be designed with noncombustible exteriors and the other principles included in (FireSmart, Partners in Protection, 2003). A single building should be placed at least 10 m beyond the crest of the slope, or placed on the bottom (or the lower portion) of the hill. Greater setback distances may be needed for taller buildings. Fuels on slopes should be modified more aggressively than on flat ground (especially for slopes greater than 10 %, and for gullied slopes, i.e. having cuts running up the slope, caused by water erosion, and easing the wind-driven fire spread).
C. Building Construction	
C.1 General requirements	***1. Classes of ignition resistance*** Not specifically addressed here. ***2. Characteristics of ignition resistant materials*** Not specifically addressed here. ***3. Building separation*** In a development plan, a minimum separation between structures should be considered in case of high-density housing. NFPA standards are referenced, recommending a separation ≥ 9 m between structures.

C.2 Roof	***1. Covering*** According to (FireSmart, Partners in Protection, 2003), in interface areas, only fire-retardant roof covering assemblies (Class A, B or C, with class A having the lower combustibility and class C having the higher combustibility) should be used. Roofing material should avoid the entry of flames/embers. Accumulation of combustible debris should be avoided. ***2. Valley flashings*** Not specifically addressed here. ***3. Eaves*** According to (FireSmart, Partners in Protection, 2003), in interface areas, undersides of overhangs (soffits) should be made of combustible materials with 0.012 m sheathing (ideally non-flammable). Open eaves should be avoided as they can increase the structural fire danger. ***4. Gutters*** Not specifically addressed here.
C.3 Walls and other external coverings	***1. Exterior walls*** According to (FireSmart, Partners in Protection, 2003), noncombustible sidings should be used (such as stucco, metal siding, brick, cement shingles, concrete block, poured concrete, rock). ***2. Wall coverings*** Not specifically addressed here.
C.4 Windows, external doors and vents	***1. Exterior glazing*** According to (FireSmart, Partners in Protection, 2003), vegetative fuels should be avoided within 10 m of windows (and glass doors). Small or multi-pane windows are more resistant to fractures and collapse. An intact plate glass will likely prevent interior ignition from thermal radiation. ***2. External doors*** Not specifically addressed here. ***3. Vents and other openings*** According to (FireSmart, Partners in Protection, 2003), soffit vents should be located at a sufficient distance from exterior walls. Openings should be located at appropriate places and screened with corrosion-resistant mesh having 0.003 m openings. Chimney outlets should be ≥ 0.6 m higher than any part of the roof which is within 3 m of the chimney. They should be ≥ 0.9 m above the point of intersection between chimneys and roof surfaces.

C.5 Decks and detachments	***1. Decks and other attachments*** According to (FireSmart, Partners in Protection, 2003), stilt construction allows fire to reach overhangs, by igniting the building. The situation is worsened if debris or combustibles are stored under the overhang. Closing balconies and decks with flame-resistant material may reduce the risk, while slotted deck surfaces may increase it, by allowing needle litter accumulation. To prevent this, spaces in slotted decks should be accessible. ***2. Detached structures*** Not specifically addressed here.
C.6 Floors and interior structures	***1. Floor*** Not specifically addressed here. ***2. Underfloor*** Not specifically addressed here. ***3. Other interior structures*** Not specifically addressed here.
D. Resources	
D.1 Utilities	***1. Water supply*** Supply level. According to the (FireSmart, Partners in Protection, 2003), the use of large diameters (> 0.025 m) for water supply mains in interface areas will provide high volumes and pressures, in case of fire suppression. Water source. According to the (FireSmart, Partners in Protection, 2003), a water source can be classified as available, if it can serve for the whole fire season, even during peak demand interface with power outage. High-volume wells or irrigation systems can be considered if quickly accessible by firefighters. Access. Not specifically addressed here. Standby power. Not specifically addressed here. Fire hydrants. According to the (FireSmart, Partners in Protection, 2003), on-site water supply can be considered as available, if fire hydrants are located near buildings and they have spacing, capabilities and main sizes complying with Fire Underwriters Survey or NFPA Standards. Dry hydrants. Not specifically addressed here. ***2. Other utilities*** Not specifically addressed here.

D.2 Firefighters	The Wildfire response should take into account FireSmart actions, by involving all the stakeholders (developing a FireSmart committee). The following activities should be promoted: • Interagency cooperation (between partners of the committee); • Cross training (for emergency crews of all agencies in order to get prepared for wildfire events, by attending specific courses on incident management, wildfire prevention, practice sessions and exercises). Some of the courses indicated in the Guidelines are offered by NFPA. The exercise undertaken should be table-top exercises (in boardrooms with various partners, analyzing a simulated emergency and reacting to different challenges), and mock disasters (in a realistic environment, for real-time evaluation of operational capabilities of the agencies). According to (Shindler, B., Olsen, C., McCaffrey, S., McFarlane, B., Christianson, A., McGee, T., Curtis, A., Sharp, E., 2014), trust-building is an important process for improving the wildfire response by the involved agencies and practitioners. The trust-building process is based on three fundamental qualities, reported as follows. • Ability o Agency level: perception of knowledge, skills and competencies of the agency, in order to provide leadership, empower practitioners; o Practitioner/field manager level: perception of knowledge, skills and competencies of the practitioner, in order to provide an effective communication and follow-through. • Goodwill o Agency level: perception of the fact that the agency will act in the best interest of the stakeholders, by creating a sincere engagement; o Practitioner/field manager level: perception of the fact that the practitioner will act in the best interest of the stakeholders, by including local concerns and building community capacity. • Integrity o Agency level: actions by the agency in accordance with values and norms of stakeholders, through transparent and open decision-making and cooperation; o Practitioner/field manager level: actions by the practitioner in accordance with values and norms of stakeholders, through transparent and open decision-making and by sharing responsibility.
D.3 Planning	***1. Fire protection plan*** Planning proposed by FireSmart includes: • Wildfire Preparedness Guide, an operational guide dedicated to communities endangered by wildfires, containing guidelines for protecting values at risk during wildfires. The Guide assists emergency response personnel. It should be updated once a year. • Wildfire Mitigation Strategy, a list of the possible FireSmart activities which can reduce the impact of wildfires on important values.

	The type of FireSmart planning required should comply with the following requirements, depending on the wildfire hazard and risk assessed (A.1.2). • FireSmart community planning may be not necessary for low wildfire hazard and risk; • Wildfire Preparedness guide should be necessary for low wildfire hazard and high wildfire risk; • Wildfire Preparedness Guide and Wildfire Hazard Assessment should be necessary for high wildfire hazard and low wildfire risk; • Both tools of FireSmart community planning should be necessary for both high wildfire hazard and risk. Wildfire preparedness guide. The following elements compose the guide: • *Local Area Description* o *Planning Area*: establish the boundaries of planning area (a community, some communities or other values), considering geographical (e.g. rivers, mountains, which can influence fire spread) and jurisdictional boundaries, or by defining a radius of influence around the community. o *Fire Behaviour Description*: obtain fire behaviour potential information during a wildfire for the community and surroundings. The wildfire threat potential is established by analysing fire behaviour potential, values at risk, fire occurrence risk and suppression capability. • *Values at Risk* o *Standard values at risk*: identify homes and residential structures, cabins, commercial and industrial facilities, mill sites, oil, gas and recreational facilities, to protect. o *Critical Infrastructure values at risk*: identify infrastructures providing critical services for residents, such as power generation, municipal buildings/facilities and water treatment facilities, communication towers, to protect. o *Special values at risk*: identify specific sites with natural, cultural, historical meaning, such as religious sites, historical or archaeological sites, wildfire zones, geographical features. providing critical services for residents, such as power generation, municipal buildings/facilities and water treatment facilities, communication towers, to protect. o *Dangerous goods values at risk*: identify specific facilities which can pose a risk for emergency responders, such as fuel stations, propane facilities, landfills, rails, waste and storage facilities, some oil and gas facilities, sites containing explosives. • *Fire Operations* o *Functional roles*: define the evacuation, wildfire operations and structural protection in case of wildfires. o *Mutual-aid communications*: review of radio communication plans between mutual-aid partners. o *Minimum auto-order list*: define the minimum number of resources required for the first operational period in case of wildfire, including responders, municipal and provincial

	firefighters, aircraft, sprinklers, engines, water tenders and heavy equipment. o *Structure protection strategies and tactics*: define strategies and tactics for structure protection, together with local fire protection experts. o *Fire suppression water supply*: identify water sources for structure protection and fire suppression, such as reservoirs, hydrants, static water supplies, tender filling locations, pumping stations, alternate power sources. o *Staging areas*: identify accessible areas near potentially endangered area but not directly threatened by a wildfire (having minimal surrounding fuels. o *Evacuation*: refer to the Municipal Emergency Plan (or Municipal Emergency Management Program Guide), reported below, including guidance for strategic evacuation (following the Emergency Management Act and the local Municipal Emergency Management Bylaw), if enough time is available; and tactical evacuation (immediately noticed, but voluntary) if the wildfire spreads quickly. o *Safe refuge areas*: define safe refuge areas (such as large parking lot or football field) in case of unsafe evacuation plan, to be used for a short period until the evacuation is safe. o *Emergency contact list*: define an emergency contact list of the possible stakeholders involved. Wildfire mitigation strategy. The following elements compose the guide: • *Introduction*: identify reasons for the plan, its goals, priorities and actors. • *Planning area and stakeholders* o *Planning areas:* same areas considered in the Wildfire Preparedness Guide, or expanded to include also areas where wildfires are not likely to originate. o *Stakeholders*: mainly the same stakeholders considered in the Wildfire Preparedness Guide. • *Hazard and risk assessment:* See section A.1.1 • *FireSmart activities:* all the possible activities included in the Guidelines which can support the following objectives: o *Increase public participation:* identify activities focusing on education and communication. o *Reduce wildfire threat*: identify vegetation management, development and legislation, and planning and policy activities. o *Increase suppression capability*: focus on cooperation, cross training an d emergency planning • *Implementation and Maintenance plan*. ***2. Other plans required/suggested*** Sprinkler deployment plan. An optional FireSmart plan which provides maps of how deploying sprinklers during a widlfire. It should be developed by a fire operations specialist expert in water delivery systems.

	Municipal development plan. Municipalities with > 3,500 people should adopt a Municipal Development Plan, defining the future (5-years term) land use in the municipality. It should integrate FireSmart principles by including wildfire hazard considerations, such as building specifications (see Section C). The same principles could be integrated in the Area Structure/Redevelopment Plan or the Concept Plan. Land use bylaws divide municipalities into land use districts. Wildfire hazard assessments can be used by municipalities for identifying high danger areas and indicate them in the land use bylaw. Development constraints in those areas should be included, by implementing FireSmart principles. Municipal Emergency Management Program Guide/Plan. Documents outlining the response of municipalities to emergency affecting communities. Before the plan implementation, emergency responders suggest recommendations. If plans are implemented, local emergency is declared and operation centres are activated.
D.4 Outreach	The Guidelines are dedicated to all the stakeholders involved in the wildfire management, prevention and protection, including residents, firefighters, authorities, communities.
E. Fire Protection Measures	
E.1 Measures for water sources	Not specifically addressed here.
E.2 Measures for buildings	***1. Sprinklers*** Included in the minimum tools which allow to consider suppression equipment on site as available, according to (FireSmart, Partners in Protection, 2003). ***2. Manual protection systems*** According to the (FireSmart, Partners in Protection, 2003), at least those items for fire suppression should be accessible in the property: hand tools, garden hose to reach roof top, ladder for rooftop and sprinkler. If they are present and accessible, the suppression equipment on site is considered as available in the Fire Suppression Checklist (A.1.2). ***3. Warning systems*** Not specifically addressed here. ***4. Spark arresters*** According to (FireSmart, Partners in Protection, 2003), chimneys used with solid or liquid fuels should have spark arresters. Arresters should be securely attached and made of 12-gauge welded/woven wire mesh screen having mesh ≥ 0.012 m.

	5. Combustible materials According to (FireSmart, Partners in Protection, 2003), <u>firewood, building materials, combustible debris piles, wooden storage shacks</u> and even neighboring buildings may be serious fire dangers. They should be avoided near buildings or at least placed > 10 m from them. <u>Propane tanks</u> should be located ≥ 10 m from the buildings and ≥ 3 m from all vegetation (which has to be cleared away in the area surrounding propane tanks). Vents of tanks should face away from buildings. <u>Burning barrels and fire pits</u> should be covered with a metal screen (0.007 m to 0.016 m wire mesh, Alberta regulations: ≤ 0.006 m). They should be surrounded by mineral soil, rock or concrete strip for a given distance (1 to 3 m is indicated in the guidelines, Alberta regulations: 3 m). Metal stakes should be used for wiring barrels. ***6. Private shelters*** Not specifically addressed here.
F. Environment	
F.1 Weather	Not specifically addressed here.
F.2 Fire history	Fire history data are considered in the definition of hazards.
G. Access	
G.1 Roads	According to the (FireSmart, Partners in Protection, 2003), the access is adequate if tank truck access can get to within 100 m of fire locations, and the following standards are implemented. The access is considered as inadequate for emergency vehicles, if more than 20 % of the area is completely inaccessible. ***1. Type/Number of access roads*** According to the (FireSmart, Partners in Protection, 2003), access routes should provide access for both emergency vehicles and public evacuation, serving also as firebreaks for fire protection and suppression. For interface fire protection, standards for access routes are divided into two categories: • Roadway standards; • Fire service access standards. ***2. Road standards*** <u>Main roads.</u> According to the (FireSmart, Partners in Protection, 2003), full tank trucks (carrying also 7,000 l, and weighing up to 20 ton) may require grades ≤ 15 %, radii of curvature ≥ 30 m, curves on a gradient ≤ 10 %, adequate bridge and pipeline crossing. Standards for main roads should be used where access routes serve ≥ 3 dwellings. <u>Driveways/Dead-ends</u>. Not specifically addressed here.

	Fire lanes. According to the (FireSmart, Partners in Protection, 2003), if an access route serves a building > 45 m from a roadway, a fire service access route should be provided, with good layout, design, construction and maintenance. Parking. Not specifically addressed here. ***3. Markings*** Road signs. Not specifically addressed here. Markers. Not specifically addressed here. ***4. Vegetation clearing*** Not specifically addressed here.

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NFPA 1144, 2013. Standard for Reducing Structure Ignition Hazards from Wildland Fire (referenced at the end of the Guide)*

http://www.fireunderwriters.ca

Emergency Management Act, 2007, Canada.

*NFPA = National Fire Protection Association

A.2 United States

A.2.1 United States: Standards

NFPA CODE 1141 Standard for Fire protection infrastructure for land development in Wildland, rural and suburban areas (2017). This standard is applied to land development or changes in land use in those areas. Wildland are subject specifically to 1144. Preliminary, working and as-built plans should comply with 1141. Suburban areas are defined in the Code as the areas in which the population density is included between 500 and 1000 persons per square mile. Below the limit of 500 persons per square mile, the area is defined as rural. If the 1141 conflicts with the local codes, the most stringent provisions will prevail.

NFPA CODE 1142 Water Supplies for Suburban and Rural Fire Fighting (2017). The purpose of the standard is to assist the authority having jurisdiction in defining the minimum water supply for fighting structural fires where inadequate water for fire-fighting is present.

NFPA CODE 1143 Standard for Wildland Fire Management (2014). The standard is aimed at developing management policies concerning wildfire prevention, mitigation, preparation and suppression.

NFPA CODE 1144 Standard for Reducing Structure Ignition Hazards from Wildland Fire (2013). The purpose of the standard is the assessment of fuel sources in the structure ignition zone and the identification of possible mitigation measures.

The NFPA Codes reviewed address all the categories inquired in this template. The provisions included in the Codes are allocated in the appropriate categories of the template, excluding the NFPA appendices, which contain only informative material. Each piece of additional information reported in an appendix is related to one of the codes reviewed, by considering the reference legend number reported on the top of the table.

All the information in the following table refer to the NFPA Codes, unless otherwise stated.

Table A.2 USA – Guide/Code: NFPA 1141 [1], NFPA 1142 [2], NFPA 1143 [3], NFPA 1144 [4]	
Category	**Provision**
A. Hazard	
A.1 Definitions	***1. Destination*** [2] A structure is considered (for the aim of computing the minimum water supply) as exposed to hazard if it is within 50 feet (15.24 m) of another structure and: • It has an area of 100 ft^2 (9.3 m^2) or larger; • It is classified as Occupancy Hazard Class 3 or 4 (see A.1.2). [3] The Wildland-Urban Interface (WUI) is defined as an area in which the authority having jurisdiction determines that: "*topographical features, vegetation fuel types, local weather conditions, and prevailing winds result in the potential for ignition of the structures within the area from flames and firebrands of a wildland fire*".

	The Wildland-Urban Intermix is defined as "*an area where improved property and wildland fuels meet with no clearly defined boundary*". [3] The values at risk in the areas examined should be analyzed, including health, safety, property and resources, for the aim of developing a risk hazard assessment. The identification of values at risk should be conducted considering all the involved stakeholders. The authority having jurisdiction should evaluate the sources of ignition (natural and human) and consider at least the following factors: • Vegetation; • Topography; • Aspect; • Fire history; • Fire weather history; • Fire danger rating; • Potential fire behavior; • Fire-fighting capabilities/limitations. ***2. Severity class*** [2] Structures are classified into five classes of occupancy hazard. This depends on the expectations about the ability of the structure occupants (people or objects) to develop fire spread rates and heat release. The classification number for the occupancy hazard varies between 3 (the most severe: e.g. cereals, flammable liquids, explosives, plastic processing, etc.) and 7 (the less severe: e.g. structures occupied by people). This number is used for the calculation of minimum water supply level (see D.1.1). If more than one occupancy is present in a given structure, the classification number should be separately developed for each occupancy, and after the lowest number should be included in the water supply calculation (representing the most severe). [2] Structures are classified into five classes of construction types. This depends on the combustibility of the materials used for building the structure. The construction classification number varies between 0.5 in correspondence of the Type I Building (the most secure) and 1.5 in correspondence of the Type V Building (the less secure). This number is used for the calculation of minimum water supply level (see D.1.1). If more than one construction type is present in a given structure, the classification number should be developed separately for each type, and subsequently the highest number should be included in the water supply calculation (representing the most severe case). Specific detailed information concerning the classification of different types of construction elements are provided in the standard. [4] A structure assessment is needed to assess the wildfire hazard in the ignition zone (area around structures, including vegetation, containing ignition sources

	potentially affecting the ignition potential of a wildfire) of each structure in the wildfire hazard areas. The assessment should include measures for vegetation, combustible sources, structures and maintenance, and their priorities. The structure assessment should include: • An overview of the surrounding environment (topographical features, local weather conditions, nearby and neighboring structures, terrain slopes); • The roof elements (type, construction and conditions of roofing materials and assemblies, skylights, construction and potential of gutters, and border areas between walls and roofs/decks, material and construction of eaves); • The part from top of walls to foundations (walls and exterior sidings, material used for gutters on exterior walls, material used for windows and other openings, location, size and screening of ventilation openings, attached structures, areas near structures where combustible materials might collect); • The part from foundations to immediate landscaped areas (vegetative fuels and other combustible materials within 30 feet or 9 m, of the primary structure, all attachments, detached structures within 30 feet or 9 m, of the primary structure potentially ignited by flames, parking areas within 30 feet or 9 m, of structures); • The part from the immediate landscaped area to the structure ignition zone (vegetation within the area, structure ignition zone, species and location of trees, separation of tree crowns, location of heat and flame sources, detached structures and structure ignition zone potentially ignited, vehicle parking areas, projections, all other factors potentially affecting ignition and spread of fire, structures failing to comply with Section C). Results from different structure assessments could be collected in a wildfire hazard severity map, including lot designations, structure locations, locations of wildfire evacuation centers/safety zones, hazard severity of each lot, overlapping ignition zones.
B. Land	
B.1 Vegetation	***1. Defensible space*** [4] Buildings located ≤ 30 feet (9 m) from vegetated slopes require special mitigation measures. Before construction, vegetation within the same distance to the foundations should be modified. If sufficient space is not present between structures and vegetation (also slopes), then a noncombustible wall or barrier should be required. Vehicle parking areas in the immediate landscaped areas should be maintained cleared of grass and fine fuels potentially ignited. ***2. Clearance between vegetation*** Horizontal clearance. [4] Vegetation within 10 feet (3 m) of chimney outlets should be not allowed. Tree crowns in the structure ignition zone should be spaced.

	Vertical clearance. [4] The height of the vegetation under trees in the fuel modification area should avoid the spreading of ground fire to the tree crowns. ***3. Maintenance*** Dead vegetation. [4] Slashes from vegetation clearing and debris should be removed before the construction is finished. Dead vegetation within 30 feet (9 m) of all buildings should be removed in coherence with the fire mitigation plan approved by the authority having jurisdiction (D.3.1). Groundcover. [4] Ground fuels within the landscaping zones should be removed/treated. Pruning. [4] Live vegetation should be pruned according to the fire mitigation plan (see D.3.1).
B.2 Topography/ Terrain	[4] Topography and terrain are included in the structure assessment, determining the wildfire hazards. In particular, the topographical factors explicitly cited are: • Flat open areas; • Ridges; • Saddles; • Steep slopes; • Natural chimneys (such as steep draws); • Small canyons. The terrain slopes are considered as well as able to influence the wildfire risk.
C. Building Construction	
C.1 General requirements	[4] Existing or planned improved properties (property with structures or similar) lying in the WU interface or intermix area should be subject to a wildland fire hazard assessment of each structure ignition zone (area around structures, including vegetation, containing ignition sources potentially affecting the ignition potential of a wildfire). ***1. Classes of ignition resistance*** Not explicitly addressed here. ***2. Characteristics of ignition resistant materials*** [4] Product for external use which has a flame spread index ≤ 25 in a 30-minutes burning test for building materials, showing no significant progressive combustion and a flame-front progression ≤ 10.5 feet (3.2 m) beyond the burner centerline during the test. These characteristics should be maintained over time and under weathering exposure. ***3. Building separation*** [1] Buildings should be separated by a distance: • ≥ 30 feet (9.1 m) from each other and from the property line,

	• ≥ 15 feet (4.5 m) if buildings are provided with automatic sprinkler systems, or one of the buildings is an accessory building of maximum 400 ft^2 (37 m^2) in ground floor area and the distance between the property line of both buildings is at least 30 feet (9.144 m); • ≥ 15 feet (9.144) from the property line for accessory buildings of maximum 400 ft^2 (37 m^2) in ground floor area having a distance from other buildings of at least 30 feet (9.144 m). • ≥ 50 feet (15.2 m) and 30 feet (9.144 m) from the property line for buildings exceeding two stories or a height of 30 feet (9.144 m), not provided with automated sprinkler systems. [4] Distances between primary and accessory structures on the same or adjacent lots, should be ≥ 30 feet (9 m).
C.2 Roof	***1. Covering*** [4] Roof coverings in accordance with the (ASTM E108) or equivalent should be used, having a specific class consistent with the wildfire assessment provided by the authority. Spaces between covering and decking should be firestopped, should avoid the intrusion of flames and embers or should be assembled with noncombustible materials. ***2. Valley flashings*** Not specifically addressed here. ***3. Eaves*** [4] 5/8 inch (0.02 m) nominal sheathing or noncombustible materials or 2 inches (0.050 m) nominal solid blocking should be used on eaves. ***4. Gutters*** [4] Gutters, downspouts and connectors should be noncombustible and the accumulation of debris should be opposed in them.
C.3 Walls and other external coverings	***1. Exterior walls*** [4] Walls should meet one of the following requirements: • Heavy-timber construction, ignition-resistant material, fire-retardant-treated wood; • Minimum 20-minute fire-rated assembly; if walls can be exposed to wildfires, unless greater protection is needed. 2 inches (0.050 m) nominal solid blocking should be used between exposed rafters at roof overhangs, under the exterior wall covering, where exposed to vegetation. Structural elements potentially resulting in a collection of combustible materials near the structure should be protected. ***2. Wall coverings*** Not specifically addressed here.

C.4 Windows, external doors and vents	***1. Exterior glazing*** [4] Exterior glazing should be made of one of the following: • Tempered glass; • Multilayered glazed panels, • Glass block, • Material with fire resistance rating ≥ 20 minutes. Window screening should be made of a noncombustible mesh able to prevent the collection and the entry of firebrands and embers. ***2. External doors*** [4] External doors should be made of solid-core wood ≥ 1.75 inches (0.045 m) thick, approved noncombustible construction or have fire protection rating ≥ 20 minutes. ***3. Vents and other openings*** [4] Vents should be covered with corrosion-resistant, noncombustible mesh. The mesh should have openings not exceeding 0.25 inches (0.0063 m). Ventilation openings in attics, foundations or walls should be covered with a 0.25 inch (0.0063 m) corrosion-resistant metal (or other corrosion-resistant) mesh. Ventilation openings should be avoided in soffits, eave overhangs, between rafters and eaves, in overhanging areas exposed to vegetation. Attic spaces should be appropriately ventilated, considering building, climate, moisture, temperature and occupancy type.
C.5 Decks and detachments	***1. Decks and other attachments*** [4] All projections (decks and similar) should be heavy timber constructions, complying with one of the following: • noncombustible materials; • fire-retardant-treated wood; • other ignition-resistant material; or 1-hour fire-rated assembly. Appendages and projections attached to walls should be able to preserve the fire resistance level of walls. ***2. Detached structures*** [4] Accessory structures should meet the requirements for structures or they should be separated from main structures of minimum 30 feet (9 m). Mobile and manufactured homes having an open space beneath, should have a skirt of noncombustible material or with minimum fire-resistant rating of 20 minutes. These spaces should have vents screened with a corrosion-resistant, noncombustible wire mesh with openings not exceeding 0.25 inch (0.01 m). Incinerators, fireplaces, barbecues and grills should not be present in hazardous fire areas if not approved by the authority having jurisdiction.

C.6 Floors and interior structures	***1. Floor*** Not specifically addressed here. ***2. Underfloor*** [4] Underfloor areas of overhanging buildings and other structural elements should be made of the same materials indicated for decks. ***3. Other interior structures*** Not specifically addressed here.
D. Resources	
D.1 Utilities	***1. Water supply*** Supply level. [1] If the required fire flow exceeds 1500 gpm (5700 l/min), the water supply system should provide that fire flow for at least 2 hours at 20 psi (138 kPa) residual pressure. Otherwise, the fire flow should be provided for at least 1 hour at the same pressure. The level of fire flow could be decreased for isolated buildings or in suburban/rural areas where this fire flow could be impractical. The required quantity can also be doubled, in specific cases sensitive to group fires/conflagrations. [2] The minimum water supply is defined depending on the following basic information about the structure, obtained through survey (by the Water Supply Officer): occupancy hazard, construction type, dimensions and exposures. Based on these, the minimum water supply is determined as follows: • $minimum\ water\ supply\ (gallons) = \frac{total\ volume\ of\ the\ structure\ (ft^3)}{occupancy\ hazard\ classification\ no.} * \ * \ construction\ classification\ number \geq 2000\ gal\ (7600\ l)$, for structures without exposure hazard (see A.1.1); • $minimum\ water\ supply\ (gallons) = \frac{total\ volume\ of\ the\ structure\ (ft^3)}{occupancy\ hazard\ classification\ no.} * \ * 1.5 \geq 3000\ gal\ (11{,}355\ l)$, for structures with exposure hazard (see A.1.1). These values can be reduced if structures are provided with appropriate automated sprinkler systems (see E.2.1), or with other automatic fire suppression systems. They can be also increased in specific cases (limited resources, extended fire department response time/distance, possible delays in discovering the fire, limited access, hazardous vegetation, presence of attached structures, unusual terrain, special uses. [2] The water delivery rate to the fire scene should be (if not adjusted by the authority):

	• 250 gpm (950 l/min) for total supply required set to < 2500 gal (9,459 l); • 500 gpm (1,900 l/min) for total supply included between 9,460 and 37,849 l; • 750 gpm (2,850 l/min) for total supply included between 37,850 and 75,699 l; • 1,000 gpm (3,800 l/min) for total supply required set to > 75,700 l. The water delivery rate should never fall below 250 gpm (950 l/min). Water source. [1] Water sources should be located "such that the required fire flow for any building in the development can be established and maintained within 5 minutes of arrival with the fire department resources available". [2] The quality of the water source should meet the requirement of the authority having jurisdiction. In order to be acceptable, water sources should be maintained and accessible over a 1-year basis and they should maintain the minimum capacity and delivery requirements on a 1-year basis, considering the 50-year drought for the water source. The level of the water source should be ≥ 2 feet (0.6 m) above the strainer and ≥ 1 foot (0.3 m) below the strainer. The connection of the fire apparatus to the water source should be compliant with the (NFPA 1963) and be approved by the authority having jurisdiction. Access. [2] Roads providing access to water supply should have: • Minimum clear lane width of 12 feet (3.7 m); • Minimum radius of 100 feet (30.5 m) to the centerline of the turn; • Maximum grade set to 8 %; • Stable roadside slopes; • Bridges, culverts or similar at all drainageway crossings, ditches deep enough and provided with special facilities if needed; • Surface treated as required for a 1-year passage; • Erosion control to protect road ditches, cross drains and cut-and-fill slopes; • Minimum diameter of 120 feet (36.5 m) for turnarounds, or larger if needed; • Load carrying capacity coherent with the expected loads; • All-weather use; • Bridges compliant with the loads of fire apparatus; • Posted vehicle load limits at the entrances of bridges. Standby power. Not explicitly addressed here. Fire hydrants. [1] Fire hydrants should be visible from the road by using reflective markings. They should be located within 6 feet (1.8 m) of the edge of the pavement (except for some specific provisions by the fire department). They should be placed within 500 feet (150 m) of each point of entry. The spacing between hydrants is defined as follows, and be approved by fire departments:

	• ≤ 500 feet (152 m) of vehicle travel distance in partially built-out or built-out areas; • ≤ 1500 feet (456 m) in unbuilt areas; Fire hydrants in residential areas should be supplied by a pipe with a diameter at least 6 inches (0.15 m) large on a looped system, or at least 8 inches (0.20 m) large otherwise (also if the hydrant is installed on a dead-end pipe longer than 300 feet, 91 m). In nonresidential areas, pipes should be calculated in detail. Dead-end pipes should not be longer than 600 feet (183 m) of length, for diameters < 10 inches (0.25 m). [1] Water pipes and fire hydrants provided for fire protection purposes are subject to the prescriptions of (AWWA M31 Distribution System Requirements for Fire Protection), (NFPA 24) and (NFPA 1142 [2]), depending on the type of property where the utilities are installed and the type of water systems. Dry hydrants. [2] Non-pressurized water supply sources should be accessible by using dry hydrants meeting the following design requirements. They should have: • Schedule 40 pipe and component fittings; • A minimum flow of 1000 gpm (3,800 l/min) at draft; • Slope and piping configurations not impeding drafting capability; • Exposed and underground surfaces protected from deterioration; • Minimum number of elbows in the piping system; • Suction hose connections compatible with the fire department measures and the (NFPA 1963). Connections should include a protective cap, corrosion-resistant; • Piping supported and/or stabilized using approved design procedures; • Stabilization (or other protections) for the elbows and other stress points; • Appropriate aggregates and soil materials to cover piping during installation; • Clean connections, appropriate sealing materials and airtight joints; • Strainers constructed to allow the required fire flow. They should be accessible in all weather conditions, visible from the roadway, having an appropriate reflective marking and signage. ***2. Other utilities*** Not specifically addressed here.
D.2 Firefighters	[2] The impact of land use change on fire protection services should be assessed, by considering the possibility of addressing the likely increased volume of calls with the current number of firefighters and fire apparatus and the current location of fire stations. The possibility of introducing special services should be considered as well. Mitigation measures should be determined in case of negative outcomes of the assessment.

	[3] Safety requirements for firefighters (e.g. protections and equipment) are regulated, mainly referring to the (NFPA 1451), (NFPA 1500), (NFPA 1521), (NFPA 1582), and (NFPA 1977). Fire fighters should have an appropriate knowledge about wildfires, and be qualified for them (NFPA 1051). [3] The incident commander ("*individual responsible for the management of all incident operations at the incident site*") should judge the extent of the fire on their arrival at the fire and he/she should take the appropriate decisions by assessing: • Special/unusual hazards; • Type/amount of fuel; • Terrain; • Weather conditions (present/predicted); • Fire behavior; • Resources; • Need for specialized firefighters/equipment. [3] The authority having jurisdiction should prepare incident reports, if required. They, together with Incident Commander, should review the firefighting actions undertaken. Those actions should be reviewed by fire personnel, with the aim of improving and correct the procedures. Those evaluations should address: • Examinations of accidents occurred, their causes and contributing factors; • The actions undertaken; • The evaluation of the new procedures used during the incident; • The identification of possible alternative procedures; • Examinations of the incident (fire causes, contributing factors).
D.3 Planning	***1. Fire protection plan*** [1] Fire protection plans should be submitted and approved by the authority having jurisdiction before the construction of infrastructures or buildings. <u>Mitigation plan</u>. [3] The authority having jurisdiction should develop a mitigation plan, based on the ignition risk assessment. The mitigation plan should address the following features: • Prevention activities for reducing human-caused ignitions; • Details of the activity of fuel modification to undertake (including maintenance); • Activities concerning the education and information of the public; • Mitigation activities for structures (according to: NFPA 1141 [1] and 1144 [4]); • Mitigation activities and modifications for infrastructures (roads, water supply, communications, utility and transportation corridors, airports, considering the NFPA 1141 [1], besides of other civil and environmental laws). [4] Permits associated with construction and occupancy cannot be issued if provisions about hazard mitigation are not satisfied.

	2. Other plans required/suggested Fire lane plans. [1] Fire lane plans should be reviewed and approved by the authority having jurisdiction and the appropriate fire department. Wintertime access maintenance plans. [1] Plans for the winter maintenance of access through gates and along the fire lanes should be submitted to the authority. Multi-agency operational plan. The authority having jurisdiction should adopt and maintain a multi-agency operational plan for protecting lives and property during incidents. This plan should contain elements concerning: command, training, notification, involvement of the community, public fire safety information/education (which includes the activity of individuating fire causes and hazards), safety and evacuation, mutual assistance. Minimum water supply plan. [2] A plan in which the determination of the minimum water supply is indicated for the new construction, should be submitted to the fire department or the authority having jurisdiction, before the construction starts. Any change in the design, including fire suppression systems, should be considered for updating this plan. Dry hydrant planning. [2] The impact of the installation of a dry hydrant should be assessed, with respect to public and private entities, through appropriate planning. Fire response planning. [3] Capabilities and limitations of the existing firefighting service should be addressed for planning future improvements (such as additional training, new techniques, recruitment, etc.). Preparedness planning. [3] The preparedness plan should include the following elements: • Identification of wildfire hazards, ignition risks and potential hazard areas; • Natural fire protection features (such as lakes, water point, firebreaks, etc.); • List of the Fire-figthing resources; • List of the Cooperating agencies (and other applicable agreements); • List of objectives related to training, safety, response times and resources; • List of resources providing fire cause analysis, idenrification of risks, assessment and proposed measures. Incident action plan. [3] Incident management systems should be used for the management of wildfire incidents (according to (NFPA 1561), including: • Management of command functions; • Management of operating procedures; • Plannign activities; • Logistic management; • Finance functions.

	The plan which contains the objectives of the operating incident response strategy is named Incident Action Plan (IAP). The incident commander should require the appropriate personnel and equipment at the accident place, according to the Incident Action Plan (IAP). Plan of containment and control. [3] The Incident Commander should adopt a plan of containment and control in response to a fire incident, addressing the following issues: • Safety of firefighters; • Resources available; • Fireline location and construction; • Application of water and chemicals from both ground and aircrafts. Construction plan. [4] Plans and specifications should be provided to the authority having jurisdiction, in order to show the compliance with the NFPA 1144 [4]. A vicinity map providing the details about all the notable elements present in the area within 300 feet (91 m) of property lines should be drawn.
D.4 Outreach	The NFPA Codes are national codes which can reach different audiences in different States. Some of their parts could be adapted while being transferred to local standards and regulations. In fact, an important role is given to the authority having jurisdiction in the specific area.
E. Fire Protection Measures	
E.1 Measures for water sources	[1] In case of municipal water systems, fire department connections for sprinkler systems should be located at a distance ≤ 100 feet (30.5 m) from the fire hydrant along an appropriate path. The systems should be promptly attached to the inlets without interference, in order to not produce delays. If water systems are not available, fire department connections should be located in order to ease a continuous supplemental water supply and be arranged in order to be promptly attached to the inlets without interference. [1] Fire hydrants in parking areas should be protected by barriers without obstructing the operation of the hydrants themselves. The area around hydrant should be cleared of obstructions and vegetation. [2] Dry hydrants should comply with the following fire safety requirements: • A minimum clear zone of 3 feet (0.9144 m) around the hydrant; • Hard suction hose maximum 20 feet (6 m) long needed; • Minimum distance from structures of 100 feet (30 m); • No parking allowed within 20 feet (6 meters) from the hydrant; • Protections against damages from vehicles, ice and other objects; • Vegetation should be cleared to within 3 feet (0.9 m) of the hydrant; • Protections against ultraviolet (UV) degradation (e.g. through painting); • Inspected at least quarterly and flow tested at least annually.
E.2 Measures for buildings	***1. Sprinklers*** [1] All residential buildings and all the buildings with > 2 stories or > 30 feet (9.144 m) tall (except if only some portions of buildings have these characteristics, and they are not populated) should be provided with automated

sprinkler systems installed and maintained according to the (NFPA 13), (NFPA 13R) or the (NFPA 13D).

2. Manual protection systems

Standpipe systems. [1] Standpipe systems should be installed and maintained according to (NFPA 14). Fire department connections should be built considering the following requirements:

- Being at a distance < 100 feet (30.5 m) from the nearest hydrant connected to approved water supply (with some exceptions approved by the authority);
- Being located between 18 and 48 inches (0.457-1.219 m) above the level of the ground, sidewalk, grade surface;
- Being promptly attachable to inlets without interference from other objects.

The above reported requirements are valid in case of available municipal water systems, for new buildings (except 1 or 2-family dwellings) with > 3 stories, and/or > 50 feet (15 m) high, containing intermediate stories or balconies, and/or with > 1 story below ground, and/or > 20 feet (6.1) below ground, and/or high-rise buildings (in the latter case, a Class I Standpipe System should be installed).

[1] In case of unavailable municipal water systems, for new buildings (except 1 or 2-family dwellings) belonging to one of the following categories:

- with > 2 stories,
- > 40 feet (12.2 m) high, containing intermediate stories or balconies,
- with > 1 story below ground,
- > 20 feet (6.1) below ground,
- high-rise buildings (in the latter case, a Class I Standpipe System should be installed),

fire department connections should be located in order to ease a continuous supplemental water supply. They should be promptly attachable to inlets without interference from other objects.

Fire extinguishers. [1] Fire extinguishers should be provided according to (NFPA 1) and installed according to (NFPA 10).

3. Warning systems

[1] Buildings should have automatic fire warning systems complying with the following:

- Local fire alarm systems designed, installed and maintained according to (NFPA 72) for residential buildings containing 2 or more living units, transmitting to an approved central station if containing 4 or more living units;
- Fire warning or alarm systems installed and maintained according to (NFPA 72) for nonresidential structures exceeding 1000 square feet (93 m^2) gross floor area, transmitting to an approved central station if > 5000 ft^2 (465 m^2).

	4. Spark arresters [4] Chimneys and flues of fireplaces and wood stoves should be provided with spark arresters constructed of a mesh ≥ 12-gauge welded wire or woven wire. Mesh openings should be ≤ 0.5 inch (0.0127 m). Approved spark arresters (or screen, or door) should be provided to openings of incinerators, fireplaces, barbecues and grills. ***5. Combustible materials*** Liquefied petroleum gas (LP-gas). [4] Flammable or combustible liquids storage (including propane) should be coherent with the (NFPA 58) and the mitigation plan described in D.3.1. Storage of combustible materials. [4] Heat and flame sources unprotected or unsupervised should be avoided within 30 feet (9 m) of the primary structures. Other combustible materials should be removed within 30 feet (9 m) of structures. ***6. Private shelters*** Not specifically addressed here.
F. Environment	
F.1 Weather	[4] Weather conditions are considered in the structure assessment, determining the wildfire risk. In particular, the following factors are explicitly cited: • Wind; • Relative humidity; • Temperature; • Fine fuel moisture content.
F.2 Fire history	[3] The fire history is explicitly considered in the assessment of ignition sources, in the estimation of values at risk.
G. Access	
G.1 Roads	[1] Access should be provided to all buildings occupying a ground floor area larger than 400 ft^2 (37 m^2) and to all public structures having structural components. [1] Approved access for fire apparatus should be provided within: • 150 feet (45 m) of the exterior building walls (extended to 300 feet, 91 m, if automatic sprinkler systems are installed), • 50 feet (15.2 m) of at least one exterior access door (except for one or two-family dwellings); • 30 feet (9.144 m) of at least 50 percent of the exterior wall perimeter for buildings (except for one or two-family dwellings) exceeding two stories or a height of 30 feet (9.144 m), and not protected with automatic sprinkler systems; • 30 feet (9.144 m) of an exterior wall for buildings exceeding three stories or a height of 35 feet (10.7 m) and protected with automatic sprinkler systems.

1. Type/Number of access roads

[1] The number of access routes is determined according to the number of households or parking spaces in the residential/mixed area. Up to 3 access routes can be required:

- 1 access route for residential area composed of ≤ 100 households, or having ≤ 1250 parking spaces;
- 2 access routes for 101-600 households or 1251-3000 parking spaces;
- 3 access routes for > 600 households or > 3000 parking spaces.

The most restrictive criterion should be considered (number of households/parking spaces) for defining the number of routes.

In case of multiple routes, they should not be close to each other, and one of them should be reserved for emergency use only (as approved by the authority).

In case of mixed areas (residential/non-residential), the parking space criterion should be used, by summing the actual number of parking spaces in the non-residential area with 5 parking spaces for dwelling unit in the residential area.

[1] If the access roads are secured, a key box should be installed and accessible for the authority having jurisdiction.

2. Road standards

Main roads. [1] Roadways should be built of a hard, all-weather surface, complying with the loads of the specific jurisdiction. The following standards are set:

- Minimum clear width of 12 feet (3.7 m) for each lane (also at curves), excluding shoulders and parking. Drainage, snowbanks, other utilities, should not influence the minimum clear width;
- Minimum nominal vertical clearance of 13 feet 6 inches (4.2 m) for all the full width of the roadway;
- Turns having a minimum radius of 60 feet (18.2 m) on the outside;
- Intersections should have median left-turn lanes, traffic signals and/or automatic control systems in order to ease the unimpeded passage of fire apparatus;
- Traffic calming measures such as speed bumps or humps should not be implemented, except from chicanes and roundabouts;
- Bridges and culverts should be designed according to a minimum of 100-year flood elevation and flows;
- Intersections should be provided with appropriate grades for avoiding accumulation of water and ice and they should be designed considering sight distance requirements;
- Installation of emergency pull-offs with appropriate spacing should be considered;
- Maximum grade of 10 %, except for some specific cases allowed by the authority;

- Maximum angles of approach and departure of 8 degrees (including intersections), except for some specific cases allowed by the authority;
- Crowning of road centers, if grades are less than 0.5 %.

Driveways/Dead-ends. [1] Dead-end roads > 300 feet (91 m) long should be provided at the end with a turnaround with an outside diameter of 120 feet (36.6 m) minimum.

Cul-de-sac roads longer than 1200 feet (366 m) should be provided with approved turnarounds at maximum intervals of 1200 feet (366 m). Cul-de-sac length should not exceed the firefighting capability of the jurisdiction fire department.

Gates should be located at a distance ≤ 30 feet (9.144 m) from intersections; they should open in the direction of emergency vehicles, except specific cases; and have a clear width at least 2 feet (0.6 m) larger than the controlled access.

Fire lanes. [1] Driveways, parking lot lanes, delivery lanes and private roads can be used as fire lanes if they comply with the following requirements:

- Built of hard, all-weather surface, complying with local load limits;
- Maximum grade of 10 % from the fire lane to the exterior wall of the building level floor;
- Curb cuts extending beyond both sides of the fire lane should be at least 2 feet (0.6 m) long for fire lanes connecting to roads;
- Minimum lane width of 16 feet (5 m), or 24 feet (7.3 m) for two-way roads, excluding shoulders, sidewalks and drainage. This width can be reduced if the fire lane is for emergency access and operations or increased for positioning apparatus for operations during incidents;
- Minimum radius of the outside curb line of 50 feet (15.2 m), and a sufficient width of the fire lane at curves for the operation of fire apparatus;
- Same requirements for grades, vertical clearance, maximum angles as for the main roads; and concerning the dead-ends and gates;
- Bridges designed for loads coherent with the fire apparatus.

Parking. [1] Parking standards are outlined in the following table. Aisles adjacent to buildings should be 24 feet (7.3 m) wide minimum; and the minimum turning radius is set by the fire department of the jurisdiction.
Parking could be not allowed in fire lanes, and appropriate no-parking signs should be posted.

Parking angle (between curb/limit line and parking slot) [°]	Minimum stall length [ft (m)]	Minimum aisle width (one-way road) [ft (m)]	Minimum aisle width (two-way road) [ft (m)]
45	27.5 (8.4)	16 (4.9)	24 (7.3)
60	23.7 (7.2)	16 (4.9)	24 (7.3)
75	20.9 (6.4)	23 (7.0)	24 (7.3)
90	18.5 (5.6)	26 (7.9)	26 (7.9)

	3. Markings Road signs. [1] The following prescriptions are provided for road signs: • Load limits should be posted at both entrances of bridges; • Signs identifying the road names should be made of noncombustible materials and installed at each intersection, minimum 7 feet (2.1 m) above the way; • Letters on signs should be minimum 4 inches (0.1 m) high, with a minimum stroke of 0.5 inch (0.0127 m), reflective and contrasting to the background; spacing between numerals or letters between 0.5 inch (0.0127 m) and 1 inch (0.025 m) and a minimum border of 1 inch (0.025 m) for letters or numerals only for premises addresses, • Signs should include references to address numbers, if required by the authority; • Signs indicating the nearest water supply should be erected, if required by the authority; • Dead-end or single-access roads should be marked with appropriate signs. • Additional signage affixed to the premises should be provided at the intersection between driveway and roadway, if the address sign is not visible from the road; • End-of-driveway sign should be mounted between 4 feet (1.2 m) and 7 feet (2.1 m) above grade, no further than 5 feet (1.5 m) from the travelled way, it should be perpendicular to the direction of travel and visible from both travel directions. Markers. [1] Addresses should be consistently assigned. Street names should be phonetically unique. [2] A water source indicator should be erected near each water point used for emergency purposes, approved by the authority having jurisdiction. ***4. Vegetation clearing*** [1] Vegetation clearing on the roadsides should be eased and permitted.

REFERENCES

[1] NFPA 1141, 2017. Standard for Fire Protection Infrastructure for Land Development in Wildland, Rural and Suburban Areas*

[2] NFPA 1142, 2017. Standard on Water Supplies for Suburban and Rural Fire Fighting *

[3] NFPA 1143, 2014. Standard for Wildland Fire Management *

[4] NFPA 1144, 2013. Standard for Reducing Structure Ignition Hazards from Wildland Fire*

ASTM E108, 2010. Standard Test Methods for Fire tests of Roof Coverings**

AWWA M31, 2008. Distribution System Requirements for Fire Protection***

NFPA 1, 2015. Fire Code*

NFPA 10, 2013. Standards for Portable Fire Extinguishers*

NFPA 13, 2016. Standard for the Installation of Sprinkler Systems*

NFPA 13D, 2016. Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*

NFPA 13R, 2016. Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*

NFPA 14, 2016. Standard for the Installation of Standpipe and Hose Systems*

NFPA 24, 2016. Standard for the Installation of Private Fire Service Mains and Their Appurtenances*

NFPA 58, 2011. Liquefied Petroleum Gas Code*

NFPA 72, 2016. National Fire Alarm and Signaling Code*

NFPA 1051, 2012. Standard for Wildland Firefighting Personnel Professional Qualifications*

NFPA 1451, 2013. Standard for a Fire and Emergency Service Vehicle Operations Training Program*

NFPA 1500, 2013. Standard on Fire Department Occupational Safety, Health, and Wellness Program*

NFPA 1521, 2008. Standard for Fire Department Safety Officer Professional Qualifications*

NFPA 1561, 2008. Standard on Emergency Services Incident Management System and Command Safety*

NFPA 1582, 2013. Standard on Comprehensive Occupational Medical Program for Fire Departments*

NFPA 1963, 2014. Standard for Fire Hose Connections*

NFPA 1977, 2011. Standard on Protective Clothing and Equipment for Wildland Fire Fighting*

*NFPA = National Fire Protection Association

**ASTM = American Society for Testing and Materials

***AWWA = American Water Works Association

A.2.2 United States: Guidelines

Five additional documents to the NFPA standards were reviewed for the United States of America, since local guidelines and programmes were found:

[1] Implementation Guidelines for Executive Order 13728 WUI Federal Risk Management. This document provides guidelines for new and existing federally-owned buildings in a moderate or greater WUI fire risk area, or building leased by federal agencies in a greater than moderate WUI fire risk area. Those guidelines provide minimum acceptable standards for the buildings, complying with IWUIC. Stricter requirements may be approved, where necessary.

[2] The Firewise USA Program (NFPA, National Fire Protection Association) is dedicated to encourage local communities in having an active role in safety from wildfires. The reviewed document is the Firewise Toolkit (A Guide to Firewise principles). The main aspects addressed in this document are: the vegetation treatment (clearing, maintenance and creation of a defensible space), building requirements, protection measures and planning. Since the toolkit is thought as an informative document, the guidelines provided are open to the general public (as opposed to authorities or response organizations), who are encouraged to adopt the proposed measures.

[3] The Colorado WUI Hazard Assessment Methodology (Edel, 2002, Colorado State Forest Service) provides a specific methodology for hazard and risk assessment in the Colorado State.

[4] The Wildfire Hazard Assessment Guide for Florida Homeowners (Florida Department of Agriculture and Consumer Services, 2002) is a document mainly dedicated to the general public in Florida State. The main aspects considered are: a detailed hazard and risk assessment and classification, guidelines for vegetation management (defensible space, clearance, maintenance), some guidelines for building construction, planning, some guidelines about fire protection measures and access (mainly driveways standards).

[5] The Planning for Natural Hazards: Wildfire Technical Resource Guide document, by the Oregon Department of Land Conservation and Development was reviewed. This covers the following issues: hazard and risk assessment, defensible space, terrain, some requirements about building construction, water supply, some indications about planning and fire protection measures.

All the information in the following table refer to the reviewed guidelines, unless otherwise stated.

Table A.2b USA Guidelines – Guide/Code: [1] Implementation Guidelines for: Executive Order 13728 Wildland-Urban Interface Federal Risk Management, [2] Firewise Toolkit, [3] Colorado WUI Hazard Assessment Methodology, [4] Wildfire Hazard Assessment Guide for Florida Homeowners, [5] Planning for Natural Hazards: Wildfire Technical Resource Guide (Oregon State)

Category	**Provision**
A. Hazard	
A.1 Definitions	***1. Destination*** [1] The method for assessing the wildfire risk included in the (International Code Council (ICC), 2015) is suggested to be adopted by the appropriate agencies. The IWUIC Code (2015) should be determined as nationally recognized within 2 years from its updated version.

	The Wildfire Risk can be also assessed using the Wildfire Hazard Potential Map developed by the U.S. Forest Service, known as WUI Toolkit assessment methodology. In any case, the tool used should incorporate the following elements: • Vegetative fuel; • Critical fire weather (frequency); • Defensible space; • Terrain; • Existing building construction and materials; • Availability of water supply. Those methodologies should comply also with the following requirements: • Be consensus based; • Be open to stakeholders, and providing transparency for developments; • Compute the wildfire risk; • Provide minimum requirements (access, water supply, ignition resistance); • Provide requirements about defensible space; • Provide requirements for fire-resistance, sprinklers, etc. The determination of the WUI areas in the United States should be based on the Wildland-Urban Interface of the Conterminous United States (2010), a tool developed by the US Department of Agriculture (USDA) or something equivalent. The WUI area is defined as in the IWUIC Code (2015). [3] Colorado WUI Hazard Assessment is based on three categories of information to define the fire danger: • Risk (ignition probability), depending on: o Density of lightning strikes (four classes: high, value 4; medium, value 3; low, value 2; very low, value 1; source: Bureau of Land Management (BLM) lightning strike data, Wildland Fire Management Information (WFMI)); o Road/railroads buffer (100 m in Colorado): value 1 for buffer < 100 m; 0 otherwise. • Hazard (vegetation/terrain), depending on: o Slope (four classes, as defined in NFPA 299, 1991: 0-5 %, value 1; 6-20 %, value 2; 21-40 %, value 3; ≥ 41, value 4) o Aspect (four classes, as defined in NFPA 299, 1991; 0-160 or 200-360 °, value 1; 160-165 or 195-200 °, value 2; 165-175 or 185-195 °, value 3; 175-185 °, value 4). o Fuels (vegetation, as identified from the Colorado Division of Wildlife, by using the GAP (Gap Analysis Program)). Vegetation classified according to the fuel hazard and disturbance regime, which is based on the average length of the return interval. Specific indications are provided in Appendix A of the document reviewed. Fuel hazard varies between 0: none and 4: very high; while disturbance rank varies between 0: n/a to 4: short). • Values (natural/man-made components having value):

	○ Housing density (six classes, as defined by Theobald and Kneeland (2002): 0-0.004 houses/acre, value 0; 0.004-0.025 houses/acre, value 3; 0.025-0.100 houses/acre, value 4; 0.100-0.500 houses/acre, value 5; 0.500-1.000 houses/acre; value 4; > 1.000 houses/acre; value 2); • Non-flammable areas (areas which will not carry fire, such as rock, water, or urban areas without significant vegetation; based on the CDOW GAP classification, having value = 0). [4] Two types of subdivisions are considered as at risk from wildfires: boundary interface subdivisions (lots forming a clear boundary with wildlands), and intermix interface subdivisions (wildlands interspersed with developed lots). A hazard and risk assessment should be conducted in the interface subdivisions where the area built out ≤ 75 %, or it is > 75 %, but they also have a boundary interface component or the vegetation is rated as extreme hazard. Wildlands < 5 acres in size and surrounded by developments (occluded interface areas) do not need to be assessed, unless the undeveloped subdivisions have high fuel loads endangering close structures, or the structures are highly flammable. The Hazard and Risk Assessment has to be conducted according to the following steps: • Identification of the areas to be evaluated (boundary or intermix interface with respect to residences, as previously defined above); • Identification of the risk: higher than the average occurrence of wildfires in the area within five miles from the inquired site (being helped in the evaluation by the Local Division of Forestry office): ○ 10 points if yes; ○ 0 points if no. • Identification of the fuel hazard type, according to the pictorial guide provided in the Appendix B of the reviewed document. Once the vegetation type has been defined, the following ratings are given: ○ 5 points for low fire hazard vegetation (grasses ≤ 4 feet, 1.219 m, blowy leaves, hardwood swamps and palmetto/gallberry < 3 feet, 0.914 m). ○ 10 points for medium fire hazard vegetation (sand pine scrub < 6 feet, 1.829 m, palmetto/gallberry = 3-6 feet, 0.914-1.829 m, cypress swamp, grasses > 6 feet tall, 1.829 m and cogongrass, dense pine 20-60 feet tall, 6.096-18.288 m). ○ 20 points for high fire hazard vegetation (palmetto/gallberry > 6 feet, 1.829 m, palmetto/gallberry with dense pine overstory, that is having at least 75 % crown closure = 3-6 feet, 0.914-1.829 m, sand pine scrub > 6 feet tall, 1.829 m). ○ 25 points for high fire hazard vegetation (palmetto/gallberry with dense pine overstory > 6 feet, 1.829 m, sand pine scrub with dense pine overstory > 6 feet tall, 1.829 m, dense melaleuca). • Evaluation of the Access features, by providing the following ratings: ○ Ingress/egress, 7 points if there is only one road in/out, otherwise 0;

	○ Road width, 4 points if < 20 feet, 6.096 m, 2 points if 20-24 feet, 6.096-7.315 m, 0 points if ≥ 24 feet, 7.315 m; ○ Road accessibility, 5 points for non-maintained dirt road, 3 points for graded dirt road, 2 points for hard surface road without drivable shoulders, 0 points for hard surface all-weather road with drivable shoulders; ○ Secondary road terminus, 3 points if most of dead-end roads > 300 feet, 91.440 m, 0 points otherwise; ○ Cul-de-sac turnarounds, 3 points if the outside radius < 50 feet, 1.240 m, 0 points otherwise; ○ Street signs, 5 points if not present, 3 points if made with combustible materials, 0 points if made with noncombustible materials. • Evaluation of the Fire Protection features, by providing the following ratings: ○ Helicopter dip (water drop) spots, 7 points if > 6 minutes turnaround or unavailable, 4 points if within 6 minutes turnaround (2-3 miles, 3218-4828 m), 2 points if within 4 minutes turnaround (1-2 miles, 1609-3218 m), 0 points if under 2 minutes turnaround (< 1 mile, 1609 m). ○ Structural fire protection, 5 points if > 5 miles, 8047 m, from staffed fire department, 0 otherwise; ○ Pressurized water supply, 10 points if no pressurized hydrants are present, 5 points if hydrants with < 500 GPM, 31.55 l/s at < 1000 feet 304.8 m spacing, 0 points for municipal pressurized hydrants. ○ Other water supply, 10 points if no draft/pressure sources < 5 miles, 8047 m are present, 3 points if draft/pressure sources via all-weather roads are within 5 miles, 8047 m, 1 point if other draft sources exist within the subdivision, having ≥ 3,000 gal., 11,356 l, 0 points if dry hydrants are always available within the subdivision. • Evaluation of the Utilities features, by providing the following ratings: ○ Gas, 3 points if underground/not marked or above ground with no brush clearance or ≤ 50 feet, 15.24 m from the structure, 1 point if above ground with 15 feet, 4.572 m brush clearance and > 50 feet, 15.24 m from the structure, 0 points if underground/clearly marked or not present; ○ Electric, 5 points if overhead with not maintained/overgrown right of way, 3 points if underground/not marked, 1 point if overhead with 20 feet, 6.096 m maintained right of way, 0 points if underground/clearly marked or not present; ○ Septic tank or drain field systems, 3 points if present and not clearly marked, 1 point if present and clearly marked, 0 points if not present. • Evaluation of the Defensible space for all structures in the interface boundary and structures within 300 feet, 9.144 m of the boundary; or in case of intermix, 25-50 % of structures bordering wildland should be inspected and an average should be provided. The following average ratings are provided: ○ 25 points if < 30 feet (9.144 m),

	o 10 points if between 30 and 100 feet, (9.144-30.480 m), o 0 point if > 100 feet (30.480 m). • Evaluation of the Building construction for all structures in the interface boundary and structures within 300 feet, 9.144 m of the boundary; or in case of intermix, 25-50 % of structures bordering wildland should be inspected and an average should be provided. The following average ratings are provided. o Roof material: ▪ 15 points if < 50 % of homes have Class A covering (including asphalt/fiberglass shingles, slate/clay tiles, cement, concrete, or metal roofing, terra-cotta tiles), ▪ 10 points if 50-75 % of homes have Class A covering described above, ▪ 0 points if > 75 % of homes have Class A covering described above. o Sofftits/siding: ▪ 10 points if < 50 % of homes have noncombustible or fire-resistant siding and soffits, ▪ 5 points if the percentage is 50-74 %, ▪ 0 points if the percentage is 75-100 %. o Skirting: ▪ 10 points if < 50 % of homes have skirting underneath raised floors/decks, ▪ 5 points if the percentage is 50-75 %, ▪ 0 points if the percentage is > 75 % or skirting is absent. • Identification of the critical facilities to be protected: o Due to their infrastructure function; e.g. power plants, transmission lines, water plants or treatment plants, well fields, lift stations, fire and law enforcement stations, communication towers. o Due to their flammability; e.g. liquid storage tanks, landfills, dumps, junk yards, sawmills, lumberyards, hazardous materials storage areas. o Due to their smoke-sensitivity; e.g. care centers, nursing or assisted living homes, airports, correctional facilities, roadways. • Evaluation of these additional features: o 10 points if there are large adjacent areas of wildlands with accumulated fuels and no prescribed burning program, 0 otherwise; o 5 points if homeowners association lacks sustained fire prevention and mitigation organizational structure, 0 otherwise; o 10 points if cross-country access to wildfires is impeded in/around the subdivision, such as by ditches, 0 otherwise; o 5 points, if the structure to structure fire spread can be eased by insufficient clearance between buildings, 0 otherwise;

	○ 10 points if < 2/3 of the lots have been developed and large wildland fuels are accumulated in the undeveloped lots, 0 otherwise. [5] The State Forester should establish a system for defining and classifying forestland-urban interface areas, and provide to the public a map of the classified areas. Property owners should be heard in the classification process. A set of minimum standards in order to reduce fire hazards in forestland-urban interface areas should be provided by the Board of Forestry (Oregon Revised Statute 477.015-061. Urban Fire Interface Fire Protection). ***2. Severity class*** [1] The Implementation Guidelines are valid in moderate or greater fire risk areas for Federally-owned buildings, or in greater than moderate WUI risk areas for building leased by Federal agencies. [3] The outputs of the risk assessment are based on the hazard computation for each point of the grid representing the considered area, made through the following equation (where the Disturbance Regime is a measure of the length of the fire return interval): Hazard = (Disturbance Regime)*0.35 + (Fuel Hazard)*0.40 + (Aspect)*0.10 + (Slope)*0.15 The resulting values of hazard are mapped. The hazard values are divided into five equal intervals, which define the hazard class, from 1 (low) to 5 (high). A final HRV grid (a combination of the layers of Hazard, Risk, Value) is obtained, showing the areas at high risk of very dangerous WUI fires. Another output is the Redzone map (high values/high hazard areas), according to a previous project in Colorado State for mapping fire hazard (Front Range Redzone Project). [4] The final hazard rating is determined as follows, by summing up the partial ratings listed above (A.1.1): • Low hazard, if total rating is < 50; • Moderate hazard, if 50-74; • High hazard, if 75-99; • Very high hazard, if 100-120; • Extreme hazard, if > 120.
B. Land	
B.1 Vegetation	***1. Defensible space*** [1] Attention should be taken to remove or reduce combustible materials within a distance surrounding a building which should be determined according to the IWUIC Code for the Federal buildings. The defensible space is defined as in the IWUIC Code (2015). [2] The home ignition zone (around up to 100 feet from the house, approximately 30 m) should be treated according to the following guidelines:

	• 5-30 feet around the home (approx. 1.5 – 9 m): maintain and mow lawns; plant only low flammable species; hardscape using rocks, gravel or stone instead of mulch; keep fuel packages out of the area; • 30-100 feet around the home (approx. 9 – 30.5 m): use low flammable, low-growing plants; extend the irrigation system to this area; • > 100 feet (approx. >30.5 m): use low-growing plants; keep low the fuel vegetation volume. [4] Defensible space should be between 30 to 100 feet (approx. 9-30.5 m), depending on the adjacent vegetation. Landscaping should be irrigated and composed of fire-resistant, well-pruned, widely spaced species. High moisture, low oil/resin content and drought resistance are optimal characteristics. Coarse gravel, lava stone, chunky bark should be used as mulch for shrubs within 5 feet (1.524 m) of structures. A 10-12 feet (approx. 3.1 – 3.7 m) section of non-flammable fencing should be provided between the home and wood fences connecting to wildlands. [5] Single-family forestland dwellings (forest and mixed agricultural/forest use) should be provided with a primary fuel-free fire break and a secondary fire break area around the dwelling (Oregon Revised Statute 215.730: Additional Criteria for Forestland Dwellings). ***2. Clearance between/from vegetation*** [2] Separation between grasses, shrubs and trees should be created in the space around more than 30 feet (approx. 9 m) from the home and tree crowns should not touch one with each other. [4] Crowns of trees should not touch one with each other in the defensible space. The clearance between chimney outlets and vegetation should be > 15 feet (approx. > 4.6 m). Limbs should not overhang roofs. ***3. Maintenance*** [2] Low branches should be <u>pruned</u> up to a height of 6-10 feet (approx. 1.8-3.1 m) from the ground, or for one third of the height for small trees. Tall grasses, vines and shrubs should be removed under the trees. [4] Crowns should be pruned to a height of 6-10 feet (approx. 1.8-3.0 m) in the defensible space.
B.2 Topography/ Terrain	Characteristics of slopes and terrain generally considered in some risk assessment procedures reviewed. [5] Single-family forestland dwellings (forest and mixed agricultural/forest use) should be built on slopes ≤ 40 % (Oregon Revised Statute 215.730: Additional Criteria for Forestland Dwellings).

C. Building Construction	
C.1 General requirements	[1] Any alteration of Federal buildings (which are > 5,000 gross square feet, 464.4 m^2 on Federal Land) within a moderate or greater WUI risk area, should comply with the IWUIC 2015 or similar codes. [5] Specific building requirements should be provided by local governments in designated wildfire hazard zones. ***1. Classes of ignition resistance*** Not specifically addressed here. ***2. Characteristics of ignition resistant materials*** [2] Non-flammable or low flammability construction materials should be used for new homes, in particular roofs, sidings and windows. ***3. Building separation*** Not specifically addressed here.
C.2 Roof	***1. Covering*** [2] Openings on roof edges should be caulked. Loose or missing roof shingles/tiles should be replaced to reduce ember penetration. [4] Roofs should be of Class A asphalt/fiberglass shingles, slate/clay tiles, metal, cement or concrete, terra-cotta tiles. [5] Single-family forestland dwellings (forest and mixed agricultural/forest use) should have a fire-retardant roof (Oregon Revised Statute 215.730: Additional Criteria for Forestland Dwellings). ***2. Valley flashings*** Not specifically addressed here. ***3. Eaves*** [2] Exterior attic vents should be covered, under-eave and soffit vents should be enclosed with metal wire mesh ≤ 1/8 inch (0.003 m) to prevent embers. [4] Eaves closed in 0.5 inch nominal sheathing (0.01 m) or in noncombustible materials should be preferred. Noncombustible soffit vents should be used. ***4. Gutters*** [4] Gutters/downspouts should be kept free of leaves and debris, and made of noncombustible materials.

C.3 Walls and other external coverings	***1. Exterior walls*** [4] Exterior walls assemblies should be made of stucco, brick, concrete block, stone, having a 1 hour fire resistant rating and noncombustible external surfaces. ***2. Wall coverings*** Not specifically addressed here.
C.4 Windows, external doors and vents	***1. Exterior glazing*** [4] Exterior windows should be made of double-paned glass, as well as skylights (glass also tempered). ***2. External doors*** [4] Exterior glass doors should be made of double-paned tempered glass. ***3. Vents and other openings*** [2] Vents and other openings should be screened or anyway protected from embers during a wildfire. [4] Non-combustible, corrosion-resistant screening having a screen ≤ 1/8 inch (0.003 m) for covering vents. Vent openings should not exceed 144 square inches (0.09 square meters).
C.5 Decks and detachments	***1. Decks and other attachments*** [2] Items under decks/porches should be removed. [4] Decks above ground and balconies should be enclosed underneath with lattice reinforced with a noncombustible, corrosion-resistant screen having mesh ≥ 1/8 inch (0.003 m). ***2. Detached structures*** Not specifically addressed here.
C.6 Floors and interior structures	Not specifically addressed here.
D. Resources	
D.1 Utilities	Characteristics of utilities generally considered in some risk assessment procedures reviewed. ***1. Water supply*** <u>Supply level</u>. Single-family forestland dwellings (forest and mixed agricultural/forest use) should be provided with a water source always containing ≥ 4,000 gallons (about 15 cubic meters) of water or a water stream

	having a flow ≥ 1 cubic foot per second (28.3 l/s) (Oregon Revised Statute 215.730: Additional Criteria for Forestland Dwellings). Water source. [5] Single-family forestland dwellings (forest and mixed agricultural/forest use) should be provided with water supply from a source authorized by the Water Resources Department. It should be a swimming pool, pond, lake or similar water source (Oregon Revised Statute 215.730: Additional Criteria for Forestland Dwellings). Access. [5] The access for water supply for single-family forestland dwellings (forest and mixed agricultural/forest use) should ≤ 15 feet (approx. 4.6 m) of the water's edge for firefighting pumping units and include a turnaround (Oregon Revised Statute 215.730: Additional Criteria for Forestland Dwellings). Standby power. Not specifically addressed here. Fire hydrants. Not specifically addressed here. Dry hydrants. Not specifically addressed here. ***2. Other utilities*** Not specifically addressed here.
D.2 Firefighters	Not specifically addressed here.
D.3 Planning	***1. Fire protection plan*** [4] Mitigation and fire response plans should be developed in order to reduce the hazard and/or develop a fire response and/or evacuation plan. The areas in which these plans are needed more urgently are the extreme, very high and high hazard areas. The strategies fo hazard mitigation include: • Fuel reduction (prescribed burning, brush mowing/chopping, herbicides, tree thinning, livestock grazing, clearing); • Community education; • Regulation. Fuel reduction techniques can be effective for only 3-5 years, and so they could be needed again. If structures are in the intermix areas, hazard mitigation treatments could be not needed again. Interface areas should be assessed every three years. ***2. Other plans required/suggested*** [2] Firewise Communities/USA Recognition Program. This Firewise program encourage residents to comply with the following steps in order to protect their homes against wildfires: • Talk to the neighbors;

	• Recruit community members to form commitees (including residents and fire professionals, but also planners, land managers, foresters, etc.), and choose a group leader/representative ("sparkplug"); • Contact Firewise (firewise.org); • Schedule a site assessment visit, to be conducted by the state liaison, the local fire protection district or by themselves, according to the Firewise Risk Assessment; • Review the site assessment and the evaluation document: findings should be discussed with the local Firewise committee, which can determine to accept or reject the findings (in the latter case, the process is ended); • Create a plan (by the Firewise committee), including Firewise events (educational events, clean-up days, etc.) and mitigation activities; • Implement the plan; by scheduling and designating responsibles for each action; • Apply for recognition by the Firewise in the context of the USA Recognition Program, once the activities have been completed; • Submit a renewal application every year. [5] Statewide planning should avoid the developments of areas likely subject to known disasters and hazards without appropriate protection (Oregon Statewide Planning Goal 7: Areas Subject to Natural Hazards).
D.4 Outreach	The Guidelines are mainly dedicated to the general public, who should manage by themselves or in communities the wildfire risk in the interfaces by following the recommendations.
E. Fire Protection Measures	
E.1 Measures for water sources	[4] Helicopter dip (water drop) spots should always have ≥ 4 feet (approx. 1.2 m) water depth with 45 feet (approx. 13.7 m) clearance from obstructions and 75 feet (approx. 22.9 m) clearance in approach at least from one direction.
E.2 Measures for buildings	Characteristics of fire protection measures for buildings generally considered in some risk assessment procedures reviewed. ***1. Sprinklers*** [5] Single-family forestland dwellings (forest and mixed agricultural/forest use) should be provided with sprinkler system if the dwellings are not within a fire protection district or they do not have a fire protection by contract (Oregon Revised Statute 215.730: Additional Criteria for Forestland Dwellings). Other feasible solutions are on-site equipment and water storage, or similar. ***2. Manual protection systems*** Not specifically addressed here. ***3. Warning systems*** [4] Smoke alarms should be checked regularly and batteries replaced every 6 months.

	4. Spark arresters [4] Spark arresters should be installed in all chimneys. [5] Chimneys of single-family forestland dwellings (forest and mixed agricultural/forest use) should be provided with spark arresters (Oregon Revised Statute 215.730: Additional Criteria for Forestland Dwellings). ***5. Combustible materials*** [2] Flammable materials should be avoided within 5 feet of the foundation, roof eave lines, gutters, deck and porch surface. [4] Firewood storage and Liquefied Petroleum Gas should be ≥ 50 feet (15.2 m) from structures, with cleared space around them of ≥ 15 feet (4.6 m). ***6. Private shelters*** Not specifically addressed here.
F. Environment	
F.1 Weather	Characteristics of weather (critical fire weather) generally considered in some risk assessment procedures reviewed.
F.2 Fire history	Characteristics of fire history generally considered in some risk assessment procedures reviewed.
G. Access	
G.1 Roads	Characteristics of access generally considered in some risk assessment procedures reviewed. ***1. Type/Number of access roads*** Not specifically addressed here. ***2. Road standards*** <u>Main roads.</u> Not specifically addressed here. <u>Driveways/Dead-ends</u>. [4] Driveways should be ≥ 12 feet (3.7 m), with vertical clearance ≥ 14.5 feet (4.4 m). Gates should have an entrance 2 feet (0.06 m) wider than the driveway and located ≥ 30 feet (9.1 m) from the road. If closed, a keybox should be installed for firefighters access. <u>Fire lanes.</u> Not specifically addressed here. <u>Parking</u>. Not specifically addressed here. ***3. Markings***

	Road signs. Not specifically addressed here. Markers. [2] Homes and neighborhoods should have legible street names and numbers. [4] Street numbers should be noncombustible, ≥ 4 inches (approx. 0.1 m) high, reflectorized on a contrast background, at each entrance of driveways, visible from both directions. ***4. Vegetation clearing*** Not specifically addressed here.

REFERENCES

[1] Implementation Guidelines for: Executive Order 13728 Wildland-Urban Interface Federal Risk Management; Barack Obama; May, 18, 2016.

[2] National Fire Protection Association and Firewise communities. 2016. Firewise Toolkit.

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Oregon Revised Statute 215.730: Additional Criteria for Forestland Dwellings, 1999.

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US Department of Agriculture and US Forest Service. Wildfire Hazard Potential Map. Available at www.arcgis.com.

US Fire Administration. Wildland Urban Interface (WUI) Toolkit. Retrievable at: https://www.usfa.fema.gov/wui_toolkit/

www.firewise.org

A.3 California: Standards/Guidelines

The 2016 California Fire Code includes a specific section (Chapter 49) concerning the requirements for WUI fire areas. While a substantial part of the 2016 California Fire Code is taken from the 2015 International Fire Code (International Code Council, 2015), the WUI section was developed separately. This section includes references to other codes (e.g. Building Code for the building construction requirements), regulations (e.g. California Code of Regulations for the definitions of hazards and defensible spaces), guidelines (e.g. General Guidelines for Creating Defensible Spaces).

The following issues are specifically treated: hazard definition, vegetation, topography, building requirements (roof, walls, openings, attachments), planning, outreach, weather influence and wildlife exposure. Specific quantitative prescriptions are provided for vegetation management (in different terrain conditions), for creating the defensible spaces around the houses and for new constructions in the WUI area. Lack of information about utilities, firefighters, access, fire protection measures, reference to fire history was found. However, general provisions about those other issues are present in the general sections of the California Fire Code. They are referenced where appropriate.

Table 2 – Guide/Code: California Fire Code (Chapter 49: Requirements for Wildland-Urban Interface Fire Areas)	
Category	**Provision**
A. Hazard	
A.1 Definitions	***1. Destination*** The Wildland-Urban Interface fire area is defined as an area identified as a Fire Hazard Severity Zone. A wildfire is generally defined as: "*any uncontrolled fire spreading through vegetative fuels that threatens to destroy life, property, or resources*". The fire hazard severity zones are defined and revised by the Director of the California Department of Forestry and Fire Protection (CDF Director). ***2. Severity class*** Three hazard severity classes are considered depending on environmental and physical factors: medium, high and very high risk. These are zones under responsibility of the State of California. Local agencies can designate other areas (upon recommendation of the CDF Director) to be considered as adjunctive very-high risk areas, in which the local agency is responsible for the fire protection.
B. Land	
B.1 Vegetation	This section integrates different prescriptions and guidelines taken from different sources ((California Government Code), Section 51175-51189) ((California Code of Regulations), Title 19, Division 1) ((California Public Resources Code), Section 4291) (State Board of Forestry and Fire Protection, California Department of Forestry and Fire Protection, 2006).

1. Defensible space

Vegetation and fuels located in the following areas:
1) Moderate, High and Very-high Fire Hazard Severity zones belonging to unincorporated lands (lands which are outside any municipality) designated by the State Board of Forestry and Fire Protection as State Responsibility Areas;
2) Very-high Fire Hazard Severity Zones designated by cities and other local entities;
should be managed to reduce the severity of wildfire exposure and fire spreading to buildings.

The prescriptions for creating a defensible space around the structure/residence in those areas are the following:

- Flammable vegetation and other combustible growth included in a distance < 30 feet (9.1 m) from the structure/residence should be removed and cleared away;
- Brush, flammable vegetation and other combustible growth included in a distance < 100 feet (30.5 m), or at a greater distance if required by specific other regulations (national or local) or by an insurance agency; should be removed (except for single specimen of trees or well-pruned and maintained trees able to avoid the rapid transmitting of fire).

Minor vegetation objects such as fallen leaves, needles, small branches, can be permitted to a depth of 3 inches (0.08 m). Stumps may be retained when isolated from other vegetation, as well as isolated dead trees, well-spaced from other vegetation, structures, roads.

If a stand of large trees with a continuous tree canopy would be maintained in the defensible space, all surface fuels > 4 inches (0.10 m) high should be removed (except not dangerous single specimens).

Exemptions or modifications to these standards could be allowed if structures are constructed with nonflammable or other specific materials; or if the land is a habitat for endangered species, is kept in its natural state, is a parkland, or other lands characterized by particular values (i.e. environmental, scenic, etc.).

2. Clearance between/from vegetation

Horizontal clearance. General clearance requirements for the zone placed between 30 feet (9.1 m) and 100 feet (30.5 m), called a reduced fuel zone, range between 4 feet and 40 feet in all directions (horizontally and vertically), depending on slopes, vegetation type and sizes.

Vertical clearance. The vertical clearance between the top of the shrub and the bottom of the tree branches should be anyway high ≥ three times the shrub, in order to prevent ladder fuels.

	3. Maintenance Dead vegetation. Dead or dying wood on trees in contact with the building; leaves, needles and other dead plants on the roofs should be removed. Groundcover. Grass and other vegetation distant > 30 feet (9.1 m) from the residence can be maintained if < 18 inches (0.46 m) high (better if < 4 inches, 0.10 m) if needed to prevent erosion and stabilize the soil. Pruning. Parts of trees which extend within 10 feet (3.1 m) of outlets of chimneys/stovepipes should be removed. Branches of trees should be removed for a height of at least 6 feet (1.83 m), up to 15 feet (4.57 m).
B.2 Topography/ Terrain	The terrain can influence the horizontal clearance between different vegetation types through the slopes. The required horizontal clearance needed for stopping the spread of fire between aerial fuels (tree crowns or high brush) is (State Board of Forestry and Fire Protection, California Department of Forestry and Fire Protection, 2006): • 10 feet (3.1 m) for trees, and 2 times the height of the shrub for shrubs, for slopes included between 0 % and 20 %; • 20 feet (6.2 m) for trees, and 4 times the height of the shrub for shrubs, for slopes between 20 % and 40 %; • 30 feet (9.3 m) for trees, and 6 times the height of the shrub for shrubs, for slopes > 40 %. In steep terrains, in presence of great fire hazard, the pruning of trees in case of a continuous tree canopy should be elevated to the upper limit of the range (15 feet, 4.57 m).
C. Building Construction	
C.1 General requirements	The information about building construction requirements in the Section C are taken from the ((California Building Code), Chapter 7A: Materials and Construction Methods for Exterior Wildfire Exposure). ***1. Classes of ignition resistance*** Not specifically addressed here. ***2. Characteristics of ignition resistant materials*** The definition of ignition resistant material refers to a building material which can resist to ignition or sustained combustion sufficiently to reduce losses from WUI conflagrations under worst cases of weather and fuel conditions (including embers and small flames). ***3. Building separation*** Not specifically addressed.
C.2 Roof	***1. Covering*** Spaces between roof coverings and decking should be made in such a manner to avoid the intrusion of flames and embers, should be fire-stopped or have a

	layer of minimum 72 pound (32.4 kg) mineral-surfaced non-perforated cap sheet (ASTM D3909) over the combustible decking. ***2. Valley flashings*** Valley flashings should be made of No. 26 gage-galvanized corrosion-resistant metal sheets. The sheets shall have a thickness of at least 0.019 inch (0.48 mm), over a layer of minimum 72 pound (32.4 kg) mineral-surfaced non-perforated cap sheet (ASTM D3909) covering all the valley, at least 36 inch (914 mm) wide. ***3. Eaves*** The material constituting the exposed roof eaves (except for some parts such as solid wood rafter tails and blockings, fascia and gable end overhangs), the exposed underside of enclosed roof eaves and roof eave soffits (except for some parts such as fascia and gable end overhangs), the exposed underside of exterior porch ceilings (except for architectural trim boards), the exposed underside of floor projections over the exterior wall (except for architectural trim boards), the underside of appendages (when required by the enforcing agency, except for expect for heavy timber structural columns and beams) should comply with one of the following requirements: 1) noncombustible, 2) ignition-resistant, 3) covered with one layer of 3/8-inch Type X gypsum sheathing, 4) the exterior part of a 1-hour fire resistive wall assembly including some specific gypsum panels and sheathings (Gypsum Association, 2015), 5) compatible with some specific performance criteria defined in (SFM Standard I2-7A-3), (ASTM E2957) (except open roof eaves). ***4. Gutters*** The accumulation of debris and leaves in gutters should be impeded.
C.3 Walls and other external coverings	***1. Exterior walls*** Exterior walls should (except for gypsum wall assemblies or sheathings described in (Gypsum Association, 2015)) be one of the following: 1) noncombustible, 2) ignition-resistant, 3) heavy timber exterior assembly, 4) log wall assembly, 5) wall assembly which passed specific test procedures after being in contact with a direct flame for 10 minutes (SFM Standard I2-7A-I). ***2. Wall coverings*** Exterior wall coverings should extend from the top of the foundation to the roof, terminating with wood blockings of 2 inches (50.8 mm) or at the enclosure of enclosed eaves.

C.4 Windows, external doors and vents	***1. Exterior glazing*** Exterior glazing (windows and glazed doors, glass veneer) should meet one of the following requirements: 1) being composed of multipane glazing with at least one acceptable tempered pane ((California Fire Code), Section 4206), 2) made of glass block units, 3) having fire-resistance rating < 20 minutes (NFPA 257), 4) being specifically tested (SFM Standard I2-7A-2). ***2. External doors*** Exterior doors should meet one of the following requirements: 1) having the external surface composed of non-combustible or ignition-resistant material, 2) made of solid core wood with prescribed thickness, 3) having fire-resistance rating < 20 minutes (NFPA 252), 4) being specifically tested (SFM Standard I2-7A-I). ***3. Vents and other openings*** Ventilation openings should be fully covered with a material complying with one of the following requirements: 1) being a metal wire mesh/vent, 2) being another acceptable vent (ASTM E2886), 3) being a non-combustible vent (excepts for vents under the roof or along its ridges, having the surface covered by noncombustible wire mesh), corrosion-resistant and with dimensions included between 1/16 inch (1.6 mm) and 1/8 inch (3.2 mm). They should be not placed under eaves or cornices (except for openings at point 2), for special eave and cornice vents approved by the enforcing agency and in other specific safe conditions).
C.5 Decks and detachments	***1. Decks and other attachments*** The material of the walking surfaces of decks, porches, balconies and stairs distant ≤ 10 feet (3.048 m) from the building should be (except for specific surface materials, (ASTM E84)) compliant with one of the following requirements: 1) being ignition-resistant according to specific performance requirements (SFM Standard I2-7A-4), (SFM Standard I2-7A-5) 2) made of exterior fire-retardant wood, 3) noncombustible, 4) being another acceptable material if the attached wall covering is noncombustible or ignition-resistant (SFM Standard I2-7A-4A). Trellises, arbors, patio covers, carports, gazebos and similar other attached structures (or detached structures not further than 50 feet from the building if required by the enforcing agency) should be made of noncombustible/ignition-resistant material.

	2. Detached structures Not specifically addressed here.
C.6 Floors and interior structures	***1. Floor*** Not specifically addressed here. ***2. Underfloor*** The underfloor area of elevated or overhanging buildings (except for heavy timber structural columns and beams) should comply with same requirements listed in C.2.3. ***3. Other interior structures*** Not specifically addressed here.
D. Resources	
D.1 Utilities	***1. Water supply*** Not specifically addressed here. ***2. Other utilities*** Not specifically addressed here.
D.2 Firefighters	Not specifically addressed here.
D.3 Planning	***1. Fire protection plan*** Projects, developments or modifications (when required by the enforcing agency) in a Wildland-Urban Interface Fire Area should be provided with a Fire Protection Plan. In this plan, the ways for minimizing and mitigating potential losses from wildfires are described. A specific Section "Plan" (n. 4903) is present in the Code, but it is reserved (possibly under development). ***2. Other plans required/suggested*** Not specifically addressed here.
D.4 Outreach	Guidelines for the property owners are provided by the California Department of Forestry and Fire Protection/State Board of Forestry and Fire Protection (State Board of Forestry and Fire Protection, California Department of Forestry and Fire Protection, 2006). They concern the preparation of the defensible space and include general practical rules to follow for protecting residences/structures from wildfire exposure. In fact, "*persons who owns, leases, controls, operates, or maintains a building or structure in, upon, or adjoining a mountainous area, forest-covered lands, brush-covered lands, grass-covered lands, or land that is covered with flammable material*" ((California Public Resources Code), Section 4291) should comply with the indications about vegetation management and defensible space.

E. Fire Protection Measures	
E.1 Measures for water sources	Not specifically addressed here. General fire protection measures (not specifically related to WUI areas) are provided in the remainder of the California Fire Code (see e.g. Chapter 5).
E.1 Measures for buildings	***1. Sprinklers*** Not specifically addressed here. General fire protection measures (not specifically related to WUI areas) are provided in the remainder of the California Fire Code (see e.g. Chapter 5). ***2. Manual protection systems*** Not specifically addressed here. ***3. Warning systems*** Not specifically addressed here. ***4. Spark arresters*** Not specifically addressed here. General fire protection measures (not specifically related to WUI areas) are provided in the remainder of the California Fire Code (see e.g. Chapter 5). ***5. Combustible materials*** Liquefied petroleum gas (LP-gas). Not specifically addressed here. Storage of combustible materials. Combustible materials should not be placed/stored within 10 feet (9.1 m) from structure/residences. ***6. Private shelters*** Not specifically addressed here.
F. Environment	
F.1 Weather	Environmental factors such as weather and winds should be considered (together with fuel loading, slopes, etc.) for the definition of fire hazard severity zones by the CFD Director (Director of the California Department of Forestry and Fire Protection), ((California Public Resources Code), Section 4201-4204).
F.2 Fire history	Not specifically addressed here.
G. Access	
G.1 Roads	***1. Type/Number of access roads*** Not specifically addressed here. General fire safety requirements (not specifically related to WUI areas) for accessibility (e.g. standards for roads) are

	provided in the remainder of the California Fire Code (mainly in the Chapter 5 and the Appendix D). ***2. Road standards*** Not specifically addressed here. General fire safety requirements (not specifically related to WUI areas) for accessibility (e.g. standards for roads) are provided in the remainder of the California Fire Code (mainly in the Chapter 5 and the Appendix D). ***3. Markings*** Not specifically addressed here. ***4. Vegetation clearing*** Not specifically addressed here.

REFERENCES

ASTM D3909, 2014. Standard Specification of Asphalt Roll Roofing Surfaced with Mineral Granules*

ASTM E84, 2013. Standards Test Method for Surface Burning Characteristics of Building Materials*

ASTM E2886, 2014. Standard Test Method for Evaluating the Ability of Exterior Vents to Resist the Entry of Embers and Direct Flame Impingement*

ASTM E2957, 2015. Standard Test Method for Resistance to Wildfire Penetration of Eaves, Soffits and Other Projections*

California Building Code, 2016

California Code of Regulations, 2016

California Fire Code, 2016

California Government Code, 2016.

California Public Resources Code, 2016

Gypsum Association, 2015. Fire Resistance Design Manual

International Code Council, 2015. International Fire Code

NFPA 252, 2012. Standard Methods of Fire Tests of Door Assemblies**

NFPA 257, 2012. Standard on Fire Test for Window and Glass Block Assemblies**

SFM Standard 12-7A-1, 2016. Exterior Wall Siding and Sheathing***

SFM Standard 12-7A-2, 2016. Exterior Windows***

SFM Standard 12-7A-3, 2016. Under Eave***

SFM Standard 12-7A-4, 2016*. Decking**

SFM Standard 12-7A-4A, 2016. Decking Alternate Method A***

SFM Standard 12-7A-5, 2016. Ignition-Resistant Material***

State Board of Forestry and Fire Protection, California Department of Forestry and Fire Protection, 2006. General Guidelines for Creating Defensible Space

*ASTM = American Society for Testing and Materials.

**NFPA = National Fire Protection Association

***SFM Standard = (California) State Fire Marshal Standard

A.4 Australia: Standards/Guidelines

A set of Australian standards are dedicated to regulations on buildings in bushfire-prone areas (bushfire is the Australian specific terminology for defining wildfires): Australian Standard, Construction of Buildings in Bushfire-Prone Areas (2009). This include regulations concerning the definition and classification of hazard zones, including a description of the methods (simplified or analytical) on how to define them. Terrain and environmental factors are considered in this calculation. A series of detailed standards and procedures are set for the building materials and construction, for each hazard zone. Vegetation, resources, fire protection measures, access, are not explicitly considered in the standard.

Complementary guidelines of the States of South Australia and Tasmania were reviewed, providing some standards for vegetation (clearing, defensible space, clearance), resources (water supply and planning), fire protection measures (measures for water sources and private shelters), access (standards for main roads, access and fire trails). They are referenced in the text, where appropriate. All the information in the following table refer to the main Australian standard for building construction in bushfire-prone areas, unless otherwise stated.

Table 2 – Guide/Code: Australian Standard. Construction of buildings in bushfire-prone areas.	
Category	**Provision**
A. Hazard	
A.1 Definitions	***1. Destination*** The standard is limited to sites where there is a specifically defined Bushfire Attack Level (BAL), based on the vegetation within 100 m of the site, the heat flux exposure and the predicted bushfire attack and exposure. A bushfire is defined as "*an unplanned fire burning in vegetation*". It is a synonymous with wildfire. Its attack includes burning embers, radiant heat, flames, possibly resulting in ignition and further damages to structures. Different classifications for hazard levels may be operated by single Australian state, such as the South Australia. It classifies the territory into three (general, medium, high) different bushfire prone areas (South Australia Development Regulations, 2008 (Version 19.9.2017)), as indicated in development plans. A tool is available for directly identifying the risk level associated to each property (Property Location Browser User Guide, Government of South Australia, 2013). ***2. Severity class*** The classes of BAL (Bushfire Attack Level) are defined as follows: • BAL-LOW (Very-Low risk). Vegetation complies with one of the following cases: - Vegetation distant more than 100 m from the site; - Single areas of vegetation less than 1 ha (10,000 m^2) in area, not within 100 m of other areas of vegetation;

- More than one area of vegetation less than 0.25 ha (2,500 m^2) in area, not within 20 m of the site or each other;
- Strips of vegetation less than 20 m in width, not within 20 m of the site or each other, or other areas of vegetation;
- Areas without vegetation;
- Low threat vegetation (managed grass and lawns, golf courses, parks and reserves, botanical and ornamental gardens, vineyards, orchards, commercial nurseries, nature strips, wind breaks).

- BAL-12.5 (Low risk). Heat flux exposure ≤ 12.5 kW/m^2, exposed to ember attack.
- BAL-19 (Moderate risk). 12.5 kW/m^2 < heat flux exposure ≤ 19 kW/m^2, exposed to increased level of ember attack, heat flux and burning debris (ignited by embers);
- BAL-29 (High risk). 19 kW/m^2 < heat flux exposure ≤ 29 kW/m^2, exposed to increased level of ember attack, heat flux and burning debris (ignited by embers);
- BAL-40 (Very high risk). 29 kW/m^2 < heat flux exposure ≤ 40 kW/m^2, exposed to increased level of ember attack, heat flux, burning debris (ignited by embers) and flames;
- BAL-FZ (Flame Zone – Extreme risk). Heat flux exposure > 40 kW/m^2, directly exposed to flames from fire front, heat flux and ember attack.

The steps of the procedure to be used for defining the BAL are reported as follows. Two methods are presented in the standards.

Procedure for defining the BAL. Method 1 (simplified procedure)

- Step 1. Determination of the FDI (Fire Danger Index), that is the chance of a fire starting, spreading, intensity and difficulty of suppression, according to different combinations of temperature, humidity, wind speed, drought effects. The equations by (Noble, Bary, Gill, 1980) are used. Different values are provided for each Australian territory (maximum value: FDI = 100 for the Australian Capital Territory and some areas of New South Wales, minimum value: FDI = 40 for the Northern Territory and Queensland). FDI values could be specifically refined in presence of more accurate data, in accordance with the authority.
- Step 2. Classification of the vegetation. Seven classes are considered: 1) forest (sub-categories: tall open forest/woodland, open/low-open forest, pine plantation); 2) woodland (sub-categories: woodland/open woodland, low/low-pen woodland/open shrubland); 3) shrubland (sub-categories: closed/open heath, low shrubland); 4) scrub (sub-categories: closed/open scrub); 5) mallee/mulga (tall shrubland); 6) rainforest (tall closed/closed/low closed forest); 7) unmanaged grassland (low open shrubland, hummock/closed tussock grassland, open/sparse open tussock, sown/dense sown pasture, open/sparse open herbfield). Figures and detailed guidelines on how to classify vegetation (based on e.g. height, foliage cover) into these seven categories are provided. If there are more vegetation types, each type should be classified separately with the worst-case scenario. Low-

threat vegetation and non-vegetated areas, complying with a BAL-LOW area definition are excluded from this classification. The vegetation classification is based on (Specht, 1970).

- Step 3. Determination of the distance of the site from the (classified) vegetation. The distance between the edge of the site and the edge of the classified vegetation should be measured on a horizontal line. The edge of the site is the external building wall, or posts/columns for attached structures without walls. Eaves and roof overhangs, tanks, chimneys and pipes, unroofed pergolas, sun blinds, landings/terraces/steps/ramps ≤ 1 m in height, unclassified vegetation (not complying with categories listed in the step 2 should not be considered in the determination of this distance.
- Step 4. Determination of the effective slope of land under the (classified) vegetation. For each vegetation type, the slope in degrees and the direction (uphill/downhill) of the land under the vegetation should be determined. Only the slope and the direction (measured by using the structure as a reference) of the vegetated land are of interest, rather than the slope between the structure and the vegetated land (e.g. if the land under vegetation is downhill, and the slope of the terrain between the structure and the vegetated land is uphill, the effective slope is considered downhill and vice versa). Since the fire travels more slowly down a hill, uphill slopes are considered as having a slope equal to 0 degrees.
- Step 5. Determination of the BAL level. The BAL level is determined according to Tables presented in the standards (Tables 2.4.2-2.4.5, pp. 29-32). Input values for the determination of the BAL level are the FDI (Step 1), the vegetation classification (Step 2), the distance between site and vegetated land (Step 3), the effective slope of land (Step 4). If input values available are not appropriate for the site, the second approach should be used.

Procedure for defining the BAL. Method 2 (detailed procedure) – Appendix B

The second approach should be used if the slope under the classified vegetation (see Step 2 of the first Method) is ≤ 30° downslope (because in this case the convective heat cannot be considered as negligible, (Cheney, 1981)) and the land slope between the site and the classified vegetation is ≤ 20° (downhill/uphill, because in this case the setback between site and vegetation can be practicable, (NSW Rural Fire Service, 2001)).

- Step 1. Determination of the FDI (Fire Danger Index). The FDI is determined as for the Method 1 (Step 1). In case of vegetation classification related to heaths, shrubs and scrubs, the nominal wind speed is used to determine the fire spread rate. It is set to 45 km/h.
- Step 2. Classification of the vegetation. The vegetation is classified as for the Method 1 (Step 2). Additional parameters to be determined are: the fuel load (w), the overall fuel load (W) and the classified vegetation height (VH). These are provided in Appendix B (Table B2). Input information is the vegetation class/type. The output values

presented in that table can be customized in accordance with the relevant fire authority, if specific studies are available, different than Specht (1970).

- Step 3. Determination of the effective slope. See Step 4 of Method 1.
- Step 4. Determination of the slope between site and (classified) vegetation. In a similar fashion as for the Step 3, the slope of the land included between site and classified vegetation should be determined.
- Step 5. Determination of the distance between site and (classified) vegetation. See Step 3 of method 1.
- Step 6. Determination of the flame length. A bushfire behavior equation is used for computing the fire spread rate *R*. Depending on the fuel type, a different equation is used: the equation by ((NSW Rural Fire Service, 2001), (Byram, 1959)) for forest and woodland (including FDI and w), the equation by (Catchpole et al., 1998), for shrubs and heaths (including wind speed and VH), the equation by (Marsden-Smedley and Catchpole, 1995), for tussock moorlands (including wind speed, moisture factor and age of vegetation).
  The fire spread rate *R* is then corrected for considering the influence of the effective slope: R_{slope} = *R exp(± 0.069) (+ for downslope, - for upslope/level)*. The flame length L_f is obtained by applying the following equations:

  $L_f = 0.0775(\frac{H\ W\ R_{slope}}{36})^{0.46}$ for shrubs, heaths, malle/mulga or tussocks (Byram, 1959), where H is the heat of combustion (18,600 kJ/kg)

  $L_f = \frac{(13\ R_{slope}+0.24\ W)}{2}$ for forests and woodlands (NSW Rural Fire Service, 2001).

- Step 7. Determination of the flame width. The flame width is assumed to be 100 m (unless there are specific conditions justifying minor values).
- Step 8. Determination of the elevation of receiver. The elevation of the receiver *h* is the level above ground at which the site will receive the incident radiant heat flux. If the assessment is aimed at defining the exposure of a given level (e.g. window level) to the radiant heat flux, *h* is set to that specific level. Otherwise, it is set to 0 if the flame centre is ≤ ground level and as: $h = (0.5\ L_f \sin a) - (d \tan \vartheta)$ if the flame centre is > ground level (*a* = angle between the flame front and the horizontal plane, ϑ = slope of the plane between the structure and the firefront, *d* = distance between site and vegetation).
- Step 9. Determination of the radiant heat flux. The radiant heat flux *q* (kW/m^2) is obtained through the following equation:

  $q = t\ \Phi\ E$

  where:
  E is the flame emissive power, determined through the Stefan-Boltzmann equation;

	Φ is the view factor, which is a function of flame geometry (including length, width and angle), location of the receiving element of the radiant heat flux (including slope of the land between site and classified vegetation, distance of the site from classified vegetation, receiver elevation). Details about its calculation are given in the Appendix B of the standard. τ is the atmospheric transmissivity, calculated according to (Fuss and Hamins, 2002). • Step 10. Determination of bushfire-attack level. Based on the computed radiant heat flux through the previous steps, the BAL level is defined: BAL-LOW, BAL-12.5, BAL-19, BAL-29, BAL-40, BAL-FZ).
B. Land	
B.1 Vegetation	***1. Defensible space*** A building classified as belonging to the class BAL-FZ (extreme risk), should have a minimum setback distance of 10 m from classified vegetation. If it is impossible to reach this distance, the elements of the building within 10 m of the vegetation should comply with the (AS 1530.8.2). Local regulations (South Australia Development Regulations, 2008 (Version 19.9.2017)) require that trees within 20 meters from a dwelling should be removed (if in the medium/high risk area). No guidance explicitly provided concerning the measures to adopt in order to create a defensible space. Some guidelines are provided in the local guidelines of Tasmania (Guidelines for Development in Bushfire Prone Areas of Tasmania, Bushfire Planning Group, 2005). In detail, the Building Protection Zone (BPZ) is a zone adjacent to the building having a significant amount of fuel reduction. The BPZ is obtained by: • Including non-flammable areas (e.g. paths, driveways, short cropped lawns); • Dams, orchards, gardens and effluent disposal areas on the fire prone side; • Avoiding highly flammable plants, radiation shields and windbreaks; • Removing fire hazard (e.g. wood piles, rubbish heaps, stored fuels); • Replacing highly flammable plants with low flammability species; • Ensuring horizontal separation and vertical clearance; • Maintaining the fuel in the area at minimum. This area is indicated to be 20 meters large for flat slope or 5 degrees slope, 25 meters for 10 degrees slope, 30 meters for 15 degrees slope and 40 meters for 20 degrees slope. The distances are measured from the external building walls along the ground. Moreover, the Fuel Modified Buffer Zone (FMBZ) is indicated as a solution to separate the BPZ from the bushfire hazard The BPZ is obtained by: • Retaining trees to catch embers and reduce wind speed; • Removing small trees/shrubs in order to create clumps separated by open spaces;

	• Removing the fuel between the ground and the bottom of the canopies or until at least 2 meters (through pruning); • Reducing at minimum fine fuels at ground level; For grassland/forests, this area is indicated to be: 10/15 meters large for flat slope, 15/25 meters for 5 ° slope, 20/30 meters for 10 ° slope, 30/45 meters for 15 ° slope, 40/50 meters for 20 ° slope. 40 meters for 20 ° slope. The distances are measured from the BPZ along the ground. ***2. Clearance between/from vegetation*** Horizontal clearance. Some general guidelines are provided in local guidelines (Guidelines for Development in Bushfire Prone Areas of Tasmania, Bushfire Planning Group, 2005). ***3. Maintenance*** Generally addressed in local guidelines (Guidelines for Development in Bushfire Prone Areas of Tasmania, Bushfire Planning Group, 2005).
B.2 Topography/ Terrain	Terrain factors (in particular slope) are considered in the definition of BAL risk levels, and so they can influence the building requirements. Slopes are considered in local guidelines (Guidelines for Development in Bushfire Prone Areas of Tasmania, Bushfire Planning Group, 2005) as influencing the required width of the defensible space.
C. Building Construction	
C.1 General requirements	Specific construction requirements for bushfire-prone areas are defined for all the BAL levels, except for the BAL-LOW level, for which the other applicable building standards are sufficient. If a given BAL level has been defined for a structure, then the building elements of the structure should be appropriate for that level or a higher level. If an elevation of the building is not exposed to the source of the bushfire attack (all its parts are obstructed by other parts of the building), then the construction requirements can be of a lower level than the main structure (anyway ≥ BAL-12.5, except if exposed elevations are BAL-LOW). If a construction element satisfies the criteria set by the (AS 1530.8.1), it is then suitable for the BAL from 12.5 to 40. If a construction element satisfies the criteria set by the (AS 1530.8.2), it is then suitable for the BAL-FZ. If the test criteria are satisfied without screening for protection from embers, the part regarding the screening of windows and doors contained in this standard should be applied. ***1. Classes of ignition resistance*** Fire Resistance Level (FRL). The nominal grading period is determined by submitting a specimen to a standard time temperature curve defined in the (AS 1530.4). The fire resistance level is determined through three different ratings (in minutes): • Structural adequacy (for a period of *n* minutes);

	• Integrity (for a period of *n* minutes); • Insulation (for a period of *n* minutes). Thus, it is reported as: FRL a/b/c (e.g. 30/30/30). ***2. Characteristics of ignition resistant materials*** Noncombustible material should be non-combustible as determined by the (AS 1530.1) or as determined by the (Building Code of Australia). Bushfire-resisting timber (natural, impregnated with chemicals, having fire-retardant coating or substrate) should meet the requirements specified in the Appendix F (including being tested with the (AS/NZS 3837), having a maximum heat release rate ≤ 100 kW/m^2, and an average heat release rate ≤ 60 kW/ m^2 for 10 minutes following ignition after exposure to irradiance level of 60 kW/ m^2). ***3. Building separation*** Not specifically addressed here.
C.2 Roof	All roof systems should be noncombustible. For BAL FZ, it should be a system complying with the AS 1530.8.2 (tested from the outside); or having a FRL of 30/30/30 or -/30/30 (tested from the outside); or a combination of the two previous elements. The junction between roofs and walls should be sealed (in order to avoid openings > 0.003 m). Roof ventilation openings should be fitted with noncombustible ember guards or a corrosion-resistant metal (steel, bronze or aluminium) sheet/perforated mesh with apertures ≤ 0.002 m. Veranda, carports, awning roofs, which are part of the main roof should meet all the requirements of the main roof. ***1. Covering*** BAL 12.5. • Tiled roofs. Should be fully sarked with sarking having: - Flammability index ≤ 5; - Location below the roof battens; - Roof cover on the entire area including the ridge; - No gaps allowing the ember entry where sarking meets fascia, gutters, etc. • Sheet roofs. Should be fully sarked with one of the following: - As for tiled roofs, except foil-backed insulation blankets over the battens; - Any gaps > 0.003 m in the roof system should be sealed by a corrosion-resistant metal (steel, bronze or aluminium) sheet/perforated mesh with apertures ≤ 0.002 m; or a mineral wool; or other noncombustible material; or a combination of the previous elements. • Roof penetrations. They should be:

	- sealed for preventing gaps > 0.003 m with noncombustible material; - of specific materials/elements when considering glazed elements, flashing elements and evaporative cooling units. BAL 19. • Tiled roofs. See BAL 12.5, adding that the flammability index is determined when testing according to the (AS 1530.2). • Sheet roofs. See BAL 12.5. • Roof penetrations. See BAL 12.5. BAL 29. • Tiled roofs. See BAL 19, except for the fourth point of BAL 12.5, which is converted into: extend sarking into gutters and valleys; • Sheet roofs. See BAL 12.5. • Roof penetrations. See BAL 12.5. In addition, pipes or conduits penetrating the roof covering, should be noncombustible. BAL 40. See BAL 29, except for roof penetrations, which have some different requirements (e.g. evaporative coolers are excluded). BAL FZ. Tiled and sheet roofs not mentioned. Roof penetrations should be sealed with mineral fiber at the roof, to avoid gaps. If the gap between covering and penetration is > 0.003 m, the sealing material should be noncombustible. Pipes or conduits penetrating the roof covering should be of metal, excluding aluminium. Roof lights and ventilators should comply with the (AS 1530.8.2) (tested from the outside) or be a system with FRL 30/30/30 OR -/30/30 (tested from the outside). ***2. Valley flashings*** BAL 12.5. Valley leaf guards should be noncombustible. Box gutters should be flashed at roof junction with noncombustible material. BAL 19. See BAL 12.5. BAL 29. See BAL 12.5. BAL 40. See BAL 12.5. BAL FZ. See BAL 12.5. ***3. Eaves*** BAL 12.5. • Gables should comply with requirements stated for the external walls; • Eaves penetrations should be protected as roof penetrations (C.2.1); • Eaves ventilation openings (> 0.003 m) should be filled as roof ventilation openings;

	• Joints in eaves, fascias, gables should be sealed with plastic strips or timber storm moulds. BAL 19. See BAL 12.5. BAL 29. In addition to requirements stated in BAL 12.5: • Fascias and bargeboards should be made of bushfire-resisting timber (if timber is used), or be appropriately fixed (if metal is used); • Eaves linings should be fibre-cement sheets (≥ 0.005 m thick); or bushfire-resisting timber; or a combination of the previous elements. BAL 40. In addition to requirements stated in BAL 12.5: • Fascias and bargeboards should comply with the (AS 1530.8.1): • Eaves linings should be fibre-cement sheets (≥ 0.006 m thick); or calcium-silicate sheet (≥ 0.006 m thick); or a combination of the previous elements. BAL FZ. In addition to requirements stated in BAL 12.5: • Fascias and bargeboards should comply with the (AS 1530.8.2): • Eaves linings should be a system: FRL of -/30/30; or complying with the (AS 1530.8.2); or a combination of the previous elements. ***4. Gutters*** BAL 12.5. Gutters should be noncombustible. BAL 19. See BAL 12.5. BAL 29. In addition to requirements stated in BAL 12.5, gutters should be metal or PVC-U (except for box gutters). BAL 40. See BAL 12.5. BAL FZ. See BAL 12.5.
C.3 Walls and other external coverings	***1. Exterior walls*** BAL 12.5. The part of the external wall which is located either ≥ 0.4 m from the ground and ≤ 0.4 m above decks, carport roofs, awnings or similar elements with ≤ 18° to the horizontal and extending more than 0.110 m in width from the wall should be made of one of the following: • Non-combustible material; • Fibre-cement external cladding (≥ 6 inches, 0.152 m thick); • Bushfire-resisting timber; • Timber species having a density of 750 kg/m3 or greater at a 12 % moisture content (Appendix E of the standard). Joints in the external surface should be treated in order to avoid gaps ≥ 0.003 m. Otherwise, sarking-type material can be applied on the outer face before fixing the cladding. BAL 19. See BAL 12.5.

	BAL 29. Walls should be made of one of the following material: • Non-combustible material; • Timber or steel-framed walls sarked on the outside with fibre-cement external cladding (≥ 6 inches, approx. 0.15 m thick), or steel sheet, or bushfire-resisting timber, or a combination of the previous elements: • A combination of the previous elements. For joints, see BAL 12.5. BAL 40. Walls should be made of one of the following material: • Non-combustible material; • Timber or steel-framed walls sarked on the outside with fibre-cement external cladding (≥ 9 inches, 0.23 m thick), or steel sheet, or a combination of the previous elements: • A system complying with the (AS 1530.8.1); • A combination of the previous elements. For joints, see BAL 12.5. BAL FZ. Walls should be made of one of the following material: • Non-combustible material (≥ 0.1 m in thickness); • A system complying with the (AS 1530.8.2); • A system having a FRL of 30/30/30 or -/30/30 if tested from the outside; • A combination of the previous elements. For joints, see BAL 12.5. ***2. Wall coverings*** Sarking on the outside of the wall, as described in the previous point.
C.4 Windows, external doors and vents	***1. Exterior glazing*** BAL 12.5. Windows should comply with one of the following requirements: - Being completely protected by a prescribed bushfire shutter; - Being completely protected externally by screens having a corrosion-resistant metal (steel, bronze, aluminium) mesh with apertures ≤ 0.002 m; - *Window assemblies*: made of bushfire-resisting timber, or timber species having a density of 650 kg/m3 or greater at a 12 % moisture content (Appendix E of the standard), or metal, or metal-reinforced (with aluminium, stainless or corrosion-resistant steel) PVC-U (for window assemblies located either < 0.4 m from the ground and < 0.4 m above decks, carport roofs, awnings or similar elements with < 18° to the horizontal and extending > 0.110 m in width from the wall). *Window sash*: metal hardware supporting the sash in opening/closing functions. *Glazing*: Grade A safety glass glazing (≥ 0.004 m thick) or glass block (for window assemblies located either < 0.4 m from the ground and < 0.4 m above decks, carport roofs, awnings or similar elements with < 18° to the horizontal and extending > 0.1 m in width from the wall). *Annealed glass* (for glazing located in other positions).

	Openings: screened with a corrosion-resistant metal (steel, bronze or aluminium) mesh (≤ 0.002 m apertures). BAL 19. See BAL 12.5, except for the sub-categories Glazing, Annealed glass and Openings belonging to the third bullet point, replaced by the following: - *Glazing*: toughened glass, ≥ 0.005 m thick, or glass blocks with no restrictions on methods for glazing (for window assemblies located either < 0.4 m from the ground and < 0.4 m above decks, carport roofs, awnings or similar elements with < 18° to the horizontal and extending > 0.1 m in width from the wall). *Annealed glass:* when annealed glass is used (for glazing in other locations than as the previous point), fixed/openable parts of windows should be externally provided with a corrosion-resistant metal (steel, bronze or aluminium) mesh (apertures ≤ 0.002 m). *Toughened glass:* when it is used, openable parts of windows should be internally or externally provided with a mesh as for the annealed glass. *Glazed elements designed for having internal screens*: should be made of toughened glass, with openable portion screened in order to have gaps ≤ 0.003 m. Screens should be as previously defined for annealed glass. BAL 29. Windows should comply with one of the following requirements: - Being completely protected by a prescribed bushfire shutter; - *Window assemblies*: made of bushfire-resisting timber, or metal, or metal-reinforced (with aluminium, stainless or corrosion-resistant steel) PVC-U. *Window sash*: metal hardware supporting the sash in opening/closing functions. *Glazing*: toughened glass (≥ 0.005 m). *Screens:* Corrosion-resistant metal (steel, bronze or aluminium) mesh/perforated sheet with apertures ≤ 0.002 m (for window assemblies located either < 0.4 m from the ground and < 0.4 m above decks, carport roofs, awnings or similar elements with < 18° to the horizontal and extending > 0.110 m in width from the wall). *Openings*: screened with a corrosion-resistant metal (steel, bronze or aluminium) mesh (≤ 0.002 m apertures). BAL 40. Windows should comply with one of the following requirements: - Being completely protected by a prescribed bushfire shutter; - *Window frames/hardware*: made of metal. *Glazing*: toughened glass (≥ 0.005 m). *Openable/Fixed window parts:* screened with a mesh having the same requirements as the second bullet point of BAL 12.5 excluding aluminium. *Seals*: made of materials having flammability index ≤ 5. BAL FZ. Windows should comply with one of the following requirements: - Being completely protected by a prescribed bushfire shutter; - *Openable/Fixed window parts:* screened with a mesh having the same requirements as the second bullet point of BAL 12.5 excluding aluminium. *Window System:* should have a FRL ≥ -/30/- or comply with the (AS 1530.8.2) (tested from outside). ***2. External doors*** Bushfire shutters should be/have:

	• Fixed to the building and non-removable; • No gaps > 0.003 m between shutter and wall, sill or head; • Manually openable from inside/outside; • Made in order to protect the entire door/window assembly; • Made of materials specific for the relevant BAL; • If perforated (for an area ≤ 20 % of the shutter), uniformly distributed perforations with apertures ≤ 0.003 m when the shutter provides radiant heat protection or 0.002 m when the shutter provide also ember protection. BAL 12.5. • External doors should comply with one of the following requirements: - Being protected by a prescribed bushfire shutter; - Being completely protected externally by screens having a corrosion-resistant metal (steel, bronze, aluminium) mesh with apertures ≤ 0.002 m; - *Doors*: non-combustible; or made of solid timber (≥ 0.035 m thick, for the first 0.4 m above the threshold); or including a hollow core door with a non-combustible kickplate for the first 0.4 m above the threshold); or a fully framed glazed door with framing similar to what required for bushfire shutters or timber species (density of 650 kg/m^3 or greater at a 12 % moisture content). *Glazing*: the same requirements as for windows of the same class. *Fitting*: doors tight-fitting to doorframe and abutting door (if applicable). *Door assemblies*: made of bushfire-resisting timber, timber species having a density of 650 kg/m^3 or greater at a 12 % moisture content, metal, metal (aluminium or stainless/corrosion-resistant steel) reinforced PVC-U (for doors located either < 0.4 m from the ground and < 0.4 m above decks, carport roofs, awnings or similar elements with < 18° to the horizontal and extending > 0.1 m in width from the wall). *Base of doors*: provided with weather strips, draught excluders/seals. • Sliding doors should comply with one of the following requirements: - Being protected by a prescribed bushfire shutter; - Being completely protected externally by screens having a corrosion-resistant metal (steel, bronze, aluminium) mesh with apertures ≤ 0.002 m; - *Glazing*: Grade A Safety Glass (complying with the (AS 1288)). *Screens of the openable part of sliding doors*: if a screen exists, it should be a mesh or corrosion-resistant metal (steel, bronze or aluminium) perforated sheet. *Fitting*: tight-fitting of doors in the frames. • Garage doors (for vehicles) should comply with all the following requirements: - The lower portion of the door (≤ 0.400 m from the ground when closed) should be made of non-combustible material, or bushfire-resisting timber or fibre-cement sheet (≥ 0.006 m thick); or timber species (density of 650 kg/m^3 or greater at a 12 % moisture content, Appendix E of the standard); or a combination of the previous elements;

- Panel lift, tilt/side-hung doors should be fitted with weather strips, draught excluders/seals or guide tracks with maximum gap ≤ 0.003 m;
- Roller doors having guide tracks with maximum gap ≤ 0.003 m and fitted with a nylon brush in contact with the door;
- They should not include ventilation slots.

- Bushfire shutters: They should comply with general requirements reported on top of this section. They should be made of noncombustible materials, or timber species (density of 750 kg/m^3 or greater at a 12 % moisture content), or bushfire-resisting timber, or a combination of the previous elements.

BAL 19.

- External doors. See BAL 12.5, except for the following sub-categories of the third bullet point. In the prescriptions about *Doors*, the framing of fully framed glazed doors does not include timber species. Prescriptions in *Glazing* are converted into the following: Glazing should be toughened glass (≥ 0.005 m).
- Sliding doors. See BAL 12.5, except for the following sub-categories of the third bullet point. Prescriptions about *Glazing* and *Screens of the openable part of sliding doors* are converted into: glazed assembly should be toughened glass (≥ 0.006 m) except if both fixed and openable parts of the doors are screened by a mesh or perforated sheet complying with the requirements in the second bullet point of BAL 12.5. The words *door assemblies* are converted into doorframes, still having the same requirements. The following requirements are further added to the third bullet point (BAL 12.5): *Doorframes* should be of bushfire-resisting timber or aluminium or steel, *panel hardware* supporting the opening/closing functions should be made of metal.
- Garage doors. See BAL 12.5, except for the first bullet-point. The requirements stated in the first bullet point of BAL 12.5 are valid for all the door, and not only for the lower portion of the door, and timber species are not allowed.
- Bushfire shutters: See BAL 12.5.

BAL 29.

- External doors should comply with one of the following requirements:
  - Being protected by a prescribed bushfire shutter;
  - Being completely protected externally by screens having a corrosion-resistant metal (steel, bronze, aluminium) mesh with apertures ≤ 0.002 m;
  - *Doors*: non-combustible; or made of solid timber (≥ 0.035 m thick, for the first 0.400 m above the threshold); or including a hollow core door protected on the outside by a screen door or a mesh/perforated sheet complying with the requirements in the second bullet point of BAL 12.5; or a fully framed glazed door with framing made of noncombustible materials or bushfire-resisting timber. *Glazing*: toughened glass (≥ 0.005 m). *Screens*: Corrosion-resistant metal (steel, bronze) mesh/perforated sheet with apertures ≤ 0.002 m (for glazing less than 0.400 m from the

	ground or < 0.400 m above decks, carport roofs, awnings, and similar elements, having an angle < 18° to the horizontal and extending more than 0.110 m in width from the door). *Panel support*: hardware support for opening/closing functions should be made of metal. *Fitting*: doors tight-fitting to doorframe and abutting door (if applicable). *Doorframes*: made of bushfire-resisting timber, metal, metal (aluminium or stainless/corrosion-resistant steel) reinforced PVC-U. *Base of doors*: provided with weather strips, draught excluders/seals. • Sliding doors should comply with one of the following requirements: - Being protected by a prescribed bushfire shutter; - Being completely protected externally by screens having a corrosion-resistant metal (steel, bronze, aluminium) mesh with apertures ≤ 0.002 m; - *Glazing*: toughened glass (≥ 0.006 m) except where both fixed and openable parts of doors are screened by a corrosion-resistant metal (steel, bronze, aluminium) mesh/perforated sheet with apertures ≤ 0.002 m. *Panel support*: hardware support for opening/closing functions should be made of metal. *Doorframes*: made of bushfire-resisting timber, or aluminium, or steel. *Fitting*: tight-fitting of doors in the frames. • Garage doors (for vehicles). See BAL 19. • Bushfire shutters: See BAL 12.5, excluding timber species. BAL 40. • External doors should comply with one of the following requirements: - Being protected by a prescribed bushfire shutter; - *Doors*: non-combustible; or made of solid timber (≥ 0.035 m thick, for the first 0.400 m above the threshold) and protected outside by metal-framed screen door with a corrosion-resistant metal (steel, bronze) mesh/perforated sheet with apertures ≤ 0.002 m; or a fully framed glazed door with noncombustible framing. *Panel support*: hardware support for the opening/closing functions should have a FRL ≥ -/30/-. *Screens*: Corrosion-resistant metal (steel, bronze) mesh/perforated sheet with apertures ≤ 0.002 m (for glazing less than 0.400 m from the ground or < 0.400 m above decks, carport roofs, awnings, and similar elements, having an angle < 18° to the horizontal and extending more than 0.110 m in width from the door). *Glazing*: toughened glass (≥ 0.006 m). *Fitting*: doors tight-fitting to doorframe and abutting door (if applicable). *Door frames*: made of metal. *Seals:* made of silicone. *Base of doors*: provided with weather strips, draught excluders/seals. • Sliding doors should comply with one of the following requirements: - Being protected by a prescribed bushfire shutter; - *Glazing*: FRL ≥ -/30/- except where both fixed and openable parts of doors are screened by a corrosion-resistant metal (steel, bronze) mesh/perforated sheet with apertures ≤ 0.002 m. *Panel support*: hardware support for opening/closing functions should be made of metal. *Doorframes*: made of metal. *Seals:* made of silicone. *Fitting*: tight-fitting of doors in the frames.

	• Garage doors. See BAL 12.5, except for the first bullet point, which is converted into: vehicle access doors should be non-combustible. • Bushfire shutters: They should comply with general requirements reported on top of this section. They should be made of noncombustible materials. BAL FZ. • External doors should comply with one of the following requirements: - Being protected by a prescribed bushfire shutter; - *Door systems*: FRL ≥ -/30/- or should comply with the (AS 1530.8.2) (tested from the outside). *Fitting*: doors tight-fitting to doorframe and abutting door (if applicable). *Seals:* should not affect the FRL or the performance by the (AS 1530.4). *Base of doors*: provided with weather strips, draught excluders/seals. • Sliding doors should comply with one of the following requirements: - Being protected by a prescribed bushfire shutter; - *Door systems*: FRL ≥ -/30/- or should comply with the (AS 1530.8.2) (tested from the outside). *Fitting*: tight-fitting of doors in the frames. • Garage doors. See BAL 12.5, except for the first bullet point, which is converted into: vehicle access doors should be non-combustible. A point is added, concerning the situation in which the garage is attached to the structure (see requirements for garages in C.5.1). • Bushfire shutters: They should comply with general requirements reported on top of this section, (except that perforations cannot be made on the door system) and with the (AS 1530.8.2). ***3. Vents and other openings*** BAL 12.5. Vents (and weepholes) in the external walls should be screened with a coorosion-resistant metal (steel, bronze, aluminium) mesh having apertures < 0.002 m, except if those vents are > 0.003 m or they are located in external walls or subfloors. BAL 19. See BAL 12.5. BAL 29. See BAL 12.5. BAL 40. See BAL 12.5. BAL FZ. See BAL 12.5.
C.5 Decks and detachments	***1. Decks and other attachments*** Veranda, carports, awning roofs, separated from the main roof by an external wall (as defined in C.3.1), should have noncombustible covering (and the support structure should be made of noncombustible material, or bushfire-resisting timber, or timber rafters lined on the underside with fibre-cement sheeting (≥ 0.006 m thick) or complying with the (AS 1530.8.1), or a combination of the previous elements for BAL class ≥ 29).

	The requirements for support structures include the other option: system complying with the AS 1530.81 for BAL 40; while the AS 1530.8.2 replaces the AS 1530.8.1 for BAL FZ. Attached structures (garage, carport, veranda or similar roofed structures) to buildings or sharing a common roof space, should comply with the building standards related to the specific risk class. Otherwise, they should be divided from the building by a wall, extending to the underside of a noncombustible roof covering, complying with one of the following requirements: • FRL ≥ 60/60/60 for loadbearing walls and -/60/60 for non-loadbearing walls (tested from the structure side), with doorways protected by FRL -/60/30 self-closing fire doors, windows protected by FRL -/60/- fixed and closed fire windows, other openings with FRL ≥ -/60/-. • Being masonry, earth walls or masonry-veneer construction with masonry leaf ≥ 0.090 m thick; doorways protected by FRL -/60/30 self-closing fire doors, windows protected by FRL -/60/- fixed and closed fire windows, other openings with FRL ≥ -/60/-. The same requirements are valid for garages and carports below the building, even if in this case, walls and flooring systems are considered for separating garage/carports from buildings. All the above described requirements should be valid for walls and flooring systems between garage/carports and the building. BAL 12.5. *Decking* < 0.300 m (on a horizontal line) from glazed elements, < 0.400 m (on a vertical line) from the deck surface should be made of one of the following material: • Noncombustible material; • Bushfire-resisting timber; • Timber species (density of 750 kg/m^3 or greater at a 12 % moisture content); • PVC-U (only for enclosed subfloor spaces); • A combination of the previous elements. This is valid for both *enclosed and unenclosed subfloor spaces of verandas, decks, steps, ramps and landings*. BAL 19. See BAL 12.5 (excluding PVC-U). BAL 29. *Subfloor spaces of verandas, decks, steps, ramps and landings* are considered as enclosed if they are made of one of the following: • Noncombustible material; • Bushfire-resisting timber; • Corrosion-resistant metal (steel, bronze or aluminium) mesh/perforated sheet; • A combination of the previous elements. And their openings are screened with a mesh/perforated sheet as described above.

	Decking of enclosed and unenclosed subfloor spaces; *support, framing, balustrades, handrails and other barriers of unenclosed subfloor spaces* should be made of one of the following: • Noncombustible material; • Bushfire-resisting timber; • A combination of the previous elements. The subfloor spaces are related to verandas, decks, steps, ramps and landings. Support includes support posts, columns, stumps, stringers, piers and poles. Requirements for balustrades and handrails are applicable only if they are < 0.125 m from glazing or combustible walls. BAL 40. *Subfloor spaces of verandas, decks, steps, ramps and landings* are considered as enclosed if they are: • Made of the same materials accepted for external walls of the same class; • Screened with corrosion-resistant metal (steel, bronze) mesh/perforated sheet (referred to openings). *Decking of enclosed and unenclosed subfloor spaces*; *support, framing,* should be made of one of the following: • Noncombustible material; • A system complying with the (AS 1530.8.1); • A combination of the previous elements. The subfloor spaces are related to verandas, decks, steps, ramps and landings. Support includes support posts, columns, stumps, stringers, piers and poles. *Balustrades, handrails and other barriers* which are < 0.125 m from glazing or combustible walls should be made of noncombustible material. BAL FZ. *Subfloor spaces of verandas, decks, steps, ramps and landings* are considered as enclosed if they are: • Made of the same materials accepted for external walls of the same class; • Screened with corrosion-resistant metal (steel, bronze) mesh/perforated sheet (referred to openings). *Decking of enclosed and unenclosed subfloor spaces*; *support, framing,* should be made of one of the following: • Noncombustible material; • Fibre-cement sheet (only for decking); • A system complying with the (AS 1530.8.2); • A combination of the previous elements; And they should have no gaps (only for decking). The subfloor spaces are related to verandas, decks, steps, ramps and landings. Support includes support posts, columns, stumps, stringers, piers and poles. *Balustrades, handrails and other barriers* which are < 0.125 m from glazing or combustible walls should be made of noncombustible material. ***2. Detached structures*** Detached structure (garage, carport, similar roofed structures) should comply with the requirements for buildings set in the standard.

	Otherwise, the detached structure should comply with one of the following: • Having a distance ≥ 6 m from the building; • Should be separated by the main building by a wall having the same requirements stated for the attached structures.
C.6 Floors	***1. Floor*** BAL 12.5. No requirements for concrete slabs on the ground and elevated floors. BAL 19. No requirements for concrete slabs on the ground and elevated floors. BAL 29. No requirements for concrete slabs on the ground. No requirements are provided for elevated floors, if the subfloor space is enclosed with the same materials required for subfloors (BAL 29). If subfloor space is unenclosed, flooring material (including layers less than 0.4 m above finished ground level, since for greater thickness the elevated floors do not need regulations), should be one of the following: • Non-combustible; • Bushfire-resisting timber; • Particleboard or plywood flooring (underside lined with sarking-type material or mineral wood isolation); • A system complying with the (AS 1530.8.1); • A combination of the previous items. BAL 40. No requirements for concrete slabs on the ground. No requirements for elevated floors, if the subfloor space is enclosed with a wall complying with requirements for external walls. If the subfloor is not enclosed, the flooring materials should be made of one of the following: • Non-combustible material; • Have the underside of combustible elements protected with non-combustible material; • Compliance with the (AS 1530.8.1); • a combination of the previous elements. BAL FZ. No requirements for concrete slabs on the ground. No requirements for elevated floors, if the subfloor space is enclosed with a wall complying with requirements for external walls. If the subfloor is not enclosed, the flooring materials should have one of the following requirements: • FRL ≥ 30/30/30 and the surface material should be non-combustible; • Have the underside of combustible elements protected with a system having a 30 minutes resistance to incipient fire spread; Compliance with the (AS 1530.8.2) when tested from the underside.

	2. Underfloor BAL 12.5. No requirements for subfloor support posts, columns, stumps, piers and poles. BAL 19. No requirements for subfloor support posts, columns, stumps, piers and poles. BAL 29. No requirements for subfloor supports if subfloor space is enclosed with: • a wall complying with requirements for external walls; • a mesh with maximum aperture of 0.002 m, made of corrosion-resistant metal (steel, bronze or aluminium); • a combination of the previous elements. If the subfloor is not enclosed, the support posts, columns, stumps, piers and poles should be made of one of the following: • noncombustible material; • bushfire-resisting timber; • a combination of the previous elements. BAL 40. No requirements for subfloor supports if subfloor space is enclosed with a wall complying with requirements for external walls. If the subfloor is not enclosed, the support posts, columns, stumps, piers and poles should be made of one of the following: • noncombustible material; • a system complying with the (AS 1530.8.1); • a combination of the previous elements. BAL FZ. No requirements for subfloor supports if subfloor space is enclosed with a wall complying with requirements for external walls. If the subfloor is not enclosed, systems including the support posts, columns, stumps, piers and poles should have one of the following requirements: • Fire Resistance Level (FRL) ≥ 30/-/-, and being non-combustible; • Compliance with the (AS 1530.8.2); • a combination of the previous elements.
D. Resources	
D.1 Utilities	Water and gas supply pipes should be made of metal. ***1. Water supply*** Supply level. According to local guidelines (Guidelines for Development in Bushfire Prone Areas of Tasmania, Bushfire Planning Group, 2005), water supply in reticulated areas should have a flow rate ≥ 600 l/minute, unless otherwise stated. If areas are not reticulated, ≥ 10,000 liters of stored water for properties < 2,500 square meters; and ≥ 20,000 liters of stored water for properties ≥ 2,500 square meters, unless otherwise stated. Inaccessible storage

	should have an accessible delivery point ≥ 270 liters/minute, through specific thread consistent with the Tasmania Fire Service specifications. Water source. According to local guidelines (Guidelines for Development in Bushfire Prone Areas of Tasmania, Bushfire Planning Group, 2005), in areas not serviced by reticular water mains, or where flow rate is insufficient, a static water supply that is always accessible water supply should be provided (dams, tanks, swimming pools). Supply in non-reticulated areas may be from a single or more sources and for individual/more properties. Access. According to local guidelines (Guidelines for Development in Bushfire Prone Areas of Tasmania, Bushfire Planning Group, 2005), a fire truck should be within 3 meters from a water supply, in order to pump it. The storage should be ≤ 5 meters from the buildings. Above ground storage should be accessible and have a specific thread consistent with the Tasmania Fire Service specifications on the storage tank, or have an opening of 0.250 m of diameter on the top. Standby power. Not specifically addressed here. Fire hydrants. According to local guidelines (Guidelines for Development in Bushfire Prone Areas of Tasmania, Bushfire Planning Group, 2005), fire hydrants in areas serviced by reticular water mains are sufficient, if they are > 120 m from all building envelopes. Dry hydrants. Not specifically addressed here. ***2. Other utilities*** Not specifically addressed here.
D.2 Firefighters	Not specifically addressed here.
D.3 Planning	***1. Fire protection plan*** According to local guidelines (Guidelines for Development in Bushfire Prone Areas of Tasmania, Bushfire Planning Group, 2005), Bushfire Hazard Management Plans can be developed, also as part of development plans. They can include the layout of the development and location of protective features (minimum requirements: fuel management areas and maintenance, access, water supply, vegetation plan). ***2. Other plans required/suggested*** According to local guidelines (Guidelines for Development in Bushfire Prone Areas of Tasmania, Bushfire Planning Group, 2005), local area planning can integrate the function of bushfire hazard management plans at a local scale.
D.4 Outreach	A mix of standards and local guidelines for the different Australian States (with also indications to the general public) were reviewed.

E. Fire Protection Measures	
E.1 Measures for water sources	According to local guidelines (Guidelines for Development in Bushfire Prone Areas of Tasmania, Bushfire Planning Group, 2005), storage tanks should be made of noncombustible and non-rust materials, or otherwise protected in the lowest 0.400 m from the ground.
E.2 Measures for buildings	***1. Sprinklers*** Not specifically addressed here. ***2. Manual protection systems*** Not specifically addressed here. ***3. Warning systems*** Not specifically addressed here. ***4. Spark arresters*** Not specifically addressed here. ***5. Combustible materials*** Not specifically addressed here. ***6. Private shelters*** South Australia regulations (South Australia Development Regulations, 2008 (Version 19.9.2017)) include the possibility of constructing private bushfire shelters in the following locations: • In front of the building line; • Within 0.9 m of a boundary of the land with a secondary street (if the land has boundaries on ≥ 2 roads); • Within 6 m of the intersection of 2 land boundaries facing a road (keeping unbuilt the 4x4 metre corner between the two boundaries).
F. Environment	
F.1 Weather	Environmental factors considered in the calculation of the index used to define the risk areas.
F.2 Fire history	Not specifically addressed here.
G. Access	
G.1 Roads	***1. Type/Number of access roads*** Main roads, access roads and fire trails, where needed. ***2. Road standards***

	Main roads. Standards for roads are provided in local guidelines (Guidelines for Development in Bushfire Prone Areas of Tasmania, Bushfire Planning Group, 2005). They are reported as follows: • Pavement: all-weather type; • Design speed: ≥ 15 kmph; • Load: ≥ 20 tonnes (bridges conforming to specific regulations); • Width: dual lane ≥ 6 m, single lane ≥ 4 m for 90 m length without turning/passing; • Curves: ≥ 10 m of inner radius; • Dips: ≤ 15 ° (27 %) entry/exit angle; • Turning area: circular, with trafficable radius ≥ 10 m; or hammerhead turnaround (T or Y) with ≥ 4 m width and ≥ 8 m length; • Passing bays: 2 m wide, 20 m long. Driveways/Dead-ends. According to local guidelines (Guidelines for Development in Bushfire Prone Areas of Tasmania, Bushfire Planning Group, 2005), access roads should have width ≥ 6 m, including passing bays. If the access width is < 6 m, passing bays having a length ≥ 20 m, every 90 m along the access should be provided. Driveways not used by fire fighting vehicles do not need to comply with standards for access/main roads. Access is provided to within 30 m of the building. At the end of non-through accesses, turning areas should be provided. Fire lanes. According to local guidelines (Guidelines for Development in Bushfire Prone Areas of Tasmania, Bushfire Planning Group, 2005), specific fire trails could be designed in order to have access to strategic locations near bushlands, where perimeter roads are not available. They should have: • Safe use for 4WD fire trucks; • Connection to road networks without dead-ends; • Passing and turning points at strategic places; • Carriageway ≥ 4 m wide. Parking. According to local guidelines (Guidelines for Development in Bushfire Prone Areas of Tasmania, Bushfire Planning Group, 2005), suitable and sufficient parking places should be provided, in order to discourage people from parking vehicles on passing bays, roads or fire trails. ***3. Markings*** Not specifically addressed here. ***4. Vegetation clearing*** According to local guidelines (Guidelines for Development in Bushfire Prone Areas of Tasmania, Bushfire Planning Group, 2005), the clearance ≥ 2 m on each side of the carriageway, for a height of 4 m should be provided.

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AS 1530.4, 2005. Methods for Fire Tests on Building Materials, Components and Structures - Fire-resistance tests for elements of construction*

AS 1530.8.1, 2007. Methods for Fire Tests on Building Materials, Components and Structures - Tests on Elements of Construction for Buildings Exposed to Simulated Bushfire Attack - Radiant Heat and Small Flaming Sources*

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*AS = Australian Standard

**AS/NZS = Australian/New Zealand Standard

A.5 New Zealand: Standards/Guidelines

The main New Zealand Codes which provides some regulations for protecting buildings and surrounding areas from wildfires are: the Fire Emergency New Zealand Act (2017), and the New Zealand Building Code (1992, with some subsequent amendments). These codes were reviewed, together with the guidelines provided by the Fire and Emergency New Zealand (FENZ) about fire safety in rural homes.

The problem of fires in WUI areas is not explicitly treated. However, provisions and guidelines which may be applicable to WUI fire prevention and protection measures were collected in the following table. These concern: hazard definition and definitions of building risk levels, defensible space and its maintenance (mainly qualitative guidelines), general provisions about building construction (and some specific requirements about exterior walls, floors and other interior structures), some guidelines about resources (water supply and evacuation routes), evacuation plans, fire protection measures for buildings and general provisions about access. Other factors, such as topography/terrain, other specific building requirements, and environmental, are not explicitly considered in the sources reviewed.

The information reported in the following table are referred to the Fire and Emergency New Zealand Act 2017 (indicated with [1]), and to the New Zealand Building Code (extract related to fire protection measures) (indicated with [2]), unless otherwise stated.

Table A.5 New Zealand – Guide/Code: Fire and Emergency NZ Act 2017 [1], NZ Building Code [2]	
Category	**Provision**
A. Hazard	
A.1 Definitions	***1. Destination*** Not specifically addressed here. ***2. Severity class*** [2] Five building types (Building Importance Levels, BIL) are indicated with respect to fires, and the related risk for their occupants. They are listed as follows: • BIL 1. Buildings providing low risk for human life and environment or low cost in case of building failure, typically non (or rarely) habitable buildings (ancillary buildings not for human habitation, minor storage facilities, detached huts). • BIL 2. Buildings providing normal risk for human life and environment or normal in case of building failure (residential, commercial, industrial buildings). • BIL 3. Buildings with higher level of importance or risks to occupants (buildings where > 300 people can meet, schools with capacity > 250, other education facilities with capacity > 500, health care facilities with capacity ≥ 50, jails, other buildings with capacity ≥ 5,000, buildings for specific facilities, buildings containing gas or explosive

	materials causing hazardous conditions not extending beyond properties). • BIL 4. Buildings that are important for post-disaster recovery or at-risk facilities (hospitals or similar, shelters, emergency garages, buildings intended to contribute to emergency preparedness, emergency backup facilities for BIL 3 structures, buildings containing gas or explosive materials causing hazardous conditions extending beyond properties, traffic control centers, buildings with national defense functions, water treatment facilities for emergency, ancillary buildings of buildings BIL 4). • BIL 5. Buildings providing extreme risk to large area (e.g. 100 km^2) or large population (e.g. 100,000), (e.g. dams, extremely hazardous facilities).
B. Land	
B.1 Vegetation	***1. Defensible space*** [1] Firebreaks (and other designated places) should be cleared from vegetation and other dangerous objects/materials, if required by the authority. The owner/inhabitant should adopt these provisions, otherwise the authority can directly conduct the operation by itself in case of imminent danger. ***2. Clearance between/from vegetation*** Horizontal clearance. Not specifically addressed here. Vertical clearance. Trees and branches should be at least 3m distant from power lines (Fire and Emergency New Zealand, Rural Home Fire Safety Checklist). ***3. Maintenance*** Paddocks should be maintained, lawn should be mown and watered, hay should be dried before baling and stacking (Fire and Emergency New Zealand, Rural Home Fire Safety Checklist).
B.2 Topography/ Terrain	Not specifically addressed here.
C. Building Construction	
C.1 General requirements	[2] Buildings with building height > 10 m in which sleeping areas, or other properties (defined as any land or building not under the same allotment or ownership) are present in the upper floors, should be designed in order to impede external vertical fire spread to upper floors (except for BIL 1). The fire spread to other properties (as previously defined) vertically or horizontally across the building limit should be avoided. Fire should not spread > 3.5 m vertically from the fire source over the external cladding of multi-level buildings. The radiation at the boundary of the building should be ≤ 30 kW/m^2, ≤ 16 kW/m^2 at a distance of 1 m beyond the boundary. ***1. Classes of ignition resistance***

	Not specifically addressed here. ***2. Characteristics of ignition resistant materials*** [2] Surface temperature of combustible building materials close to fixed appliances using controlled combustion and other fixed equipment (which should ensure a low probability of hazardous and explosive conditions in the building) should be ≤ 90 °C. [2] The structural stability of the building during a incident must be guaranteed during and after the fire, by taking into account fire severity, automatic sprinkler systems, other active fire systems, failure of safety systems. ***3. Building separation*** Not specifically addressed here.
C.2 Roof	Not specifically addressed here.
C.3 Walls and other external coverings	***1. Exterior walls*** [2] External walls < 1 m from the lot limit must be made of one of the following materials: • Noncombustible material; • Material not igniting for 30 minutes, if subject to a radiant flux of 30 kW/m^2 (valid for BIL 3 and 4); • Material not igniting for 15 minutes, if subject to a radiant flux of 30 kW/m^2 (valid for BIL 1 and 2). ***2. Wall coverings*** Not specifically addressed here.
C.4 Windows, external doors and vents	Not specifically addressed here.
C.5 Decks and detachments	Not specifically addressed here.
C.6 Floors and interior structures	***1. Floor*** [2] Floor surface materials, in the following areas, should meet the indicated requirements concerning minimum critical radiant flux, if tested according with (ISO 9239-1: 2010): • Sleeping areas and exit ways in care/detention facilities, 4.5 kW/m^2 (building not protected with automated sprinkler system), 2.2 kW/m^2 (protected building); • Exit ways in all other buildings, 2.2 kW/m^2; • Firecells (defined below) for > 50 persons, 2.2 kW/m^2 (building not protected with automated sprinkler system), 1.2 kW/m^2 (protected building); • All other occupied spaces different than household units, 1.2 kW/m^2.

	2. Underfloor Not specifically addressed here. ***3. Other interior structures*** [2] Walls and ceiling materials in sleeping areas of care/detention facilities, in exit ways, in all occupied spaces in BIL 4, and the internal surfaces of ducts for HVAC systems should be made of the following materials defined in (ISO 9705: 1993): • Group Number 1-S for buildings not protected with automated sprinkler system; • Group Number 1 or 2 for building protected. Walls and ceiling materials in crowded and sleeping areas (except household units and care/detention facilities), should be made of the following materials defined in (ISO 9705: 1993): • Group Number 1-S or 2-S for buildings that are not protected with automated sprinkler system; • Group Number 1 or 2 for protected buildings (group 3 only for ceiling). Walls and ceiling materials in all other building locations, external surfaces of ducts for HVAC systems, acoustic treatment and pipe insulation in plenum spaces in sleeping areas, should be made of the following materials defined in (ISO 9705: 1993): • Group Number 1, 2 or 3. The above reported requirements do not apply to detached dwellings, household units in multi-unit dwellings, ancillary buildings. [2] Firecells (space inside a building, enclosed by a combination of fire separations, external walls, roofs and floors) < 15 m of the lot limit of a building that is not protected by automated sprinkler systems, and containing fire load > 20 TJ or with floor area > 5,000 m^2 must be constructed in order to allow a radiation flux ≤ 4.5 kW/m^2 a 1.5 above the floor, and a smoke layer ≥ 2 m above the floor, when the firefighter firstly conduct fire suppression with water.
D. Resources	
D.1 Utilities	***1. Water supply*** [1] A novel code for defining the requirements for water supply (code of practice) should be developed and take effect. It should be submitted to the Minister for approval, and published by the Fire and Emergency New Zealand (FENZ), in accordance with local authorities and advisory committees. When the code will be available, it must be reviewed every 3 years. Currently, the New Zealand Fire Service Firefighting Water Supplies Code of Practice is available (2008). Supply level. Not specifically addressed here. Water source. Not specifically addressed here.

	Access. [2] Water for firefighting purposes should be delivered and accessible in all parts of the building. Moreover, it should be clearly indicated (Fire and Emergency New Zealand, Rural Home Fire Safety Checklist). Standby power. Not specifically addressed here. Fire hydrants. Not specifically addressed here. Dry hydrants. Not specifically addressed here. ***2. Other utilities*** [2] Buildings should be provided with escape routes and means of escape able to ensure a safe evacuation for all occupants. The evacuation time should allow all occupants to avoid exposure to: • fractional effective dose of carbon monoxide and thermal effects > 0.3; • visibility < 10 m except in rooms < 100 m^2 wide (visibility < 5 m). Those requirements are not applied if it is not possible to expose a number of occupants > 1,000 in a firecell (as previously defined in C.6.3) protected with automated sprinkler systems.
D.2 Firefighters	[2] The design and construction of buildings should allow firefighters to reach the origin of the fire at the appropriate floor and protect the means of egress.
D.3 Planning	***1. Fire protection plan*** Not specifically addressed here. ***2. Other plans required/suggested*** Evacuation plans. The owner of a buildings that have: • Gathering spaces ≥ 100 persons; • Employment facilities for ≥ 10 persons; • Accommodation for ≥ 6 persons; • Hazardous materials exceeding the allowed level; • Detention/care facilities; must provide an evacuation scheme, indicating the procedures for a safe evacuation in a reasonable time span. This provision does not apply if the following conditions are present: • The building provides employment facilities for ≥ 10 persons or accommodation for ≥ 6 persons; • The building has an automatic sprinkler system; • The owner notifies FENZ that the building does not need an evacuation scheme.
D.4 Outreach	Not specifically addressed here.
E. Fire Protection Measures	
E.1 Measures for water sources	Not specifically addressed here.

E.2 Measures for buildings	***1. Sprinklers*** [2] The presence of automated sprinklers is considered for classify buildings and setting requirements (A.1.2). ***2. Manual protection systems*** Suitable and quickly accessible fire extinguishers are recommended in places (e.g. kitchen, garage, farm buildings, on machinery) where fires may break out (Fire and Emergency New Zealand, Rural Home Fire Safety Checklist). ***3. Warning systems*** [2] Buildings should be provided with "*effective means of giving warning of fire*". Smoke alarms in every bedroom, living area, hallway on each floor are recommended (Fire and Emergency New Zealand, Rural Home Fire Safety Checklist). ***4. Spark arresters*** Not specifically addressed here. ***5. Combustible materials*** [1] The lighting of fires and some other activities in open air may be prohibited or restricted in risky areas, including the access to those areas (except if a specific permit is provided). The following recommendations apply (Fire and Emergency New Zealand, Rural Home Fire Safety Checklist): • Petrol, diesel fuels are stored in single specifically dedicated locations; • Rubbish, firewood, oily leftover and similar materials are appropriately stored away from ignition sources; • Machinery are cleaned of combustible oil, dust, grass and similar materials; • Firewood should be not stacked near dwellings/farm buildings. ***6. Private shelters*** Not specifically addressed here.
F. Environment	
F.1 Weather	Not specifically addressed here.
F.2 Fire history	Not specifically addressed here.
G. Access	
G.1 Roads	[2] Hard-standing for fire service vehicles should be provided at within 20 m along an unobstructed path of the access into the building or of the inlets to automatic sprinkler systems or fire hydrants.

	The access for fire service vehicles should be provided to ≥ 1 side of firecells with floor area ≥ 5,000 m^2, not protected by automated sprinkler systems. Requirements for access and firefighters do not apply to detached huts and dwellings, household units in multi-unit dwellings, ancillary buildings. ***1. Type/Number of access roads*** Not specifically addressed here. ***2. Road standards*** Not specifically addressed here. ***3. Markings*** [2] Buildings must be provided with means giving clear information to firefighters about the location of the fire, the fire safety systems available and the presence of hazardous materials. Rural Address Property Identification (RAPID) should be visible to emergency vehicles (Fire and Emergency New Zealand, Rural Home Fire Safety Checklist). ***4. Vegetation clearing*** Not specifically addressed here.

REFERENCES

[1] Fire and Emergency New Zealand Act 2017

[2] New Zealand Building Code (Extract: Clauses C1-C6, A3, Department of Building and Housing), 2012.

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ISO 9239-1, 2010. Reaction to Fire Testing for Flooring - Part 1: Determination of the Burning Behaviour Using a Radiant Heat Source*

ISO 9705, 1993. Fire Tests - Full-scale Room Test for Surface Products*

SNZ PAS 4509, 2008. New Zealand Fire Service Firefighting Water Supplies Code of Practice**

*ISO = International Organization for Standardization

**SNZ PAS = New Zealand Standard, Publicly Available Specification

A.6 International Standard

The International Wildland-Urban-Interface Code (IWUIC 2015) is an International Code developed by the International Code Council. It is member of a series of International Codes (International Code Family), which include also the International Fire Code and the International Building Code.

The IWUIC is specifically devoted to define the fire safety provisions to be adopted in the WUI area. It includes provisions regarding all the inquired categories: hazard definition, land, building construction, resources, fire protection measures, environment, access. Provisions are missing only for the firefighter sub-category. The IWUIC makes often reference to other International Codes (such as the ones for buildings and fires) and Standards (mainly ASTM standards). Suggestions which are not intended to be adopted as provisions are attached at the end of the code. Some of these suggestions are referenced in the filled template, where appropriate.

The information in the following table refer to the IWUIC Code (2015 Version), unless otherwise stated.

Table A.6 International – Guide/Code: International Wildland-Urban-Interface Code	
Category	**Provision**
A. Hazard	
A.1 Definitions	***1. Destination*** The Wildland-Urban-Interface area is defined as the "*geographical area where structures and other human development meets or intermingles with wildland or vegetative fuels*". It should be defined locally by the appropriate authority, based on findings of fact, and mapped. Boundaries of the WUI area should correspond to natural or artificial features. The code official (the local interpreted and enforcer, or the representative of the IWUIC) should revise the WUI areas on a 3-year basis (or more frequently, if required). ***2. Severity class*** Inside the defined WUI area, three classes of fire hazard severity are defined (Moderate Hazard -M-, High Hazard, -H-, Extreme Hazard, -E-). They depend on a combination of the following features: • Fuel model (Light, Medium, Heavy) • Critical fire weather frequency (defined as: "*a set of weather conditions whose effects on fire behavior make control difficult and threaten fire fighter safety*", classified into: heavy, light and medium). • Terrain slope (divided into three classes: minor or equal than 40 %, between 41 and 60 %, greater or equal than 61 %). The fuel model represents the predominant type of vegetation in the area. The different fuels are classified as follows:

	• Light fuel includes vegetation made of herbaceous plants and round woods (< 0.25 inch, 6.4 mm in diameter). • Medium fuel includes round wood vegetation (included between 0.25 and 3 inches, 6.4 to 76 mm). • High fuel includes round wood vegetation having a large diameter (included between 3 and 8 inches, between 76 to 203 mm). There are specific models for different types of vegetations belonging to these three categories, provided in the Appendix D of the IWUIC. The critical fire weather conditions are those sets of the following variables (see Appendix E): temperature, relative humidity, precipitation, flooding condition, wind speed, duration of high speed wind, wind direction, fog and other atmospheric conditions, which are able to negatively affect the fire behavior. Those sets of conditions should be locally defined based on local data.
B. Land	
B.1 Vegetation	***1. Defensible space*** Persons leasing, controlling, operating or maintaining structures built by complying with the requirements about defensible space (see C.1) should comply with a fixed distance of "fuel modification" set to: • 30 feet (9.14 m) for the moderate hazard area, • 50 feet (15.24 m) for the high hazard area, • 100 feet (30.48 m) for the extreme hazard area. • Greater distances, based on site-specific analyses. This means that they should reduce/alter the non-fire resistive vegetation included in this distance in order to reduce fire load. In any case, the fuel modification distance should not be < 30 feet (9.14 m). It is set to the distance from the lot line, if distant < 30 feet. Distances are measured on a horizontal plan from the limit of the structure. ***2. Clearance between/from vegetation*** Horizontal clearance. Trees can be maintained in the defensible space, if the horizontal clearance between: • crowns of close trees, • crowns and structures, including chimneys, is ≥ 10 feet (3.05 m). Vertical clearance. Trees can be maintained in the defensible space, if the vertical clearance between crowns and power lines (or other fuels) is ≥ 10 feet (3.05 m). ***3. Maintenance*** Dead vegetation. Deadwoods and litters should be removed from trees, as well as dead vegetation from roofs.

<table>
<tr><td></td><td>Groundcover. Ground covered with ornamental or cultivated vegetal fuels are allowed in the defensible space, if they are not able to transmit fire to other structures.

Pruning. Limbs of trees placed < 6 feet (1.83 m) above the ground should be regularly pruned.</td></tr>
<tr><td>B.2 Topography / Terrain</td><td>Terrain slopes are considered in the definitions of the different hazard severity classes (A.1.2) and in the prescriptions for decks and detached structures (see C.5.1 and C.5.2).

The definition of the WUI areas themselves should take into account topographic considerations (as suggested in the Appendix E, giving only not mandatory suggestions). These include information about elevation, ridges, drainages, escarpments, grades, roads, bridges, railroads, exposure.
Other issues to be considered concern the relationships between man-made infrastructures and geographic factors including: fuel type distribution (see Appendix D of the IWUIC Code), earthquake risk zones, routes on which hazardous materials are carried, artificial boundaries, vulnerability of infrastructures.</td></tr>
<tr><td colspan="2">C. Building Construction</td></tr>
<tr><td>C.1 General requirements</td><td>Structures in the WUI areas should be constructed according to the IWUIC Code, except for accessory structures (not exceeding 120 square feet, 11 m^2) located ≥ 50 feet (15.24 m) from populated buildings and agricultural buildings located at a similar distance.

1. Classes of ignition resistance

Structures in the WUI areas should be built by considering the classes of ignition resistance reported in the following Table (Table 503.1 of the IWUIC Code), depending on the fire hazard severity and the compliance with the prescriptions about the defensible space and the water supply:

<table>
<tr><th rowspan="3">Defensible Space</th><th colspan="6">Fire hazard severity</th></tr>
<tr><th colspan="2">Moderate hazard</th><th colspan="2">High hazard</th><th colspan="2">Extreme hazard</th></tr>
<tr><th colspan="2">Water supply</th><th colspan="2">Water supply</th><th colspan="2">Water supply</th></tr>
<tr><th>Conforming</th><th>Non-conforming</th><th>Conforming</th><th>Non-conforming</th><th>Conforming</th><th>Non-conforming</th></tr>
<tr><td>Non-conforming</td><td>IR2</td><td>IR1</td><td>IR1</td><td>IR1/N.C.</td><td>IR1/N.C.</td><td>Not Permitted</td></tr>
<tr><td>Conforming</td><td>IR3</td><td>IR2</td><td>IR2</td><td>IR1</td><td>IR1</td><td>IR1/N.C.</td></tr>
<tr><td>1.5 x Conforming</td><td>Not Required</td><td>IR3</td><td>IR3</td><td>IR2</td><td>IR2</td><td>IR1</td></tr>
</table>

In the above reported table:
• IR 1 stands for ignition-resistance class 1;
• IR 2 stands for ignition-resistance class 2;
• IR 3 stands for ignition-resistance class 3.</td></tr>
</table>

	• N.C. means that exterior walls (including log walls) should have a fire-resistance rating < 1 hour and their external surfaces should be noncombustible. The specific characteristics of structural elements which are part of the structures in the WUI areas, and belonging to a class from IR 1 to IR 3, are listed in the sections from C.2 to C.5. ***2. Characteristics of ignition resistant materials*** Ignition resistant building materials used in the WUI areas should belong to one of the following three categories. Specifically tested materials. Materials tested on all sides (except from panel products, only on the front and back faces) according to the procedure defined in the (ASTM E84 (UL 723)) or the (ASTM E2768) Standards (excluding some specific products). They should also have: • A maximum flame spread index (comparative measure of the flame spread versus time) equal to 25 and a combustion not exceeding the extended 30-minute test; • A flame front not exceeding the 10.5 feet (3.20 m) beyond the burner centerline during the extended 30-minute test; • Performance requirements for weathering contained in the standards: (ASTM D2898) (for fire-retardant-treated wood, wood-plastic composite and plastic lumber materials), (ASTM D7032) (for wood-plastic composite materials), (ASTM D6662) (for plastic lumber materials); • The identification showing results of the fire test. Noncombustible materials. Materials which will not ignite and burn when exposed to fire (not valid for finish materials). They are defined in the (ASTM E136). Materials having a structural base of materials defined as noncombustible (with a covering material less thick than 0.125 inches, 0.0032 mm, and having a flame spread index of 50 or less) are considered as noncombustible materials as well. If a material could exceed those definitions of noncombustible materials, due to age, moisture or atmospheric conditions, then it should not be classified as noncombustible. Fire-retardant-treated wood. Fire-retardant-treated wood, as defined in the ((International Building Code, 2015), Section 2303.2). If this material is included in roof coverings, then it should be classified as class A roof assembly ((International Building Code, 2015), Section 1505.2), and it should comply with the (International Building Code, 2015) requirements (Section 1505.6). ***3. Building separation*** Not specifically addressed here.
C.2 Roof	***1. Covering***

	Existing structures. Roof coverings of existing structures in the WUI areas, replaced for a percentage greater or equal than 25 % in a 12-month period, should be replaced with the roof coverings described below for new constructions. Class IR 1. Roof assembly complying with class A rating (test provided by (ASTM E108 (UL 790)), except some specific cases). Space between roof covering and decking should be firestopped in order to avoid the entrance of flames and embers, or having a layer of 72-pound (32.4 kg) mineral-surfaced, nonperforated cap sheet (complying with (ASTM D3909)) over the combustible decking. Class IR 2. See Class 1, except for roof assembly complying with class B rating (test provided by (ASTM E108 (UL 790))) or an approved noncombustible roof covering. Class IR 3. See Class 1, except for roof assembly complying with class C rating (test provided by (ASTM E108 (UL 790))), or an approved noncombustible roof covering. ***2. Valley flashings*** Class IR 1/2/3. Valley flashings should be made of a corrosion-resistant metal sheet (No. 26 galvanized sheet gage) minimum 0.019 inch (0.48 mm) thick, over a 36 inches wide (0.914 m) 72-pound (32.4 kg) layer of mineral-surfaced nonperforated cap sheet (complying with (ASTM D3909)) for all the valley length. ***3. Eaves*** Class IR 1. The underside of eaves and soffits should be protected with one of the following: • ignition-resistant materials; • materials approved for ≥ 1-hour fire-resistance-rated construction (according to the test procedures in the (ASTM E119 (UL 263))), except those materials complying with the ((International Building Code, 2015), Section 721); • 2 inches (0.051 mm) nominal dimension lumber; • 1 inch (0.025 mm) nominal fire-retardant-treated lumber; • 0.75 inch (0.019 mm) nominal fire-retardant-treated plywood. The materials should be valid for exterior use and complying with the ((International Building Code, 2015), Section 2303.2). Fascias should be protected on the back part with one of the materials listed at the first three bullet points. Class IR 2. Combustible eaves, fascias and soffits should be enclosed by using solid materials minimum 0.75 inch (0.019 mm) thick. Rafter tails are not permitted if not constructed of heavy timber. Class IR 3. No prescriptions.

	4. Gutters Class IR 1/2/3. Gutters and downspouts should me made of noncombustible materials. The accumulation of leaves and debris should be avoided through approved means.
C.3 Walls and other external coverings	***1. Exterior walls*** Class IR 1/2. Exterior walls should be built (from the top of the foundation to the underside of the roof) according to one of the following methods: • Materials approved for maximum 1-hour fire-resistance-rated exteriors; • Approved noncombustible materials; • Heavy timber/log wall; • Fire-retardant-treated wood for external use ((International Building Code, 2015), Section 2303.2); • Ignition-resistant materials for external use. Class IR 3. No prescriptions. ***2. Wall coverings*** Not specifically addressed here.
C.4 Windows, external doors and vents	***1. Exterior glazing*** Class IR 1/2. All the exterior glazing (windows and doors) shall be made of tempered glass, multi-layer glazed panels, glass block or have a minimum fire protection rating of 20 minutes. Class IR 3. No prescriptions. ***2. External doors*** Class IR 1/2. External doors should be approved noncombustible construction made of solid core wood minimum 1.75 inches (0.045 mm) thick, or having a minimum fire protection rating of 20 minutes (excluding vehicle access doors). Class IR 3. No prescriptions. ***3. Vents and other openings*** Class IR 1/2. All vents (including ventilation openings) should not exceed 144 square inches (0.093 square meters). They should be covered with a noncombustible corrosion-resistant grid with openings not exceeding a 0.25 inch diameter (0.0064 mm), or approved for preventing flame or ember penetration. Some locations are discouraged for vents: attic ventilation openings in soffits, eave overhangs, between rafters at eaves, in other overhang areas; gable end and dormer vents < 10 feet (3.048 m) from lot lines; underfloor ventilation openings far from grade.

	Class IR 3. No prescriptions.
C.5 Decks and detachments	***1. Decks and other attachments*** Class IR 1/2. Decks (and other structures attached to buildings with habitable space) should be one of the following construction: • 1-hour fire-resistance-rated; • Heavy-timber; • Approved noncombustible materials; • Fire-retardant-treated wood (International Building Code, Section 2303.2); • Ignition-resistant building materials. If the projection of the deck is over a descending slope surface more than 10 percent, the underfloor area of the structure lying under the ground should be enclosed to within 6 inches (0.152 m), and having exterior walls designed according to C.3.1. Class IR 3. No prescriptions. ***2. Detached structures*** Class IR 1/2. Detached structures located 50 feet (15.24 m) from a populated building should have exterior walls built according to section C.3.1 (except from ignition-resistant materials which are not necessary). The underfloor areas of detached structures having their projection over a descending slope surface more than 10 percent, should meet the same requirements of the previous point, with exterior walls designed as in C.3.1, underfloor protection as in C.6.2. Class IR 3. No prescriptions.
C.6 Floor and interior structures	***1. Floor*** Not specifically addressed here. ***2. Underfloor*** Class IR 1/2. Underfloor enclosure (underfloor areas enclosed to the ground) should be provided with exterior walls built as described at point C.3.1 (complete enclosure is not required if the underside is protected according to the 1-hour fire-resistance rating, including heavy timber and fire-retardant-treated wood). Class IR 3. See Class IR 1/2, excluding prescriptions for external walls. ***3. Other interior structures*** Not specifically addressed here.
D. Resources	
D.1 Utilities	***1. Water supply***

	New buildings (groups or isolated buildings) in the WUI areas should be provided with an appropriate water supply (except from garages, carports, sheds, agricultural buildings smaller than 600 square feet, 56 square meters; or other specific structures, see C.1). Supply level. The water supply should meet the following requirements (to be approved by the code official, if a fire department of Class 9 or higher is available (ISO Commercial Rating Service, 1995)): • Dwellings hosting from 1 to 2 families should be provided with 1,000 gallons/minute (63.1 l/s) for 30 minutes minimum (fire flow calculation area < 3,600 square feet, 334 m^2), or 1,500 gallons/minute (95 l/s) otherwise (flow reduced of 50 % if the building is provided with an approved sprinkler system); • Other dwellings should be provided with a water supply approved by the code official (flow reduced of 50 % if the building is provided with an approved sprinkler system), but ≥ 1,500 gallons/minute (95 l/s) for 2 hours; Water source. The water source should meet the following requirements: • The water source should be ≤ 1,000 feet (305 m) far from the building (following an unobstructed path) and be approved by the code official; • A man-made water source can be feed with rainfall, pumped from a well, hauled by a tanker, hauled by seasonal high water (stream/river). Its location, design, maintenance and access (which must be unobstructed and clearly identifiable) should be approved by the code official; • Natural water sources should have a minimum annual water level/flow complying with the minimum requirements of water supply above listed, not influenced by freezing, identifiable, and provided with unobstructed access; • The water source should be equipped with a hydrant (man-made source) designed according to national standards or a draft site (natural source) approved by the code official (for design, construction, location, access, maintenance); Access. Both draft sites and pumper access points should have emergency vehicle access from an access road (as defined in G.1). Pumper access points can be also approved driveways (not longer than 150 feet, 45.72 m). The pumper apparatus should not obstruct roads/driveways. Standby power. If the water supply system requires power supply, a standby power system (according to the ((International Building Code, 2015), Section 2702); ((International Fire Code, 2015), Section 601) capable of providing power for at least 2 hours should be provided (except from underground supply systems or those serving only one dwelling unit). ***2. Other utilities*** Not specifically addressed here.

D.2 Firefighters	Not specifically addressed here.
D.3 Planning	***1. Fire protection plan*** If required by the code official, a fire protection plan should be developed for the WUI area, based on a specific wildfire risk assessement including location, topography, flammable vegetation, climate and fire history. The plan should concern water supply, access, building ignition, fire resistance factors, protection systems, equipment, defensible space and vegetation management. ***2. Other plans required/suggested*** Site plans. Site plans to be developed according to the (International Building Code, 2015) should include, for the WUI areas, also information about topography, width and grade of access roads, details about landscape and vegetation, location of structures, presence of overhead utilities, building types, information about ignition resistance, appendages, roofs, water supply sytems. Information about the structures, land, fuel breaks (strategical areas near fire-prone areas, where vegetation has been removed or replaced, in order to fight more easily wildfires), water supply and access roads in a range included within 300 feet (91.44 m) from the lot line. Vegetation management plans. It is possible to reduce the severity class of the WUI area by submitting for approval to the code official a vegetation management plan. It includes at least the following elements: • Site plan; • Methods and time schedules for interventions, control and maintenance of vegetation, including slash, snags, plants overlapping with electrical lines, dead vegetation and other fuel types; • A maintenance plan for the proposed measures of fuel reduction.
D.4 Outreach	The IWUIC Code can be adopted by other countries/states/local authorities as it is or with local modifications according to different jurisdiction standards.
E. Fire Protection Measures	
E.1 Measures for water sources	Water tanks and pumps with electrical equipment in the WUI areas should be protected with defensible space (see B.1).
E.2 Measures for buildings	***1. Sprinklers*** Approved automatic sprinklers should be installed (according to national standards) in all buildings in the WUI areas which belong to the IR Class 1. ***2. Manual protection systems*** Not specifically addressed here. ***3. Warning systems*** Not specifically addressed here.

	4. Spark arresters Chimneys (of fireplaces, barbecues), incinerators or heating instruments in which fuel is used should be provided with spark arresters. Spark arresters should be made of woven or welded wire screening (12 USA standard gage wire, 0.105 inch, 2.66 m), with openings not exceeding 0.5 inch (0.0127 mm). Net free areas of spark arresters should be minimum 4 times the net free area of the chimney outlet. ***5. Combustible materials*** Liquefied petroleum gas (LP-gas). Installation and maintenance of LP-gas equipment should be made in the defensible space, according to the (International Fire Code, 2015) or other similar standards. Storage of combustible materials. Firewood and combustible materials can be stored in the defensible space at minimum 20 feet (6.096 m) from structures and at a minimum horizontal distance of 15 feet (4.572 m) from the crown of trees. Some not mandatory other instructions are given in Appendix A of the IWUIC Code. ***6. Private shelters*** Not specifically addressed here.
F. Environment	
F.1 Weather	Climatic factors should be considered for the definition of WUI areas (as suggested in the Appendix E, giving some not-mandatory suggestions), including: temperature, relative humidity, precipitation, flooding, wind speed, duration of high wind speeds, wind direction, fog and other atmospheric conditions (see also section A.1.2).
F.2 Fire history	The fire history is explicitly included among the factors to be considered for assessing the wildfire risk, in particular for developing fire protection plans (D.3.1).
G. Access	
G.1 Roads	***1. Type/Number of access roads*** New buildings (and groups of buildings) in the WUI areas should be provided with fire apparatus access roads according to the International Fire Code (International Fire Code, 2015). Individual houses should be provided also with appropriate driveways. Anyway, if any building is > 150 feet (45.72 m) far from the access road, it should be provided with driveways. If the access roads are secured, a key box should be installed and accessible for the code official.

	2. Road standards Main roads. The fire apparatus roads in the WUI areas should be open all year and have the following requirements: • Minimum width of 20 feet (6.10 m); • Clear height of 13 feet and 6 inches (4.12 m); • Adequate structure in order to accommodate fire apparatus loads; • Adequate radii of curvature in order to accommodate turning of fire apparatus; • Adequate gradient, with respect to the common fire apparatus in the jurisdiction. • All-weather surface made of an acceptable material used in the jurisdiction to allow the passage of fire apparatus. Driveways/Dead-ends. Driveways in the WUI areas should comply with the following requirements: • Less or equal than 5 dwelling units served (except if driveway standards comply with main roads standards); • Minimum unobstructed width of 12 feet (3.66 m); • Minimum unobstructed height of 13 feet and 6 inches (4.12 m); • Turnarounds for driveways longer than 150 feet (45.72 m), except if the driveway is connected to the main road in more than one point (and the changes of direction comply with the radii prescriptions); • Turnouts for driveways longer than 200 feet (60.96 m) and narrower than 20 feet (6.10 m), located as required by the code official; • Turnarounds for dead-end roads longer than 150 feet (45.72 m), as approved by the code official; • Inside turning radii greater or equal than 30 feet (9.14 m); • Outside turning radii greater than 45 feet (13.72 m); • Turnouts made of all-weather road surface ≥10 feet (3.05 m) wide and 30 feet (9.14 m) long; • Vehicle load limits for bridges should be posted and design loads established by the code official; • Grade minor than the maximum grade allowed by the code official. ***3. Markings*** Road signs. Approved signs (by the code official) should be provided and maintained for access roads/driveways in the WUI areas, in order to prevent their obstruction. They should comply with the following requirements: • Made of noncombustible materials; • Minimum 4 inch (0.102 m) high reflective letters with 0.5 inch (0.013 m) stroke; • Contrasting 6 inch (0.152 m) high sign; • Bottom of the road identification signage at a height of 7 feet (2.13 m) from the road surface.

	Markers. Appropriate markers (approved by the code official) should be provided for identifying the fire protection equipment and fire hydrants, and for the addresses of buildings in the WUI areas. They should comply with the following requirements: • Buildings should have a posted address at each driveway entrance and visible from the roads from both directions; • In case of a driveway serving more buildings, a single marker should be placed at the entrance of the driveway, and specific address signs should be repeated where the driveways divide; • In case of driveways serving commercial/industrial buildings, the address sign should be placed at the closest intersection which gives access to them. • Existing roads, buildings and fire protection equipment should be provided with address markers. ***4. Vegetation clearing*** Not specifically addressed here.

REFERENCES

ASTM D2898, 2010. Standard Test Methods for Accelerated Weathering of Fire-Retardant-Treater Wood for Fire Testing*

ASTM D3909, 2012. Standard Specification for Asphalt Roll Roofing (Glass Felt) Surfaced with Mineral Granules*

ASTM D6662, 2013. Standard Specification for Polyolefin-based Plastic Lumber Decking Boards*

ASTM D7032, 2010. Standard Specification for Establishing Performance Ratings for Wood-plastic Composite Deck Boards and Guardrail Systems (Guards or Handrails)*

ASTM E84 (UL 723), 2013. Test Method for Surface-Burning Characteristics of Building Materials*

ASTM E108 (UL 790), 2011. Standard Test Methods for Fire Tests of Roof Coverings*

ASTM E119 (UL 263), 2012. Standard Test Methods for Fire Tests of Building Construction and Materials*

ASTM E136, 2012. Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 °C*

ASTM E2768, 2011. Standard Test Method for Extended Duration Surface Burning Characteristics of Building Materials (30 Minute Tunnel Test)*

International Code Council, 2015. International Building Code.

International Code Council, 2015. International Fire Code.

*ASTM = American Society for Testing and Materials.

A.7 European Standards

Two EU Regulations: the EEC 2158/92 concerning the "Protection of the Community's forests against fire", the EC 2152/2003 concerning the "Monitoring of forests and environmental interactions in the Community (Forest Focus)" have been reviewed.

Those regulations provide some directives for the EU Member States mainly concerning the definition of hazard zones and protection plans. All the others parameters inquired are not considered in those regulations: land, building construction, resources (utilities and firefighters), fire protection measures, environment, access. However, the two regulations do not explicitly mention the WUI fires, but instead focus on forests in general.

The information in the following table refer to the EU Regulation 2158/92 (labelled with the number [1]) and the EU Regulation 2152/2003 (labelled with the number [2]).

Table A.7 Europe – Guide/Code: EU Regulations (2158/92 [1], 2152/03 [2])	
Category	**Provision**
A. Hazard	
A.1 Definitions	***1. Destination*** [1] Three risk zones should be individuated in the territory of the European Union with respect to forest fires: high risk, medium, risk, low risk. The WUI fires are not explicitly mentioned. [1] The disaggregation of the territory into zones for defining the risk zones should be operated by considering the NUTS III zones as a minimum level of aggregation. ***2. Severity class*** [1] The areas which should be identified by each European Country as "high risk zones" should be exposed to a permanent or cyclic forest fire risk assessment. This risk should be recognized as able to endanger the ecological equilibrium, the level of safety and/or to accelerate desertification processes. [1] High risk zones may be identified only in the following areas: • Portugal, • Spain, • France (in the regions: Aquitaine, Midi-Pyrenées, Corse, Languedoc-Roussillon, Provence-Alpes-Côte d'Azur, in the departments: Ardèche and Drôme), • Italy (Southern regions, other regions: Lazio, Toscana, Liguria, Umbria, Marche, Emilia Romagna, provinces of: Cuneo and Alessandria (Piemonte region), Pavia (Lombardia region), mountainous forest areas in the Northern Italy), • Greece. Other zones could be considered upon request by a Member Country.

	[1] Medium risk zones are exposed to a forest fire risk which, even if it is not permanent and cyclic, can endanger the forest ecosystem. [1] All the other zones are low risk zones.
B. Land	
B.1 Vegetation	Not specifically addressed here.
B.2 Topography/ Terrain	Not specifically addressed here.
C. Building Construction	
C.1 General requirements	Not specifically addressed here.
C.2 Roof	Not specifically addressed here.
C.3 Walls and other external coverings	Not specifically addressed here.
C.4 Windows, external doors and vents	Not specifically addressed here.
C.5 Decks and detachments	Not specifically addressed here.
C.6 Floors	Not specifically addressed here.
D. Resources	
D.1 Utilities	Not specifically addressed here.
D.2 Firefighters	Not specifically addressed here.
D.3 Planning	***1. Fire protection plan*** [1] Fire protection plan should be developed for the forests in the high risk and medium risk zones. [1] Fire protection plans in the high risk areas should include: 1. A description of the existing situation and the current measures of prevention, protection and firefighting; 2. The fire history of the previous 5 years, with information about the causes of previous fires; 3. A description of the aims of the plan concerning the elimination/reduction of fire risk, and the improvement of prevention systems/firefighting activities; 4. A description of the measures to be used in order to reach those aims; 5. The indication of the partners associated in the forest protection activities. [1] Fire protection plans in the medium risk areas should include all of the above described points for the high risk areas (excluding point 2 and the information and measures about firefighting activities).

	2. Other plans required/suggested [2] A scheme should be defined at the Community level (then transferred to EU Member states) in order to provide data about risks concerning European forests. In particular: • Data collection, handling and assessment; • Data evaluation and integration at the Community level; • Improve the quality of data; • Further develop the monitoring activity; • Enhance the knowledge about the influence of different factors on forests; • Study the dynamics, causes and impacts of forest fires; • Develop forest risk assessment indicators and methodologies.
D.4 Outreach	The EU Regulations should be adopted by each country of the European Community, by transferring the provisions at the European level to each member country.
E. Fire Protection Measures	
E.1 Measures for water sources	Not specifically addressed here.
E.1 Measures for buildings	Not specifically addressed here.
F. Environment	
F.1 Weather	Not specifically addressed here.
F.2 Fire history	[1] Data about fire history should be part of the fire protection plan in high risk zones (point 2 of the requirements in D.3.1).
G. Access	
G.1 Roads	Not specifically addressed here.

REFERENCES

[1] EU Regulation EEC 2158/92 "Protection of the Community's forests against fire".
[2] EU Regulation EC 2152/2003 "Monitoring of forests and environmental interactions un the Community (Forest Focus)".

A.8 France: Standards/Guidelines

Wildland-Urban Interface (Interface Habitat-Forêt) fires are a well-known problem in France (see Table 1). However, there is no dedicated code/guideline specifically devoted to WUI fires. Nevertheless, several requirements concerning the fire safety of these areas are included in the main regulation related to forests, and in the referenced standards and guidelines, which are also applied locally.

The Code Forestier is the specific French code devoted to forests. It includes specific sections about forest fires - how to prevent and fight them. Some of these provisions derive from the Environmental Code (Code de l'Environment). Specific plans are required for different parts of the territory, depending on the hazard class of their location, according to previously developed EU regulations (EC 2158/92). Those plans are named: "Plans de Prevention des Risques Naturels Previsibles" (Plans for preventing predictable natural risks) and a specific plan is devoted to forest fires ("Incendies de foret") -PPRIF. Guidelines on which features should be included in those plans are given in the official "Guide Methodologique" (Methodologic Guide) provided by the involved French Ministries involved. However, those indications are more qualitative, since some freedom in setting specific boundaries is left to local agencies. Some PPRIF plans are currently adopted by local agencies in different French areas. For this reason, an example of local PPRIF adopted in a region (Corse) where there is a high percentage of communities exposed to the wildfire risk has been reviewed, to provide an order of magnitude of the possible measures adopted. Moreover, since the Code Forestier provides the "debrouissallement" (clearing) at some distances from the urban settlements, but it does not give detailed provisions on how to conduct it, a local guideline was also reviewed (Department of Haute-Corse), to give a picture of the guidance required to function rather than the guidance only provided in one document.

Information for all categories were found, each of which provided different levels of detail. The information in the following table refers to the Code Forestier, unless otherwise stated.

Table A.8 France – Guide/Code: Code Forestier	
Category	**Provision**
A. Hazard	
A.1 Definitions	***1. Destination*** The zones defined as subject to the forest fire risk are: the regions Aquitaine, Corse, Languedoc-Roussillon, Midi-Pyrénées, Poitou-Charentes, Provence-Alpes-Côte d'Azur and the departments of Ardèche and Drôme. (The region Poitou-Charentes was further added to the list present in the EC 2158/92 ((Council Regulation (EEC) No 2158/92 of 23 July 1992 on protection of the Community's forests against fire)). The modalities for identifying the specific risk zones in those regions are defined in (Plans de prevention des risques naturels (PPR). Risques d'incendies de foret. Guide méthodologique), considering both the probability and the intensity of risks.

	2. Severity class Two main hazard zones should be defined among the total area inquired (Code de l'Environment. France. (Updated Version, 2017), Article L562.1) according to the level of risk. In the "danger zone", all types of new construction and industrial/commercial operations should be prohibited (except for some few strict cases, such as the buildings devoted to the protection of the forest, or modifications to existing buildings under given conditions (Plans de prevention des risques naturels (PPR). Risques d'incendies de foret. Guide méthodologique)). In the "precaution zone", construction and industrial/commercial operations could aggravate the risk or cause new risks. Hence, other measures should be provided for this zone too. Those two zones are further defined (Plans de prevention des risques naturels (PPR). Risques d'incendies de foret. Guide méthodologique) as a red zone (high risk zone, where it is not possible to build new structures) and a blue zone (classified into two sub-levels: B1 – moderate risk and B2 – low risk, where it is possible to build new structures under some specific conditions). The conditions for building new structures in the danger zones (in terms of materials, structures, access, protection measures) are listed in the appropriate fields of this table. However, while general requirements for developing the plans, identifying the danger zones and prescribing different measures are given in (Plans de prevention des risques naturels (PPR). Risques d'incendies de foret. Guide méthodologique), the specific delimitation of these zones is made by local authorities.
B. Land	
B.1 Vegetation	***1. Defensible space*** In the areas which are considered as danger zones, the authorities can require that vegetation is removed, in accordance with prescribed procedures. The owner should (at his/her own expense), clear the vegetation to within 50 meters of the structures. If this distance includes other properties, the clearing of vegetation should be conducted also in those other properties, at the expenses of the respective owners. In the areas subject to the provisions of a PPRIF, a buffer distance included between 50 and 200 meters should be maintained between the constructions and the forest. The vegetation included in this distance should be kept cleared. This provision applies to all constructions which are placed ≤ 200 meters from the forest. Some guidance regarding vegetation planting in the WUI area is given in (Ganteaume, 2016). For example, the planting of green cypresses is discouraged because of their high combustibility. The removal of dead vegetation is encouraged. ***2. Clearance between/from vegetation*** Specific provisions for clearing of vegetation are locally defined through decrees from the relevant agency. Referring to an example of a local decree

	(Arrêté n. 2013071-2002 (2013.03.12) Relative au Débroussaillement legal. Direction departementale des territoires et de la mer de la Haute-Corse), the following prescriptions are provided for the vegetation clearing: <u>Horizontal clearance.</u> • Vegetation ≤ 3 meters (bushes) high should not be ≥ 5 meters wide. Adjacent bushes should have a horizontal clearance of at least the width of the wider bush among the two bushes considered (at least ≥ 2 meters wide). The horizontal clearance with respect to trees (≥ 3 meters high) should be high at least three times the bush (but anyway > 2 meters). The distance between bushes and structures (considering their openings or the exposed boundary of the structure) should be greater than three times the bush height (at least > 3 meters). • Vegetation ≤ 2 meters high and ≤ 1 meter wide (hedges) should have a horizontal clearance of three times their height (but anyway > 2 meters) with respect to the vertical projection of the boundary of the crown of an adjacent tree (> 3 meters high). The horizontal clearance with respect to adjacent bushes should be greater than the bush width (at least > 2 meters). The distance between hedges and structures (considering their openings or the exposed boundary of the structure) should be high ≥ three times the hedge (but anyway > 3 meters). • Vegetation > 2 meters high and < 2 meters wide (high hedges) should have a horizontal clearance of at least 2 meters with respect to the vertical projection of the boundary of the crown of an adjacent tree (more than 3 meters high). The horizontal clearance with respect to adjacent bushes should be high ≥ three times the bush (but anyway > 2 meters). The distance between high hedges and structures (considering their openings or the exposed boundary of the structure) should be ≥ three times the high hedge. • Trees should be at least 3 meters from structures (considering the boundary of the tree crown). The same minimum clearance is required from the vertical projection of the boundary of the roof of lighter structures (named as vacation homes). Prescriptions slightly different than the above reported ones concern the camping structures. <u>Vertical clearance.</u> • The vertical distance between the lower boundary of a tree crown and the top of a bush should be high ≥ 2 times the height of the bush (but anyway > 2 meters). • The vertical clearance between the road surface and the bottom of the tree crowns should be ≥ 4 meters. The clearing of vegetation should be conducted on the two sides of a paved public road for a width ≤ 20 meters. In the danger zones (see A.1.2), the power lines should be maintained and treated (including the clearing of nearby vegetation) according to their height and width. Quantitative provisions should be locally imposed. In fact, some specific provisions were found in local guidelines (Arrêté n. 2013071-2002 (2013.03.12) Relative au Débroussaillement legal. Direction departementale des territoires et de la mer de la Haute-Corse):

	• Low voltage lines (< 1000 V), having non-protected cables, should have a vertical clearance ≥ 1 meter with respect to the top of tree crowns; • Low voltage lines in isolated cables should not be touched by the top of tree crowns; High voltage lines (≥ 1000 V) should be at least three meters from the vegetation in all directions. ***3. Maintenance*** Dead vegetation. Not specifically addressed here. Groundcover. Not specifically addressed here. Pruning. Trees can be maintained if pruned for a height ≥ 30 % of the total height (for the leaves) and of the 50 % (for the resin) or 2 meters.
B.2 Topography/ Terrain	Data about topography should be considered while identifying the risk areas (Plans de prevention des risques naturels (PPR). Risques d'incendies de foret. Guide méthodologique). Three parameters are explicitly considered: the gradient, the orientation (e.g. the exposure to wind), and the exposure to sunlight. However, those factors (i.e. the ground slope) are not mentioned among the factors which may influence the procedure of vegetation clearing (Arrêté n. 2013071-2002 (2013.03.12) Relative au Débroussaillement legal. Direction departementale des territoires et de la mer de la Haute-Corse).
C. Building Construction	
C.1 General requirements	***1. Classes of ignition resistance*** Not specifically addressed here. ***2. Characteristics of ignition resistant materials*** Not specifically addressed here. ***3. Building separation*** Not specifically addressed.
C.2 Roof	Local guidelines (Plan de Prevention des Risques Naturels previsibles. 'Incendies de Foret'. Commune de Borgo (Corse). Reglement. (2011).) are considered for the specific quantitative provisions. ***1. Covering*** The roof covering should be classified in the M0 category of fire resistance (calorific value of 2,5 MJ/Kg). Coverings belonging to the other classes (M1, not flammable (not able to produce notable heat); M2, hardly flammable; and M3 moderately flammable), are allowed if placed upon an incombustible material or a panel of wood or other materials equally resistant to fire, as indicated by the "Comité d´etude et de la classification des matériaux et des

	élément de construction", (Norme technique de la classement de la résistance au feu des matériaux. Arreté ministériel du 21 Novembre 2002. France.). ***2. Valley flashings*** Not specifically addressed here. ***3. Eaves*** Awnings should be made of materials classified as M1 and they should not cross the external walls. ***4. Gutters*** Gutters should be made of materials classified as M1.
C.3 Walls and other external coverings	Local guidelines (Plan de Prevention des Risques Naturels previsibles. 'Incendies de Foret'. Commune de Borgo (Corse). Reglement. (2011).) are considered for the specific quantitative provisions. ***1. Exterior walls*** Walls should have a fire resistance (measured in time) of 30 minutes. Combustible parts should be avoided in correspondence with the junction between the roof and the walls. ***2. Wall coverings*** Wall coverings should belong to the M0 category of fire resistance.
C.4 Windows, external doors and vents	Local guidelines (Plan de Prevention des Risques Naturels previsibles. 'Incendies de Foret'. Commune de Borgo (Corse). Reglement. (2011).) are considered for the specific quantitative provisions. ***1. Exterior glazing*** Not specifically addressed here. ***2. External doors*** Not specifically addressed here. ***3. Vents and other openings*** It should be possible to cover all the openings with objects having a fire resistance of 30 minutes. Airtight joints should be used. The ventilation of attics should be protected with a metal grid, in order to avoid the introduction of embers. Chimney stacks should be externally covered with materials classified as M0, having a fire resistance of 30 minutes. They should be internally provided with

	a valve providing protection against fire and their upper part should be protected from sparks. It should be possible to activate a closing device of the chimney stack, stable against fire and protecting from embers, directly from the interior of the building.
C.5 Decks and detachments	Local guidelines (Plan de Prevention des Risques Naturels previsibles. 'Incendies de Foret'. Commune de Borgo (Corse). Reglement. (2011).) are considered for the specific quantitative provisions. ***1. Decks and other attachments*** Not specifically addressed here. ***2. Detached structures*** Fixed barbecues should be protected against sparks, provided with an ashtray far from vegetation and with a quick system of fire suppression. Other pipes and channels external to the residence should have a fire resistance of 30 minutes.
C.6 Floors and interior structures	Not specifically addressed here.
D. Resources	
D.1 Utilities	***1. Water supply*** The defensible space should be provided with water supply points, allowing the supply of water for all the vehicles in the zone (Plans de prevention des risques naturels (PPR). Risques d'incendies de foret. Guide méthodologique). However, no quantitative guidance was found regarding the number, volume and spatial distribution of water supply. The notion of defensible space is left unclarified too. Some provisions in this sense derive from some accessibility requirements (see point 7). Supply level. In the local guidelines (Plan de Prevention des Risques Naturels previsibles. 'Incendies de Foret'. Commune de Borgo (Corse). Reglement. (2011).) reviewed, water supply resources present in the red zone, are standardized (according to the regulations (Regulation (Norme): NFS 61-211. France.), (Regulation (Norme): NFS 61-213. France.)). They should provide at least 60 m^3/h for minimum 2 hours. Moreover, a water tank exclusively devoted to fire suppression purposes should be built. It should contain a volume of water included between 30 and 120 m^3. All new construction is required to be within 150m of a main road and a water supply. Water source. Not specifically addressed here. Access. Not specifically addressed here. Standby power. Not specifically addressed here.

	2. Other utilities Not specifically addressed here.
D.2 Firefighters	Firefighting equipment should be stored in dedicated places, near the hazard zones. These places should be provided with public right of way.
D.3 Planning	***1. Fire protection plan*** For all the regions and departments interested by the forest fire risk, a department/inter-departmental plan should be developed by the relevant local authority, indicating specific provisions to be adopted with respect to the prevention of forest fire risks. This plan is named: "Plan de Prevention des Risques Naturels Previsibles" (Plan for preventing predictable natural risks) and a specific plan is devoted to forest fires ("Incendies de foret") -PPRIF-. Guidelines on the contents of these plans are given in the official "Guide Methodologique" (Methodologic Guide) provided by the involved French Ministries (Plans de prevention des risques naturels (PPR). Risques d'incendies de foret. Guide méthodologique.). The PPRIF should include (according to the Code Forestier) an information report and an attached document, provided with graphical depictions. The information report should include: • An assessment of the forest area, including detailed information about the current means for prevention, protection and fire suppression, and about the methods used for the diagnosis; • The history of previous fires, together with their causes. The document attached to the information report should include: • The objectives in terms of elimination of the main causes of fires; • The description of the action to be taken; • The prescriptive indications about vegetation clearing (see point 2.1 Vegetation); • The territories in which the plan should be urgently developed; • The involved actors; • Criteria for evaluating the results of the plan implementation. The attached graphical drawings should indicate the hazard zones (see point 1. Hazard) and the zones which are less than 200 m from forests. ***2. Other plans required//suggested*** Not specifically addressed here.
D.4 Outreach	Detailed guidelines devoted to the local authorities on how the plans should be developed are provided (Plans de prevention des risques naturels (PPR). Risques d'incendies de foret. Guide méthodologique.). General guidelines devoted to the public concerning the vegetation maintenance around the residences are also locally available (see e.g. (Ganteaume, 2016)).
E. Fire Protection Measures	
E.1 Measures for water sources	Not specifically addressed here.

E.1 Measures for buildings	Not specifically addressed here.
F. Environment	
F.1 Weather	Specific environmental factors which should be considered for the development of fire protection plans are mentioned: dryness of the climate, intensity of winds, the amount of combustible vegetation among the total, the presence of dead vegetation, the current state of forests/woods. Other factors are further specified in the guidelines (Plans de prevention des risques naturels (PPR). Risques d'incendies de foret. Guide méthodologique.): speed and direction of winds, temperature, humidity.
F.2 Fire history	The fire history is explicitly included among the factors to be considered for delimiting the danger zones, since it contributes to the estimation of the probability of occurrence.
G. Access	
G.1 Roads	***1. Type/Number of access roads*** Access to the designated defensible spaces should be designed in order to avoid a dead-end road, to avoid crossing of traffic streams (Plans de prevention des risques naturels (PPR). Risques d'incendies de foret. Guide méthodologique.). While new constructions should be preferably conceived as groups of houses in the blue zone, each of them should have access to a public road. Specific design standards of roads should be locally defined (Plans de prevention des risques naturels (PPR). Risques d'incendies de foret. Guide méthodologique.). An example of these local prescriptions is provided in (Plan de Prevention des Risques Naturels previsibles. 'Incendies de Foret'. Commune de Borgo (Corse). Reglement. (2011).), which divide the roads in both the red and the blue zones into three classes: • Main service roads, • Secondary service roads, • Driveways. ***2. Road standards*** <u>Main roads.</u> Main service roads (according to the local prescriptions reviewed (Plan de Prevention des Risques Naturels previsibles. 'Incendies de Foret'. Commune de Borgo (Corse). Reglement. (2011).)), allowing the passage of emergency services, should have the following features: • width > 5 meters excluding parking lots, • free height > 4 meters, • be always practicable, • maximum gradients set to 20 %, • a double exit path from each dead-end road in order to allow easy maneuvers of the emergency services (T-turn). Secondary service roads should have the same standards as the main service roads, but must ≥ 3 meters wide (excluding parking lots).

	The access to the places defined in D.2 should normally have a maximum width of 6 meters, and should be not placed close to limits of other structures. Groups of houses (Plan de Prevention des Risques Naturels previsibles. 'Incendies de Foret'. Commune de Borgo (Corse). Reglement. (2011).) should be served by a main service road (if more than 6 houses) or by a secondary service road (if less than 6 houses). The roads internal to the group of houses should avoid cul-de-sacs (except if ≥ 80 meters long and having a turning area or allowing a proper T-turn movement), have radii of curvature > 8 meters, maximum gradients set to 15 %, minimum width of 5 meters. Public structures (Plan de Prevention des Risques Naturels previsibles. 'Incendies de Foret'. Commune de Borgo (Corse). Reglement. (2011).) (capable of hosting more than 100 persons) should be served by a main service road. Driveways/Dead-ends. Driveways (links between houses and service roads) should (according to the local prescriptions reviewed (Plan de Prevention des Risques Naturels previsibles. 'Incendies de Foret'. Commune de Borgo (Corse). Reglement. (2011).)): • have a width larger than 4.5 meters (if serving more than six houses) or larger than 3 meters (if serving a single house), excluding parking lots, • clear height greater than 4 meters, • maximum average gradients set to 15 % (instantaneous gradient can be 20 % maximum), allow T-turn (as service roads) and be always practicable. All individual houses (Plan de Prevention des Risques Naturels previsibles. 'Incendies de Foret'. Commune de Borgo (Corse). Reglement. (2011).) should be < 60 meters from a service road, and be connected with it through a driveway above described. If the individual house is < 20 meters from a service road, the driveway is not needed. In this case, a pedestrian path minimum 1.80 m wide should be implemented. The service roads serving more than 6 houses should be built by following the prescriptions for main service roads (if > 200 m long) or for secondary service roads (< 200 m long). Hospitals and similar structures should be served by at least one driveway linked at the two extremes to a main service road. ***3. Markings*** Road signs. Not specifically addressed here. Markers. Not specifically addressed here. ***4. Vegetation clearing*** Main roads. Both sides of public paved roads in the hazard zones should be cleared from vegetation for 20 meters. If the PPRIF defines a road as used only for fire protection, a territorial organization may ask to the local authority the right to clear and manage the

	vegetation placed on the road sides. However, the clearance cannot exceed an area within 100 meters of the road. Driveways. Both sides of driveways of constructions placed at less than 200 meters from the forest should be cleared from vegetation for a distance of 10 meters.

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A.9 Italy: Standards/Guidelines

The main Italian Code reviewed is the: "Legge quadro in materia di incendi boschivi" (Framework law concerning wildfires), L. 21.11.2000, n. 353. It includes a general framework for defining the activities of forecasting, prevention and firefighting activities. Specific reference to Wildland-Urban Interface fires is not present; however, this issue is addressed in the: "Raccomandazioni per un più efficace contrasto agli incendi boschivi, di interfaccia e ai rischi conseguenti. Allegato (2017)." (Recommendations for a more efficient fight against wildfires, interface fires and related risks. Attached document).

Since the Italian law transfers responsibility to regions for wildfire planning activities, an example of regional plan (Region Molise) has been reviewed. It includes reference to interface fires. Moreover, guidelines for another region (Piemonte) were reviewed since they include a framework for defining danger zones with respect to structures and wildfires. Considering all the sources reviewed, the main aspects covered are: hazard definition and classification, vegetation, terrain, some generic requirements about building construction, firefighters, planning, some generic requirements about fire protection measures, access.

The information reported in the following table are taken from "Legge quadro in materia di incendi boschivi" (Framework law concerning wildfires), L. 21.11.2000, n. 353, unless otherwise stated.

Table A.9 Italy – Guide/Code: Legge Quadro in materia di incendi boschivi (Framework law concerning wildfires)	
Category	**Provision**
A. Hazard	
A.1 Definitions	***1. Destination*** The areas considered are those affected by wildfires. A wildfire (incendio boschivo) is defined as (translated from Italian): "*Fire susceptible to expand on woods, brushes or forests, including also human structures and infrastructures in the above cited areas, or on cultivated or wild fields and grazing adjacent to those areas".* In the document approved by the (Regione Molise. Assessorato Agricoltura, Foreste e Pesca Produttiva, 2004), the interfaces are defined as settlements within a distance < 30-50 m of the possible source of propagation of a wildfire (based on a referenced study by Radtke, 1992). Based on (Bovio, G., Camia, A., Marzano, R., Pignocchino, D., 2001), danger zones can be identified according to the index I.P.S.I. (Indice di Pericoosità Specifica in area di Interfaccia – Specific Danger Index in Interface area). This index is based on the Woodland Home Forest Fire Hazard Rating used in the Shenandoah county in Virginia, USA, adapted to the Piemonte region. It works by considering reference square areas having side of 200 m, and by assigning partial ratings to the following categories. The partial ratings are assigned by considering the predominant class in the reference areas for each category.

	• Fuel (A): meadow (1 point), shrubs (2 pt.), woods without undergrowth shrubs (3 pt.), woods with undergrowth shrubs (4 pt.), woods with high vegetative fuel, full of shrubs (5 pt.). • Slope (B): moderate, 0-20 % (1 point), medium, 20-40 % (2 pt.), high, > 40 % (3 pt.). • Structure (C): Noncombustible roof and roof covering (1 point), Noncombustible roof with combustible covering (3 pt.), mixed roof with noncombustible covering (4 pt.), mixed roof with combustible covering (6 pt.), combustible roof with noncombustible covering (7 pt.), combustible roof and roof covering (10 pt.). • Defensible space (D), for the dwellings that do not have at least 10 m of defensible space between structures and combustible fuels: 30 % of dwellings (3 points), 31-60 % of dwellings (6 pt.), 61-100 % of dwellings (10 pt.). • Access, additional 3 points given only if one of the following condition occurs: only one access/exit road, insufficient road width for two-way traffic, maximum grade > 15 %. The final rating is obtained as follows: I.P.S.I. = A*B + C + D (+ access, if applicable) ***2. Severity class*** According to (Bovio, G., Camia, A., Marzano, R., Pignocchino, D., 2001), four danger zones are identified, based on their computed I.P.S.I. score: • Low specific danger, I.P.S.I.: 1-10 points; • Medium specific danger, I.P.S.I.: 11-16 points; • High specific danger, I.P.S.I.: 17-20 points; • Very high specific danger, I.P.S.I.: > 20 points. The priority of interventions is indicated by the level of danger zone. In the document by (Regione Molise. Assessorato Agricoltura, Foreste e Pesca Produttiva, 2004), the interface areas are included in the prioritized areas of interventions, with respect to planning and firefighting activities (including a distance of 100 m from them).
B. Land	
B.1 Vegetation	***1. Defensible space*** Based on previous studies, (Bovio, G., Camia, A., Marzano, R., Pignocchino, D., 2001) report the following recommendations for the defensible space: • An area of (about) 10 m surrounding the structure, totally deprive of vegetation, with the only exception of mowed grass, ≤ 0.015 m in height; • An area between (about) 10 and 20 m around the structure, with reduced vegetation of a maximum height of 0.045 m. Isolated trees are not included in this provision. The defensible space should be modified according to the slopes upon which the structure is placed (see B.2).

	Three strategies should be adopted for fuel vegetation in the defensible space (Bovio, G., Camia, A., Marzano, R., Pignocchino, D., 2001): • Removal, if vegetation is too close from the structure, according to the distances considered for the defensible space. Species which should be particularly removed are of the evergreen and dry leaves kinds (since most of the fires in Piemonte region are concentrated in the winter period). • Reduction, such as pruning. • Substitution: around the structures, broadleaf vegetation could be preferred to evergreen and dry leaves vegetation (which could be maintained at greater distances). In the document by (Regione Molise. Assessorato Agricoltura, Foreste e Pesca Produttiva, 2004), the defensible space is set to ≥ 50 m for the protection against crown fires and to ≥ 10 m for the protection against fires close to the ground. ***2. Clearance between/from vegetation*** Horizontal clearance between tree crowns should be ≥ 2.5 m within the 10 to 20 m within the structure. Tree crowns should be distant ≥ 3 m from chimneys (Bovio, G., Camia, A., Marzano, R., Pignocchino, D., 2001). Vertical clearance between tree crowns and chimneys should be ≥ 3 m (Bovio, G., Camia, A., Marzano, R., Pignocchino, D., 2001). ***3. Maintenance*** Branches of isolated trees within 10 to 20 m of the structure, should be pruned to a height of 2.5 m. Debris, dead leaves and similar objects should be removed from the ground (Bovio, G., Camia, A., Marzano, R., Pignocchino, D., 2001).
B.2 Topography/ Terrain	Damages to structures are very likely if they are placed upon slopes > 20 %, reported by (Bovio, G., Camia, A., Marzano, R., Pignocchino, D., 2001), based on (National Fire Protection Association (NFPA), 1990). Based on previous studies, (Bovio, G., Camia, A., Marzano, R., Pignocchino, D., 2001) report the following recommendations for extending the total defensible space in case of structures placed upon slopes: • Up to 30 meters for slopes between 0 % and 20 %; • Up to 45 meters for slopes between 21 % and 40 % (with the only exception of the downhill side, for which the distance should increase to 60 m); • Up to 60 meters for slopes > 40 % (with the only exception of the downhill side, for which the distance should increase to 100 m). In the document by (Regione Molise. Assessorato Agricoltura, Foreste e Pesca Produttiva, 2004), structures placed upon slopes > 20 % are more likely to be damaged.

C. Building Construction	
C.1 General requirements	Forests and grazing which were subject to fires cannot have a change in the land use destination for at least 15 years after the fire. The construction of public buildings necessary for public and environmental safety is allowed. The construction of buildings on wildlands which were subject to fires, where regulatory plans are absent, is forbidden for 10 years. The same provision applies to commercial/industrial buildings and structures. The planting of new vegetation and the public environmental interventions are not allowed for 5 years, unless in specific situations. ***1. Classes of ignition resistance*** Not specifically addressed here. ***2. Characteristics of ignition resistant materials*** Not specifically addressed here. ***3. Building separation*** Clearance between structures/infrastructures should be ≥ 10 m (Bovio, G., Camia, A., Marzano, R., Pignocchino, D., 2001).
C.2 Roof	Not specifically addressed here.
C.3 Walls and other external coverings	Not specifically addressed here.
C.4 Windows, external doors and vents	Not specifically addressed here.
C.5 Decks and detachments	Not specifically addressed here.
C.6 Floors	Not specifically addressed here.
D. Resources	
D.1 Utilities	Not specifically addressed here.
D.2 Firefighters	In the document by (Regione Molise. Assessorato Agricoltura, Foreste e Pesca Produttiva, 2004), firefighters are authorized to remove all the trees surrounding structures in case of interface fires, if necessary during the incident. In case of high risk fires in the interfaces, firefighters can evacuate structures and occupied buildings (if not defendable), activate all the possible defence means, evacuate the pets, use all available water sources, close roads, switch off electric lines, evacuate vehicles.
D.3 Planning	***1. Fire protection plan*** Italian regions have to approve the regional plan for forecasting, preventing and fight wildfires, based on guidelines and directives, including: • Individuation of fire causes and factors;

	• Individuation of the areas subject to fires in the previous year and the areas exposed to wildfire risk; • Description of the vegetation in the risk areas; • Indication of the time periods more exposed to wildfire risk, including a wind data collection; • Computation of danger indexes; • Individuation of actions which can ease the fire starting in the risk areas; • Planning of the interventions for forecasting and prevent wildfires, including monitoring activities; • Evaluation of the means, tools, resources and procedures to fight wildfires; • Evaluation of the access and water supply; • Plan for maintenance operation; • Plan for education, information and financial activities. Areas already identified as protected regional areas, should be provided with a specific plan developed by the Ministry of the Environment, in accordance with the regions, the appropriate agencies and the State Forestry Division (Corpo Forestale dello Stato). Indications by the (Presidenza del Consiglio dei Ministri, Italia, 2017) explicitly address interface fires. In particular, the following recommendations are provided: • Adapt the firefighting regional provisions to the local conditions; • Train firefighters through continuous educational activities; • Diversify the available fleet into rotating-wing and fixed-wing aircraft; • Ensure integration with State Administration, for resources and knowledge; • Guarantee an appropriate number of firefighters; • Ensure integration with Civil Protection department (Protezione Civile) activity; • Prepare monitoring and operating facilities, allowing continuous operations during critic events; • Evaluate the possibility of joint firefighting activities between different Regions; • Increase the safety of aircraft firefighting activities (i.e. by removing all possible obstacles to aircraft firefighting activities, such as constructions or facilities), including both the Civil Protection department (Protezione Civile) and the National Agency for Civil Aviation (Ente Nazionale Aviazione Civile, ENAC) in the process; • Ensure to rationalise the request for aircraft interventions; • Promote the awareness of pilots for signaling noticed fires to the appropriate agency managing the aircraft traffic; • Increase the number of water sources for aircraft firefighting; • Promote agreements with appropriate agencies for using sea as water source.

	According to the document by (Regione Molise. Assessorato Agricoltura, Foreste e Pesca Produttiva, 2004), a planning in the interface areas should be conducted once information about topography, risk areas, interface areas between dwellings and wildlands are known. ***2. Other plans required//suggested*** Evacuation plan. In the document by (Regione Molise. Assessorato Agricoltura, Foreste e Pesca Produttiva, 2004), the following requirements are set for evacuation plans: • Define modality of evacuations; • Define required evacuation times; • Identify refugee areas and shelters; • Identify possible first-aid necessities; • Define evacuation for animals.
D.4 Outreach	The Italian law reviewed transferred planning activities to the regions. Each region is then responsible for developing a plan for forecasting, prevention and firefigthing activities against wildfires.
E. Fire Protection Measures	
E.1 Measures for water sources	Not specifically addressed here.
E.2 Measures for buildings	***1. Sprinklers*** Not specifically addressed here. ***2. Manual protection systems*** Not specifically addressed here. ***3. Warning systems*** Not specifically addressed here. ***4. Spark arresters*** Not specifically addressed here. ***5. Combustible materials*** In the document by (Regione Molise. Assessorato Agricoltura, Foreste e Pesca Produttiva, 2004), combustible and explosive materials are indicated as specific risk factors for interface fires, especially near industrial activities or facilities. ***6. Private shelters*** In the document by (Regione Molise. Assessorato Agricoltura, Foreste e Pesca Produttiva, 2004), population should be informed of the possibility of staying

	in the houses and closing all the openings (doors, windows), when the evacuation is not possible.
F. Environment	
F.1 Weather	Not specifically addressed here.
F.2 Fire history	Not specifically addressed here.
G. Access	
G.1 Roads	In the document by (Regione Molise. Assessorato Agricoltura, Foreste e Pesca Produttiva, 2004), the absence of evacuation routes and the existence of one evacuation route (eventually not suitable for emergency vehicles) are among the risk factors in interface areas. ***1. Type/Number of access roads*** Not specifically addressed here. ***2. Road standards*** Main roads. According to (Bovio, G., Camia, A., Marzano, R., Pignocchino, D., 2001), the following criteria should be provided for roads: • Width of access and evacuation routes (excluding shoulders): ≥ 5 m; • Maximum grade ≤ 12 %, cross slope ≤ 5 %; • Radius of curvature: ≥ 15 m; • Diameter of roundabouts: ≥ 30 m, in case of uphill roads. Driveways/Dead-ends. Not specifically addressed here. Fire lanes. Not specifically addressed here. Parking. Not specifically addressed here. ***3. Markings*** Not specifically addressed here. ***4. Vegetation clearing*** Not specifically addressed here.

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