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Wildfire Evacuation Modelling of Tourist Campsites

Borja Rengel[*1], Enrico Ronchi[2], Amina Labhiri[2], Virginie Dréan[1], Bruno Guillaume[1] and Eric Guillaume[1]

[1]Efectis France, Research and Development Department, Saint Aubin, France
[2]Lund University, Division of Fire Safety Engineering, Sweden

Abstract Wildfires pose a serious risk to tourist campsites in the wildland-urban interface, where evacuation can be challenging due to limited access and transient populations. This study evaluates evacuation strategies at campsites through two French case studies, using crowd- and traffic-modelling simulations. Key findings highlight the impact of pre-movement delays, evacuation modes, and travel distances on overall evacuation efficiency. Recommendations include optimizing assembly points, improving communication, and establishing nearby safety zones.

Keywords Wildfire evacuation, tourist campsites, crowd and traffic modelling

Extended Abstract

Wildfires pose a serious threat to populations in the wildland-urban interface (WUI), where vegetation and urbanized populated areas intersect [1]. This risk is of special importance to tourist areas characterized by a mix of people with different cultures and languages, as well as a variety of infrastructures and emergency strategies. Tourists are transient populations who may come from non-wildfire-prone areas and be unfamiliar with their temporarily residential environment, thus meaning that they are potentially exposed to a risk they are not familiar with. Serious wildfires have occurred in tourist destinations worldwide, highlighting the numerous difficulties tourists may encounter during such events and potentially rendering them a vulnerable population. Notable examples include the 2016 Madeira fire in Portugal [2], the 2023 Maui Fire in the USA [3], and the 2023 Rhodes Fire in Greece [4].

Campsites, often located in remote, wooded areas, represent some of the most wildfire-hazardous vacation spots, particularly due to possibly rapid spread of fire. The number of tourists at campsites is typically higher during the summer season, coinciding with the peak risk of wildfires. These locations often have limited access roads and narrow pathways, which can significantly impede the evacuation process. The primary challenge lies in ensuring the safety of tourists and staff, especially when faced with the urgent need to evacuate most of the accommodations without fire protection measures due to a wildfire. Effective evacuation strategies are essential for mitigating risks in wildfire-prone camping areas; however, many campsites adopt their own strategies based on available resources and specific needs, which may not always be the most effective.

Crowd movement simulation models are highly valuable for evaluating evacuation strategies by identifying the safest routes, ensuring optimal resource allocation, and facilitating scenario analysis to uncover potential bottlenecks. They also implicitly consider the impact of variables such as weather and terrain on evacuation times, informing policy and decision-making for more effective evacuation strategies.

This paper aims to assess the evacuation strategies in campsites through two case studies in southeastern France, namely Le Bois de Pins and Le Bois Fleuri (see Figure 1), which differ significantly in terms of surface area, number of occupants, evacuation mode (by private vehicle or on foot), and types of accommodation. To achieve this, crowd-modelling simulations have been performed using Pathfinder [5], which can simulate the movement of tourists within the campsite. These simulations account for a set of behavioural itineraries, including tourists grouping by family members, reaching assembly points, returning to their accommodations to pick up belongings, and then either leaving the campsite or taking their vehicles. Additionally, traffic simulations with SUMO [6] have been conducted to estimate the travel time from the campsite to a site of relative safety.

For each campsite, different evacuation scenarios have been proposed, taking into account the occupant‘s state - whether they are awake or sleeping - as well as the possibility of blocked emergency exits. Tourists were distributed according to the accommodation capacity, with a significant number of children included, given that (i)

* Email of the corresponding author: borja.rengel@efectis.com

campgrounds are often family-oriented tourist destinations and (ii) children typically have reduced travel speed (a conservative assumption). Tourist profiles have been defined based on existing data [7-9], with adjustments for reduced movement speed due to terrain irregularities and possible obstacles along the main evacuation routes.

The results reveal that, as expected, pre-movement and waiting times at various locations significantly influence the overall evacuation time. Additionally, the distance between assembly points/exits and individual plots greatly affects the total evacuation time, particularly in larger campsites. The mode of evacuation (on foot or by car) also has a substantial impact on the time required for tourists to reach a safety point. Recommendations include (i) implementing multiple assembly points well-distributed throughout the campsite or bypassing them altogether by providing key evacuation information via sirens and other means (e.g. speakers and apps), and (ii) establishing a vegetation-free safety zone near the campsite (reachable on foot) to accommodate occupants.

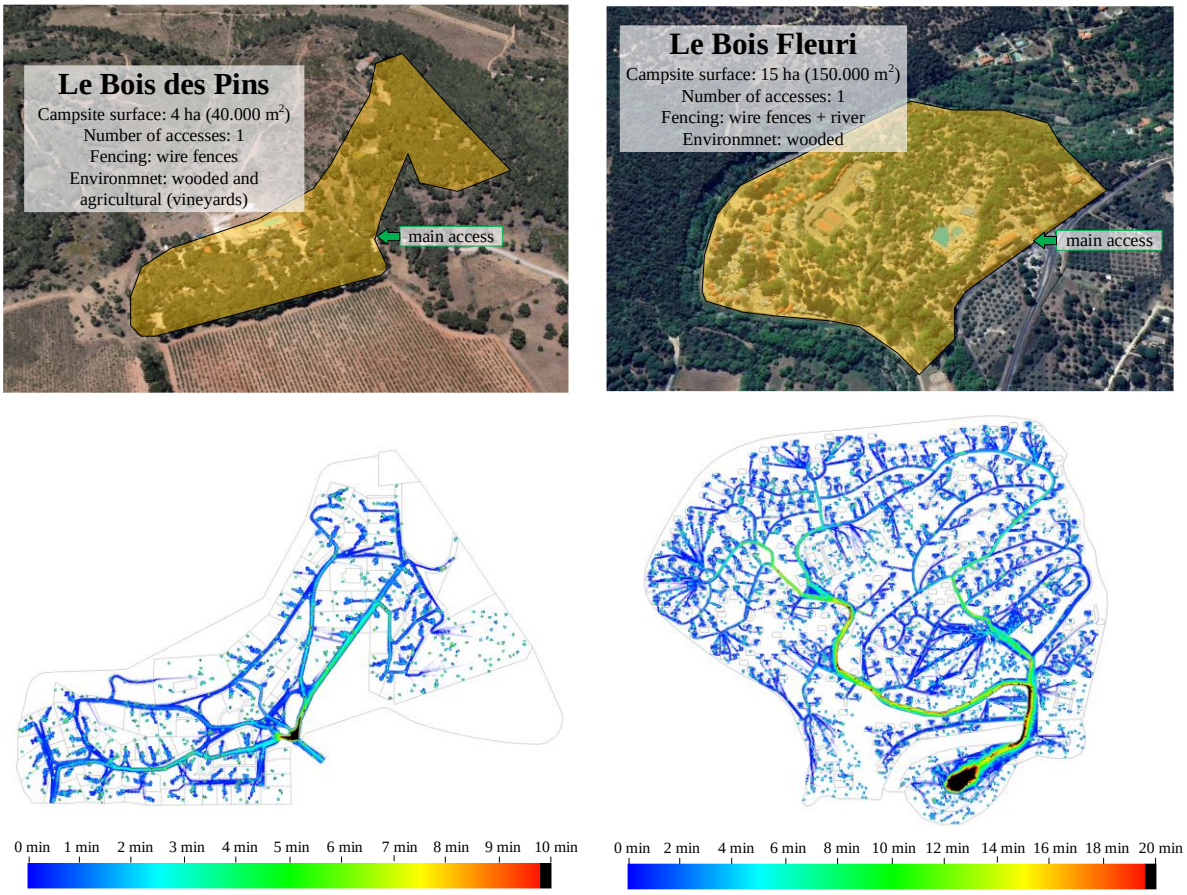

Figure 1: French campsites selected (up) and example of some Pathfinder results (down).

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