Fire Safety Journal 47 (2012) 54–61

Contents lists available at SciVerse ScienceDirect

Fire Safety Journal

journal homepage: www.elsevier.com/locate/firesaf

Field evaluation of two image-based wildland fire detection systems

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ARTICLE INFO

Article history:
Received 9 June 2011
Received in revised form
10 August 2011
Accepted 3 November 2011
Available online 21 November 2011

Keywords:
Fire detection
Forest
Camera
Field evaluation

ABSTRACT

Rapid detection of wildfire outbreaks is a critical component of fire management because suppression activities are most effective when fires are small. One method of fire detection and location is computer analysis of images from sensors mounted on towers. In this paper we report on a trial of two image-based detection systems under operational conditions in forests and pasture in south-eastern Australia. The systems were deployed for 3 months in autumn, 2010, during which time a total of 12 experimental fires, 31 planned fires lit by public land management agencies, approximately 250 planned fires lit by private individuals, and 1 unplanned fire were recorded. Both image-based systems were able to detect and locate fires. They performed well for larger planned fires but poorly for small fires (<1 ha area) at moderate distances (10–20 km). System performance was compared to a human observer for a subset of fires. For these fires the human observer had a higher detection rate and shorter reporting time than the image-based systems. All methods of detection had a similar level of error for locating fires in the landscape once they had been detected. Operator skill was an important factor in the performance of all systems. Image-based fire detection could be a useful complement to other detection methods already in use in Australia.

1. Introduction

Wildfires, or bushfires, are a major concern around the world, resulting in significant economic, ecological and social costs each year to infrastructure, ecosystems, lives and property. The earlier the outbreak of a fire is detected, the smaller it will be when the initial attack response arrives and therefore the greater the potential for the initial attack to be successful [1,2]. That is, the early detection of wildfires is critical to the success of subsequent actions to suppress them [3].

One method which can be used to detect and report fires is computer analysis of images obtained from either visible light or near infra-red sensors. Fire detection using image analysis has been an active area of research in recent years [4–10] and several commercial systems using these methods have been developed. Field studies to test detection systems have been performed in Canada [11], Greece [12], and Turkey [6,7].

These systems use "supervised detection" to report fires. That is, a human operator is required to assess images and alerts from the camera system to determine whether a fire has been observed and needs to be reported. So the potential for human error is inherent in the systems. Assessment of detection by human tower observers in Portugal found that atmospheric conditions [13], topographic roughness [13] and tower location [14] also affect likelihood of detection. Thus, the success of image-based detection systems in operational use depends not only on the performance of the detection algorithms but also on the design of the detection network and the skill of the human operators.

This paper presents the results of a field trial of two image-based systems in south-eastern Australia during March–May 2010. The aim of the trial was to measure the performance of the systems in an operational context. The detection systems were assessed on their ability to detect and report fires to fire managers, and on the speed and accuracy of the reports. For a subset of fires the performance of image-based detection was benchmarked against a trained and experienced tower observer.

This work was part of a project sponsored by the Australian Commonwealth Attorney General's Department to consider the feasibility of image-based detection systems [15].

2. Methods

2.1. Experimental layout

Two locations were used in the field trail: the Otway ranges in Victoria and an area centred on Bondo State Forest in New South

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doi:10.1016/j.firesaf.2011.11.001

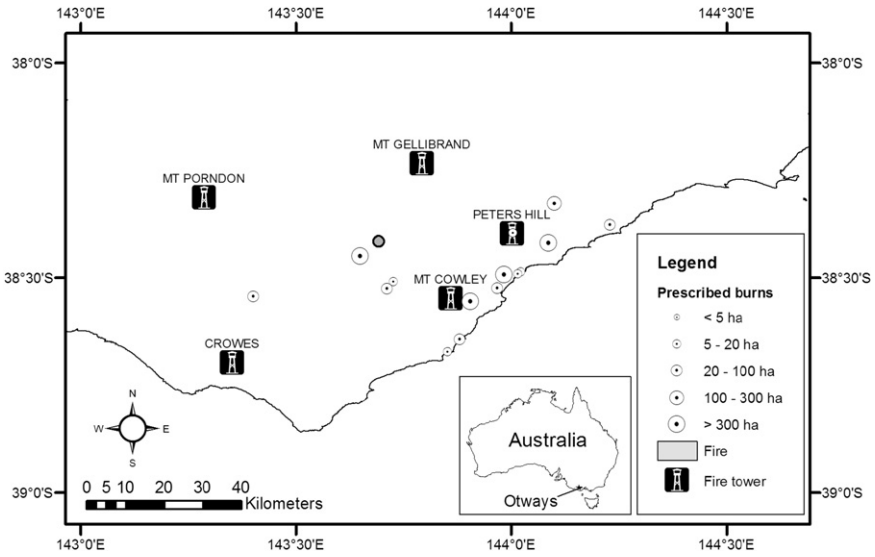

Fig. 1. Location of fire towers and fires in the Otway region of Victoria.

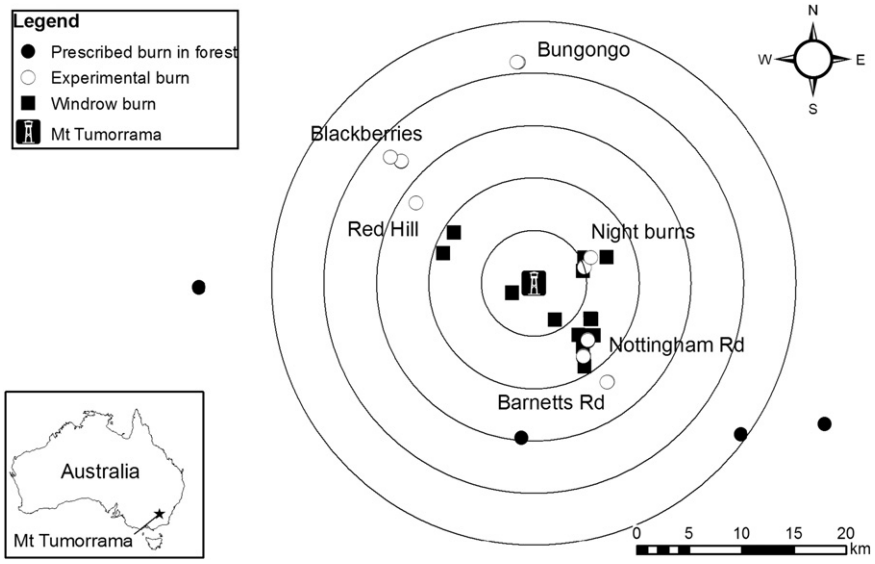

Fig. 2. Location of fires near Bondo State Forest, NSW. The fire tower is located at 148°30′E, 35°15′S. Ranging circles are at 5 km intervals. Named localities are sites of experimental fires.

Wales (NSW). The Otway ranges (Fig. 1) is a mix of native forest and private agricultural land in moderately complex topography located on the south-western coast of Victoria. Five fire towers oversee this region. The Bondo area (Fig. 2) is primarily softwood plantation, with some native forest, surrounded by private agricultural land in undulating topography on the western slopes of the Great Dividing Range. One fire tower at Mt. Tumorrama oversees this area. The trial was conducted in autumn, running from March 16th to May 9th, 2010. Operational constraints prevented the commencement of the trial during the peak fire season in summer.

2.2. Weather observations

Daily weather records were obtained from the Commonwealth Bureau of Meteorology for stations in the trial areas: Gundagai in NSW, 45 km north-west of Mt. Tumorrama, and Mt. Gellibrand in Victoria (Fig. 1). Records included daily rainfall to 9 am, minimum and maximum temperature, 3 pm relative humidity, and 3 pm wind speed covering the period May 1st, 2009 to May 9th, 2010. Keetch-Byram drought index (KBDI, a measure of seasonal rainfall deficit [16]) was calculated using a computer algorithm adapted from Bureau of Meteorology methods (K. Finkele,[1] pers. comm.).

2.3. Fires

2.3.1. Experimental fires

Three sites were established for experimental fires in forests in the Bondo region: two in native eucalypt forest at Bungongo and Barnetts Road, and a third in pine forest at Red Hill (Fig. 2). At each site existing roads and additional bulldozer lines were used to establish plots of approximately 100 m by 100 m (1 ha area). Three fires were conducted at the Bungongo site, two at Barnetts Road, and one at Red Hill. For each fire, conditions driving the fire were measured:

- Local weather conditions under the forest canopy using a 2-m automatic weather station.

[1] Dr. Klara Finkele, Research Scientist, Bureau of Meteorology.