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RURAL FIRE RESEARCH UPDATE
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Rural Firefighter Workload

This research aims to improve the health and safety of rural firefighters by determining, under New Zealand operational conditions, the physiological workload of firefighting tasks. The physiological workload of firefighters was measured by recording firefighters' heart rate and concurrently measuring the concentration of carbon monoxide (CO) in the breathing zone of the firefighter and the breathing rate of the firefighter.

The research also measured fire suppression productivity under real fire conditions to provide real data for incorporation into fire management decision support systems. The novel suite of data collection equipment developed by the research team was used to record visual, physiological and geographical information relevant to firefighting.

This update will only describe the two complete data sets to date that have collected CO in addition to heart rate and GPS location. Data collection will continue in coming fire seasons and subsequent data sets will be added for analysis.

Photograph: J. McCaughans, Aorangi Rural Fire Team.

Background

Many tasks in rural firefighting are physically demanding and result in high levels of fatigue. The firefighter's heat load and level of fatigue are influenced by complex interactions among work practices, work environment and clothing. There are no published reports measuring New Zealand rural firefighter workload other than the work by Parker et al. (2010, 2008 & 2007) and Parker (2010) done as part of the broader NZ research.

The presence of carbon monoxide (CO) will have a significant influence on physiological workload and must be taken into account in any reliable measures of physiological workload and associated productivity. CO is a colourless and odourless gas which when inhaled binds to haemoglobin in the blood and reduces the capacity for blood cells to carry oxygen. Continuous exposure to high levels of CO may therefore lead to reduced work capacity.

Productivity of initial attack crews and more specifically of fireline construction has been of interest for many years and has been the subject of numerous international studies, although few studies have actually measured productivity under real fire conditions.

This project sought to understand the physiological workload demands of rural firefighters in New Zealand, by:

1. Measuring the concentration of CO within the breathing zone of rural firefighters at real fires.
2. Combining CO measures with actual physiological workload and productivity associated with rural firefighting tasks at real fires.
3. Relating measured workload and productivity for firefighting tasks to fitness and productivity requirements.
4. Contributing to recommendations for fatigue and shift length management and productivity guidelines.

Left: Mopping up with a peat/duff probe

Middle: fire break construction using hand tools

Right: Pulling hose

Methods

This study involved monitoring firefighting tasks during wildfires. The fieldwork for this study occurred over the years 2008 to 2010. Data sources for the study were earlier versions of the instrumentation that included miniature body worn video cameras, heartrate monitoring, CO and GPS tracking sensors (Figures 1).

Rural firefighters frequently change location, work with others and undertake a range of varied tasks, so video recording was supplemented with heart rate monitoring and GPS location monitoring. In previous studies (Parker et al., 2008; Parker, 2010) the authors found firefighters had great difficulty donning and activating all the data collection sensors in an emergency situation.

Since this time, and after considerable consultation with firefighters, we moved all sensors, other than the heart rate monitor which had to remain in contact with the chest, onto the helmet (Figure 2). The video, GPS and CO data loggers were secured in pockets mounted on rural fire helmets (Pacific Helmets, Model BR1T) by the manufacturer. All modifications ensure the helmets continued to conform to the relevant fire helmet standard (AS/NZS 1801 Type 3). This ensemble of sensors allowed for more comprehensive monitoring of participants that were often highly mobile.

Data collection was opportunistic. Data collection ensembles were distributed to five fire crews around New Zealand. A crew member would wear the ensemble to a fire and return the ensemble for downloading of the data. Some data sets were incomplete and some data were lost. Some fire crews attended no fires while in possession of a data collection ensemble.

Figure 1. Wearable ensemble of sensors

Figure 2. Modified helmet with sensors attached

Figure 3. Monitoring activities using modified helmet

Results

Complete data sets to date have only been collected at two fires. Fire A was mopping-up with water and Fire B was a hay barn which had caught fire and subsequently collapsed when the rural fire crew arrived.

One of the reasons it is very difficult to collect data on firefighters at real fires is because it is an emergency situation, and the firefighters' priority is to suppress the fire. Therefore the instrumentation kits needs to be unobtrusive and not take time to put on or get in the way of the job being done. Clearly, the data collection had to be opportunistic because we could never be sure where a fire would occur.

Task analysis

The two firefighters were working at quite different fires and had different roles at their fires. The firefighter at Fire A was on undulating terrain and was a crew leader. He was assessing the developing situation, speaking regularly with his crew members and maintaining communication with those interacting with his crew.

In contrast, the firefighter at Fire B was a crew member and engaged almost completely with removing roofing iron and raking burning hay under very smoky conditions.

GPS

The firefighters covered remarkably long distances during the observation periods. None of the firefighters, on questioning, realised they travelled such distances in the normal course of their work. The data in this study has been used, primarily, in a qualitative way to understand where on the terrain the firefighter was positioned when they were at the fire relative to the fire and work activities being undertaken.

Left: Using knapsack sprayer

Middle: Manning the nozzle

Right: Smokey conditions during mop-up

Heart rate

Workload of the two firefighters in this study was measured by heart rate recording. It is difficult to directly compare the two firefighters in the studies presented here because they were of different ages, working in different terrain and undertaking completely different tasks. But this series of studies has shown physiologically useful data can be collected in the field at real fires under normal operational conditions (see figure 5). General observations were that heart rates were often elevated for considerable periods of time over a shift, demonstrating that firefighters are undertaking physically demanding work.

Carbon monoxide

CO occupational exposure limits are 30 ppm for an 8 hour work day, 200 ppm for 15 minutes and a peak of 400 ppm that should not be exceeded at any time.

In the current study, the firefighter mopping up with a hose was exposed to transient peaks of 30 to 50 ppm on occasions when applying water to smouldering tree stumps and roots (Figure 3). However, peaks of CO exposure of 350 ppm and 180 ppm occurred when the firefighter was working immediately beside or near a Wajax pump.

The firefighter engaged in mopping up after a hay barn fire was exposed to much higher concentrations of CO (Figure 4). In a 10 minute period he was exposed to a CO concentration in excess of 400 ppm for 4 minutes and 20 seconds.

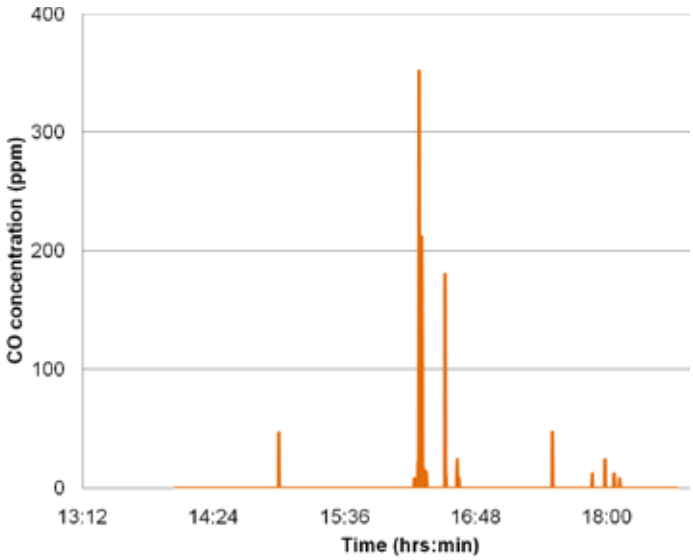

Figure 3: CO concentration exposure at Fire A

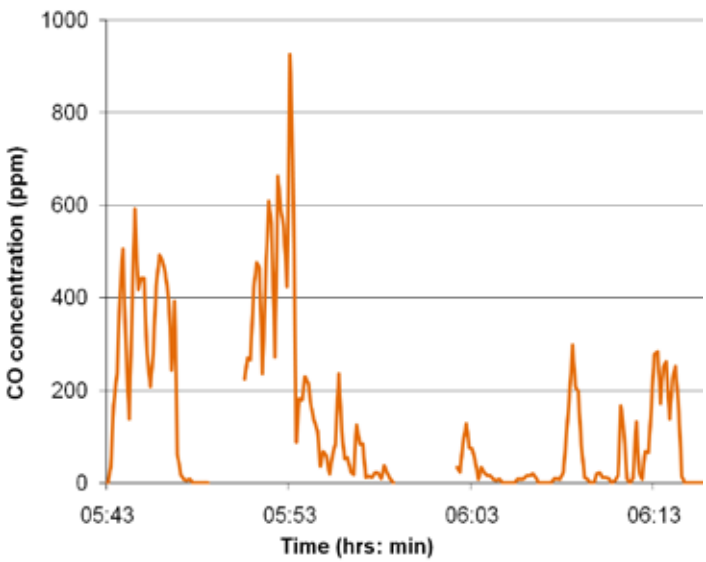

Figure 4: CO concentration exposure at Fire B

Conclusion

The objectives of the study were to:

- measure the concentration of CO within the breathing zone of rural firefighters at real fires;
- combine CO measures with actual physiological workload and productivity associated with rural firefighting tasks;
- relate measured workload and productivity for firefighting tasks to fitness and productivity requirements;
- contribute to guidelines for fatigue and shift length.

The data collected at the two fires have provided a comprehensive understanding of the work environment of the firefighters at real fires under New Zealand conditions. Over time, more data will be collected at future wildfires.

Acknowledgments

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Left: filling monsoon bucket

Middle: working with a Wajax pump

Right: rolling or “pineappling” hose

Further information

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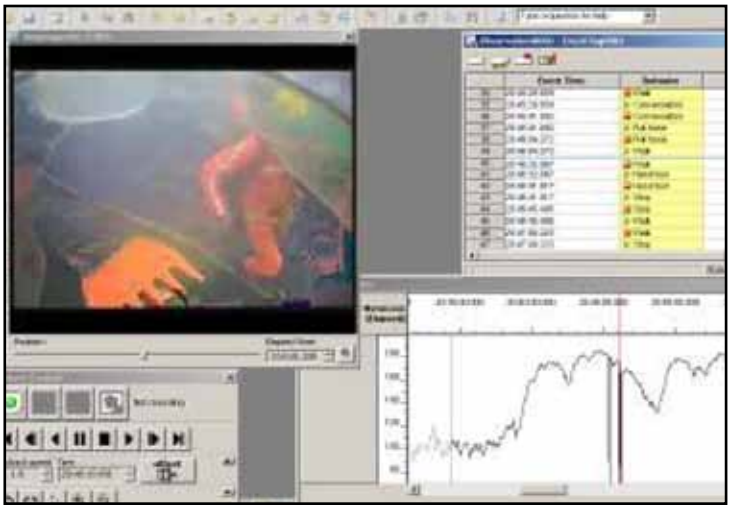

Figure 5: Observation window used to capture data. The video image is from a helmet mounted camera, tasks are displayed in the top right window and heart rate displayed at the bottom.

For more information, contact:
Scion Rural Fire Research Group
PO Box 29237, Fendalton,
Christchurch 8540
Telephone: 03-364 2949
www.scionresearch.com/fire

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