



WHAKARATONGA IWI

FIRE
EMERGENCY

NEW ZEALAND

IMPROVING SAFETY AT CONTROLLED BURNS THROUGH LAND MANAGER KNOWLEDGE AND PRACTICES

Scion

September 2018

Fire and Emergency identified a need to better understand how the existing knowledge and awareness of fire behaviour translates into practices when conducting a controlled burn. Three recent fatalities, and a number of reported injuries occurring when undertaking controlled burns, have motivated the call for this research.

The aim of this research was to better equip Fire and Emergency and key stakeholders to produce safe burning practice guidelines and training for the use of fire by land managers.



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Improving safety at controlled burns through land manager knowledge and practices

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Improved safety at controlled burns through land manager knowledge and practices

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31 July 2018

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Executive summary

Purpose

Despite a number of studies investigating safe practices and lessons learned to reduce risks from prescribed fire and fire suppression activities by firefighters, there is limited knowledge on what actions lead to injury and fatality during farmer controlled burn-offs. Fire and Emergency New Zealand (Fire and Emergency) have a lack of adequate insight into how land managers approach controlled burns, and in particular whether information provided to improve safety is practised at the farm level.

In response to the need, this report identifies actions taken by farmers to reduce the risk of injury to themselves and their staff, as well as retrospectively assessing the actions that contributed to injury and death of rural personnel when using fire.

Methods

This project has:

- Compiled and analysed known incidents, including four detailed cases, to assess actions taken that contributed to fatality or injury.
- Surveyed land managers to determine the usefulness of the information provided when a fire permit is issued, and whether this information is considered in the approach taken by land managers during a controlled burn.
- From interviews with those experienced in high country burning, examined common practice when undertaking a controlled burn.

Key findings

New Zealand does not have a definitive database of fatalities, injuries, and near miss events from use of fire on farms to remove vegetation. Most of the known incidents are from anecdotal accounts or newspaper reporting. Our research has compiled from both official and unofficial records a list of known rural fire incidents since 1878, resulting in 68 serious harm injuries, 38 fatalities and 72 persons involved in incidents but uninjured.

Aside from verbal advice and visitations from a Rural Fire Officer (RFO), very little information made available to farmers was used by farmers to ensure they were burning safely and effectively. In most cases, it appears that burn plans and permit conditions are the only formal written information most farmers consult before lighting. The onsite engagement by the RFOs is most critical in the exchange of knowledge around safe burning practices, with evidence that farmers are both listening to and responding to RFO advice. Farmers conducting permitted burns were confident in their abilities to conduct burns safely.

The larger issue is in transmitting pre-existing knowledge to farmers and instilling good working methods, rather than redevelopment of safe work methods.

Very few farmers (around 10%) we spoke with were aware of the term LACES. While experienced high country burners use most elements of LACES, knowledge of LACES within the wider farming community appears inadequate.

From the available descriptions and reports of known incidents, the most common contributing factors were due to entrapment and working alone. Arms, hands and face/ head appear to be the most likely body parts burned.

The major contributing factors that led to farmer injury or fatality were:

- Lack of preparation -
 - no safety zones identified or escape routes
 - opportunistic burning of small areas
- Communication failure
 - working alone
 - not following the plan
 - no cellphone or radio coverage
- Being in the wrong place
 - Positioning uphill of fire
 - Positioning in unburnt fuel
 - Entering gullies and lighting
- Trying to extinguish a fire or rescue animals
- Equipment failure or accident
 - Use of liquid fuels (drip or leak)
 - Inadequate or unsuitable clothing
 - Helicopter or appliance accidents
 - Not carrying a wet sack or hand tool
 - Leaving radio or equipment on the farm bike/ ute

Recommendations

From these findings, we recommend the following:

1. **Database of rural farm-based incidents.** In updating the Fire Incident Reporting Management System, ensure that aspects of human decision making and human action are included alongside aspects such as terrain, fuels, weather and fire behaviour as contributing factors recorded for farm burn offs, and that the database is examined regularly to discover common denominators and lessons learned.
2. **Standardise the wording in permit conditions.** Currently, fire permit conditions differ throughout the country; however some conditions are common to all regions. The wording of these could be standardised to reduce confusion.
3. **Provide practical information to farmers on how to conduct a burn safely and effectively.** “A Landowners Guide to Land Clearing by Prescribed Burning” is not pitched to the farming community. Farmers require simple and practical tools or demonstrations with which to improve safety when undertaking controlled burning.
4. **Working with Federated Farmers, empower RFOs to undertake knowledge extension on safe and effective practice within their farming communities.**
5. That Fire and Emergency **places greater emphasis on communicating with farmers the main contributing factors of injury** when conducting controlled burns, in particular:
 - Situational awareness, including identification of safe zones and escape routes.
 - Preparedness and safe equipment (Adequate clothing and non-drip/non-spray fuels).
 - Not working with fire independently of others, or on your own.
 - Awareness of risks from smoke inhalation, delayed medical intervention, and shock.
 - Identifying alternatives to burning on foot in more dangerous terrain or heavy fuel (e.g. gullies or thick vegetation).

Introduction

Project Brief

Fire and Emergency New Zealand (Fire and Emergency) identified a need to address the lack of adequate knowledge surrounding how land managers in New Zealand approach a controlled burn off procedure. In particular, the organization needs to better understand how the current level of knowledge and awareness of fire behavior translates into practices undertaken during a controlled burn. Three recent fatalities, in conjunction with a number of reported injuries due to undertaking controlled burns, have motivated the call for this research.

While fire behavior and environmental factors are similar between fire fighter suppression and farmer controlled burn-offs, in the latter, the farmer is attempting to use the fire to control vegetation, and thus encouraging fire spread through vegetation, rather than to suppress fire from spreading. This report addresses the Fire and Emergency objective of better understanding the approach and practices of those managing and participating in controlled burns. It includes an examination of the current state of land manager knowledge regarding approaches to land clearing burns, and identifies the risk factors from recent fatalities and 'near-miss' injuries at controlled burns.

Aims and objectives

The aim of the research is to better equip Fire and Emergency and key stakeholders involved in producing safe burning practice guidelines and training around the use of fire with land managers. The objectives include:

- identify actions (practices followed) taken at controlled burns that resulted in fatalities;
- understand the considerations made when conducting controlled burning from the perspective of land managers;
- assess the level of knowledge and experience of fire behavior within the rural land manager community, and the suitability of current safe practice guidelines for this audience; and,
- provide guidance to relevant stakeholders and authorities within Fire and Emergency and rural fire districts, charged with reducing the number of serious injuries from fire in rural communities.

Rural fire injury and fatality statistics

There does not appear to be a definitive nor official database of recorded injuries and fatalities from vegetation fire incidents in New Zealand.

Statistics from ACC due to claims for injury or death due to fire on farms show that the number of fatalities is very low. An average of 122 ACC claims for fatalities on farms were made per annum from Jun 2012 to Jun 2017. Of these, between 0 and 3 per annum were caused from fire.

A breakdown of claims for burn injuries from fires on farms by region, age and gender shows:

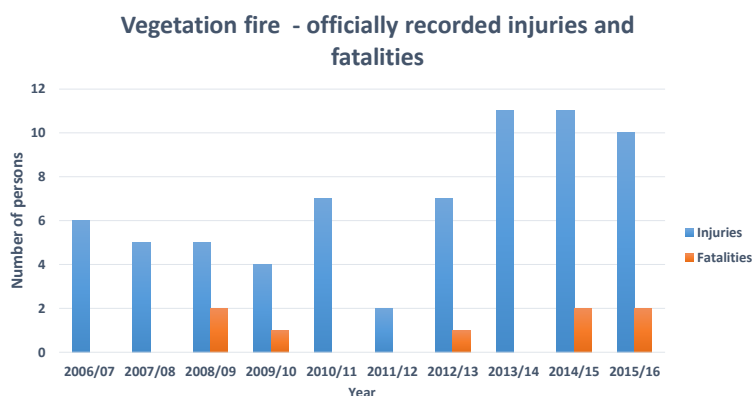
- Nearly all injuries and fatalities were to males
- Those aged between 30 and 70 years old received the largest claim values
- The values of claims were greatest from the Waikato, Canterbury and Otago regions.

This corresponds to the usual farming workforce age groups and gender, as well as claims from regions that are largely agricultural. A majority of rural burning occurs in the Otago and Canterbury regions. Southland and Taranaki regions, which alongside Waikato, also have a lot of agricultural industry, did not have large claims.

Worksafe New Zealand investigated a total of 10 incidents during 2016/17 that were due to fire (implosion, explosion or fire) in the agricultural or forestry sector, but no further breakdown into details surrounding the incidents are provided.

It is also important to distinguish the level of risk between different types of fire use. While high country burn-off practices in New Zealand have recorded and anecdotal incidents of both injury and fatality, we were unable to find any known incidents involving crop stubble burning, beyond slight burns to the hand due to ignition injury. Similarly, very few injuries were reported involving pile burning, with no known fatalities.

Fire and Emergency have also made publically available some statistics on rural fire injuries and fatalities (Fig 1).

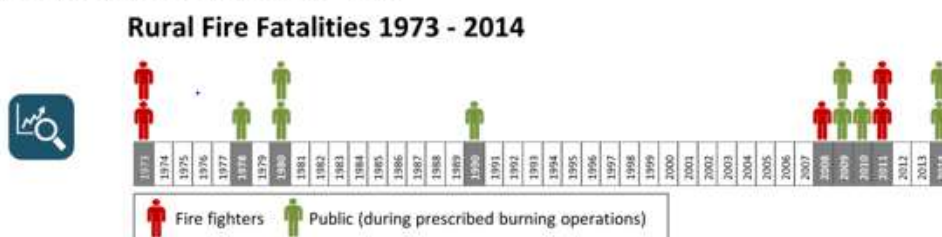


Source: FENZ Incident Statistics for NZ 1 July 2006 – 30 June 2016. OIA2017 Request # 4076 by Saskia Holditch – available from fyi.org.nz

Figure 1: Official statistics on injury and fatalities from vegetation fire in New Zealand 2006-2016, Provided under Official Information Request # 4076.

Rural fire fatalities, broken down by farmer or fire fighter are also provided within the NZ Fire Services (NZFS) Review Discussion data from May 2015 (DIA, 2015) (Fig 2). However these figures do not agree with the official statistics as above (Fig 1), possibly due to the inclusion of different fire types and vehicle accidents etc. (i.e. not just from vegetation fire) in the rural fire fatality statistics. The NZFS incident reporting system of firefighter injuries has provided a list of occurrences, but little in detail about the factors contributing to the fire. This makes it difficult to compare between the two groups.

Figure 8: Rural fire fatalities 1973 - 2014



Source: DIA, 2015 Fire Services Review Discussion Document, May 2015

Figure 2: Rural Fire fatalities 1973 -2014 highlighting farmer deaths (in green)

Materials and methods

A: Compiling and analysing a database of known incidents

Statistics concerning death and injury due to fire on farms and from agricultural practices were compiled from Fire and Emergency, and the Worksafe NZ and ACC online databases.

A previous report, Millman (1993), along with a conference presentation by Millman (2000) outline a number of incidents and their causes in a table format.

Incidents identified from newspaper reports prior to 1945, and from the United Fire Brigades Association database of firefighter incidents, were cross-checked against the two tables of injuries and near misses from Millman (1993). In addition, other historical known incidents from research reports, databases and recent newspaper articles were added.

Twenty six incidents contained more detailed reported facts or eye witness accounts. All known rural fire incidents on farms were then analysed for common contributing factors leading to death, injury, or near miss.

Four cases of fire incidents involving farmers, for which there is quite detailed information on the circumstances (a fire investigator report, interview with the victim, or court reports), were selected as cases to be analysed in greater depth. These cases involved:

1. *Farmer burned when knapsack spray unit leaked, igniting trousers. Burns to right calf.*
2. *Farmer entrapment due to extremely dry fuels, wind change, and lack of planning. Body severely burned.*
3. *Fatality from a burnover due to farm scrub fire*
4. *Fatality caused by farmer overcome by smoke in a gully fire*

B: Review of permitting process and assessment of information provided to land managers

Information review

The Principal Rural Fire Officers for the districts in each region of the new Fire and Emergency structure were contacted by email requesting how permits are issued, and if information brochures are sent with permits in their regions.

This information was tabulated into an overview spreadsheet describing the permit process and information provided by region and district, as well as an assessment in terms of whether information is provided about: fire behaviour; actions farmers can take to keep safe; legal requirements and conditions for burning; and levels of ambiguity within the information.

Knowledge exchanged with farmers

A short interview (approximately 10 minutes) was conducted by phone with thirty one land managers recently receiving a permit. The interviews probed their need for a permit, how the permit was sought and delivered; the information provided by the RFA and the level of attention paid to written versus verbal information; knowledge around safe practices (including awareness of LACES – Lookouts; Anchor points/Awareness; Communication;

Escape Routes; and Safety zones); and the steps taken to ensure the burn was conducted in a safe manner.

C. Determining behaviours that impact on farmer safety at controlled burns

Interviews with land managers experienced in high country controlled burns

A further series of 'expert' interviews were conducted with six high country land managers and two Federated Farmer representatives, all known to be very experienced in conducting controlled burns. During these interviews, respondents were asked to identify hazards associated with burnoffs, and procedures they undertake to ensure safe burning practice.

These telephone interviews were semi structured, in an informal dialogue format (discussion), using the following question structure:

- What are the hazards that you have to deal with when burning?
- How do you manage for these/ how do you do the job safely and effectively?
- What are you usually burning (vegetation) and how do you light the fires (ignition tools and patterns)?
- What would make the job safer?
- Have you ever had an unexpected situation occur when conducting a burn?
- What about a near miss or anyone injured? What happened...
- Do you know of anyone else that had an unexpected situation / near miss/ injury? What happened...
- Who else should we talk to?

Further questions pertaining to their particular situation were used to probe further. Interviews took an average of 45 minutes per respondent.

Results and discussion

PART A: A compilation of known rural fire incidents and their causes

Known rural fire incidents in NZ involving farm workers and /or vegetation fire

Millman (1993) undertook a national survey of attendees at the Advanced Fire Behaviour Refresher Course, requesting them to complete incident report forms of known incidents under three categories:

- fatality fire
- “near miss” incident resulting in an injury
- “near miss” incident without injury

Working off Millman’s (1993) initial list, and an excel spreadsheet provided by Fire and Emergency of known rural fire incidents, these were cross referenced against media reports, data from past Scion and Fire and Emergency fire investigations, and anecdotal incidents provided from the interviews. This revealed, since 1878 (refer Fig 3):

- 38 known fatalities;
- 68 serious harm injuries; and,
- 72 persons involved in incidents but uninjured.

Only two RFOs could provide the contact details of farmers known to have had a past fire incident. One was willing to discuss their incident, and was subsequently interviewed.

Our study concurs with Millman’s (1993) finding that “much of the information on injuries at vegetation fires in New Zealand is anecdotal”, with very few incidents on record. Along with the two recent farmer fatalities from 2014 (in Cromwell and Hurunui), a further ten incidents were recalled as a result of conducting interviews with the ‘expert’ farmers and through contacting fire managers, of which six were not officially reported. There is not presently a definitive nor official database of injuries and fatalities that can be studied, although the new incident reporting systems under Fire and Emergency is likely to address this going forward, so that future incidents will be categorized. Our study provides a more comprehensive list of known incidents covering 1878-present, with many attributed to fire runs, working alone and helicopter crashes.

PART B: Analysis of farmer actions that led to safety incidents

Actions taken by farmers that resulted in injury and fatalities

Due to the level of information available concerning the incident, four incidents leading to injury or fatality were selected as case studies to determine contributory actions. In all cases interviews undertaken with either the person involved or witness(es) to the event were available, and a fire investigation report was also available for each of the first three cases. The court report from Case 1 also provided additional details of the incident:

Case 1: A fatality near Cromwell (2014)

Case 2: A fatality in the Hurunui (2014)

Case 3: A serious injury in the Rakaia (1995)

Case 4: An injury involving leaking from a ‘Solo’ backpack spray unit

Details of contributing actions from these four case studies can be found in [Appendix A](#).

Total NZ persons involved in rural fire fatalities, injuries and near miss without injury

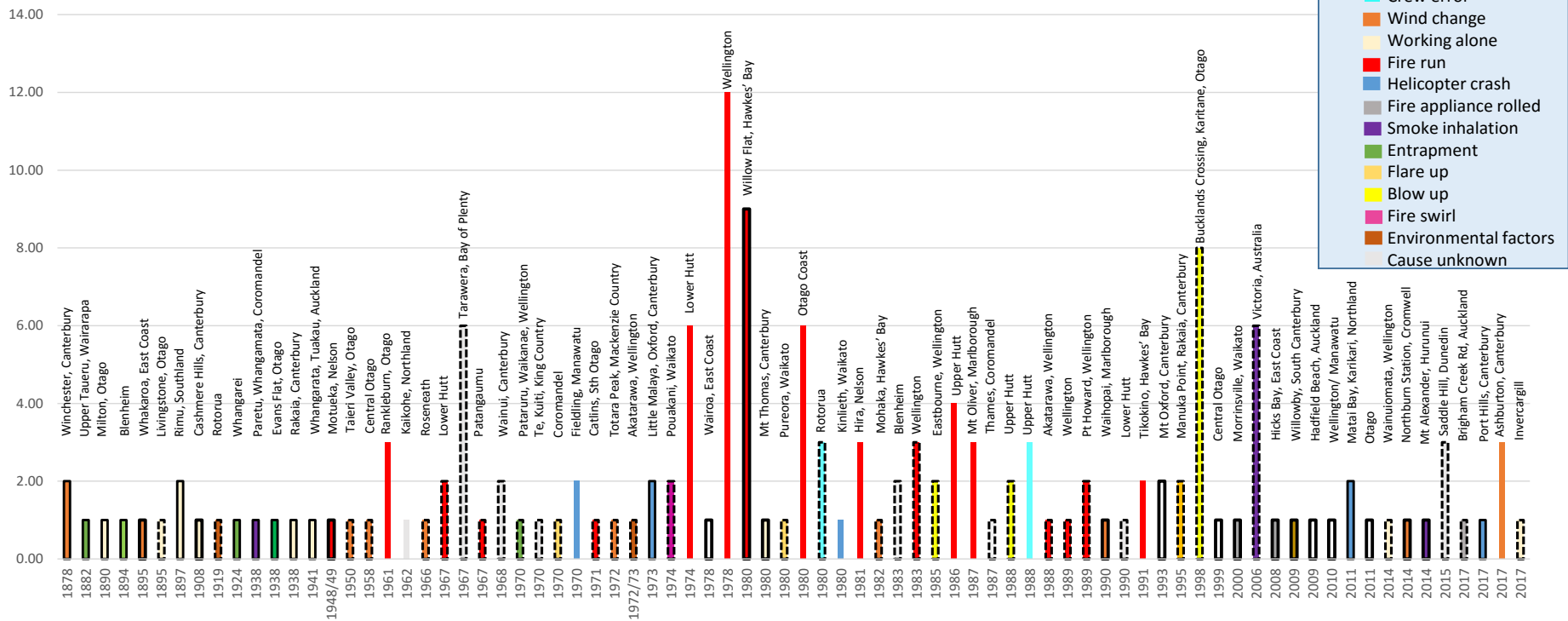


Figure 3: Known New Zealand rural fire incidents since 1878, by contributing factor, location, number of persons involved and outcome

General contributing factors leading to injury or fatality

From the available descriptions and reports of known incidents, the most common contributing factors were due to lack of escape (burnover) and working alone (Table 1). At times this was compounded by a wind change that altered the fire’s course so that it either cut off access to the escape route, or meant that the fire ran too fast for them to reach the escape zone. Arms, hands and face/ head appear to be the most likely body parts burned.

Table 1: Contributing factors to injury and body parts burned as a result of incident

Contributing factors	Number of incidents	Burn injuries	Number of incidents
Burned over by fire/trapped	7	Arms	8
Working alone	7	Hands	6
Wind change	6	Face	6
Unsuitable clothing for task	6	Torso	4
No identified safe zone	5	Legs	3
Working in steep gully	5	Mouth	1
Trying to extinguish fire	5	Eyes	1
Overcome by smoke	5	Neck	1
Unexpected fire behaviour	4		
Working uphill of fire	4		
Lost communication	3		
Delayed medical assistance	2		
Fire crossed firebreak	2		
Use of flammable chemical	2		
Tripped over	2		

Actions that were common to multiple known incidents

The following actions were identified from 26 incidents where details on the conditions and actions taken by persons involved are available (see [Appendix B](#)). It is important to note that these more detailed examples represent only around 15% of all the known rural fire incidents (including wildfires and fire-fighting incidents) we have compiled, and they include only those occurring on farms:

- **Opportunistic burning** – In three incidents, the farmer was not intending to burn on the day, but felt they would undertake burning when they assessed the vegetation and felt conditions were suitable to burn. In all three cases this occurred later in the afternoon, in two cases as the farmer was returning back to the house. All three expected to conduct a simple burnoff on a small patch of land. In one case the farmer was burning to create a fenceline, in another case the farmer was tidying up an area of firebreak in preparation for a major burn.
- **Not following the plan** – In a news report of the recent fatality in Hurunui in 2014 the deceased man was “Miles off the track he was supposed to be”. An incident involving fire fighters at Willow Flat (1980) saw six of the crew fleeing via the pre-planned escape route to a safety zone while three did not follow this plan and instead ran downhill towards the creek.
- **Working alone** – The majority of earlier fire incidents (pre 1950) indicate that farmers were not working in the company of others. Both recent farmer fatal incidents in 2014,

while involving multiple persons in the operation, saw individuals working independently of each other. The Cromwell incident saw the two men that were lighting separate and lost sight of each other. The situation was compounded by reliance on cellphones, though reception was patchy, and by not having a lookout. The Hurunui fatality had a similar pattern of independently lighting up on different slopes, reliance on radio communication when out of sight, and while one of the people did act as a lookout at times, using binoculars, he was also carrying out concurrent spraying operations on another part of the farm.

- Communications failure – Both the 2014 fatalities relied on radios or cellphone communication, which failed. Despite this, it is interesting to note that our ‘experts’ placed little emphasis on the need for operable communication devices, mostly as they liked to work within sight of each other. It was also noted that sometimes radios are left behind in utes and on bikes, therefore rendering them useless.
- Placing themselves uphill of fire on a slope – Placing oneself uphill of fire on a slope, especially with unburned fuel between, is a well-known potential danger. Four incidents (including a near miss) could be attributed to this action. In all cases the fire began to burn uphill towards them as the result of a wind change.
- Getting trapped within a gully – In over half the seven incidents, the farmers were likely overcome by smoke before they were burned over. In four incidents, the gully also contained thick scrub material. The majority were trapped near the base of the gully. All but three ended in a fatality (two walked out but later died). The four people that managed to walk away from the fire had all sought shelter from the flames: one lay in a small depression due to pig rooting; and two lay face down in small waterways.
- Trying to extinguish fire – In three cases, people attempted to extinguish a small vegetation fire, all three trying to stop it spreading into neighbouring heavier fuels, and were burned in the process.
- Injured while saving animal or child from fire – There are two cases where farmers were injured (one from burns, one to smoke inhalation) while trying to save their animals from fire. In 1878, a mother attempting a burnoff while caring for a young child was injured while trying to save the child.
- Tripped and fell into burning material – Two instances of farmers tripping into burning material. In one instance, this was while trying to beat out flames, so reduced visibility was possibly a factor. The other instance had a farmer wearing gumboots at a larger pile fire and tripping into embers.
- Use of knapsack spray unit - Using ‘Solo’ spray units with an adapted flamethrower to burn roots and woody scrub, and the attachment is cheap and easily obtained¹. In the US, recent firefighter lower leg injury reports show one incident per year is due to dripping fuels igniting (mostly from a leaking drip torch). In addition, firefighters have noted the ‘telltale signs’ of small yellow patches on the lower legs of Nomex overalls where the oily drips have stained the material (Wildlife Lessons Center, 2014).

¹ An engineering firm has [these attachments for sale](#) at RRP \$NZ171.00.

Pearce et al. (2004) lists a set of six “common denominators” found to contribute to fire behavior in fatal and ‘near-hit’ fires:

- Most incidents occur on small fires or on isolated sectors of a larger fire
- Flare-ups generally occur in light, flashy fuels
- Most fires seem innocent before unexpected wind change (speed or direction) result in flare-ups.
- Sometimes incidents occur in mop-up stage
- Fires respond to topography, running rapidly uphill on a steep slope
- Helicopters and air tankers can adversely affect fire behavior – blasts of air can cause flare-ups.

Millman (2000) notes eight key contributors to injuries and fatalities in New Zealand prior to 2000:

- Rapid fire development
- Change in wind direction/ sudden wind shift
- Unexpected fire behavior
- Being caught uphill of fire
- Being trapped/ caught in burnover
- Strong winds/ unstable weather patterns
- Rugged or broken terrain
- Fire on slope

From our analysis, the following could be added as additional contributing risk factors to rural fire injuries and fatalities in New Zealand:

- **Working alone.** The advantages of working together mean that if someone does catch alight, or is in danger, this is both able to be noticed by others; and those not affected can help keep the situation calm and raise the alarm.
- **Delayed medical assistance.** In two incidents, receiving prompt medical assistance was a contributing factor in preventing death. Burn injuries may seem minor at first, but the injury can continue to develop and must be cooled and treated urgently. Similarly, smoke inhalation may not show as physical respiratory injury immediately but can develop into inflammation and even pneumonia up to 36 hours after exposure.
- **Entering gullies and lighting.** Due to the difficulty to predict where the fire will go, the risk of oxygen deprivation (due to the swirling fire removing all available oxygen), and the limited opportunities for safety zones or maintaining escape routes. One interviewee stated: “People get themselves into positions I wouldn’t have gone into”.
- **Trying to extinguish a fire.** Five incidents of injury occurred when people attempted to extinguish what was initially a small fire. One RFO we spoke with stated there is often a statement in the permit conditions of preventing a fire from spreading into neighbouring lands. However trying to extinguish the fire when ill equipped may be putting people in greater danger than having the fire escape.
- **Unsuitable clothing or equipment.** Several severe injuries are due to unsuitable clothing, and the poor choice of equipment. For example, farmers may not be aware of the dangers present in using knapsack spray units converted as flamethrowers.

PART C: Review of information available to farmers to improve safety when undertaking controlled burning

Information provided to land managers

Information received through the permitting process

In Region 5, the permit application was followed up with at least a phone call from the Rural Fire Officer (RFO), or a visit to the property, mostly to discuss the parameters around conducting the burn (i.e. to write a burn plan). The majority of the burn plans required were created during the visit from the RFO, and submitted with the application. In a few cases the permits were granted over the phone rather than visiting.

None of the respondents could recall any information provided over and above the verbal advice and visitations, and the permit with its conditions. Some did however state that they were referred by staff to the website as a follow-up. It appears that in addition to the burn plan and permitting conditions, very little other written information is sought or used by the rural community for many of the burns conducted. Even the permit itself may not be referred to – 25% of respondents from Region 5 made statements that suggested they had not read the permit conditions/opened the envelope/opened the email associated with the permit.

In Nelson region, all respondents were conducting pile burning. This district issues a permit number to a property, and the permit is renewed over the phone for a short period (3-4 weeks at a time) as required for land managers to conduct their burning throughout the year. Some respondents remembered receiving a short booklet or brochure the first time they had applied for a fire permit, although respondents did not receive updated information when renewing the permit.

The Chatham Islands conduct a site visit as a matter of course in the permitting process, while other RFAs indicated they would visit only when they considered this necessary and, in some cases (where a strong relationship of trust exists with the land manager, or they know they are well experienced in safe fire practice), would simply have a conversation over the phone before issuing a permit.

Some RFAs did indicate that they may provide brochures to those applying for a permit, on specific aspects depending on the type of fire, (such as Firesafe properties, the 10 Standard Firefighting Orders, a sheet on LACES, etc.). Permit conditions are very different across all regions, and even between different permitting authorities within the new Fire and Emergency regions. Despite this, there are a number of common elements that are present across the majority of permit condition lists. These include:

- Ensuring compliance with the Forest and Rural Fires Act 1977
- Keeping fires a certain distance from boundaries and/or structures
- Not lighting in windy conditions, or if the weather is unsuitable
- Checking the fire season is not in 'prohibited' before conducting the burn
- Notifying neighbours (and others as required) prior to conducting the burn
- Extinguishing the fire completely
- Showing the permit to any authorities that request it
- Maintaining adequate supervision of the fire at all times
- Having a means to extinguish the fire if needed
- Not creating a smoke nuisance / keeping fire effects inside the property boundary
- That a permit does not excuse the holder from liabilities of escape

Note that although these elements are common to many permits, they are each worded differently for each issuing authority. This can cause confusion, particularly when land managers move to a new region.

Depth of information available

At the time of reviewing the information (July and August 2017), a large range of information types in terms of best practice in rural fire were available to land managers. Information provision at the time was through the local RFA. Some authorities did little more than refer the inquirer to the RFA/ Fire and Emergency website, while other authorities provided a suite of online custom-written information for different situations and local conditions, in an easily downloadable format (refer [Appendix C](#)).

Alongside the National Rural Fire Authority (NRFA) publication “A Landowners Guide to Land Clearing by Prescribed Burning”, the following were very good examples of safe practice brochures and guidelines:

- Otago RFA “Health and Safety manual”; and the “10 standard vegetation fire orders”
- Marlborough-Kaikoura RFA “Safety and Wellbeing commitment” page
- Tasman District Council “Good practice to outdoor burning”

Pumicelands, Auckland RFA and Southern Rural Fire all had very comprehensive websites with much information on both fire behaviour and safe burning practices.

Many prescribed fire guidelines are available internationally, but the majority outline technical fire behaviour and best practice in conducting a burn, rather than having a dedicated focus on safety. There are, however, some excellent short guides, mostly from US State Universities, that outline how particularly private land managers can keep themselves and others safe during burning:

- The Sandhills Land Trust (US) provides an [online checklist](#) for safety prior to burning
- Iowa State University (US) provide a [checklist](#) for planning, preparation, and on the day, along with a burn template. They also provide an excellent [booklet](#) around safety equipment you can obtain – PPE; firefighting hand tools; and machinery for cutting firebreaks.
- Kansas State University (US) have an excellent [guide on safety](#), including personal and public safety. They particularly focus on PPE, public notifications and smoke management.
- North Carolina State University (US) have a [website](#) that outlines LCES and PPE. They have a few factors that are not often noted, such as the need to keep yourself hydrated, and ends with a warning around complacency due to previous history of successful burns.
- Duke Energy (US) have a very good short [brochure](#) on safety around powerlines during prescribed burning.
- Teagasc (Ireland) has a [Code of Practice](#) and Prescribed burning guidelines that include chapters on LACES and have appendices for human hazard risk assessment, and a burn plan template.

These resources should form the basis for some national-level guidelines.

PART D: Current state of land manager knowledge concerning fire behavior and best practices for controlled burns

Knowledge of LACES

Only three of the 31 farming respondents we interviewed had heard of the term LACES. However, on explaining the acronym a further two stated this was their standard health and safety practice, but they did not term it that way. One permit holder we interviewed was clearly supplied with the LACES framework and 10 standard fire orders (the Pink card), but could not recall this information. When respondents were asked what measures were taken to ensure the burn was conducted in a safe manner, various elements of LACES were stated, though very few cited all five elements. The most common element stated was communication (39%), with most using handheld radios. Safe zones and escape routes were each mentioned by 20% of respondents; with 10% stating they used a spotter or lookout. Only one respondent mentioned anchor points, and this was in relation to a large forestry fire.

Following the death of a worker in 2016 where “a worker with no experience of burn-offs was sent into an area of dry vegetation in a steep gully, with effectively no escape routes to a safe zone, and was trapped, being "engulfed" by fire after the wind changed direction” the prosecution cited LACES procedure. However, the defense lawyer “accepted the LACES fire plan might have been well-known among rural firefighters as best practice but it was not well-known within the rural community” (ODT, 2016). Our findings would support the defense lawyer statement.

Very few authority websites and permits explicitly mention LACES, and only one website was found which outlined what the acronym stood for and how to apply this to rural burning. The brochure “A Landowners Guide to Land Clearing by Prescribed Burning” from the NRFA refers to LACES but frustratingly it has no in-depth description as to what this means, or how to apply LACES in practical terms.

While one respondent stated they did not use LACES, they did use SMEACC as a pre-burn communicative briefing tool. SMEACC stands for: Situation, Mission, Execution, Administration, Command and Communication.

Information such as LACES must become embedded within the context that has meaning to the recipient, in this case land managers and farmers (Dunningham et al., 2015).

Fire-safe behaviours and approaches taken by farmers

All respondents mentioned the need to ensure the conditions were suitable before lighting, and stated they were aware of the weather conditions in their local area under which fire could become dangerous. Most of those undertaking large land clearing burns stated that burn plans were now a part of the Health and Safety requirements for their farm operation. Following a fatality from a burn-off in October 2014, Worksafe NZ issued a safety alert, highlighting the need for planning when conducting a burn, and effective communications². The alert also directed readers to the Worksafe guidelines for farmer workplace health and safety, as well as the NRFA publication “Working safely at vegetation fires”³. Although farms are now required to identify and manage hazards (which would include burn plans and fire hazard management if conducting controlled burns) Worksafe estimate 20% of farms still fail to have required Health and Safety procedures in place.

² <http://www.worksafe.govt.nz/worksafe/news/alerts/controlled-burn-offs>

³ <http://www.nrfa.org.nz/training%20materials/3285%20study%20guide.pdf>

Two respondents significantly altered the way they had initially planned to undertake the burn following advice from the RFO. In one case this involved the direction of burn (uphill versus downhill) and the light-up patterns; in the other case this involved the time of day to ensure a good burn with minimal dew present.

Other actions taken to keep family, staff and the public safe were notifying neighbours and the fire authority, and also the airlines where smoke drift might emerge from a large scale burn. Thirty three per cent spoke of firebreaks, and 39% mentioned water reserves – either tankers, large reservoirs, helicopter and monsoon bucket on standby, or natural boundaries and creeks. Two respondents had moved to lighting using helicopters due to safety and escape risk, but also used a small ground crew for support. Having signage around major roads to warn traffic of upcoming smoke danger, communicating with the RFO on the day of the fire and ensuring everyone involved was in the correct position prior to lighting were also cited as measures taken for keeping people safe.

Farmer confidence in the use of fire as a tool

Farmers conducting permitted burns were, however, confident of their abilities to conduct the burn safely, or had become confident enough through the process of discussions with the RFO and/or discussions with other trained and experienced persons. This agrees with the findings of our national survey (Clifford et al., 2016) which found 39% stating they were “very confident” in their ability to conduct a controlled burn, and felt that there were adequate guidelines in place. This was especially true for those who had burned off recently (within two years), who also felt they were adequately informed about safe practices with fire. The survey found those who had not burned in the past decade felt significantly less confident in using fire and didn’t feel adequately informed. These also tended to be the younger farmers. With fewer land clearance burns conducted, and less area burned per annum, the level of knowledge is possibly waning, especially amongst those not burning very regularly.

Opinions differ between farmers and the RFOs around the level of knowledge and how adequate this is. One fire officer stated he felt only “1 in 50” of those he issued permits to had sufficient and capable knowledge of fire behaviour. Most of the high country farmers we spoke with, however, cited they had many years of experience and had very few fires that escaped, if any. In contrast, one ‘expert’ farmer spoke of his reliance on tacit experience to ‘read’ a fire and also to know how to respond when conditions changed. He felt that younger members of the farming community may not have the depth of experience to read a situation quickly and take action, instead they are relying on rigid burn plans rather than noting the fire’s behaviour. Two respondents stated they felt there was inadequate personal knowledge in the farming community around safe practices with fire, with too many still relying solely on the Rural Fire Officer to ensure safe practices at their burn.

From a recent national survey of fire use in the rural sector as a land management tool, the majority of land clearing burns undertaken were to clear under 50 ha of vegetation. The survey (Clifford et al, 2016) also found that only around half of controlled burns for land clearance (i.e., not piles) had obtained a permit to undertake the burn, and that this was a consistent proportion independent of the size of the burn area. This statistic is higher than that for pile burns, where 26% of those conducting a pile burn received a permit. This indicates that a majority of farmers are burning without receiving even very basic information on how to do so safely.

Known hazards to farmers' safety when burning hill country land

A number of hazards in undertaking a controlled land clearance burn in steep hill country were identified from interviews with eight farmers that were experienced in conducting controlled land clearance burns (six 'expert' high country farmers and two Federated farmer representatives):

Weather patterns

All respondents noted the critical hazard presented in burning off in high winds, or very dry conditions, and the need to check weather forecasts ahead of a burn, as well as regularly monitor the weather during the burn. The majority preferred to burn after lunch, once the weather pattern for the day is established. Farmers around the Wakatipu area used the lake as a measure of wind, they could see wind coming up the lake when conducting burns. Light winds were preferred, though still days were also used for burning, as "fire creates it's own wind" and therefore a light breeze that assisted in smoke dispersion and carrying the fire.

Difficult patches of terrain or vegetation

Some farmers had decided that certain areas were too risky to burn. These included areas of heavy (especially volatile) fuels around craggy outcrops or towards gullies; steep gullies and chimneys; fires near area planted in native vegetation that need protection; or areas with limited safe escape zones (often gullies and creek beds). Farmers used three strategies to deal with such areas: (1) doing small back-burns to create a firebreak around the area; (2) using a helicopter to burn such areas; and (3) on larger blocks leaving smaller more difficult areas unburnt.

Smoke inhalation

Several respondents noted that becoming overcome by fire is often caused by smoke, fumes and heat, rather than the flames. Smoke fumes can cause victims of burnovers to fall unconscious prior to any flames reaching them. Only one respondent stated they actively operated to avoid smoke inhalation, although most carried some protection, usually a wet cloth or sack, that could be used to breathe through if overcome. One respondent stated that because water is not always available, his father always carried a cotton handkerchief that he could urinate into and cover his face if trapped by fire, a preventative measure he still undertakes. Smoke can affect not only airways, but also visibility due to watering eyes, and fire sucks oxygen out of the air, reducing breathing capacity.

Clothing

Farmers are aware of the dangers of synthetic materials, with all stating they wore only natural materials, usually cotton and wool. Some wore trousers of polycotton blend, also. There is a balanced pragmatism in clothing, as farmers state that burning off vegetation requires a person to move fast and keep going through the vegetation, without clothing and equipment encumbering them. A couple of respondents noted that firefighting clothing (overalls and jackets) was unsuitable. Many mentioned it is very physical work, and therefore they also had to balance a desire to cover limbs and face with the potential for overheating. The majority wore lightweight merino or woolen knit singlet or shirt, and either shorts or close fitted trousers (polycotton or moleskin). Not many wore hats, due to the heat, though most wore gloves. All respondents stated the need for good sturdy boots.

The experience of one burn victim shows the need for outer clothing that is easily removed if someone finds themselves alight.

Rolling terrain

Two of the high country farmers we interviewed stated they perceived their very steep alpine terrain as easier to control when using fire than terrain that was in rolling country or foothills with gullies. Partly this is because alpine terrain has a constant slope for fire to run from base to top, so that fire once begun is very fast moving on such high altitude slopes, and the farmers tend to retreat once lit and watch the progress, rather than walking through vegetation and lighting runs in multiple patches and slopes which occurs in more rolling country.

Actions that experienced farmers have taken to reduce the risks – best practice

Our eight 'expert' farmers exposed the following 'best practice' actions, from a farmer perspective:

1. Good preparation.

- a. Ensuring all persons involved walk the boundary, view the area to be burned from a nearby ridge or helicopter, or site a map of the area prior to burning.
- b. Ensuring exit points, safe zones and any areas of potential danger or difficulty are known by all those involved before lighting.
- c. Going through the plan, and checking that communication devices such as radios are in working order.

2. Working together

- a. All those interviewed spoke of the need for a small team (maximum of 2-3 people) who worked in close proximity of each other. The need to work closely together was threefold:
 - i. So that multiple fires aren't lit around the area that others are not aware of. At most only one or two were lighting at once, in sight of each other.
 - ii. To ensure communication is effective, particularly if situations change. None of the farmers relied on radios or cellphones for communication, preferring visual communication. This ensures you know where people and equipment are if things go wrong.
 - iii. So that those lighting ensure they don't get too far ahead of others that are beating or directing the fire. One farmer relayed a near miss situation involving a wind change, stating: "If someone was way ahead of the others and didn't know where they were, it could have been disastrous".
- b. In addition, having someone as a lookout on another ridge or a safe area.
- c. Ensure the people working with you are experienced in BOTH controlled burning and the local terrain.

3. Awareness of conditions and likely impact on fire behavior

- a. Taking caution. Not burning areas if the danger posed is too great. Or using a helicopter rather than burning on foot.
- b. Vigilance and aware to possible dangers.
- c. Waiting until the conditions are right to burn. This may mean delaying the burn or even leaving some areas unburnt due to the danger posed. Farmers we spoke to were mostly concerned with ensuring the wind conditions and direction, along with air temperature were suitable. This usually meant a light breeze, (or very calm conditions if backburning), air temperatures of around 10 degrees and ensuring dewfall or rain was forecast at night following the fire, and waiting till later in the day to ensure the weather pattern was well established. One farmer also liked to check the forecast hourly throughout the day in case weather patterns were changing.

- d. Instead of reliance on expected fire behavior, thinking about where the fire (and smoke) could go, and what you might do if it did. From their past experience, some of the maxims such as “Fire won’t travel in lighter fuels” or “Fire will go out once it reaches the snowline” are known to not always be true.

4. Taking precautionary actions “Just in case”.

- a. These included:
 - i. Having multiple escape routes and safety zones.
 - ii. Wearing appropriate clothing made from natural fibre to protect your body should you get caught. Protect the torso (including shoulders) and wear good sturdy boots.
 - iii. Having a helicopter and/or tanker on standby.
 - iv. Carrying a wet sack or a damp rag to protect yourself if you got in trouble.
 - v. Conducting backburns off the natural firebreaks to increase the area. For two farmers, this included putting in a backburn to create a firebreak directly beneath the snowline, in recognition that fire can move beneath snow and cross over the top.
 - vi. Lighting with the wind at your back, so that the fire will always move away from you.
 - vii. Lighting from off a firebreak, so you always have a safer area to retreat to should the wind change.

5. Observe standard lighting procedures if working on a hill slope

- a. When lighting a slope, always ensure you are on the base of the fire, don’t position yourself uphill. The standard procedure is to either light from the base of the slope and follow the fire uphill, alternatively to head down from the top and burn back up to the snowline or firebreak, then move further down the hill using this newly burned area as a new firebreak, progressing in sections down.
- b. There is a need for awareness of where smoke will go – keeping below the fire can help reduce smoke inhalation. Carrying a damp rag to breathe through can also help if smoke drifts backwards.
- c. The standard ignition tool used is a kerosene/diesel soaked rag inside an old tin can on the end of a wire. This is seen as more reliable (and cheaper and less hassle) than using matches to ensure the vegetation will catch, and allows the placement of the torch in under areas where fine dry fuel is present. It is easier to light up as you walk along this way. This tool also does not involve liquid or dripping fuel. Two of the farmers also employed a small handheld gas torch, and spare canisters. The torch has a trigger to ignite, which unlike the tin can allows one to extinguish the lighting tool when not required.

6. Don’t be a hero.

- a. If fire escapes or the wind changes, it is important to follow the plan – go quickly to a safe zone and call in the helicopters.
- b. Experience shows fire will eventually burn itself out. Once lit, and the fire was progressing well, most of the farmers stated they retreated to a safe area to watch the fire. The farmers also spoke of the futility in trying to outrun a fire going uphill.
- c. If caught in fire, advice from farmers who were burned over included:
 - i. Protecting the body by lying face down on the ground, and with arms underneath you.
 - ii. If available get into waterway or wrap self in a wet sack
 - iii. Or close eyes and cover face and walk quickly (but don’t run or you may trip) through the fire front – apparently this takes a lot of willpower so stamping the feet helps.

Summary and Recommendations

Improving the safety of farmers at controlled burns – summary of lessons

Usefulness of information provided to farmers

Farmers invariably are responding to verbal information provided by the RFO, or *easily accessible* on Fire Authority websites. It appears that the rural community rely heavily on the verbal advice and fire behaviour knowledge of their local fire authority and Rural Fire Officers. If so, then the verbal information provided to permit applicants, and the onsite engagement by the RFOs is most critical in the exchange of knowledge around safe burning practices. There is evidence that farmers are both listening to and responding to the information received from their RFO, and that some learning is occurring, particularly on aspects such as preparation (burn plan), and light up patterns, though there appears fairly limited knowledge of fire behavior as a whole. Where knowledge is gained on fire behavior, this is through past experience in conducting fires on their local lands. Farmers conducting fire on one type of land may therefore have very limited knowledge of how fire would behave in a different landscape, or with varying fuel types or under new climate conditions.

Only 3 of the 31 people we spoke with who had received a permit knew of the acronym LACES. While experienced high country burning is using most elements of LACES, knowledge of LACES within the wider farming community appears inadequate. Less than half of the permit holders interviewed spoke in terms of LACES elements at all, instead citing weather forecasts, adequate use of firebreaks and having water reserves on hand as their main safe practice checklists. When prompted on LACES, many were conducting some of these elements, but very few enacted all five. There is very limited information available on safety during fires on farms. While LACES and the “watchout” are available, very few authority websites and permits explicitly mention LACES

Burn plans for large land clearing burns are prepared jointly between RFOs and land managers (but only it appears where it is felt they are required, rather than as an essential step in preparing for every burn) as part of the permitting process. There is scope to adapt international guidelines around safety at prescribed burns to New Zealand conditions, and create standardised burn plan templates for various types of fires (piles, scrub, tussock, stubble etc.), along with checklists for preparing and planning for using fires for these different activities.

Behaviour and actions that contribute to the risk of injury and fatality

Fatalities and injuries due to controlled burns are fortunately rare, however due to the lower frequency of controlled burns compared to other farming activities involving risk, there are still a significant number of incidents occurring.

The hazards identified by ‘expert’ farmers are similar in many respects to those known by rural firefighters. Farmers in particular highlighted awareness of smoke inhalation and to work together as a team, using good verbal or signaling communications. These farmers also spoke of the need for caution and vigilance when undertaking a burn, especially in anticipating what might change and how one would act if it did. In addition, ensuring the right clothing and equipment is used, and ensuring adequate preparation and planning would significantly increase safety of controlled burn-offs undertaken by the farming community.

In contrast to the Fire and Emergency advice (and sometimes permit condition) to attack an escaped fire if safe to do so, our expert farmers instead stressed the need for farmers to “not be a hero”, and not to place themselves in danger, which included retreating to safety and letting the fire escape.

Recommendations

From these findings, we recommend the following:

1. **Database of rural farm-based incidents.** In updating the FIRMS, ensure that aspects of human decision making and human action are included alongside aspects such as terrain, fuels, weather and fire behaviour as contributing factors recorded for farm burn offs, and that the database is examined regularly to discover common denominators and lessons learned.
2. **Standardise the wording in permit conditions.** Fire permit conditions currently differ widely throughout the country; however some conditions are common to all regions. Standardised wording could reduce confusion.
3. **Provide practical information to farmers on how to conduct a burn safely and effectively.** “A Landowners Guide to Land Clearing by Prescribed Burning” is not pitched to the farming community, nor is there adequate information for different fire types. There is also very limited information available on safety during fires on farms. Farmers require simple and practical tools or demonstrations with which to improve safety when undertaking controlled burning.
4. **Working with Federated Farmers, empower RFOs to undertake knowledge extension on safe and effective practice within their farming communities.** It appears that the rural community rely heavily on the verbal advice and fire behaviour knowledge of their local fire authority and Rural Fire Officers. Very little written or online information is sought by farmers. If so, then the verbal information provided to permit applicants, and the onsite engagement by the RFOs with farmers is most critical in the exchange of knowledge around safe burning practices.
5. That Fire and Emergency **places greater emphasis on communicating with farmers what are the main contributing factors of injury** when conducting controlled burns, in particular:
 - a. Situational awareness, including identification of safe zones and escape routes.
 - b. Preparedness and safe equipment (Adequate clothing and non-drip/non-spray fuels).
 - c. Not working with fire independently of others, or on your own.
 - d. Awareness of risks from smoke inhalation, delayed medical intervention, and shock. Smoke is often viewed as a nuisance and a byproduct of burning, and it seems most are thinking of the flames as the major hazard where smoke can cause serious injury also, especially if not treated.
 - e. Identifying alternatives to burning on foot in more dangerous terrain or heavy fuel (e.g. gullies or thick vegetation).

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Fire and Emergency New Zealand Incident reports

Appendix A

Case studies

The following outlines chronologically the actions that were taken by those involved that contributed to the incident:

CASE 1: A FATALITY NEAR CROMWELL (2014)

- The burn was originally planned to use a helicopter for lighting. For economic reasons, the owner of the property later decided (on the day of the burn) to undertake burning on foot.
- The decedent (Mr. X) had limited farming knowledge, and had conducted only two controlled burns previously, both earlier in the week on the same property.
- After briefing on the plan, ignition points and where to meet up by an experienced prescribed fire operator (Mr. Y), Mr. X and Mr Y. then separated, working independently 800m apart, and out of sight of each other.
- Mr. X did not light from the agreed and arranged ignition point for his flanking fire.
- Mr. X was instructed to walk down to the bottom of a spur and to light the fire while moving back up the spur. Instead, he lit the fire as he moved down the spur towards a creek.
- Although Mr. Y could see smoke in an area where there was not supposed to be fire, he took no immediate action to investigate why. When Mr. Y later noted the wind change and went to alert Mr. X, he could not get cell coverage, so had to move to higher ground. This delayed his ability to alert Mr. X to the danger.
- Due to his earlier ignition pattern and position, Mr. X found himself at the bottom of the spur with no effective escape route out when the wind changed direction and blew back down the spur towards him.
- Although instructed that an “informal safety zone” of less dense vegetation was available to the west of the spur, the wind change closed off this escape route. Due to the impenetrable nature of the spur vegetation, Mr. X could not reach an alternative south eastern safety zone either within 20 minutes, although it appears he attempted to do so.
- A fire had was on the Northern face earlier in the morning. The wind from fires lit by Mr. X on the Southern face drew the earlier fire down into the gully, where it crossed the creek and trapped Mr. X. It appears also that Mr. X was unaware the Northern fire had crossed the creek, and also had underestimated its speed in reaching him on the Southern face. The speed of the approaching Northern fire was impacted by the topography and convective pull from the Southern face fire. As Mr. X had no real knowledge of fire behavior, he was not aware of such danger. Two actions further confirm his lack of awareness of the danger:
 - When Mr. Y called Mr. X on his cellphone to alert him that the wind had changed and to get out of the area, Mr. X “did not appear to be panicking”.
 - The evidence also suggests Mr. X did not take cover, and was impacted by the fire when he was still in an upright position.
- The farm manager and owner did not have a hazard register or any register of training.
- Although he was unable to contact Mr X., Mr. Y had a cellphone on his person, but made no attempt to call anyone else from the cellphone to alert them that he could not make contact with Mr. X over the course of the 1.5 hr and 3.5km cross country trek back to his farm vehicle, where he then raised the alarm.

CASE 2: A FATALITY IN THE HURUNUI AREA (2014)

- Mr X (the decedent) was instructed by Mr. Z (the farm manager) to walk along a fairly straight track to the east and backburn 5m in. About halfway along the track, Mr. X veered from the arranged path, heading in a Southerly direction into the area where burning was occurring, following a slope to the gully bottom.
- As Mr. X progressed down the slope, he continued lighting back burning fires that ran to the West towards those created on the Western boundary of the area to be burned.
- Mr. Z was acting as the lookout for the two men burning, but was also concurrently spraying other vegetation in another part of the property. He checked on progress after 10 minutes by binoculars, and tried to alert Mr. X by radio, but Mr. X did not pick up. When he noticed Mr. X lighting in the wrong area, he stopped spraying and moved to where he could verbally alert Mr. X – about 60-100m away above where Mr X was burning.
- Mr. X. was told by Mr. Z to exit the area immediately by walking up the slope toward him and back to the vehicle, but Mr. X stated he wanted to finish off his nearly empty tank of fuel before exiting and returning to the vehicle.
- Smoke from the burn conducted by another farm worker (Mr. Y) had drifted up the gully, obscuring Mr Z's view of Mr X; and the noise from the fire made further verbal communication difficult. Mr. Z thus returned to his vehicle where he lit a patch of scrub next to it while waiting for Mr. X. to appear.
- Mr. Y. (an experienced rural fire service volunteer) stated that the attitude of Mr. X was that he was caught up in the “excitement” of the burn and probably lost his sense of direction, causing him to move away from the boundary and into the burn area. Mr. Y believes this is a recognized reaction that some people have to large vegetation fire events.

CASE 3: A SERIOUS INJURY IN THE RAKAIA GORGE (1995)

- A father and son undertook a burnoff of a small area for a fence line.
- The burn was not intended to occur that day, so no burn plan or suppression equipment was on hand.
- The father usually wore a woolen singlet when conducting burns. As no burning was planned, the father was wearing a polypropylene singlet. This contributed to the level and severity of burns to his upper body. However, as a woolen jersey was tied around his waist, burns were not present on his lower back.
- The pair noted a patch of sparser vegetation uphill of the fire, and identified this as a safe area which should the fire enter, it would just burn itself out due to the lack of fuel. Due to the faith placed in this low vegetation area, and as they did not foresee anything going wrong with such a small burn-off, no escape routes were identified nor did they discuss a plan for the eventuality of the fire becoming out of control.
- After lighting, both the father and son followed the fire up the hill as the fire progressed, fanned by a stronger Easterly breeze that formed after lighting.
- With the expectation that it would burn out on reaching the sparse vegetation, the father positioned himself uphill of the fire to watch the progress. There was also unburnt light fuel between his position and the fire.
- The light fuels ignited much more easily and carried the fire much more rapidly than the pair had predicted, and a concurrent 180 degree wind shift trapped the father between the fire front and an outcrop of rocks, blocking any means of escape.
- The father ran through the flames, and also lost consciousness due to smoke and fumes, which caused him to tumble 30-40m down the burned slope.

- The farmer and son noted that the vegetation was dry, and there was recent rain, but did not account for the steep slope (27 degrees) or the very cured grass (near 100%) in assessing the safety of burning.
- The son splashed water from a nearby creek onto the father's burns, but it is not stated whether the burns were adequately cooled either by submersion or held under running water.

CASE 4: A LEAKING KNAP SACK SPRAY UNIT (DATE UNKNOWN)

- Two farmers were attempting to put in a firebreak on the slope ahead of the main burn – Mr. X had used a dozer but there was a small area under a bluff that had more scrubby material, it was also wet and greasy on a dark face and the dozer couldn't get into it. They decided to burn this off before the main fire as a safety precaution. Mr. X was aware that such areas can sometimes draw prescribed fires into them and cause a more intense and volatile situation in marginal scrubby land – he didn't want the main fire getting into this area of sprayed scrub.
- Ms. Y dropped him off at the top of the slope, and drove the farm bike to the bottom to wait and watch the burn.
- Mr. X then realized a wet sack was still on the back of the bike, but didn't attempt to get it back.
- Mr. X used a Solo knapsack sprayer (15L) with a flame thrower attachment on the spray nozzle, which he had used before on flat ground, but never on a hillside.
- About 90% of the burn was complete when the incident happened Mr. X felt he had lost pressure in the sprayer – felt the pressure drop off in the handle.
- Mr. X looked and could see a spray of kerosene behind him, so he thought the hose had come off. He immediately put the handle down and dropped the spray unit – sliding it down off his shoulders – putting it 3-4 feet away, and had the sense still to place the flame thrower nozzle farthest away from the fire.
- Mr. X began walking quickly away from the scene – he thought he had gone about 10-15 metres away, but later found it was more like 40-50m away.
- Mr. X knew he had fuel (kerosene) on his coat, but due to the close fitting coat design found it was very difficult to remove. The fitted coat was chosen to allow good movement with the knapsack spray unit. The coat was longer and also allowed the fuel to drip onto his trousers.
- Mr. X thinks he must've had a spark or ember on the trousers or boots and the fumes or fuel had dripped down from the coat onto his lower legs.
- Mr. X. knew then he was on fire, so rubbed his hands over the trouser legs to put the fire out by smothering flames, but when he removed his hands the flames reflared. If Mr. X had had the wet sack handy, he would have used that instead to extinguish himself when on fire.
- Panic had set in – Mr. X sat down. He had the realisation that if he 'stop drop and roll' on the vegetation, he would just set it alight. Mr. X instead pulled the top of his trousers down over the lower legs and smothered flames that way. Mr. X also smothered flames on his boots with the trouser in the same manner.
- When Mr. X rolled the trousers further down skin peeled away from his right calf.
- Ms. Y later put water and a wet towel on the burn. They were told later that immediately wrapping in gladwrap would have prevented infection.

"I felt it was just backburning - simple – but I should've had someone with me...I wasn't even going to have [partner] there, but it was the end of the day– I said "Just wait at the bottom of the hill and you can take me home." We were only 50m apart and she was watching me the whole time but she didn't notice [I was on fire]" Mr. X

Appendix B

Known details of fire incidents on farms when burning vegetation

Incident	Incident type	Contributing factors
<p>20/08/1878 Canterbury <i>"Between 2pm and 4pm the deceased and I were engaged in burning tussocks in a gully at the back of the house [about 500 yards from house]. The wind suddenly changed, and sent flames up the hill towards us. We were about 40 yards apart at the time, and finding it impossible to get away from the flames I ran through them. I then looked around for my wife and heard a low moan. I then ran to her and found her clothes were all in flames. I tried to extinguish them by rolling her over and over on the ground, but finding this was no use, we both ran to the creek, and I there put the flames out."</i> The woman received severe burns to her body and legs, face and her mouth was severely blistered so she was unable to swallow. She died 12 hours later due to shock caused by the fire. The man received severe burns to his neck, face, hands and wrists, and blistering to his legs and thighs.</p>	<p>Fatality and injury</p>	<p>Wind change Lack of fast medical intervention</p>
<p>02/02/1882 Wairarapa <i>"We were burning fern and manuka,.... There was nothing to hinder a man in his 'right senses getting out of the gully.....His clothes were burnt off with the exception of a small piece on his leg. The ground about there was burned clear, • and there ' had .evidently been a fierce fire. ...The man must have been burning near 'the creek and the fire at the back of him must have been carried up to him suddenly by a strong wind, and he was overtaken by it so he could not escape...The scrub burned with a good deal of smoke....Could not say whether the smoke was think enough to suffocate a man."</i></p>	<p>Fatality</p>	<p>Working alone Caught in gully -entrapment Smoke inhalation</p>
<p>01/10/1890 Otago Man engaged in cutting a gorse hedge set fire to hedge and was caught in flames. Burned body found at scene.</p>	<p>Fatality</p>	<p>Working alone</p>
<p>23/09/1894 Blenheim <i>"[Mr X] was hemmed in between two fires in a gully and could not escape. He sought refuge in a small excavation in the ground caused by pig-rooting, and lay amidst the suffocating smoke while the flames passed over one-half of his body. After the danger was over, [Mr. X] made his way to a camp, and was conveyed to Blenheim Hospital. One side of the body was much injured, while his arm was burned almost to the bone, and the face disfigured. He died yesterday morning."</i></p>	<p>Fatality</p>	<p>Working alone Burnover Caught in gully -entrapment Smoke inhalation</p>

Incident	Incident type	Contributing factors
<p>Sept 1895, Otago Man badly burned while rescuing a sheep from a tussock fire. All clothing burned off him except an undershirt. Received burns to face, hands, arms and eyes. Prompt assistance was rendered by his neighbours. Taken to Kurow by train for medical assistance.</p>	Injury	Prompt assistance
<p>20/02/1897, Southland Mother burning chipped tussock near the house left sleeping child (1 yrs old) at side of burn area in some shaded grass. On igniting the tussock the flames moved towards where the child was. Child received burns to arms, hands and one side of face, and later died from injuries. Mother received burns when scooping child up out of flames.</p>	Fatality and injury	Working alone Wind change ?
<p>Nov 1924, Whangarei <i>"deceased had left home - to burn scrub about a mile away. When he saw the victim again it was at some distance from the fire. The deceased was then; in a sitting position. His clothes were almost burned off and: he was suffering -very acutely, his face hands and limbs being badly scorched. In reply to an inquiry deceased said that the accident happened when he had been burning off some tea-tree, and the fire had surrounded him. In order to escape he had run through the fire as far as the creek into which he had thrown himself. Witness added that his brother was conscious until within half a mile of the hospital, to which he was taken by car. He was suffering badly from shock, from which he never, rallied."</i></p>	Injury	Entrapment
<p>September 1938, Otago Farmer " had considerable experience in burning. His body was found in a deep gully with thick scrub. He had evidently lit the fire at the bottom of the gully and been caught. " The death was estimated to have occurred around 2pm. The gully was seen to have dense smoke and had been swept by a severe fire.</p>		Entrapment
<p>March 1938, Waihi Farmer, 84, " was engaged in burning off scrub on a 20-acre area when the fire got ahead of him, crossing a fire break. Making an attempt to beat out the flames, [Mr. X] evidently fell on a burning tree trunk and became overcome by the smoke and fumes". He fell unconscious and died shortly after.</p>	Fatality	Trip hazard Smoke inhalation Age
<p>03/10/1938, Rakaia <i>"[Man], 63, died in hospital ...as a result of burns received a week ago while burning gorse at his brother-law's farm at Rakaia."</i></p>	Fatality	
<p>January 1941, Tuakau <i>"Severe burns to the right side and arms, from which he later died in the Auckland hospital, were received by a farmer while engaged in burning off scrub and noxious weed on his farm at near Tuakau. The deceased...aged 43, was using sodium chlorate and his clothing became ignited"</i>.</p>	Fatality	Clothing and use of chemical

Incident	Incident type	Contributing factors
<p>1980, Hawkes Bay The report states nine men were located on a firebreak ridge. "[fire] entering a very steep sided and abruptly rising gully on the immediate west side of the eastern firebreak along which were standing [Mr. X's] men. The gully fanned out at Matai Road, but the middle section, or throat, was narrow and very steep, and was aptly called a "chimney"". The fire was reported by witness to move 500metres in 4.5 minutes up the step gully. 6 men fled to safety zone on Matai road. Three went downhill through burnt material to a stream, but only one survived.</p>	<p>Fatality, and injury</p>	<p>Fire run</p>
<p>11/08/1995, Rakaia <i>"On the 11 August 1995 at approximately 2.30pm conditions seemed perfect for a safe fire to be lit to burn out an area of vegetation to create a fence line. It was calm and there had been considerable rain over the preceding days. Mr X and son intended to burn a small area out. Above the area the vegetation was sparse which would prevent the fire from escaping. A test fire was lit in a clump of cocksfoot (dactylis glomerata) in the gully. ... There was some difficulty getting the fire started. After a short period of approximately 10 minutes an easterly wind came in that picked up the momentum of the fire. Mr X and son followed the fire up the hill expecting it to burn itself out when it reached an area of little vegetation. Mr X positioned himself above the fire ... to keep an eye on progress. At this stage there was a violent 180 °wind shift. The fire was observed to have moved 20-30 metres in 2 seconds eventually trapping Mr X between the fire front and a outcrop of rocks. He yelled out to his son to run. Because of this precarious position the fathers only option was to run through the flames. At some stage he lost consciousness and rolled or tumbled down through the fire some 30-40 metres. The son was aware his father was in difficulty and found him shortly afterwards. He supported his father to the nearby creek and threw water over his burns. Approximately half an hour had elapsed since lighting up the burn. The son was also having some difficulty as the smoke had flared up his asthma. Immediately after attending to his father the son made his way down the steep slope to the homestead where arrangements were made to get the local helicopter and paramedic to the scene. Approximately 40 minutes had elapsed before the son was back with his father. The helicopter was on site with the paramedic within 40 minutes of being called."</i> Mr. X received very severe burns to 80% of his body. A woollen jersey tied around the midriff reduced burns to lower back.</p>	<p>Injury</p>	<p>No escape route.</p> <p>Being uphill of the fire.</p> <p>Positioning one self in unburnt fuel.</p> <p>Type of clothing worn</p> <p>Lack of planning – initially had no intention to burn</p> <p>Immediately called for a helicopter in an emergency-speedy recovery operation probably contributed to survival</p>
<p>02/12/2013, Wanaka Tramper cooking tea using a small propane gas cooker. He <i>"turned his back for 2 mins"</i> and the gas cooker ignited grasses surrounding the cooking area, with fire spreading across DOC land. Evidence that the grasses and flaxes were 1m tall and that bases of Spaniard grass vegetation was within 55cm of the cooker location. The tramper attempted to extinguish the flames using a fleece jacket, but got burned in process. The fire burnt the tent and his belongings. When it became apparent he could not extinguish the fire the tramper started to walk out of camp but could not reach the road before nightfall. The tramper took shelter under a bush for the night and walked out in the morning. He was only wearing charred jandals as his boots were burned. He was treated for burns and blisters to his arms and checked for hypothermia. No rocks were placed around the cooker or vegetation removed before lighting. A more suitable cooking area near a creek and in beech forest was available 70m from the campsite.</p>	<p>Injury</p>	<p>Inattention to fire</p> <p>Inappropriate campfire spot – given surrounding vegetation</p> <p>Clothing</p>

Incident	Incident type	Contributing factors
<p>04/09/2014, Cromwell</p> <p><i>"[The deceased] was part of a two-man team conducting a controlled burn-off at the station on Wednesday afternoon."</i></p> <p><i>"He was working alone when his co-worker lost contact with him"</i></p> <p><i>"[The deceased] died when he became trapped by a fire in a gully"</i></p> <p><i>"[He] had been sent into an area of dry vegetation in a steep gully with effectively no escape routes."</i></p> <p><i>"a worker with no experience of burn-offs had been sent into an area of dry vegetation in a steep gully, with effectively no escape routes to a safe zone, and was trapped, being "engulfed" by fire after the wind changed direction"</i></p> <p><i>"It was decided to do the burn-off on foot.....The two men took hand-held propane burners and separated once they got to the site, losing sight of each other.....[The deceased] went down a spur area, where vegetation had been sprayed the previous year and lit the fire as he walked back up the hill....He was surrounded by impenetrable vegetation....The only way out was back the way he had come...When the wind changed direction half an hour later, his colleague phoned [The deceased] on his cellphone to alert him....[The deceased] said he was moving out. He took a further call from his colleague 20 minutes later and said he was still on the move....Cellphone reception was patchy in that part of the farm... and after that the two men lost contact... [The deceased]'s burning body was found by searchers at 6pm."</i></p>	Fatality	<p>No lookout</p> <p>No escape route</p> <p>Wind change</p> <p>Working alone</p> <p>Lack of training</p> <p>Poor communication</p> <p>Caught in gully</p>
<p>15/10/2014, Hurunui</p> <p><i>"The burn-off happened at the back of a farm property Police have confirmed one person has died and two others there at the time are uninjured."</i></p> <p><i>"[the deceased] was helping two other men at the farm with the burn-off on a steep gully."</i></p> <p><i>"[the deceased] was believed to have been overcome by smoke inhalation."</i></p> <p><i>"He told [the deceased] to head "basically in a straight line" towards a gate with a knapsack flame thrower....With binoculars, [Farm manager] soon realised [the deceased] was "miles off the track where he was supposed to be" - 20 metres above a creek bed..."He was still lighting fires around himself as he walked down the creek bed."...Unable to reach him on a radio, [Farm manager] moved closer and yelled to Hazlett, asking him how much fuel he had left and told him to come back up the hill. [The deceased] said he had a quarter of a tank left and he would use the rest before returning." After two minutes of attempting to burn off just using matches, as he did not have a flame thrower, [Farm manager] looked up to where he thought [the deceased] would be but he could not see him". [Farm manager] said: "I started panicking; I could see smoke where he had been, but not [the deceased]." He rushed to the ute and picked up [Mr Y] before driving to the spot where they last saw [the deceased]. [Farm manger] then walked down the creek bed. "I could see the spots where where [the deceased] had been lighting the fires as he was walking along. I looked up the hill and saw [the deceased] then. He was still on fire but was obviously dead."</i></p> <p><i>"[The deceased] was found extensively burned 50 metres from the bottom of a gully on a steep hill.... it was likely [the deceased] was overcome quickly by smoke inhalation, and existing ischaemic heart disease contributed to him being incapacitated and unable to escape....[Mr. Y] told police the "adventure and excitement" of big flames kept [the deceased] going further. "As I understood it the fire crossed the creek and came in behind him, so he probably focussed on going forward"</i></p>	Fatality	<p>Failure to follow instructions</p> <p>Fire crossed creek</p> <p>No working radio</p> <p>Smoke inhalation</p>

Incident	Incident type	Contributing factors
<p>(cont'd) <i>"[The deceased] was told he wasn't needed, but he insisted on helping. The duo were instructed by [Farm manager] during a briefing, "if you want to pull out, now's the time to say so" but both were keen to carry on. Before starting, the trio's radios were working. Both men began the burn-off using portable flamethrowers while [Farm manager] was spraying other parts of his property"</i></p>		
<p>10/11/2014, Wainuiomata <i>"Farmer hospitalised with second degree burns received while trying to put out the out-of-control fire. A man has been taken to hospital after getting burned while trying to put out an out-of-control burnoff in Wainuiomata. Fire communications said two regular fire service engines attended the scene, on the Wainuiomata Coast Rd, yesterday afternoon, along with the Wainuiomata rural fire brigade. At one point the fire was threatening a house, but crews were able to contain it. The regular fire service has now left the scene and the rural fire force is now working to put the fire out. The man received second degree burns while trying to extinguish the fire and was taken to hospital for treatment."</i> This was a mid-afternoon fire involving a man living in lean to beside caravan and cooking on an open fire in a patch of nearby bush. This was his well established and regular cooking spot. A log from the cooking fire rolled down the hill starting a hillside fire. The man tried to extinguish the fire using pots and pans as there was no water on hand but it raced along and up a gully and got into gorse. In trying to extinguish the fire he got burned on arms and face. Had to spend two days in hospital. Fire was unpermitted.</p>	Injury	<p>Log escaped from fire</p> <p>Trying to extinguish fire</p>
<p>2015, Unknown location, Forestry block Digger caught fire in forestry block. Driver used two fire extinguisher canisters trying to put out the fire but in doing so got burns from hot oil and also suffered from bad smoke inhalation. Fire brigade arrived and extinguished fire. Fire officer tried to call ambulance on arrival but man refused medical assistance.</p>	Injury	<p>Smoke inhalation</p> <p>Trying to extinguish fire himself</p>
<p>10/11/2017, Ashburton <i>"[she] was the first one on the scene and managed to get the tractor and bailer out of one of the sheds, as well as saving one dog. He said she had been treated for a small amount of smoke inhalation. It was thought the fire could have started from old embers from a fire on the property a few weeks ago which had been "picked up" by the wind and spread."</i></p>	Injury/ Near miss	Reignition
<p>03/12/17, Invercargill A 75 year old male had been burning tree cuttings and rubbish etc. The wind had picked up in the evening and he had gone out to check the fire, using a rake to turn the fire over to extinguish hotspots. Walking through the remains of the fire he tripped on an object and fell forward. Putting his arms forward he landed about elbow deep in hot ashes. He also suffered burns to his legs. While initial crew treated the man for burns until ambulance arrived, about twenty minutes later. Other responding crews extinguished the fire. The gentleman was wearing gumboots and normal trousers and shirt. The fire was about 25-30 square metres in size on a reasonably flat area of paddock on a lifestyle block on the edge of Invercargill. The call was received about 22:30 hrs. The occupants called a relative to call the Fire and Emergency.</p>	Injury	<p>Trip hazard</p> <p>Clothing</p>

Incident	Incident type	Contributing factors
<p>Unknown date and location Burning off scrub for a firebreak, in a patch where digger wouldn't reach. The farmer used a knapsack spray unit with a flamethrower attachment. The kerosene in the knapsack began to leak, and wet Goretex jacket, and dripped fuel onto trousers and boots. Embers or sparks from the fire had landed on boots and they caught the trousers on fire. The farmer removed the knapsack unit, moved away from fire but didn't realise his legs were alight. Used top of trousers to extinguish flames on lower legs by rolling trousers down his legs and over boots. The man's wife was watching as a lookout at the bottom of the hill but did not realise he was on fire. Farmer received severe burns to back of right calf.</p>	Injury	Clothing/ Clothing Ignition equipment Not working alone
<p>Unknown date, Otago Farmer burned over in a gully in rolling hill country. Farmer saw flames coming and lay face down in a bog while fire passed over him. Received reasonably bad burns to his back but survived.</p>	Injury	Protecting face and arms in bog Burnover
<p>Unknown date, Otago Three persons engaged in burning off a slope climbed a way up the hill and lit the fire. A slight wind change developed, and the fire took off back up the hill again past areas that had been burned, entering into a nearby patch of higher fuel- scrub and matagouri, sprayed 5 years ago but not yet burned. Higher flames developed than they had expected and the fire was not running the direction they had anticipated. The fire went underneath them but they were able to get out to the safe zone. A helicopter was called and the fire was extinguished within 20 mins.</p>	Near Miss	Not working alone – working together as a crew Safe zone identified Radio communications
<p>Unknown date, Otago While undertaking a burnoff, a large boulder dislodged from 100m above where the personnel were operating. The boulder had been loosened when vegetation holding the boulder in place was burnt. The boulder hurtled down the slope and passed within a few metres of one of the crew.</p>	Near miss	Shear luck!
<p>Unknown date, Unknown location Farmer on a digger blew the transmission hose and started a vehicle fire. Farmer tried to stick out fire and extinguish it himself, receiving burns.</p>	Injury	Trying to extinguish fire himself
<p>Unknown date, Otago Farmer caught above fire with a wind change and walked through fire front to safety. Received burns to face and arms.</p>	Injury	Wind change

Appendix C

Overview of permit process – PRFO and DPRFO responses

	How are permits issued?	What information is sent by mail/email to the permit holder?	What other information do you provide to the permit applicant either verbally, online or by hardcopy?
Region 1	Last year – www.havingafire.org.nz or by calling/emailing the office	Fire and Emergency forms for permit paper form, so only the information on the permit itself.	No, usually by the time an office arrives to issue a permit, the customer has already been online and knows about the website. If they call the office, are visited for permit issue, or look online then there is further information provided- usually by the DPRFO or PRFO
Region 2	<i>No response from Zone 2</i>		
Region 3	<p>You apply on line, at http://trfa.co.nz/alright2light/ Now directed from http://www.checkitsalright.nz/</p> <p>We receive an email advising of the application We download the email, and save as a PDF to our permit dropbox We open the permit onto an I Pad We visit the farm, take pictures, give advice, and discuss any compliance, or requirements, we then fill out the permissions, (or decline) on the I pad, and have the requester sign, and we sign and date When back in the office, we then upload the permit to dropbox, and email a copy to the requester. We update the website, http://trfa.co.nz/alright2light/ which populates the map. And the task is complete</p> <p>They can print out a copy of the application and send it in if they wish. Some people in the past have rung through and we have filled it out for them initially if they do not have access to a computer, or the councils would assist if they went in.</p> <p>In Wellington, using the new Fire and Emergency permits, copy is emailed back with each completed permit</p>	None its all on line,	<p>Any new permit requester will get an on farm visit. In order to deliver advice, and to take pictures which get attached to the permit they receive in a soft format via email. This is the role of the DPRFO if a requester is a regular, then generally a phone call will suffice. We feel that relationships are what carry the weight in regards to compliance.</p> <p>In Wellington district inspect all or burn sites before a permit is issued. We use this time to ensure the site is safe, look at water supplies, access and fuel types, size etc. We provide a couple of handouts re keeping your property safe from fire and keeping driveways clear - 4x4 metre rule... This is done by DPRFO's and contractor RFO's .</p>

	How are permits issued?	What information is sent by mail/email to the permit holder?	What other information do you provide to the permit applicant either verbally, online or by hardcopy?
Region 4	West Coast are using both the interim online system, and the manual pads from Fire and Emergency; Kaikoura are using the old system, and Canterbury the new interim one.	Canterbury are using the interim online system from Fire and Emergency, so the information provided is that which is generated by the interim fire permit system, which is being managed nationally A hard copy can be downloaded from www.mkrfa.com The applicant receives a confirmed or declined application with tick boxes indicating conditions	Due to the size of the West Coast District , we rely on local knowledge – are building some teams. We also provide a fire burn plan (large areas only). Verbal information is provided upon request (Canterbury) – for instance I spoke to a land manager this morning on safe burning practices upon receiving a phone call. Either the PRFO, DPRFO or Business Services Coordinator may field and respond to such requests for information, wither from phone calls, emails or face-to-face contact. DPRFO or RFO visit site and provide verbal advice in MKRFA
Region 5	Our customers are still applying on line by visiting www.otagoruralfire.org.nz from there they are able to find all the information they need. Example fire season status, and check if they require a permit. Second process is they receive permit by email if no email provided by post	Permit and conditions	Verbal information is often delivered when a site visit is undertaken, or by our staff over the phone. Also if the burns require a burn plan there is often verbal dialog. Sometimes we send them a copy of LACES. I'm not aware of any reference material available for the applicants to read online but we generally discuss with the applicant, on site, what they are wanting to burn, the light up patterns, and how to light-up – some fires are best lit via helicopters, use of fire breaks, numbers of people involved, weather conditions for the burn, time of day to light up, other factors such as public access , smoke nuisance, neighbours, flight paths, power lines .. This is generally delivered by a rural fire officer (DPRFO, PRFO)