Next generation biomaterials

Fire Technology Transfer Note

NUMBER 42 JUNE 2011

Mitigating the risk of human caused wildfires: literature review and stakeholder study

Mary Hart and E. R. (Lisa) Langer [1]

[1] Scion Rural Fire Research Group

Summary

In New Zealand, as in many areas of the world, human activity is responsible for the vast majority of wildfires. The Scion Rural Fire Group has undertaken a study of wildfires with a direct human cause through malicious intent or carelessness, and accidents by recreationists and landowners. Each wildfire has the potential to take human lives and seriously impact upon land, property and livestock. Therefore reducing the risk of such fires occurring is extremely important. Such fires accounted for over 30% of all New Zealand wildfires and nearly 65% of the area burned between 1991/92 and 2006/07 (Doherty et al., 2008).

This *Fire Technology Transfer Note* summarises a report by Hart and Langer (2011) that suggests methods to mitigate the risks of human caused wildfires. The recommendations outlined in this summary have emerged from a comprehensive literature review and qualitative research with stakeholders. Although the latter primarily had a Canterbury focus, the issues and resolutions identified have national relevance.

It is hoped that appropriate agencies and individuals (such as the National Rural Fire Authority, Department of Conservation, New Zealand Police, fire managers and landowners) will seriously consider implementing these recommendations to help reduce the risk of direct human-caused wildfire in New Zealand.

Figure 1. In New Zealand, over 30% of wildfires and 65% of area burned have been recorded as being caused by human activity through malicious intent, carelessness or accidents by recreationists and landowners.

Background

Naturally occurring wildfires play an important ecological role in many parts of the world; however, modern day wildfires can be a serious problem to society. Every year, fires incur massive social, economic and environmental costs by destroying millions of hectares of forest, damaging property and threatening lives.

New Zealand has suffered approximately 3000 wildfires, burning around 6000 hectares each year in the 16 year period from 1991 to 2007 (Doherty et al, 2008). The causes of these fires are listed in Table 1. Although the areas burned are small compared to countries such as Australia and the United States of America, wildfire is a frequent and considerable risk for the small, predominantly rural country.

Figure 2. Wildfires are a considerable risk in New Zealand, and can threaten rural or rural-urban interface communities.

New Zealand has maritime influenced weather patterns, including rapidly changing atmospheric conditions and strong winds, which increases the risk of fires becoming out of control. In general, the eastern and northern parts of both the North and South Islands have the most severe fire climates, as they are prone to föhn wind and drought conditions and there are extensive areas of rural land (Pearce & Clifford, 2008). Lightning strikes in New Zealand tend to be accompanied by rain ('wet' lightning) and are rarely a source of wildfire.

***Table 1**. Causes of wildfire in New Zealand, 1991-2007 (Doherty et al., 2008).*
*Note: * > 26,700 ha; on average 1,670 ha per year.*

Cause	No. of fires as % of total	Damage as % area of total area burned
Escaped land clearing[1]	20%	**47% ***
Indirect human caused fires[2]	17%	**5%**
Human negligence such as fireworks	6%	**6%**
Recreational causes	3%	**2%**
Smoking	1%	**1%**
Arson (Note: the true figure may well be higher)	0.1%	**0.3%**
Miscellaneous[3]	33%	**7%**
Unknown cause	**13%**	**> 25%**

[1] Land clearing burns are burns carried out by farmers and landowners. Examples include the burning of crop stubble, the burning of grasslands and woody vegetation, and burning piles of vegetation material such as cleared shrubs and trees.
[2] Indirect human-caused vehicle fires include vehicle fires from accidents, vehicle exhausts etc., farming machinery and operations such as situations with blades from harvesting or sparks from mowing machinery and build-up of combustible material around the hot engines and exhausts of farm machinery).
[3] Miscellaneous fires tended to be small fires which included fires classed as: careless; careless smokers, chainsaws etc; children; electrical faults; and other.

Research approach

This research involved a literature review to document international knowledge and best practice, and to guide the subsequent interviews and focus groups. Literature was sourced from international online databases, websites of international organisations with interest in wildfire and national fire bodies. Wildfire was generally defined as any uncontrolled, non-structural fire burning in a grass, scrub, bush or forested area.

The qualitative component of the research had a Canterbury focus, and involved two in-depth focus groups and seven semi-structured interviews. The focus groups were held with the Canterbury West Coast Regional Rural Fire Committee (RRFC) and Canterbury arable and high country farming representatives of Federated Farmers of New Zealand (referred to as Federated Farmers), with between four and six participants in each. Each group was presented with a number of scenarios. For the RRFC focus group, these scenarios covered escaped stubble fires, an escaped campfire and suspicious fires. The Federated Farmers representatives were given scenarios that related to fire risks resulting from increased numbers of lifestylers living in rural communities, escaped stubble and high country fires, and general fire risk in rural communities (to cover accidental and maliciously lit fires). Participants were asked whether such situations were common, what methods were currently used to try and prevent such risks, and what other measures could be undertaken to reduce the risk further.

The seven interviews were carried out with representative stakeholders including National Rural Fire Authority (NRFA) and Department of Conservation (DOC) staff representing national issues, and Canterbury Rural Fire Authority (RFA) officers and DOC staff, as well as a representative from each of the Fire Awareness Intervention Programme (FAIP), New Zealand Police and insurance stakeholders. The interviews all used open-ended questions relating to the categories of human-caused wildfire targeted at the particular stakeholder's role and position. All responses were explored for common themes, and examples of current best practice were extracted to contribute to the recommendations. While the qualitative study had a Canterbury focus and it is recognised that situations and approaches may differ in other parts of the country, the study provides a good starting point for recommendations to mitigate the risk of human-caused fires in New Zealand.

Arson and Maliciously Lit Fires

Context and Findings from Literature Review

There is general agreement internationally that figures relating to arson are misleading and that the true number is far greater. One important reason for this discrepancy is that in many countries, including New Zealand, the term 'arson' can only be attributed when there is some proof or a conviction. In attempts to determine a more realistic figure for wildfire arson, researchers estimate that a fifth of wildfires in the United Kingdom are attributable to arson; and around half of the wildfires in Australia that occur each year. A large body of literature has found significant links between arson and other crime and delinquent behaviour (see Muller and Stebbins, 2007 for a brief overview).

Figure 3. Worldwide, wildfire arson and maliciously lit fires are likely to be considerably more common than statistics suggest.

Research has found that: most arsonists light fires close to their homes; wildfire arson happens close to structures; and arson wildfires often happen close to walking

tracks and residential areas. Spatial and temporal modelling in Australia and the USA has shown that arson was most common at weekends, late afternoons and after sunset. Few arsonists, urban or rural, are ever convicted. This means that a small number of people can be responsible for a large number of wildfires.

Findings from the Stakeholder Study

All stakeholders in the Scion study shared the opinion that wildfire arson was a serious and increasing problem, and was very hard to prevent. Canterbury stakeholders identified weekends, school holidays and nor'wester winds as being times of particular danger. There was general agreement that it was difficult to prove arson had been committed and therefore official figures were misleading.

Credit was given by stakeholders in the study to the public's reactions and alerts to emergency services upon spotting suspicious behaviour or fires. Participants involved in fire investigations suggested that profiling of wildfire arson would be very valuable in assisting the police to catch offenders, some of whom might be responsible for many fires.

Further mapping work to build on the limited work that had been undertaken in the past was widely seen as beneficial to understanding the risks of arson fires and enabling mitigation of those risks. Mapping could allow hotspots to be identified, so that agencies could target those areas.

Another common theme to emerge was the desirability of more multi agency work, specifically between agencies such as the NRFA/RFAs, New Zealand Police, New Zealand Fire Service (NZFS) and insurance companies, that would help prevent suspicious fires. This cooperation would be particularly useful if agencies ensured they had a unified data collection process; were aware of the links between fire setting and other criminal behaviours; and if more resources were devoted to fighting suspicious wildfires.

Figure 4: Investigation of suspicious fires increases the number of fire-related prosecutions and acts as a deterrent for others.

Recommendations

Wildfire arson and malicious lighting of fires are likely to be much more prolific than official statistics suggest. These fires pose a serious risk to New Zealand communities, especially as many such fires are lit close to residential areas. The following mitigation methods have been identified by the literature review and the qualitative component of the research. They are recommended for New Zealand.

- **Mapping techniques** – model and map incidents of arson to allow an accurate understanding of incidence, which can then lead to targeted intervention programmes and increased security.
- **Investigation and sentencing deterrents** – increase the number of fire-related prosecutions and ensure they are publicised, to act as a deterrent for others. Collect and share information on suspicious fires between agencies to identify hotspots, improve mapping and develop policies.
- **Target hardening measures** – strengthen the security of arson-prone areas (such as forests); prescribed burning to reduce fuel load; construction of firebreaks; encouraging the public to report suspicious behaviour; and promptly removing targets such as abandoned cars to reduce the incidence of wildfire arson.
- **Intervention schemes** – continue to develop educational initiatives such as the New Zealand Fire Awareness Intervention Programme aimed at children, which have been beneficial in reducing the recurrence of arson behaviour in its participants (Lambie et al., 2009).

Accidental Fires: Escapes from Fires Lit for Recreational Purposes

Context and Findings from Literature Review

Recreationists light fires for a variety of reasons. These include fires for cooking, fires for comfort and companionship, the lighting of fireworks for entertainment, as well as fires lit in emergencies to keep people warm and possibly alive. DOC figures from 1987 to 2010 show that 12% of fires on public conservation land were caused by picnic fires and campfires.

Figure 5. DOC statistics suggest 12% of fires on public conservation land were caused by picnic fires and campfires.

There is very little information in the literature regarding incidents of escaped recreational fires, even though accidental wildfires, particularly those started from unattended or poorly extinguished campfires, are common in many fire prone areas of the world. One exception is a qualitative study commissioned by DOC's Northland Conservancy (Wilson, 2009), which found that most people causing such fires had inadequate understanding of fire management and control, and lacked awareness of the dangers.

Findings from Stakeholder Study

Stakeholders believed that New Zealand is lucky that more serious accidental fires have not occurred since so many recreationists, domestic visitors and foreign tourists engage in unsafe fire practices in fire prone areas. A theme that emerged from the research was that a continuum of actions can cause wildfire, from an unlucky accident through to behaviour bordering on negligence. Many of the stakeholders involved in cost recovery talked of the discretion that must be applied in distinguishing negligence, especially in its legal definition, from accidents and nuisance. For example, ignition caused by fireworks could be deemed as negligent, nuisance, deliberate or accidental, depending on the exact circumstances and intent.

Stakeholders agreed that good information was vital in reducing the risk of visitors causing wildfires, and that targeting overseas visitors would be useful. There was acceptance that material would need to be well designed; the approach would need to be consistent across fire authorities; and there might be a need for regional and national information. Participants agreed that a widespread media campaign would be helpful to inform people about the dangers of fire in the rural landscape and how rapidly such fires can catch and spread.

Figure 6. Further restrictions or banning public use of fireworks could reduce some accidental fires.

Figure 7. Public education is an important tool to prevent the ignition and spread of wildfires.

Recommendations

People who use New Zealand's rural areas for recreation can be responsible for wildfires. Literature and the stakeholder study identified the following recommendations to reduce these accidental fires:

- **Restrictive measures** – ban or restrict vehicles from fire prone areas such as beaches; further restrict or ban the public's use of fireworks; and prosecute, when appropriate, individuals who cause accidental fires.
- **Public education** – use public education as a tool to prevent the ignition and spread of wildfires. Include integrated programmes of fire education within schools and information campaigns promoting fire messages. Other initiatives include informing schools by email release on days of high fire danger so that they could alert students (who could in turn alert their families and whanau); and improving the information available on NRFA and DOC websites relating to fire danger and safe practices.
- **Fire danger signs** – improve roadside 'half grapefruit signs' to include information about appropriate behaviour according to the level of fire risk.
- **Targeting tourists** – display signs in other languages; ensure DOC website highlights fire safety information to overseas visitors; and use rental car and campervan providers as a means of disseminating information.

Fires originating in the Rural-Urban Interface: Lifestylers

Context and Findings from Literature Review

In many developed countries, including parts of Europe, the USA, Australia and New Zealand, population demographics are changing from the traditional rural / urban split, (Bones, 2005). More people are relocating away from the cities and to the surrounding countryside, often on the edge of forests, shrublands or national parks. Such areas can be defined as areas where structures, including residential, industrial, recreational or agricultural, are adjacent to or among combustible fuel. The term 'rural-urban interface' (RUI) has been used to describe such areas.

Figure 8. Newcomers to RUI areas are often less aware of fire issues and risks, and regard protection as the role of fire services.

Statistics New Zealand projections (Bayley & Goodyear, 2005) suggest that the increase in the number of lifestyle blocks[4] and subdivisions (applicable to many areas of New Zealand) is increasing. The likelihood of wildfires being caused by carelessness is higher since the newcomers are unlikely to have an understanding of fire, in contrast to landowners and long term residents. International research suggests newcomers to RUI areas were less aware of fire issues and fire risks and, furthermore, employ urban models of responsibility (i.e. that protection is the role of fire services). Such factors therefore increase the risk of wildfires being caused by people's carelessness, while at the same time contributing to the spread of any fire by failure to adopt fire prevention strategies. Another fire risk

[4] 'Lifestyle block' is a distinctly New Zealand term introduced by real estate agents in the 1980s to describe small rural holdings purchased by people who want to live a rural lifestyle but who derive their principal income from non-farming activities (Paterson, 2005).

associated with the expansion of the RUI is additional visitors to nearby areas, thus creating more opportunities for careless fires to be started.

Findings from Stakeholder Study

The rapid increase in lifestyle blocks in New Zealand over the last decade and a relatively high turnover in property ownership was recognised by all stakeholders. Participants shared concerns about the resulting changes in land use and the introduction of more trees and fuel, as summed up by one interviewee:

> *"And now there's little mini forests every 100 m, they've got a 2 ha little forest and they've got a bit of grazing, and then they've got fuel up the fence lines and fire just jumps from one to another."*
>
> (Interviewed Canterbury stakeholder)

One problem repeatedly identified by stakeholders was lifestylers' ignorance around fire. It was strongly and unanimously believed that lifestylers who had previously lived in urban areas or overseas, and often still worked in the cities, commonly displayed ignorance and bad practice in their dealings with fire. Numerous examples were provided. Such behaviour was identified as an enormous risk for RUI communities and neighbouring farmers. Stakeholders shared the view that many lifestylers were ignorant of different aspects of safe behaviour around fire, fire regulations, land management and fire safety.

All stakeholders suggested that informing and educating lifestylers was the best method of reducing risks of wildfires at the local level, particularly in fire prone regions of the country. Many stakeholders agreed that having personal contact with lifestylers to enable them to talk about issues was most helpful, but due to limited resources was often unfeasible.

> "*If you really want to get the message across, it's the personal visit, going round whenever the opportunity arises."* (RRFC focus group)

Figure 9. Informing and educating lifestylers is an important means of reducing localised wildfire risk.

Recommendations

New Zealand, in common with many countries, has experienced a growth in the population living in the RUI. A major theme to emerge from the stakeholder study was the lack of fire knowledge among lifestylers around fire regulations, land management and fire safety. All stakeholders suggested that informing and educating lifestylers was the best method of reducing risks of wildfires at the local level, particularly in fire prone regions of the country, and identified the following recommendations:

- **Educational material** – place booklets and resources in local visitor/service centres and libraries; use websites; place information in local media; and distribute leaflets and letters to rural box holders.
- **Other organisations** – work with other organisations such as real estate agencies, insurance companies and mortgage providers to distribute information and inform people of their responsibilities around fire.
- **Development of best practice guidelines** – evaluate the effectiveness of current methods used by different RFAs to inform lifestylers of appropriate fire behaviours, risks and regulations; and share information about appropriate ways to communicate with RUI communities.
- **Fire danger signage** – the 'half grapefruit' signs should be improved to include information about expected behaviour.
- **Prosecution** - increase publicity on related prosecutions that take place, even in other regions, to help inform and educate people about their responsibilities and issues around public liability.
- **Council responsibility** - continue improvement of green waste and waste collection in rural areas to mitigate the risk of wildfire, by removing material that might otherwise be burnt.

Escaped Land Management Fires

Context and Findings from Literature Review:

In New Zealand, farmers often burn residue/stubble from crops after harvesting. This activity is particularly common in mid Canterbury, Otago and Southland which are traditionally the main cropping regions. It is estimated that several thousand stubble burns take place annually in Canterbury alone. In addition, high country farmers periodically burn areas of tussock grassland to improve grazing and stock access and/or reduce woody vegetation.

Figure 10. In New Zealand, 47% of the land burned each year by wildfires is attributed to escapes from land clearing burns.

Within New Zealand, 47% of the land burned each year by wildfires is attributed to escaped land clearing burns, accounting for one fifth of all wildfires (Doherty et al., 2008). DOC figures show that 8% of fires on public conservation land were from permitted fire escapes from 1987 to 2010, while 14% were from unauthorised fires escaping.

The rules covering stubble burning are the same as for other types of fire lighting: that no permits are required for outdoor fires (fires in the open air) in an open fire season; permits are required within a restricted fire season; and no fires are allowed within a prohibited fire season (although special permits can be applied for in some cases). However, there are some nuances in the application of these rules that add an element of confusion.

Different RFAs have different policies on stubble burning. Some, including DOC Canterbury (for land within a 1 km boundary of DOC land, where this applies), operate a code of best practice for stubble burning. Farmers are not required to apply for individual permits in a restricted fire season, but do need to operate within the conditions set out by a statutory authority and the code of practice, around weather, timing, firebreaks, firefighting equipment and manpower. Other RFAs may issue fire permits on a case by case basis, or for an entire season. Again, conditions of permit issue vary, with some requiring site inspections by RFA officers.

All areas require that fires are carried out in safe weather conditions, with an adequate firebreak and with suppression equipment on site (although exact firebreak, weather and suppression requirements may differ). Additionally land owners are required to take into consideration the smoke from their fire, to ensure that it does not drift across roads and become a traffic hazard or environmental nuisance.

Figure 11. Permits are generally required for burning within a restricted fire season.

This review found a notable scarcity of research on the topic of escaped land clearing and land management burns, and could find no evaluation of the effectiveness of legislative and policy procedures such as fire permit procedures or access restrictions against wildfire ignition.

Findings from Stakeholder Study

A clear theme to emerge from the Canterbury farmers' focus group and interviews with fire managers was farmers' desire to keep the right to burn which they viewed as a privilege. Farmers and fire managers all cited the value of burning stubble as a more financially viable and environmentally sustainable option than mechanical methods or applying large quantities of insecticides and fungicides. They also recognised the value for high country farmers of being able to undertake burns which were felt to be the only practicable solution to clearing land of woody vegetation in such areas.

Figure 12. Bad practice among a small minority of farmers could risk farmers' rights to burn, ultimately affecting their livelihood.

Interestingly, although statistics show that land management fire escapes account for a substantial proportion of total rural fires, as well as area burned, many stakeholders including DOC personnel, farmers and fire managers believed that it was not a major issue. This was because such a large proportion of the many thousands of fires annually do not escape. However, there was agreement that bad practice among a small minority of farmers could risk farmers' rights to burn, ultimately affecting their livelihood.

> "*But that's where the privilege of maintaining this right to burn is, you know, gets eroded, put it that way*." (Farmers' focus group)

Stakeholders, including farmers and fire managers, noted that Federated Farmers, the NRFA and RFAs work together, which helps to foster good relationships, understanding and farmer input into rural fire management. For example, Federated Farmers have a representative on the National Rural Fire Advisory Committee, and the Regional Rural Fire Committees coordinating regional fire activities all have Federated Farmers representatives together with other land managers (e.g. forestry, Regional Councils) and RFAs.

Stubble Burning

Three reasons for possible escapes of stubble burns were cited: inadequate firebreaks; a change in wind direction or strength; and accidents. The 'accident' was usually a rabbit or hare catching fire in the paddock and running across the firebreak, but occasionally there might be an unexpected and unforecast wind change. Another issue identified was that crop harvesting, and stubble baling and burning, happen late in the summer when conditions are usually drier. By this stage of a busy farming season, machinery such as balers is often getting worn, thereby increasing the risks of the machinery itself causing a fire.

Figure 13. A farmer's knowledge, experience and safe fire management methods are essential in minimising the risk of escaped fires.

Stakeholders interviewed understood that a farmer's knowledge, experience and safe fire management methods were essential in minimising risks. Of crucial importance was having sufficient suppression measures on hand to account for any unforeseen eventuality. Again there was agreement that a small minority of people did not undertake safe practices around firebreaks, weather conditions or suppression measures. These people "*push the boundaries just a little bit too far*" (Farmers' focus group).

In common with stakeholders' perceptions of a continuum of behaviours among other land owners, recreationists and tourists, some stakeholders, including all farmers in the focus group, spoke of farmer behaviours around the use of fire. Thus there was agreement that should a farmer light a stubble burn when there was a gale force nor'wester, the definition of such behaviour verged on arson and could not be put down to an accident or even reduced duty of care should such a fire escape. Similarly, some stakeholders felt that farmers who did not have back up suppression were culpable should there be escapes.

Fire managers and farmers came to the same conclusions regarding why some people were less careful than others: ignorance, and a culture of carelessness. Newcomers, such as farmers moving from wetter to drier parts of the country (e.g. Taranaki to Canterbury), were cited as among those who could display ignorance, due to their lack of experience in fire prone areas. There was also widespread agreement that some people had a culture of not burning safely, perhaps passed on from previous generations. They were felt to have "*got away with it*" in the past and so continued to display poor fire management practices. This minority of farmers were considered to be arrogant, to feel that they knew best and did not need to follow different/recommended methods.

There was a consensus of opinion amongst all stakeholders interviewed that it was vital that landowners were made aware of requirements and continued to be reminded of them.

Land Clearing Burns

Stakeholders explained that high country farmers' land clearing burns were riskier than stubble burns because they would be over a bigger area, often hundreds of hectares; were often in high country with mixed topography and localised wind conditions; and since they were bigger, there was more risk of a change in weather conditions or an ember being carried outside the perimeter of the burn. Additionally, the vegetation being cleared would have root systems that could themselves burn, sometimes underground and emerge at a different spot or even several days later. Land clearing burns in high country were also likely to be a considerable distance from a local fire brigade, sometimes over an hour's drive away, so that should the burn get out of control the consequences could be much worse.

Figure 14. High country farmers value the right to undertake burns which they felt to be the only practicable solution to clearing land of woody vegetation.

There was agreement amongst all stakeholders that high country farmers usually had extensive knowledge of burning and the risks involved. The Federated Farmers stakeholders also agreed land clearing was a stressful and difficult activity due to the risks, and therefore high country farmers were very cautious. One such farmer spoke of being "*gun shy*" of carrying out prescribed burns. This was often made riskier by the difficulties of finding an optimum time to burn, which could often compound the dangers through the accumulation of more fuel.

A representative from DOC's Canterbury Conservancy spoke of efforts to foster a relationship of understanding with their neighbours and the public on fire restrictions over the last decade. This was felt to have had positive outcomes, with fewer fires needing suppression than in previous years. The main problems for DOC concerning farmers were when farms were taken over by new owners who were unfamiliar with the area, weather and fuel conditions and the fire regulations, and could be unaware that some of their land fell within DOC's 1 km fire safety margin. The other group of high risk farmers identified

were, as with stubble burning, farmers who had a culture of carelessness and thought they did not need advice.

Recommendations

It is common practice in some areas of New Zealand, especially Canterbury and Central Otago, for arable and high country farmers to use fire for removing crop residue or other vegetation. The Canterbury Federated Farmers' focus group and interviews with other stakeholders highlighted the value of this land management practice, and most viewed it as a privilege that farmers did not want to lose. Recommended measures to reduce the risk of escaped land management burns included:

- **Prosecution** – increase publicity on related prosecutions that take place, even in other regions, to help inform and educate people about their responsibilities and issues around public liability. Work with the insurance industry to show a united front and highlight consequences for farmers who were responsible for fire escapes.
- **Education and information** – continue to remind farmers about restrictions and permit regulations, and the use of codes of best practice. Current measures include radio announcements, newspaper advertisements, letters delivered to rural box holders, NRFA leaflets and booklets, and RFA websites.
- **Suppression resources** – ensure that anyone undertaking a burn has suppression resources available at all times, whatever the fire season. Actively highlight to landowners the wider impact of escaped burns and encourage them to think of the consequences upon the local volunteer fire force and businesses in which members are employed, rather than just the cost or prosecution. Only allow lighting of stubble fires after 4 pm when fire brigade or rural fire force personnel were more likely to be available.
- **Policy revision** – review DOC's policy on prescribed fire, especially in the context of land tenure review; consider the use of firebreaks and controlled burns.

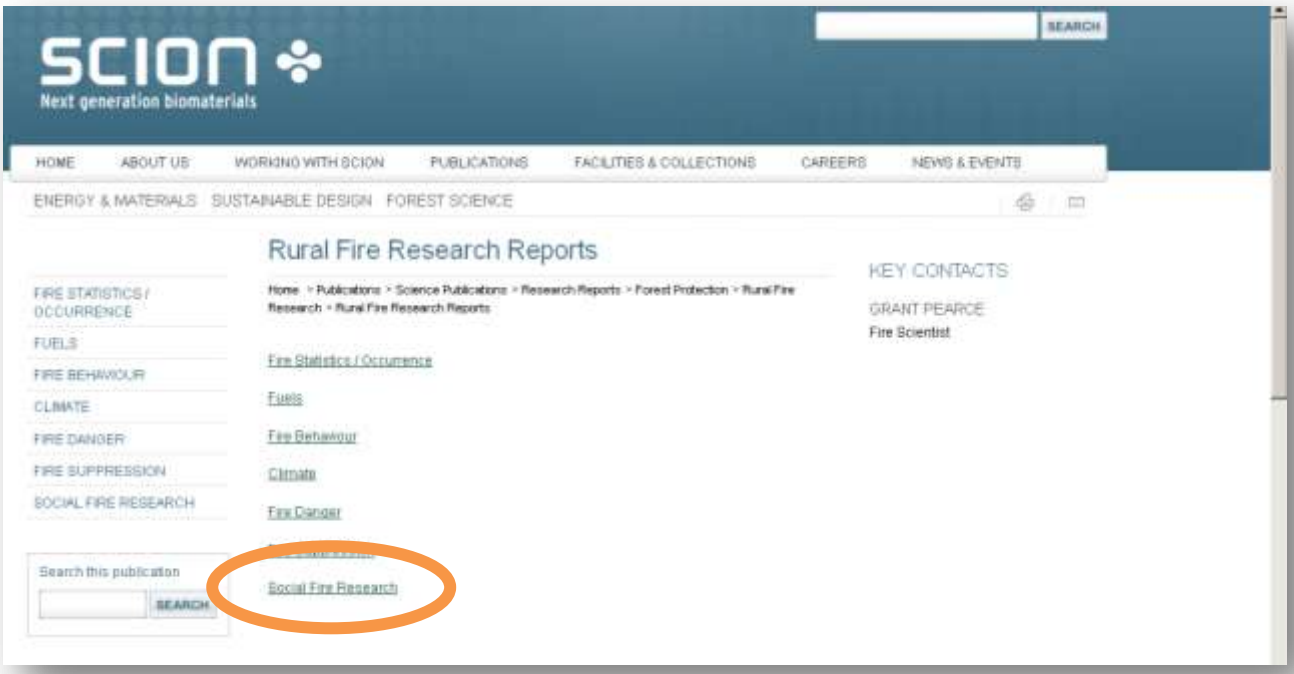
Figure 15. All land owners need to be continually reminded about restrictions and permit regulations, and the use of codes of best practice for burning.

Acknowledgments

This project was financially supported by Scion's Rural Fire Research Group through funding from the Foundation for Research, Science and Technology (FRST) (Contract C04X0403) and the rural fire sector (through members of the Rural Fire Research Advisory Committee). The involvement of the individual members of the stakeholder groups who participated in this study is also greatly appreciated. Images in this tech-note were kindly supplied by: Herb Christophers (Figure 1), Marlborough Express (Figures 2 & 3), Bob King (Figure 4), National Wildfire Coordinating Group (Figure 5), and the NRFA (Figures 8, 9 & 15).

Further information

For more information on any of these recommendations, issues raised or study methodology, refer to the full report *Mitigating the risk of human caused wildfires: literature review and stakeholder study* (Hart and Langer, 2011) which is available from the Scion rural fire research website (www.scionresearch.com/fire).



References

Bayley, A., & Goodyear, R. (2005). *New Zealand: An urban / rural profile.* Wellington: Statistics NZ.

Bones, H. (2005). *Wildfires and communities: International perspectives.* Ensis Forest Biosecurity and Protection, Scion.

Doherty, J. J., Anderson, S. A. J., & Pearce, G. (2008). *An analysis of wildfire records in New Zealand: 1991-2007.* Christchurch: Scion.

Hart, M., & Langer, E.R. (2011). Mitigating the risk of human caused wildfires: literature review and stakeholder study. Scion Rural Fire Research Group, Christchurch. Scion Contract Report No. 18090. 56 p.

Lambie, I., Randell, I., Ioane, J., & Seymour, F. (2009). *An outcome evaluation of New Zealand Fire Service Fire Awareness and Intervention Programme. Final Report.* Wellington, New Zealand: New Zealand Fire Service Commission.

Muller, D. A., & Stebbins, A. (2007). Juvenile arson intervention programs in Australia. *Trends and issues in crime and criminal justice*. Canberra: Australian Institute of Criminology.

Paterson, J. (2005). What is a “lifestyle block” and is it a form of “rural gentrification"? *Focus on Rural Research, Waikato Branch of the New Zealand Geographical Society*. from www.waikato.ac.nz/wfass/subjects/geography/research/rtp/trtwebpage1.doc

Pearce, H. G., & Clifford, V. (2008). Fire weather and climate of New Zealand. *New Zealand Journal of Forestry, 53*(3), 13-18.

Wilson, C. (2009). *Why start wildfires? The motivation behind arsons and accidents*: Northland DOC, Unpublished report.

Funding for the Scion Rural Fire Research Group is provided by: