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Preparing homeowners and communities in the rural-urban interface for increasing wildfire risk

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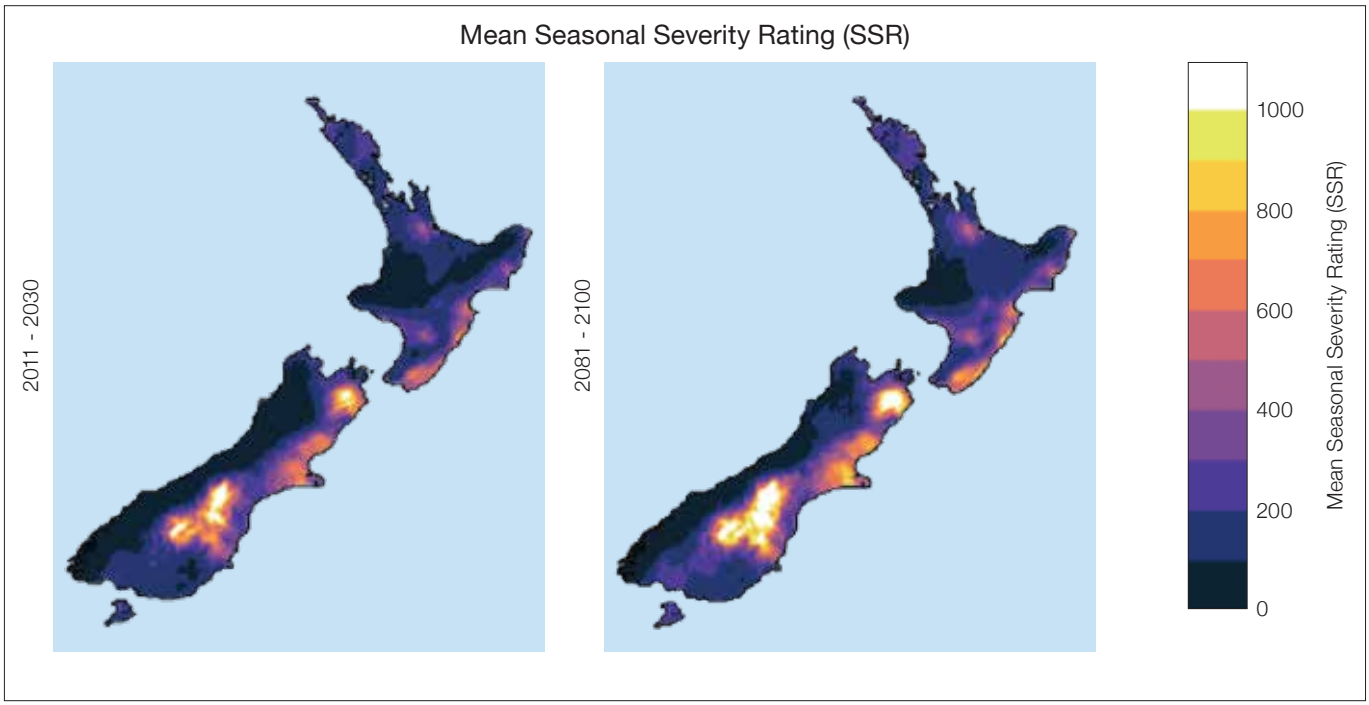

Figure 1. *Mean Seasonal Severity Rating (SSR) for 2011-2030 and 2081-2100.*

Summary

Extreme fires are becoming more frequent in Aotearoa New Zealand, and these fires are increasingly affecting people living in the rural-urban interface (RUI). For many parts of the country, climate change is expected to increase temperatures and reduce moisture, creating the potential for more frequent extreme wildfires. At the same time, the population is expanding into the RUI, exposing vegetation to more sources of potential ignition and exposing more people to wildfire threats.

The primary aim of this study has been to support agencies in planning for and reducing the growing risk of extreme wildfires in Aotearoa New Zealand's vulnerable RUI. To do so, we have applied the latest high-resolution climate models and new mapping of the growing RUI to help enable improved wildfire threat assessment. This in turn will help prioritise engagement and risk reduction efforts. We have recommended best practice wildfire risk reduction, mitigation and preparedness actions which agencies can communicate when engaging with at-risk RUI communities.

These findings can assist Fire and Emergency New Zealand (FENZ), district and regional councils, and other agencies working with RUI homeowners and the wider community to provide guidance about wildfire risk mitigation and preparedness.

Introduction

Extreme fire weather and fire behaviour is increasing in Aotearoa New Zealand. While the country has not seen fires as devastating as those in the Australian 2019-2020 fire season, recent fires near Nelson, Marlborough, Hanmer, Hawke's Bay, in the Mackenzie Country and on the Port Hills of Christchurch serve as graphic warnings. More homes were destroyed during the 2016/17 fire season, and then again even more dramatically in 2020-2021, than there had been in any of the previous 100 years.

Climate change increases the overall wildfire risk[1] by increasing temperatures and reducing moisture. Higher temperatures reduce relative humidity and prolong droughts, making fire fuels more vulnerable to ignition. Changing rainfall patterns also affect the distribution of risk, with increased rainfall in some areas but drier conditions in others.

Previous studies found that climate change will increase wildfire risk in many regions of New Zealand, but these relied on obsolete climate simulations and sparse data. This resulted in high uncertainty and poor understanding of how risk increases would be spatially distributed.

At the same time, the number of New Zealanders living and recreating within the rural-urban interface (RUI)[2] is rapidly growing. Because the RUI represents areas where humans (and their activity) interact with flammable vegetation, it is an area with both increased wildfire ignition risk and more people potentially exposed to harm from wildfires. International studies have shown that human activity is associated with more frequent wildfires. Across New Zealand, more than 99% of wildfires are attributed to human causes. It is necessary, therefore, to understand where the RUI is located so agencies can better plan and prepare.

Additionally, evidence suggests the general public does not fully appreciate the increasing wildfire risk or understand their mitigation options (Langer and Wegner, 2018). While there have been efforts to educate rural and lifestyle block property owners about wildfire risk reduction and preparedness in New Zealand, guidance for residents in urban and suburban areas of the RUI is lacking. There is a need for wildfire risk reduction and preparedness recommendations that are appropriate and practical for residents, homeowners and communities in the RUI.

The primary aim of this study has been to support agencies in planning for and reducing the growing risk of extreme wildfires in New Zealand's vulnerable RUI. To do so, we have applied the latest high-resolution climate models and new mapping of the growing RUI to enable wildfire threat assessment and prioritisation of engagement and risk reduction efforts. Following this we have recommended best practice wildfire risk reduction, mitigation and preparedness actions which agencies can communicate when engaging with at-risk RUI communities.

This work was part of three associated studies funded by the Ministry for Primary Industries (MPI) Sustainable Land Management and Climate Change (SLMACC) Fund, Resilience to Nature's Challenges Kia Manawaroa – Ngā Ākina o Te Ao Tūroa, and Fire and Emergency New Zealand (FENZ). Additional funding for the climate change fire risk research component was provided by the Ministry for Business, Innovation and Employment (MBIE) "Preparing New Zealand for Extreme Fire" programme.

Research approach

Changing wildfire risk with climate change. To better understand how future climate will affect wildfire risk for New Zealand, we used the latest global climate change models and scenarios from the Intergovernmental Panel on Climate Change's Fifth Assessment Report (IPCC AR5)[3] to provide new estimates of future changes at a high spatial resolution.

Detailed climate change predictions were produced by the National Institute of Water and Atmospheric Research and based on IPCC AR5 global climate models on a 5x5 km grid covering New Zealand (Ministry for the Environment, 2018). The projections incorporated four future climate scenarios known as representative concentration pathways (RCPs) that describe climate change in the year 2100 relative to 1750. One scenario describes a climate with less CO_2 than today, two describe climates where emissions have stabilised at different levels, and the fourth describes a climate with very high greenhouse gas concentrations. Regional simulations for these four scenarios were conducted using six global models.

This study used the regional predictions to estimate changes in inputs to wildfire risk included in the Fire Weather Index (FWI) system (i.e. temperature, precipitation, relative humidity and wind speed) commonly used in New Zealand as the basis for calculating daily severity ratings (DSRs) and seasonal severity ratings (SSRs). DSRs are a numeric rating describing the difficulty of controlling a wildfire in given conditions; SSRs are the sum of DSR values for the entire year. These values in turn allowed us to calculate the fire season length and fire intensity 'ranks' for a range of potential fire behaviours and vegetation characteristics, and to estimate the frequency of extreme wildfire danger conditions (Figure 1).

Mapping of the rural-urban interface at-risk communities. To help identify where wildfire is likely to intersect with people and valued assets, we developed an improved map of the extent of RUI. This considered existing methods for quantifying and mapping wildfire risk in New Zealand (e.g. the NZ Wildfire Threat Analysis System, Wildfire Prone Areas, FireSmart communities, and Strategic and Tactical Fire Management Planning/Wildfire Risk Management Planning) and internationally.

A simple methodology was identified that defines the extent of the RUI using the new national building footprint dataset and Land Cover Database4 (LCDB4) vegetation types, together with internationally recognised definitions for 'interface' and 'intermix' areas based on building density and proximity to flammable vegetation (Figure 2). However, the threshold distance of housing units to vegetation was reduced to 500 m instead of the 2.4 km commonly used in international studies to match the shorter estimated ember travel distances for common plant species in New Zealand, including gorse, mānuka/kānuka and pine.

This methodology was validated against the extent of the RUI for three pilot study areas used in previous studies (Wellington, Christchurch and Rotorua), followed by mapping the national RUI extent across the entire country using this same methodology. Further review and refinement of the mapping process at local scales is being undertaken before results are made public.

[1] Wildfire risk is defined as the combination of likelihood and consequence of an event impacting a community.

[2] The RUI is defined as having two components. The *intermix* is where small residential properties and other urban-associated buildings are interspersed with predominantly rural land uses. The true *interface* or *urban fringe* is where dense blocks of suburban housing or industrial development adjoin—but are sharply delineated from—large areas of vegetation.

[3] This work was carried out before the Sixth Assessment Report was released in August 2021.

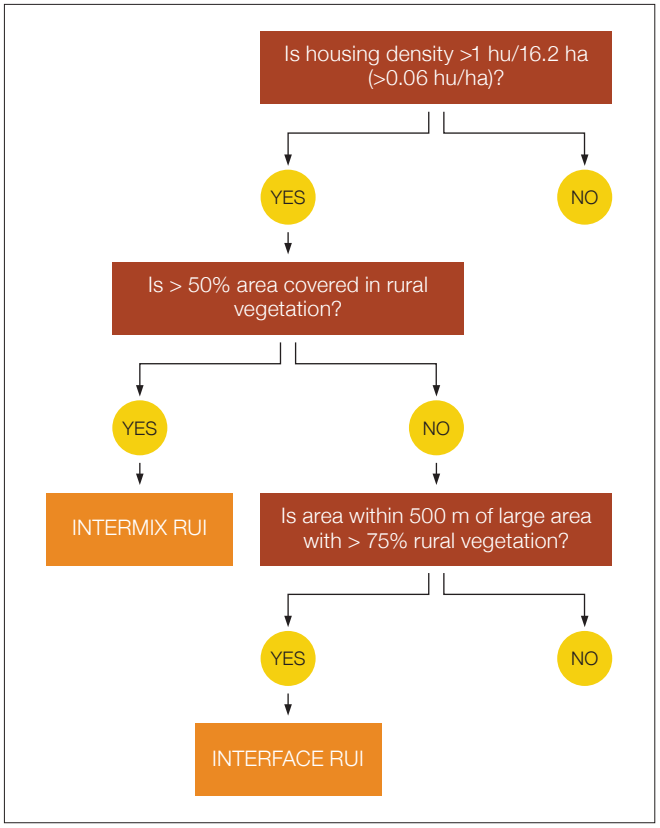

Figure 2: *Method for distinguishing between intermix and interface RUI[2] (adapted from Stewart et al., 2007). ('Hu' = housing unit).*

Northern Wānaka/Albert Town community case study. Following FENZ advice, we designed an Otago case study to understand residents' wildfire risk perception, and to identify needs and opportunities for agency engagement in an area of ongoing RUI development and high wildfire risk.

The Central Otago and Queenstown Lakes districts have been identified as having high wildfire risk and rapidly growing RUI areas. Our research focused on northern Wānaka/Albert Town, north of Highway 84 and south of the Clutha River, about 70 km northeast of Queenstown (Figure 3). As of the 2018 census, this area contained approximately 2,418 occupied dwellings and a usual resident population of approximately 6,564 (Statistics New Zealand data, 2019). It is a high socio-economic community of principally New Zealand European and European residents with tertiary education. The high proportion of holiday homes, high growth rate and large tourism industry mean many in these communities are new residents or short-term visitors who may lack awareness and preparedness for wildfires.

Figure 3: *Case study area with survey zones labelled from an allied FENZ survey.* (1. *Mt Iron,* 2. *Clutha River,* 3. *Sticky Forest,* 4. *elsewhere within northern Wānaka, and* 5. *elsewhere in Albert Town).*

Particular attention was given to residents in the more than 250 homes built among highly flammable native kānuka (*Kunzea ericoides*) vegetation on the slopes of Mt Iron (Figure 4). Kānuka is classified as Threatened – National Vulnerable, and the area has been designated a Significant Natural Area. The clearing of vegetation, and kānuka in particular, is therefore restricted by

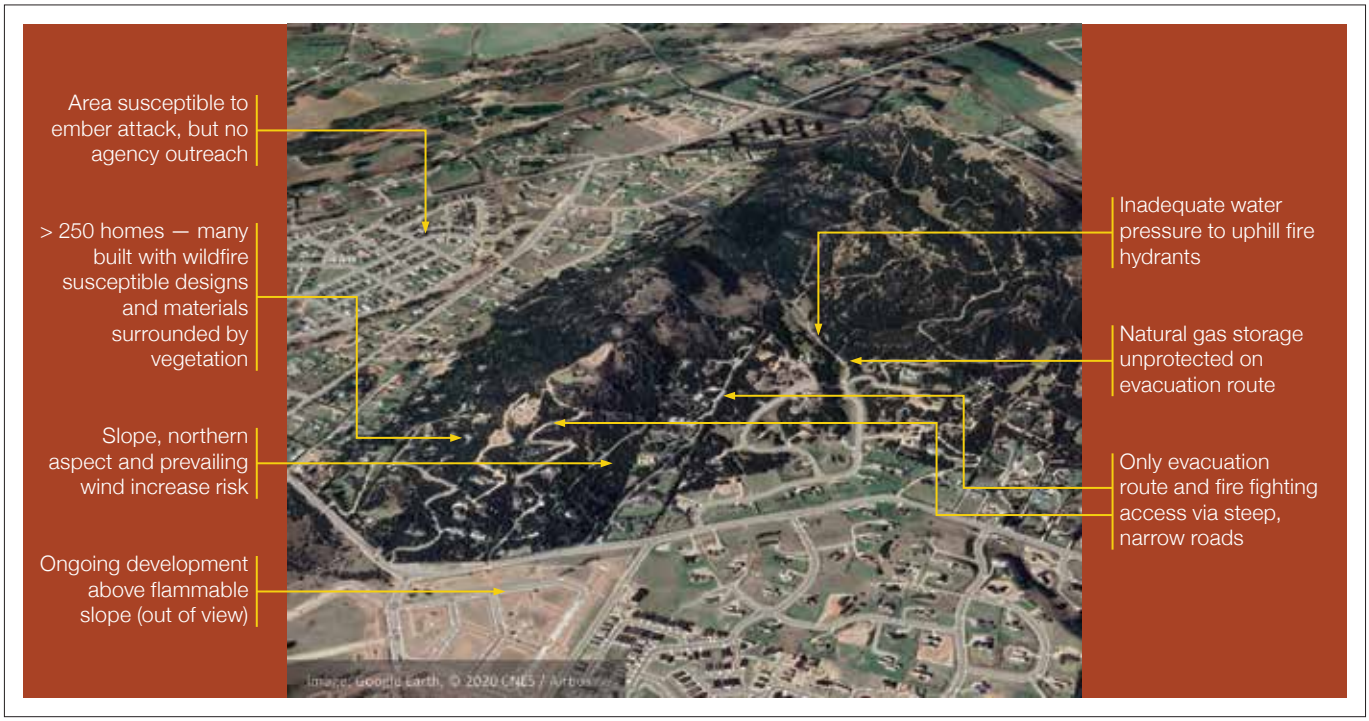

Figure 4: *Wildfire issues in the Mt Iron community.*

district plan rules to protect biodiversity and maintain visual character, as well as by individual property covenants requiring vegetation coverage. Many properties have wildfire susceptible designs and materials, and some have only one evacuation route and limited firefighting access via steep, narrow roads. This area is a focus of concern for agencies and the community, and has been designated a 'red zone' with a total year-round fire ban.

We held a series of interviews, focus groups and workshops with 64 key stakeholders and RUI residents. Participants included 24 agency professionals (Otago FENZ, Queenstown Lakes District Council (QLDC), Otago Regional Council (ORC), Emergency Management Otago, Department of Conservation (DOC) staff and a wildfire consultant), two elected councillors, three representatives from local Māori organisations and 35 community residents.

Throughout this case study the research team worked collaboratively with local representatives from FENZ, QLDC, Emergency Management Otago, DOC and the Wānaka Community Board, who have since established a Mt Iron Wildfire Risk Reduction Project to help support the evaluation and implementation of risk reduction actions.

Wildfire mitigations for homeowners and communities. Best-practice recommendations from more than 120 publications from Aotearoa New Zealand, Australia, Canada and the United States were compiled to produce a list of wildfire risk mitigation and preparedness actions for homeowners and communities in the RUI. Following coding, grouping by topic and merging of repeating or overlapping concepts, an initial synthesis list of approximately 250 recommendations was produced. These were revised to suit New Zealand contexts and to ensure they do not conflict with relevant legislation or codes following review by FENZ, MPI and a Scion expert.

Feedback was collected in April 2021 through interviews and workshops with FENZ regional and national staff, QLDC, representatives of two local Māori organisations and the northern Wānaka/Albert Town community to discuss their practicality and likely uptake by RUI residents in the case study community. Following revisions, further review is being undertaken by FENZ.

Key findings

Changing wildfire risk with climate change. This research has updated our knowledge on wildfire risk for New Zealand and the effect of climate change (see Langer et al. (2021) for more detailed findings).

Like many countries, climate change is predicted to increase the severity of fire seasons with more days with high wildfire risk over a longer period of time. Our highly detailed climate model simulations describing wildfire danger projections explicitly in every 5x5 km grid cell across the country have found that climate change will increase the frequency, severity and season length of fire weather conditions in many areas (Figure 5).

This increase is predicted to occur until at least mid-century, regardless of climate mitigation efforts represented by the different climate scenarios. For many regions, the wildfire risk is likely to become appreciably worse through the rest of the century compared to the last two decades. This will have

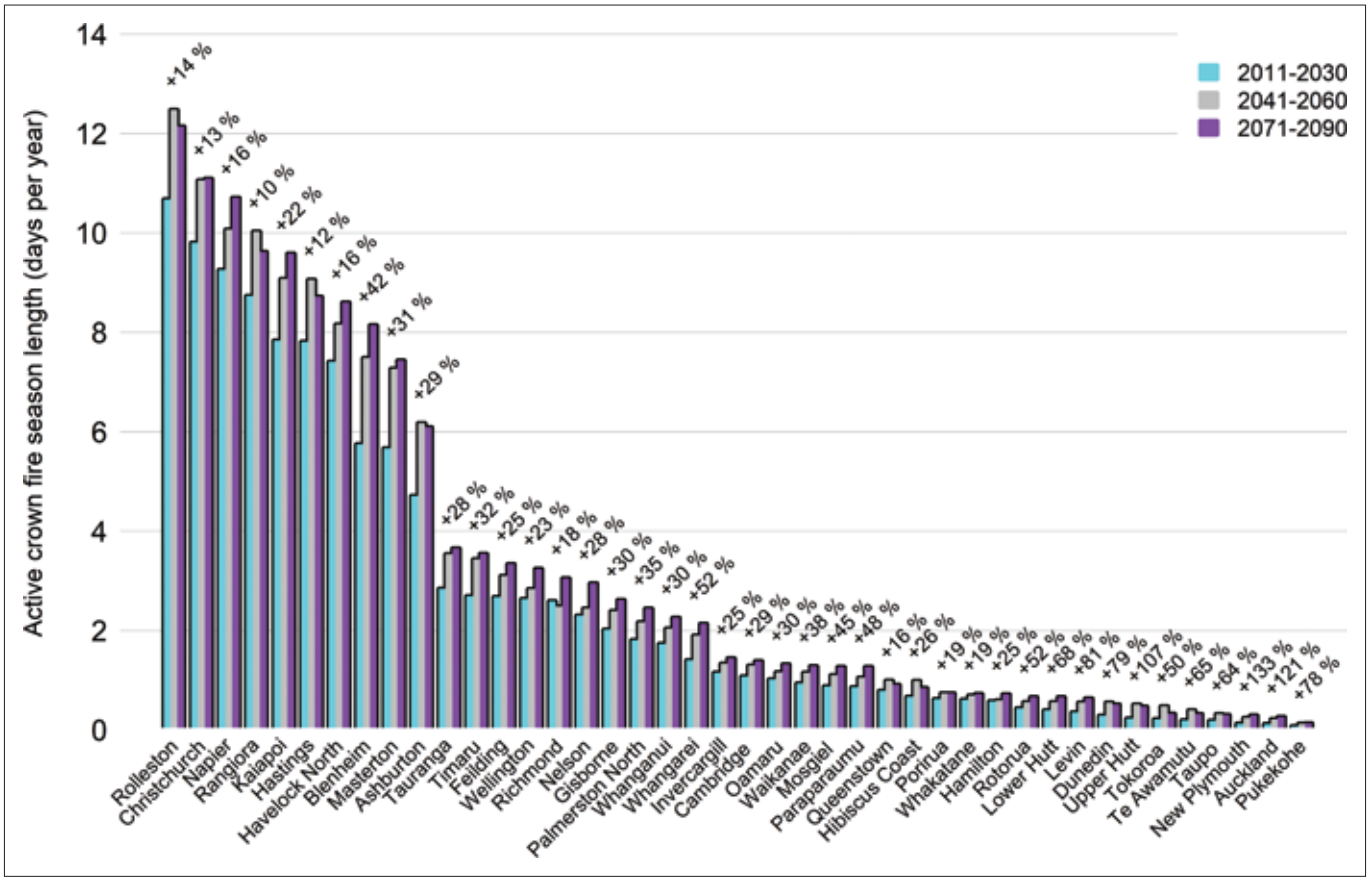

Figure 5: *Projected percentage changes in fire season length for major New Zealand city/towns (population > 10,000) under climates where emissions have stabilised from 2020 – 2090. Estimates are based on number of days per year exhibiting active crown fire potential (DSR values > 11.8, equivalent to FWI > 31).*

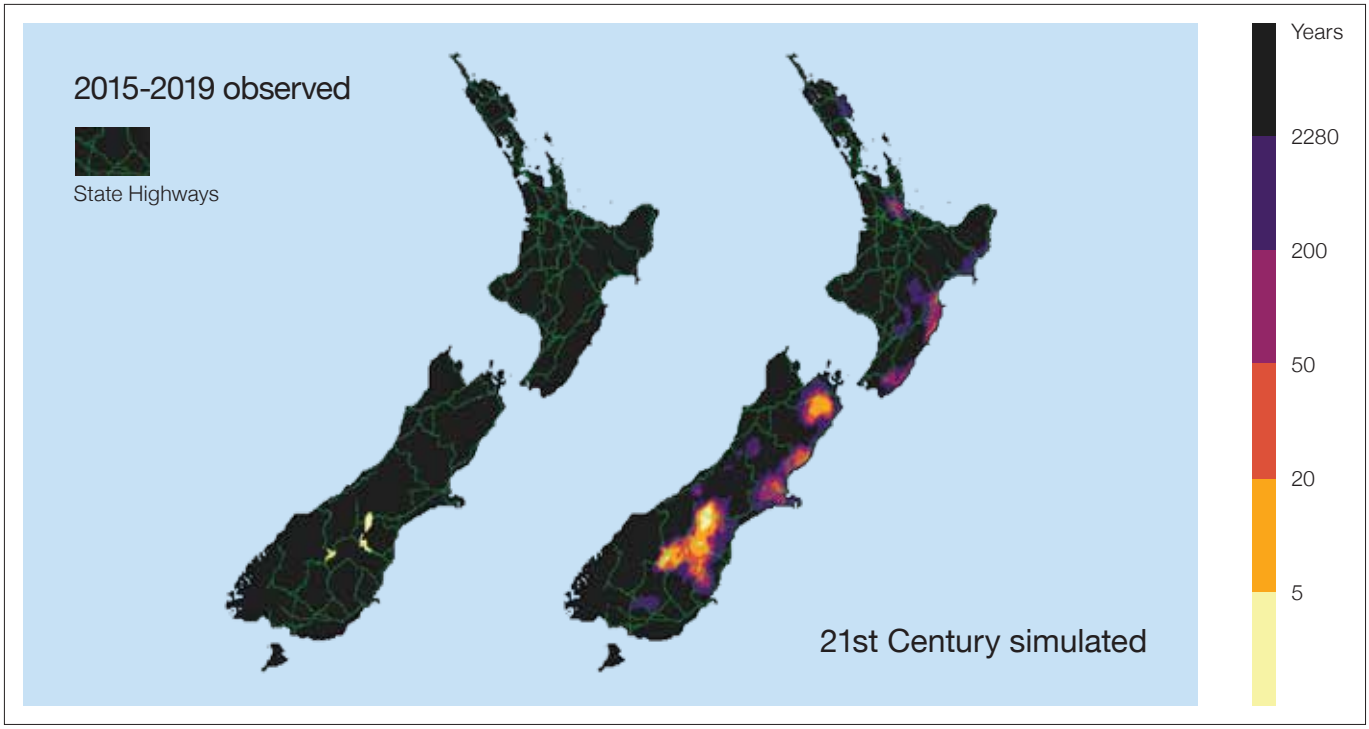

Figure 6: *Observed current (left) and predicted 21st Century (right) return period in years of extreme wildfire risk from all simulations. Areas in yellow indicate places where conditions similar to the Australian 2019/20 'Black Summer' wildfires already do or will occur at frequencies of once every five years or less.*

significant implications for climate adaptation and emergency readiness.

Hotspots, with elevated SSR values, were found in areas of Central Otago and inland South Canterbury, northern Marlborough, South Wairarapa and Hawke's Bay. The highest wildfire dangers and greatest absolute increases in both wildfire danger and fire season length were found in the currently seasonally drought-prone and arid locations of New Zealand (central Canterbury, Hawke's Bay and Marlborough). Considering this impact on cities and towns with more than 10,000 residents, the number of days with potential for extreme fire behaviour (e.g. crown fires in forests) from 2020 to 2090 is highest in parts of Canterbury (Rolleston, Christchurch, Rangiora and Kaiapoi) and Hawke's Bay (Hastings and Havelock North) (Figure 5).

Intermediate and less severe locations—for example, New Plymouth, Auckland and Upper Hutt—may still see comparatively significant increases (including doubling or trebling of the number of days each year with extreme fire behaviour potential), but over a longer time period (by 2090 compared with 2050 for more severe locations) (Figure 5). An average of a 32% increase in fire season length is expected by 2090 in our northern Wānaka/Albert Town case study area in Otago.

Concerningly, it was also found that conditions[4] that led to the devastating 'Black Summer' fires in Australia during 2019-2020 already occasionally occur in New Zealand in parts of Central Otago, but could become much more frequent with climate change, occurring every 3-20 years for areas of the Mackenzie Country, Central Otago and Marlborough (Figure 6). The observed highest risk areas have return frequencies of less than once every five years, and are found in the Mackenzie Basin and Central Otago regions – around Lake Tekapo (on State Highway (SH) 8), Lake Aviemore and the Waitaki River (SH83), and the areas around Lake Dunstan (following SH6 and SH8) and the settlement of Cromwell.

Mapping of the rural-urban interface. Following the review of local and international literature and development of a simple GIS mapping methodology, RUI mapping has brought an increased understanding of RUI locations and extent across New Zealand. From nationally generated maps, we estimated the area of land falling within the RUI, both within the interface and the surrounding intermix. Provisional analysis suggests that nearly 17% of the country (over 4.6 million ha) falls within the RUI. This is made up of around 0.8% (almost 221,000 ha) of higher density interface and 16.1% (nearly 4.4 million ha) of the less densely populated intermix.

As expected, with its higher population, the area of RUI (both interface and intermix) is higher in the North Island than the South Island. Regionally, the proportion of both interface and intermix is highest in the northern North Island (FENZ Region 1, Te Hiku), and lowest in the south of the South Island (Region 5, Te Kei).

Where the RUI intersects with climate conditions and fuels that make wildfires more likely and more severe, the result is extreme wildfire risk. However, due to the sensitivity associated with identification of specific areas of RUI as higher risk, further work is underway to validate the results from this mapping at local scales prior to results being made public.

Northern Wānaka/Albert Town community case study. Permanent residents in the Mt Iron intermix area engaged in the case study exhibited high wildfire awareness and anxiety, amplified by the recent wildfire that destroyed half the village

[4] 'Black Summer' conditions are a combination of two criteria: seven days mean FWI > 54 and rolling 30-day DSR > 20.

(48 houses) at Lake Ōhau, 70km away, in October 2020. Mt Iron residents have voiced their concerns about the potential wildfire threat to lives and property to local agencies. Their concerns focus on issues such as restrictions to removing protected kānuka vegetation around their properties, flammability of cedar cladding of their houses, access for fire trucks on the one-way evacuation routes for residents, and the added issue of large daily numbers of recreational walkers on Mt Iron.

Mt Iron permanent residents in the study who are very aware of the wildfire risk have started taking individual household and collective community preparedness actions and are considering additional actions, such as further vegetation management, early warning systems and vegetation drenching systems. Limitations that have resulted from historic development planning and roading decisions, and apprehension about their on-going ability to insure their properties, remain.

The wider northern Wānaka/Albert Town area includes holiday homes with intermittent use, short and long-term rentals for both domestic and international visitors, pre-schools, a primary school and a popular holiday park with short-term and semi-permanent residents. The wildfire awareness and preparedness measures of this wider community differ from the very aware Mt Iron residents who took part in our study. A lower wildfire risk awareness appears apparent, and there are reports of use of fireworks and braziers and inappropriate disposal of cigarette butts.

A relatively small but growing proportion of the community identify as Māori compared with the wider New Zealand population. While many Māori in the area are affiliated with Ngāi Tahu and some are mana whenua (hapū and iwi with customary land rights), the majority of Māori in the area are mataawaka (Māori living in an area but who are not mana whenua) from other iwi. These residents bring their own traditional, generational knowledge of fire. Examples include knowledge that north-westerly winds bring fire; cooking should be done at night when the air temperature is cooler; and fires should be lit near a water source rather than near habitation.

Networks and active communication are strong, although no marae or communal meeting ground exists in the Queenstown/Wānaka area. The Mana Tāhuna Charitable Trust (a Queenstown based pan-Māori organisation formed to support whānau (families) through the response to Covid-19 in March/April 2020 with support from Ngāi Tahu) aims to improve the wellbeing of Māori within the Tāhuna community. The Hawea Māori community also has a strong network that meets regularly. These groups bring the opportunity for agencies to extend their engagement and transfer knowledge with the wider community, which could lead to greater uptake of individual and collective wildfire preparedness actions.

Wildfire mitigations for homeowners and communities. Around 170 recommendations have been developed which describe mitigation actions homeowners can take to prepare themselves and their homes to reduce their risk from wildfire. The list of recommended mitigations can be accessed from https://www.ruralfireresearch.co.nz/tools

The recommended mitigations have been divided into five categories that apply to people at different stages of preparation and response:

- When building or remodelling a home
- When landscaping or designing outdoor spaces and property infrastructure
- When making a wildfire plan
- When preparing for the start of each wildfire season
- When a wildfire occurs.

Overall intent to accompany mitigation recommendations

- These recommendations can help you improve the chances that you and your home will survive a wildfire, but remember that no amount of risk reduction can guarantee safety. Some wildfires may overcome even the strongest mitigations and the best efforts of firefighters.
- Always evacuate if a wildfire threatens your home, and do not wait for an official warning to evacuate if a fire is nearby. Only shelter in place as a last resort if escape is no longer possible.
- No single action is enough. The recommended actions are intended to work together to collectively reduce your wildfire risk. Even major mitigation actions, such as installing exterior sprinkler systems will not be effective unless taken alongside other measures.
- The recommendations describe the ideal and will not all be feasible or practical in all situations. If more susceptible sites, construction materials, designs or landscaping cannot be avoided, compensate by taking greater precautions in other ways. Consider the intent of the recommendations and consult with Fire and Emergency NZ representatives, fire engineers or other experts to find alternative solutions that will work for you.
- Be sure to follow the Building Code and all applicable local regulations. Work with your local council to ensure you remain compliant.

Figure 7: *Introductory information with caveats to share with homeowners and communities to accompany wildfire risk reduction and preparedness mitigation recommendations.*

The recommended actions are aimed primarily at RUI situations and not necessarily to wider rural contexts (e.g. farming, animals, etc.). Importantly, the recommended mitigations are based primarily on the consensus of advice internationally, expert insight, anecdotal evidence and correlation of a limited number of variables. Other than those materials and designs which have been tested in a laboratory, it is not currently possible to provide a definitive scientific assessment as to the effectiveness of most recommended mitigations, to prioritise them for action, or to define objective thresholds for how they should be applied (e.g. precisely how many metres of vegetation clearance should be recommended). In addition, the mitigation actions recommended may conflict with competing priorities, such as ecological protection or urban growth, and may not be appropriate in all local contexts. Therefore, FENZ and other agencies should determine which of the recommended mitigations they wish to promote in which contexts.

The recommended mitigations identified form only one part of what must be a coordinated communications and engagement effort that also includes educating communities, homeowners and residents in the RUI about wildfire and what factors shape their individual risk. This should include:

- The principles of how wildfires spread and what factors affect the rate and direction of spread.
- The limits of firefighting capacity and capability against wildfires of different intensities.
- What to consider when making an evacuation plan, including information about the speed of wildfire spread, likelihood of traffic congestion and the difficulty of driving through smoke.

In addition, information must be included as preface to the mitigation recommendations to explain how they should be interpreted and applied (Figure 7).

Conclusion

For many regions of Aotearoa New Zealand, climate change is predicted to increase the wildfire risk appreciably, with an increase in the frequency, severity and season length of fire weather conditions through until at least mid-century, regardless of climate mitigation efforts represented by different emission pathways. This has significant implications for FENZ, regional and local councils, primary industry land managers and investors, and property owners.

Mapping of RUI locations which intersect with climate conditions and fuels to make wildfires more likely and potentially more damaging allows agencies to focus on priority communities vulnerable to extreme wildfire risk.

Improving wildfire awareness and preparedness among homeowners and communities is essential as climate change and growing development in the RUI increase the risk to communities from wildfire. Some residents in a wildfire prone area of northern Wānaka/Albert Town were acutely aware of the wildfire risk (Figure 8) and have commenced or plan to take mitigation and/or preparedness steps, whereas others have not, highlighting the need for further agency engagement.

Wildfire mitigation and preparedness actions for suburban contexts have been developed for agencies to guide homeowners and communities in constructing or remodelling a home, landscaping or designing defensible spaces, preparing at the start of each wildfire season, making response plans and during a wildfire event. Agencies should undertake engagement to share these mitigation recommendations with RUI residents, and explain their basis and benefits to better enable their uptake.

Figure 8. *Highly flammable kānuka on the slopes of the wildfire prone Mt Iron above the residential area of Wānaka.*

Recommendations

- Making the findings of this study available to regional and district councils, to Government agencies including FENZ, National Emergency Management Agency, DOC, Land Information New Zealand and the Ministry for the Environment, and to stakeholder organisations such as the New Zealand Forest Owners Association and Federated Farmers NZ.
- Reviewing, and where necessary, refining the RUI mapping results and methodology, including integration of this property exposure information with maps of wildfire climate, fuels, slope and other factors affecting wildfire risk.
- Further reviewing of the wildfire preparedness mitigations to provide recommendations and more definitive, easily understood guidance to RUI homeowners and communities nationally.
- Engaging and working in partnership with homeowners and the community to raise awareness of wildfire risk.
- Encouraging residents to implement wildfire preparedness mitigations on their properties in RUI areas identified as particularly wildfire prone under climate change.
- Extending community engagement and transfer knowledge to Māori community groups to benefit from their strong networks to encourage individual and collective wildfire preparedness actions.
- Investigating ways to raise wildfire awareness and preparedness of short-term residents and visitors.

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Acknowledgements

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