Wildfire risk in New Zealand, 1997-2023

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Contents

Executive summary

The Ministry for the Environment contracted the National Institute of Water and Atmospheric Research to provide the full record of fire risk data from 1997-2023. The New Zealand Fire Danger Rating was used for this study, specifically the monthly and annual number of days of Very High (VH) or Extreme (E) fire danger. Fire and Emergency New Zealand uses this Fire Danger Rating System to monitor fire risk in New Zealand. Fire danger ratings are calculated using four weather variables: 24-hour rainfall, temperature, relative humidity and wind speed.

Thirty regionally representative locations were selected for investigation, and fire danger ratings were calculated using each of Forest, Grass, and Scrub as the primary fuel type, respectively. Analyses demonstrated considerable variability of VH and E fire danger days.

Using “Forest” as the primary fuel type:

- Nine stations out of 30 observe an annual average of at least seven VH fire danger days.
- The annual average number of VH fire danger days range from 18 at Blenheim, to 0 at Whangaparāoa, Taumarunui, Reefton, Hokitika and Milford Sound.

There are several options for improving this indicator in future, including adding more locations, and exploring the potential to extend calculations of wildfire risk back earlier than 1997. Other metrics such as the annual number of wildfires are not stored by NIWA, but may be available via Fire and Emergency New Zealand.

1 Introduction

NIWA currently operates the Fire Weather System (FWS) for Fire and Emergency New Zealand (FENZ), monitoring daily fire danger at multiple sites around the country (https://fireweather.niwa.co.nz/). The FWS is based on the internationally recognised Fire Danger Rating System, originally developed in Canada. The system has been modified for New Zealand conditions by Scion, and has been used by Fire and Emergency New Zealand for many years.

The Fire Danger Rating System has five categories: Low, Moderate, High, Very High and Extreme (Figure 1-1). The two highest categories "Very High" (VH) or "Extreme" (E) represent a significant risk for large wildfire outbreaks that may require considerable control efforts. Therefore, a count of the number of days where the fire danger is VH or E is a useful indicator of the wildfire risk at that location for a given month or year.

Figure 1-1: A display board used to communicate daily Fire Danger.

2 Methodology

The methods used to calculate fire danger were originally presented in Macara and Sutherland (2017), and readers are referred to that report for a description of relevant data quality control procedures. Calculation of the fire danger rating and the selection of regionally representative stations are described below.

2.1 Calculation of Fire Danger Rating

Daily fire danger rating is calculated at approximately 373 New Zealand climate stations. It is calculated using a combination of four weather variables (wind speed, relative humidity, temperature and 24-hour rainfall), fuel moisture codes (FFMC, DMC and DC), and fire behaviour indices (ISI, BUI, ROS, HFI). Weather data obtained by NIWA from climate stations is typically in hourly or ten minute intervals, however only midday values of each weather variable are required to calculate the fire danger rating. The fire behaviour indices provide quantitative estimates of fire behaviour based on fuel, topography and weather. Fuel and topography information is unique to each climate station, and has been derived by FENZ from Land Information New Zealand (LINZ) geographic databases.

A fuel type may be one of “forest”, “grass” or “scrub”. Subsequently, the calculation of fire danger ratings at each station is based on the associated fuel type selected. Note a glossary of abbreviations is provided in Section 6. A schematic of the Fire Danger Rating components is shown in Figure 2-1. For the “grass” fuel type, the Rate of Spread index also requires a “grass curing” input (not shown in Figure 2-1). The grass curing input is an observed percentage of grass that has dried out.

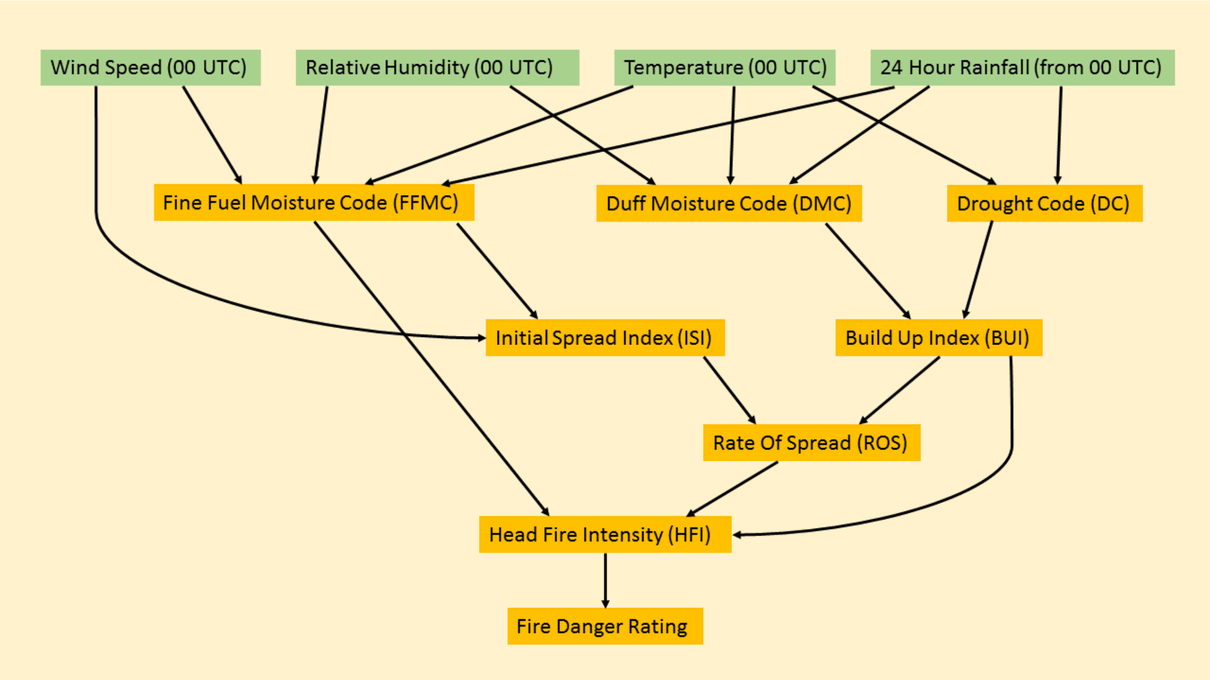

Figure 2-1: Components required to calculate the Fire Danger Rating.

2.2 Selection of regionally representative stations

Of the approximately 210 climate stations where fire danger ratings are calculated, 30 were selected for this investigation. The stations selected are consistent with previous updates provided to MfE, except for Blenheim Research Ews (station selected for Blenheim). Blenheim Aero Aws was previously supplied to MfE (Macara and Sutherland, 2017; Macara et al., 2020), however data from this station were unavailable for the present report. Note, 10 "SYNOP" stations that were previously provided have been switched with "Aws" stations. These stations (including their instrumentation, and data) are the same; the difference in nomenclature results from different sources used to access the data. Table A-1 (Appendix A) lists the metadata for the stations selected in this study.

For this report, fire danger was calculated for the period 1997-2023 using each of the three fuel types ("forest", "grass" and "scrub") at each station, respectively. This differs from previous reports (Macara and Sutherland, 2017; Macara et al., 2020) where fire danger was only calculated for the primary fuel type at each station.

3 Results

Annual counts of days where the fire danger rating was VH and E were calculated from all available data for each of the 30 stations. These data were collated in Excel files and sent to MfE, and a subset of these results are described in this section. Figure 3-1 and Figure 3-2 show the average annual count of VH fire danger days for North Island and South Island locations, respectively, using "forest" as the fuel type. Based on these data, Napier observes an annual average of 15 days of VH fire danger, which is the highest average for North Island locations included in this study. Blenheim observes an annual average of 18 days of VH fire danger, which is the highest average of the South Island locations included in this study.

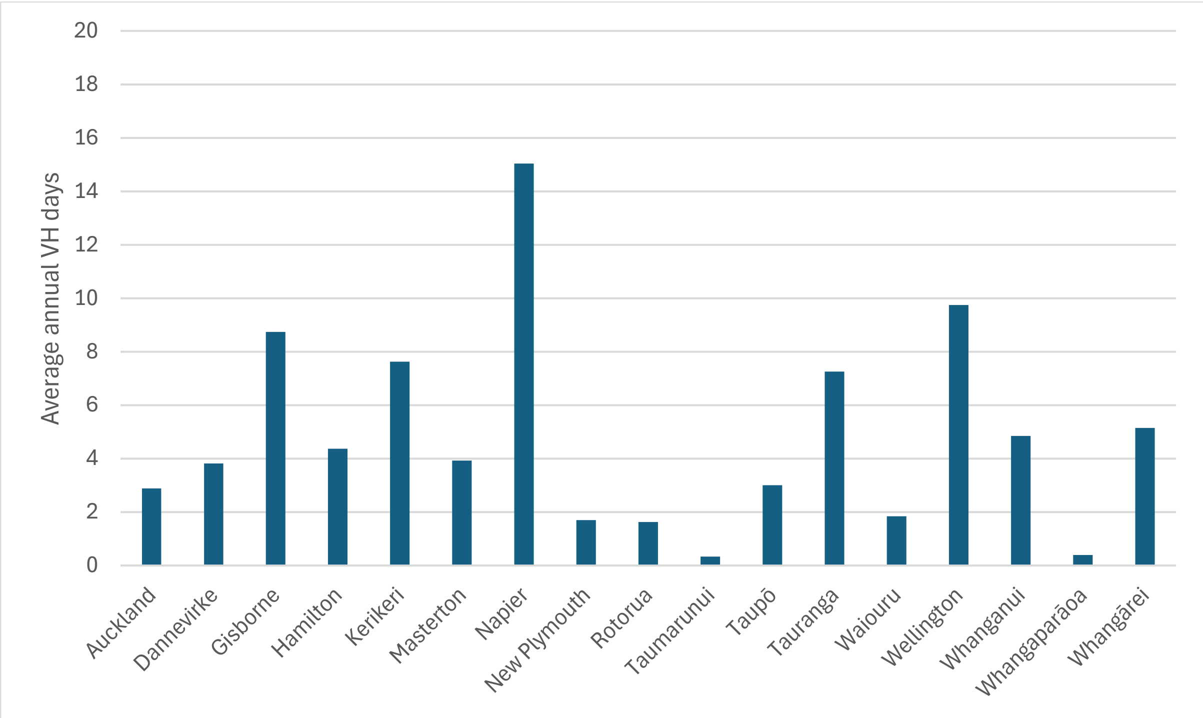

Figure 3-1: Average annual number of days with Very High (VH) fire danger for North Island locations. Calculated using "forest" as the fuel type.

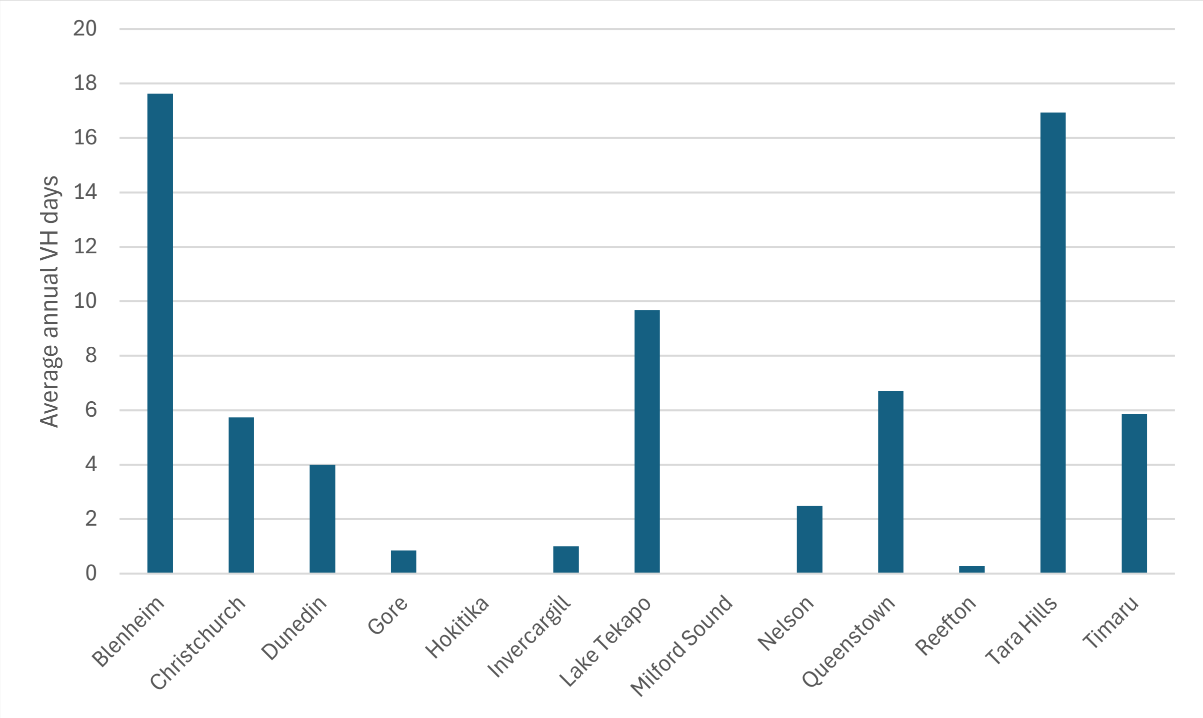

Figure 3-2: Average annual number of days with Very High (VH) fire danger for South Island locations. Calculated using "forest" as the fuel type.

Figure 3-3 shows the average annual count of VH fire danger days for North Island locations, using “grass” as the fuel type. Based on these data, Napier observes an annual average of 19 days of VH fire danger, which is the highest average for North Island locations included in this study.

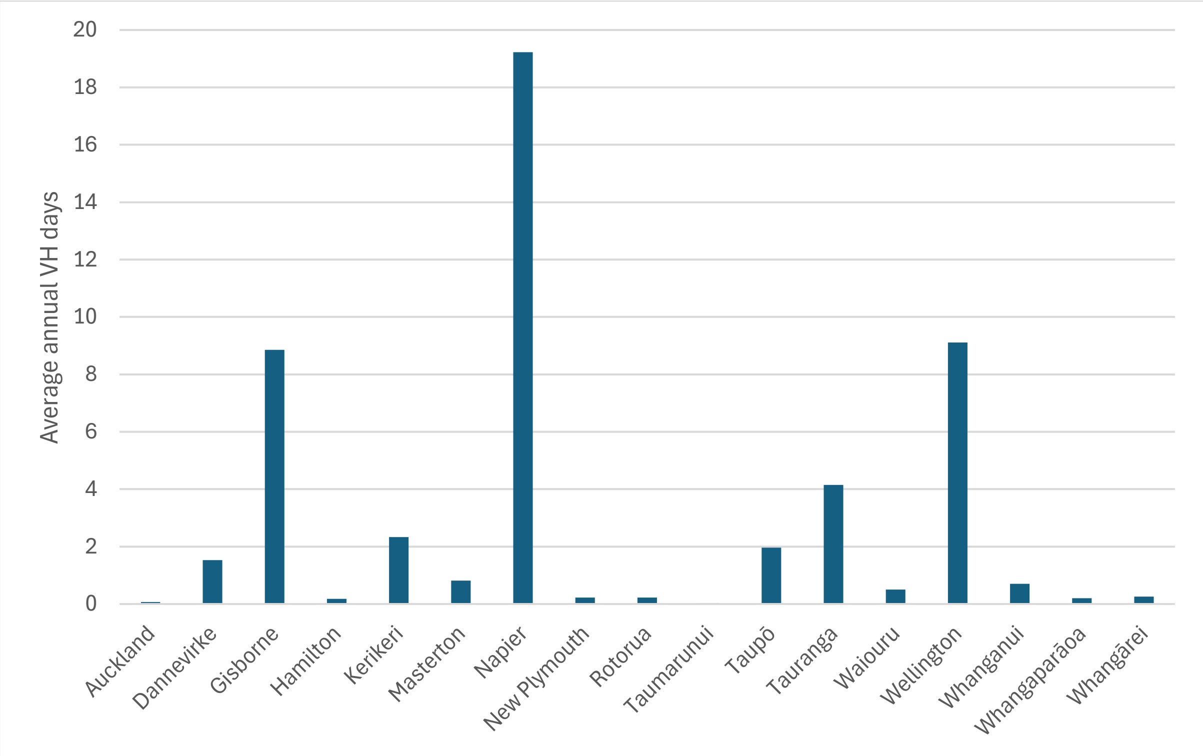

Figure 3-3: Average annual number of days with Very High (VH) fire danger for North Island locations. Calculated using "grass" as the fuel type.

Figure 3-4 shows the average annual count of E fire danger days for South Island locations, using "scrub" as the fuel type. Milford Sound observes an annual average of 80 days of E fire danger, which is the lowest average of the South Island locations included in this study.

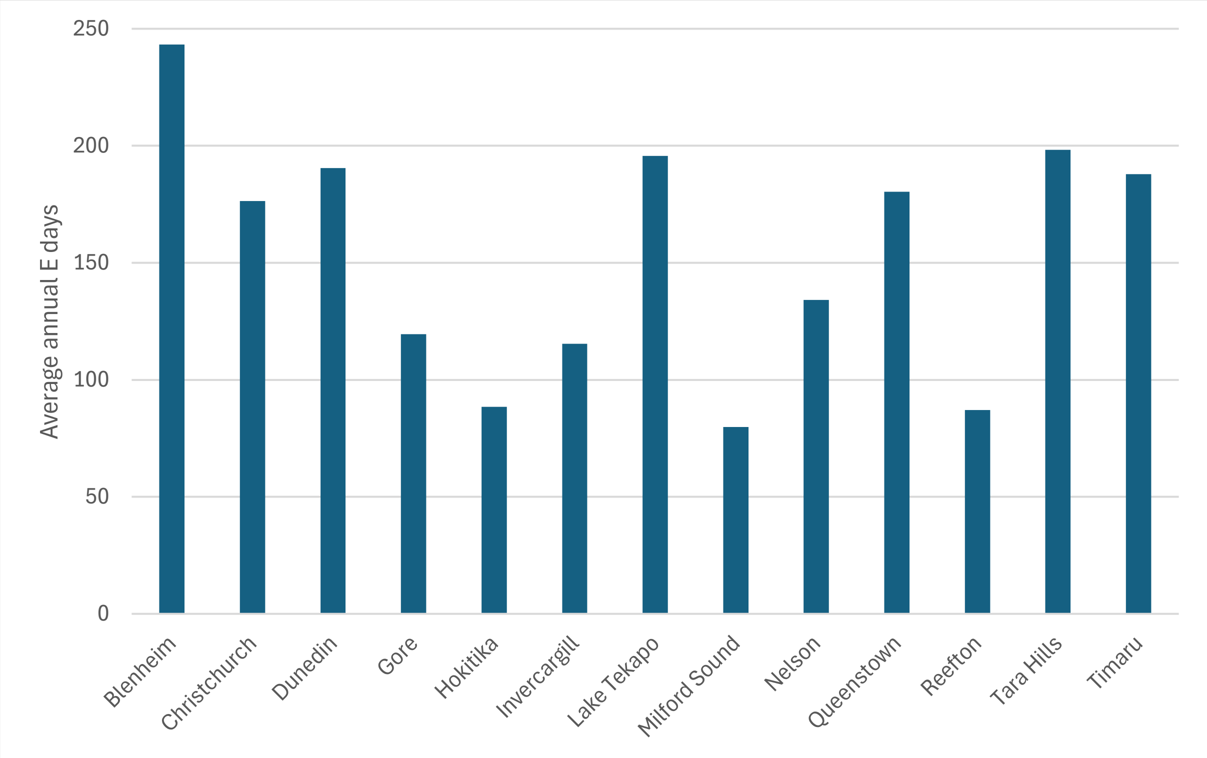

Figure 3-4: Average annual number of days with Extreme (E) fire danger for South Island locations. Calculated using "scrub" as the fuel type.

Figure 3-5 illustrates the annual variability of VH fire danger days for Napier, using “forest” as the fuel type. Napier’s highest annual count of 35 VH fire danger days occurred in 2013, while the lowest annual count of 2 VH fire danger days occurred in 2018.

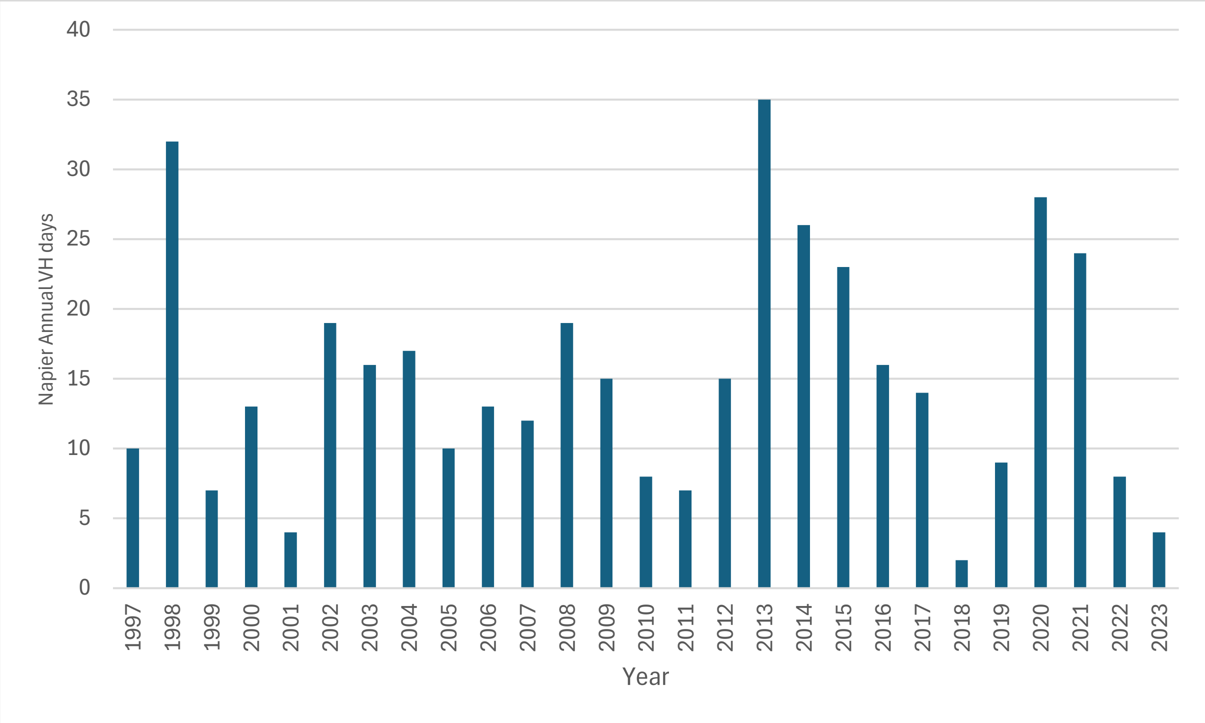

Figure 3-5: Annual number of days with Very High (VH) fire danger for Napier. Calculated using "forest" as the fuel type.

4 Future developments and improvements

There are several options to improve this indicator in future:

- Include more locations in the assessment.
  - At present, only one station is selected per location. Some locations have a relatively large geographic area (e.g. Auckland), and it may be useful to include additional stations for a more comprehensive understanding of wildfire risk for the city.
  - Adding more locations to the existing list of 30 may enable a more informed assessment of wildfire risk variability within each of New Zealand's territorial authorities.
- Explore the potential to extend calculations prior to 1997.
  - At present, fire danger calculations are available back to 1997. It may be possible to extend calculations further back in time. This would enable an improved understanding of observed wildfire risk in New Zealand.
- Utilise the New Zealand Reanalysis project (Pirooz et al., 2023) to calculate gridded reanalyses of fire danger across New Zealand.
  - This would be available back to 1990, and serve as a useful comparison with the existing station-based fire danger data.

MfE have indicated an interest in additional measures of wildfire in future updates, specifically: i) number of wildfires reported annually, ii) number of wildfires reported by season, and iii) annual hectares burnt by wildfire. It is NIWA's understanding that these statistics are captured by FENZ (e.g. Gross et al., 2024). MfE are advised to contact FENZ for more details about the availability of these data for future updates.

5 Acknowledgements

Grant Pearce (FENZ) is thanked for sharing context around the production of annual wildfire statistics reports.

6 Glossary of abbreviations and terms

BUI	Build Up Index. Combines the DMC and DC and represents the total amount of fuel available for combustion.
DC	Drought Code. A rating of the average moisture content of deep, compact, organic layers. This code is a useful indicator of seasonal drought effects of forest fuels and amount of smouldering in deep duff layers and large logs.
DMC	Duff Moisture Code. A rating of the average moisture content of loosely compacted organic layers of moderate depth.
E	"Extreme" fire danger rating.
FENZ	Fire and Emergency New Zealand.
FFMC	Fine Fuel Moisture Code. An indicator of the relevant ease of ignition and flammability of fine fuels.
FWS	Fire Weather System. Operated by NIWA, and monitors daily fire risk throughout New Zealand.
HFI	Head Fire Intensity. Estimates the intensity of the head of a fire (kW/m).
ISI	Initial Spread Index. Combines the effect of wind speed and the FFMC, providing a numerical rating of fire spread rate.
MfE	Ministry for the Environment.
NIWA	National Institute of Water and Atmospheric Research.
ROS	Rate of Spread. Combines the ISI and BUI to indicate the intensity of a spreading fire. Dependent on fuel type.
VH	"Very High" fire danger rating.

7 References

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Appendix A Stations selected

Table A-1: Stations selected for each location.

Location	Station selected	Station Latitude, Longitude (decimal degrees)
Auckland	Clevedon Coast Raws	-36.922, 175.008
Blenheim	Blenheim Research Ews	-41.499, 173.963
Christchurch	Bottle Lake Forest Raws	-43.470, 172.682
Dannevirke	Dannevirke Ews	-40.208, 176.110
Dunedin	Traquair Raws	-45.811, 170.131
Gisborne	Gisborne Aws	-38.659, 177.985
Gore	Gore Aws	-46.115, 168.887
Hamilton	Hamilton Aws	-37.865, 175.336
Hokitika	Hokitika Aws	-42.713, 170.984
Invercargill	Slopedown Raws	-46.392, 169.132
Kerikeri	Waitangi Forest Raws	-35.283, 173.986
Lake Tekapo	Tekapo Raws	-44.001, 170.404
Masterton	Holdsworth Station Raws	-40.912, 175.559
Milford Sound	Secretary Island Aws	-45.221, 166.885
Napier	Napier Aero Aws	-39.470, 176.865
Nelson	Hira Raws	-41.282, 173.33667
New Plymouth	New Plymouth Aws	-39.008, 174.184
Queenstown	Queenstown Aero Aws	-45.018, 168.740
Reefton	Reefton Ews	-42.116, 171.860
Rotorua	Rotorua Aero Aws	-38.107, 176.316
Tara Hills	Tara Hills Aws	-44.528, 169.890
Taumarunui	Waimarino Forest Raws	-39.399, 175.189
Taupō	Taupō Aws	-38.743, 176.081
Tauranga	Tauranga Aero Aws	-37.675, 176.192
Timaru	Timaru Aero Aws	-44.305, 171.221
Waiouru	Tapuae Raws	-39.995, 175.723
Wellington	Wellington Aero Aws	-41.322, 174.804
Whanganui	Wanganui, Spriggens Park Ews	-39.939, 175.045
Whangaparāoa	Mahurangi Forest Raws	-36.364, 174.572
Whangārei	Whangarei Aero Aws	-35.769, 174.364