RURAL FIRE RESEARCH UPDATE
July 2011 | Issue 8 | ISSN 1178-7775

Fire Climate Severity

The objective of this study was to provide improved information on fire climate severity across New Zealand. This was achieved by conducting an updated analysis of historical fire weather records using additional data collected since the previous analysis in 2003, and then mapping regional variability in fire climate severity.

The resulting information provides an improved description of New Zealand's fire climate for use in a range of rural fire management planning activities. This includes describing wildfire risk, identifying further weather station requirements, and assisting with delineation of boundaries for Enlarged Rural Fire Districts. It also provides a baseline on our current climate for comparing the effects of climate change on future fire climate severity (see Update #9).

Regions of the country with the highest fire climate severity values were:
- inland South Island (the Mackenzie Basin and Central Otago)
- Marlborough
- Canterbury
- Eastern North Island (Hawkes Bay and Gisborne)
- areas of elevated values were also present in the Wairarapa and Northland.

The lowest fire climate severity values were found in:
- the South Island's West Coast and Fiordland
- Southland
- western of the North Island (Taranaki)
- central North Island (inland Wanganui/Manawatu).

Method

Fire climate severity was compared using two measures of severity – the Daily Severity Rating (DSR), and the frequency of days of Very High and Extreme (VH+E) Forest fire danger – that have been used in previous research. Both these measures describe the influence of weather on fire danger levels and therefore subsequent fire climate severity. They capture the influences of higher temperatures, decreased rainfall and increased wind speeds on drying out fuels. These factors increase the likely fire behaviour, particularly potential fire intensity, and indicate the increasing amount of work and difficulty of controlling a fire as fire intensity increases.

Station datasets established as part of the previous Pearce *et al.* (2003) analysis were updated by downloading and adding the most recent data from the Fire Weather Monitoring System (FWSYS) archive. Of the total 222 stations, 77 were identified that had the same, consistent period of weather data record (from 1 October 1995 to 30 September 2010) capturing 15 full fire seasons.

The use of a consistent length and period of record from as many of the available stations as possible aimed to address short-comings identified in previous analyses . The short comings included variable lengths of fire weather data record, and limited numbers of stations with poor spatial coverage. Comparison of averages produced from 10 versus 15 years of data showed that longer record lengths were better. These records were less likely to be influenced by short-term climate cycles (such as El Nino/Southern Oscillation), resulting in more accurate representation of long-term average fire climate.

Once an accurate, continuous record of daily weather inputs had been established for each of the 77 stations, values of the six FWI System components, as well as the DSR and Forest fire danger class, were calculated for each station. These were then averaged over fire season months and the full calendar year as the basis for comparing and mapping fire climate severity across the country.

Results

Station fire climate severity

Individual weather stations were ranked (Table 1) on the basis of their average values for the two fire climate severity measures, DSR and days of VH+E Forest fire danger. These values were then combined to produce an overall station ranking for the region. Rankings were very similar to those found for individual stations in the previous analysis of Pearce *et al.* (2003).

Stations that exhibited the most severe fire climates tended to be in the drier parts of the country where fire season and/or annual rainfall is low. The lowest ranked stations typically occurred at sites exhibiting higher rainfall.

The individual stations with the most severe fire climates were:

- Awatere Valley and Woodbourne Aero in Marlborough
- Tara Hills in inland South Canterbury
- Lauder in Central Otago
- Balmoral, Christchurch Aero and Darfield in Canterbury.

Those with the least severe fire climates were:

- Haast, Hokitika and Westport on the West Coast
- Milford Sound and Invercargill Aero in Southland
- Marco in Taranaki.

Table 1. Fire Climate Severity for Individual Weather Stations.

Most severe		Least severe
Awatere Valley (Marlb.)	1	Haast (West Coast)
Woodburne Aero (Marlb.)	2	Milford Sound (South.)
Tara Hills (South Cant.)	3	Hokitika (West Coast)
Lauder (Central Otago)	4	Westport (West Coast)
Balmoral (Canterbury)	5	Marco (Taranaki)
Christchurch Aero (Cant.)	6	Waiouru Aero (W/M.)
Darfield (Canterbury)	7	Invercargill Aero (South.)
Napier Aero (Eastern)	8	Athol (Waikato)
Dansey Pass (Otago)	9	Slopedown (South.)
Ngawihi (Wairarapa)	10	Glenledi (Otago)

Regional fire climate severity

When rankings for individual stations were averaged across the 16 Regional Rural Fire Committee areas (Table 2), the regions with the most severe fire climates were:

- Canterbury
- South Canterbury
- Marlborough
- Wairarapa.

This differed slightly from the Pearce *et al.* (2003) study, where Marlborough ranked highest, followed by Canterbury, Otago and South Canterbury.

The regions with the least severe fire climates were the same as those found by Pearce *et al.* (2003), being:

- West Coast
- Southland
- Taranaki
- Waikato.

Changes in the rankings of the regions are likely due to differences in the number and locations of the individual stations analysed within each region in the two studies. This highlights the significant microclimatic variability that exists between stations within each region of the country, and also across New Zealand as a whole. It re-emphasises the need to base climatic analyses on both a consistent and a long record as possible, to ensure all stations capture the same climatic cycles (e.g. El Nino/Southern Oscillation (ENSO).

Table 2. Fire Climate Severity for Regional Rural Committee Areas.

Most severe		Least severe
Canterbury	1	West Coast
South Canterbury	2	Southland
Marlborough	3	Taranaki
Wairarapa	4	Waikato
Eastern North Island	5	Auckland
Otago	6	Central North Island
Wellington	7	Nelson
Wanganui/Manawatu	8	Northland

Image taken in the Mackenzie region.

Mapping fire climate severity

Average values of the fire climate severity measures for individual station locations were mapped using GIS software, and “surfaces” fitted through the data to describe the spatial pattern of fire climate across the country.

A range of spatial interpolation techniques available within the ArcGIS Geostatistical Analyst extension were tested (the technique chosen is know as cokriging). This technique was favoured because it allowed inclusion of station elevation as an additional prediction variable, and consistently produced the lowest surface error estimates.

The patterns of variability in fire climate across New Zealand were similar to those reported in other previous studies, including the 2003 analysis and mapping of Hazard layers as part of the New Zealand Wildfire Threat Analysis System.

The spatial patterns for values of the two fire climate severity measures were very similar. Regions of the country with the highest values were:

- Marlborough
- inland South Island (Mackenzie Basin & Central Otago),
- Canterbury
- eastern North Island (Hawkes Bay and Gisborne).

Areas of elevated values were also present in the Wairarapa and Northland.

The lowest values of the DSR and days of VH+E were:

- the South Island’s West Coast
- Fiordland
- Southland
- western areas of the North Island (Taranaki)
- central North Island (inland Wanganui/Manawatu).

Stations were also grouped by the fire climate regions identified by NIWA and the MetService general climate regions (not shown here). Visually, the Regional Rural Fire Committee areas proved to be best at capturing the geographic trends in fire climate severity across the country (Figures 1 & 2).

Electronic versions of the maps for the fire climate severity measures, FWI System components and weather inputs based on these 15-year averages are available in GIS format for more widespread use. Tabular summaries of long term averages and extremes for each station are also being prepared.

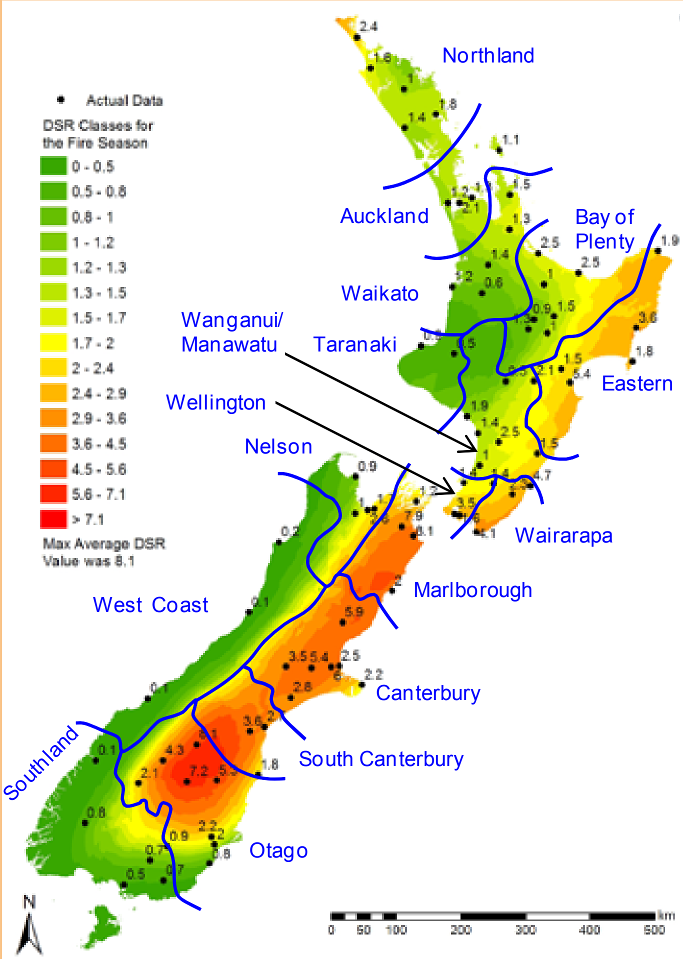

Figure 1. Variation in fire climate severity by Regional Rural Fire Committee (RRFC) area described using the average fire season Daily Severity Rating (DSR).

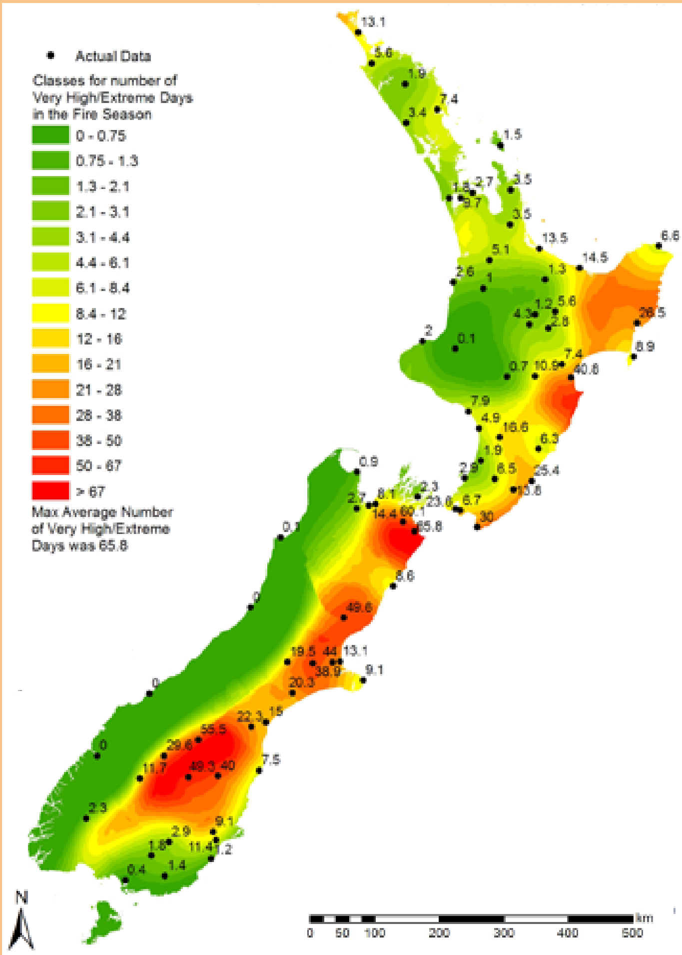

Figure 2. Variation in fire climate severity described using the average number of Very High and Extreme (VH+E) Fire Danger days during the fire season.

Recommendations

A key feature of the study was addressing issues identified in previous analyses, which included limited numbers of stations, inconsistent record lengths, poor spatial coverage, and associated data averaging and interpolation problems. The study sought to overcome these issues through use of a consistent length and period of record from as many of the available stations as possible. Despite resulting in a reduced number of stations with suitable date record length for analysis (77 compared with the previous study's 127), the updated study was more robust. Recommendations arising from the results are as follows:

- The 15-year averages produced as part of the study (and associated maps) be used in preference to those for shorter periods to describe New Zealand's fire climate. This length of record (15 years) is also recommended as a minimum for future studies, to best capture climate cycles such as the El Nino/Southern Oscillation.
- Fire season averages (and maps) should also be used in preference to these for the full year, as that is the period during which the most severe weather days and therefore majority of fires typically occur. However, annual averages (and maps) may also prove useful in those areas where fires frequently occur outside the recognised fire season period.
- Electronic versions of the maps for the fire climate severity measures, FWI System components and weather inputs based on these 15-year averages are available in GIS format for more widespread use.
- A process for updating station fire weather data within the Fire Weather Monitoring System (FWSYS) is required to capture the filling of gaps, correction of errors and recalculation of FWI values undertaken during the updating of existing FWSYS data sets.
- Weather station locations (lat/long) should also be checked, as there are a number of different versions in use that can lead to mis-location of some stations and incorrect spatial interpolation. There is also a need to clarify station history, especially where locations or names of stations have changed, as this can affect data continuity and availability of long-term datasets for analysis.
- Multivariate spline interpolation techniques are widely used for interpolation of climatic data. They are already used within the New Zealand Wildfire Threat Analysis System (NZWTAS) hazard layers and for mapping of fire danger within the Fire Weather Monitoring System (FWSYS). Therefore, this technique warrants further investigation for use in modelling the effects of topography and other climatic factors on spatial variability in New Zealand's fire climate.

Acknowledgments

Appreciation is extended to Wayne Tyson (DOC Canterbury) for GIS support and assistance with spatial interpolation. Acknowledgment is also made to NIWA and the NZFSC, for providing access and data from the National Climate Database (CliFlo) and NRFA Fire Weather archive (FWSYS), respectively. The research undertaken was completed under contract for the NZFSC Contestable Research Fund's Mapping of Fire Climate Severity project, but was also supported by funding provided by the Foundation for Research, Science and Technology (FRST) and rural fire end-users as part of contract C0X0403 (Rural Fire).

Further information

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Funding for the Scion Rural Fire Research Group is provided by the Foundation for Research, Science and Technology (FRST) along with direct funding and significant in-kind support from NZ Rural Fire Sector organisations (National Rural Fire Authority, NZ Fire Service Commission, NZ Forest Owners Association, Department of Conservation, members of Local Government NZ, NZ Defence Force and Federated Farmers of NZ Inc).