Study Guide

RFFWI-sg

Apply Fire Weather (FWI) Index System

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Contents

Introduction

This material outlines the information Rural Fire personnel need to know to apply fire weather index system data for fire reduction and readiness measures. This course covers the information in unit standard 14556 Apply Fire Weather Index System data for fire reduction and readiness measures version 3.

People credited with this unit standard are able to:

- demonstrate knowledge of the Fire Weather Index (FWI) system
- demonstrate knowledge of the FWI tables and their use
- select fire reduction and readiness measures

What are the prerequisites?

The prerequisite for this course is 14564 demonstrate knowledge of the fire environment on vegetation fire behaviour; or demonstrate equivalent knowledge and skills.

What do I need?

- Study guide and workbook
- Fire Weather Index System Tables for New Zealand

Read through the study guide and complete the workbook before attending the practical course. The workbook must be completed and submitted at least one week before attending the practical course to the course director.

Assessment

There is a theory assessment that can be completed at the end of the practical course.

Section 1: Fire Danger Rating

Introduction

Evaluation and rating of fire danger provides us with an aid for making informed decisions about the management and control of fire activities.

We classify fire danger into various levels or classes because it enables fire authorities:

- To prevent fires and encourage fire prevention by sending a standard message to the public about the daily fire danger conditions over a broad area (Fire Danger is an indicator of the ease of ignition of a vegetation fire)
- To look at the likelihood of a fire starting, spreading and damage is
- To anticipate resource needs (Fire Danger is also indicator of the difficulty of control of a vegetation fire)

Fire danger indices

Fire Danger Rating (FDR) requires a process of systematically evaluating and integrating the individual and combined factors that influence fire danger and representing them in the form of fire danger indices.

Fire danger rating systems in general produce one or more indices of the potential for ignition and probable fire behaviour that are used as guides in a wide variety of fire management activities.

What does a FDR system do?

A fire danger rating system should supply an answer to the question: What is the probability of a fire starting, spreading and doing damage today?

What does it measure?

A Fire Danger Rating System:

- Measures the variable elements that cause day to day changes in fire risk (ignitions) and fire hazards (fuels) or fire danger
- Enables the information gained to be properly interpreted

Fire Danger system uses

There are many uses of a Fire Danger Rating System. We can use it to assist in making decision to:

- define the fire season
- plan fire prevention measures
- assess the likelihood of fire occurring
- determine initial attack dispatching requirements
- determine fire suppression response and resource requirements
- inform the public
- make decisions to close areas at high risk
- issue or cancel burn permits
- plan and conduct prescribed burns

The New Zealand Fire Danger Rating System (NZFDRS)

The New Zealand Fire Danger Rating System is used by Rural Fire Authorities (RFAs) to assess the probability of a fire starting, spreading and doing damage. It provides information that supports fire management decision-making.

The NZFDRS is derived from its Canadian equivalent, the Canadian Forest Fire Danger Rating System (CFFDRS), which includes a number of subsystems or modules.

Fire Weather Index (FWI) System

FWI is a set of codes and indices based on the current and preceding weather conditions, which estimate the relative flammability and availability of fuel and their effect on potential fire rate of spread and intensity.

It was the first sub-system of the CFFDRS adopted in NZ, and was introduced in 1980/81 following an evaluation of the major fire danger rating systems in use around the world.

A crucial part of the NZFDRS is the (FWI) System. It is a key component in the monitoring and evaluation of the variable fire danger factors.

It enables fire managers to properly assess fire danger levels and, accordingly, make fire prevention and fire presuppression arrangements.

Fire Behaviour Prediction (FBP) System

This combines the FWI spread indicators with data on fuel type and topography to make quantitative predictions of fire behaviour (e.g. head, flank and back fire rate of spread and fireline intensity). It has been adopted in part in NZ, with several of the Canadian fuel models being used for fire danger rating and fire behaviour prediction.

Accessory Fuel Moisture System

An incomplete system being developed to allow the estimation of fuel moisture content for a range of components (e.g., elevated scrub, twigs, grass, forest litter) and larger woody material. Factors taken into account include the effects of temperature, relative humidity, time, topography, latitude and season.

Fire Occurrence Prediction (FOP) System

FOP hasn't yet been fully developed in Canada, but aims to combine causes of ignition and their location as a means of predicting the probability of ignition from both natural (e.g. lightning) and human causes.

Fire Danger Classes

Each segment of the sign is identified by a descriptive term (e.g. Low, Moderate, High, Very High, or Extreme), and/or a colour code (e.g. green, blue, yellow, orange, or red).

The Fire Danger Classes are generally displayed on half grapefruit Fire Danger Class display signs.

What do Fire Danger Classes provide?

Fire Danger Classes provide a general indication of the level of difficulty of control of fire burning in standard fuel types (i.e. Forest, Grassland, or Scrubland fuels).

Minimum fire suppression resources

Each fire danger class within the NZFDRS has an implied interpretation describing likely fire behaviour, including qualitative descriptions of rate of spread and flame size, difficulty of control and the types of suppression resources likely to be most effective.

By themselves, the Fire Danger Classes provide only a reflection of fire intensity, and do not give any indication of how fast a fire will expand in size.

Minimum fire suppression resources are based on fire intensity and on the effectiveness of various types of resources in controlling fire as the intensity increases, up to a point where fires are considered to be uncontrollable using conventional means (i.e. > 4000 kW/m).

Fire Suppression Effectiveness

Fire Danger Class	Fire Intensity (kW/m)	Minimum fire suppression resources for direct head fire attack
Low	0-10	Ground crew with hand tools
Moderate	10-500	Ground crew and back-pack pumps
High	500-2000	water under pressure and heavy machinery
Very High	2000-4000	Head fire attack using aircraft and long-term retardants may be effective, but it may be too dangerous for ground crews.
Extreme	>4000	Head fire attack not likely to be effective, and it will be too dangerous for ground crews

The chart on the next page should not be used as a guide for Firefighter safety. Fires can be potentially dangerous or life threatening at any level of fire danger! This table is also in the Rural Fire Management handbook (Green Book)

Fire Danger Class Criteria Table

Fire Danger Class	Description of Probably Fire Potential and Implications of Fire Suppression	Nominal Max. Flame Height
Extreme	The situation should be considered “explosive”. The characteristics associated with the violent physical behaviour of conflagrations or firestorms is a certainty (e.g. rapid spread rates, crowning in forests, medium to long range mass spotting, firewhirls, towering convection columns, great walls of flame). As a result, fires pose an especially grave threat to persons and their property. Breaching of roads and firebreaks occurs with regularity as fires sweep across the landscape. Direct attack is rarely possible given the fire’s ferocity – except immediately after ignition and should only be attempted with the utmost caution. The only effective and safe control action that can be taken until the fire run expires is at the back and along the flanks.	**3.6 + metre**
Very High	Burning conditions have become critical, as the likelihood of intense surface fires is a distinct possibility; torching and intermittent crowning in forests can take place. Direct attack on the head of a fire by ground forces is feasible for only the first few minutes after ignition has occurred. Otherwise, any attempt to attack the fire’s head should be limited to helicopters with buckets, or to the use of fixed wing aircraft – preferably dropping long-term chemical fire retardants. Until the fire weather severity abates, resulting in a subsidence of the fire run, the uncertainty of successful control exists.	**2.6 to 3.5 metres**
High	Running or vigorous surface fires are most likely to occur. Any fire outbreak constitutes a serious problem. Control becomes gradually more difficult if it is not completed during the early stages of fire growth following ignition. Water under pressure (from ground tankers or fire pumps with hose lays) and bulldozers are required for effective action at the fire’s head.	**1.4 to 2.5 metres**
Moderate	From the standpoint of moisture content, fuels are considered to be sufficiently receptive to sustain ignition and combustion from both flaming and most non-flaming (e.g. glowing) firebrands. Creeping or gentle surface fire activity is commonplace. Control of such fires is comparatively easy but can become troublesome as fire damages can still result and fires can become costly to suppress if they are not attended to immediately. Direct manual attack around the entire fire perimeter by firefighters with only hand tools and back-pack pumps is possible.	**Up to 1.3 metres**
Low	New fire starts are unlikely to sustain themselves due to surface moisture fuel conditions. However, ignitions may take place near large and prolonged or intense heat sources (e.g. camp fires, windrowed slash piles) but the resulting fires generally do not spread much beyond their point of origin, and if they do, control is easily achieved. Mop-up or complete extinguishment of fires that are already burning may still be required provided there is sufficient dry fuel to support smouldering combustion.	**No visible flame**

Rural Fire Management Handbook (the Green Book)

This table is included in section 6.15 of the Green Book

What Fire Danger classes don't do

Fire danger classes are not appropriate for determining initial attack preparedness or the dispatch of fire fighting resources, or for suppression strategies and tactics at ongoing fires. You need to use the Fire Behaviour Prediction System.

Caution

Because the FWI component of the FWI System represents fire intensity, this single component has often been used to derive fire danger classes, and until the mid-1990's, this was common practice for many fire authorities in New Zealand.

It is impossible to communicate a complete picture of daily fire potential in a single number, as in the fire danger reading,

If we want a proper interpretation of the effects of weather on fire potential, we need to examine each of the subsidiary components of the FWI System (see diagram in section 2)

Summary – Fire Danger Rating

Fire danger rating

An assessment of both fixed (topography, fuel types) and variable (weather) factors of the fire environment that determine the ease of ignition, rate of spread, degree of difficulty of control and fire impact

Fire danger classes

A general indication of the difficulty of control of fire burning in "standard" fuel types (i.e. Forest, Grassland, or Scrubland fuels)

Section 2: The Fire Weather Index System

FWI Overview

The FWI System accounts for the cumulative effects of weather on fuels and fire behaviour. We use FWI information to assist in making informed decisions about fire control including assessment of appropriate fire prevention and preparedness measures.

History

The FWI System is the major sub-system of the New Zealand Fire Danger Rating System (NZFDRS). It was evaluated during the late 1970's for its suitability for use in New Zealand and proved suitable for rating fire danger for this country. It was introduced nationally for the 1980-81 fire season and provides a uniform method of rating fire danger in New Zealand.

Six Components

The FWI System is made up of six components that provide relative numerical ratings for various aspects of ignition potential and fire behaviour based solely on selected weather inputs.

There are 3 fuel moisture codes and 3 fire behaviour codes

What does it do?

The FWI System uses past data and consecutive daily noon measurements of selected weather inputs to give an indication of **mid-afternoon fire danger** conditions. It assumes a reference fuel type (a mature pine stand), and applies to dead forest floor material in this fuel type. The FWI System ignores the effects of topography and fuels (as these are accounted for in the FBP System), and assumes an ignition has or will take place (with ignitions being accounted for in the FBP System).

Daily weather readings of selected weather inputs

The weather readings, taken at noon standard time (1pm Daylight Saving time) are:

Table looking at the significance of each component.

Observation	Influences	Description	Measurement
Air temperature	Influences the rate of drying and fuel moisture content of all fuel components. It affects the ease of ignition of fuels and fuel flammability.	A measure of the degree of hotness or coldness of the air.	Measured in degrees celsius at 1.2m high and in the shade, taken at 1200hrs NZST.
Relative humidity (RH)	Influences drying of fine fuels. Low RH values indicate low fuel moisture levels. RH affects the ease of ignition of fuels.	A measure of the amount of water vapour/moisture in the air.	Given as a percentage, and measured at 1.2m high and in the shade, taken at 1200hrs NZST.
Wind speed	Influences the rate of drying of fine fuels and the rate of fire spread.	A measure of the strength or velocity of movement of air.	Measured in kilometres per hour at 10m high over a 10min average, taken at 1200hrs NZST.
Rainfall	Influences fuel moisture content. Light rain affects fine fuel moisture levels very quickly. Sustained rainfall is required to affect larger fuel components.	A measure of the liquid form of moisture falling from the sky.	Measured in millimetres. either over each hourly interval or over a 24hr period at 12 noon NZST.

Summary

The FWI assesses the influence of weather conditions on fuel moisture and potential fire behaviour, providing information about the probability of a fire starting, spreading and doing damage.

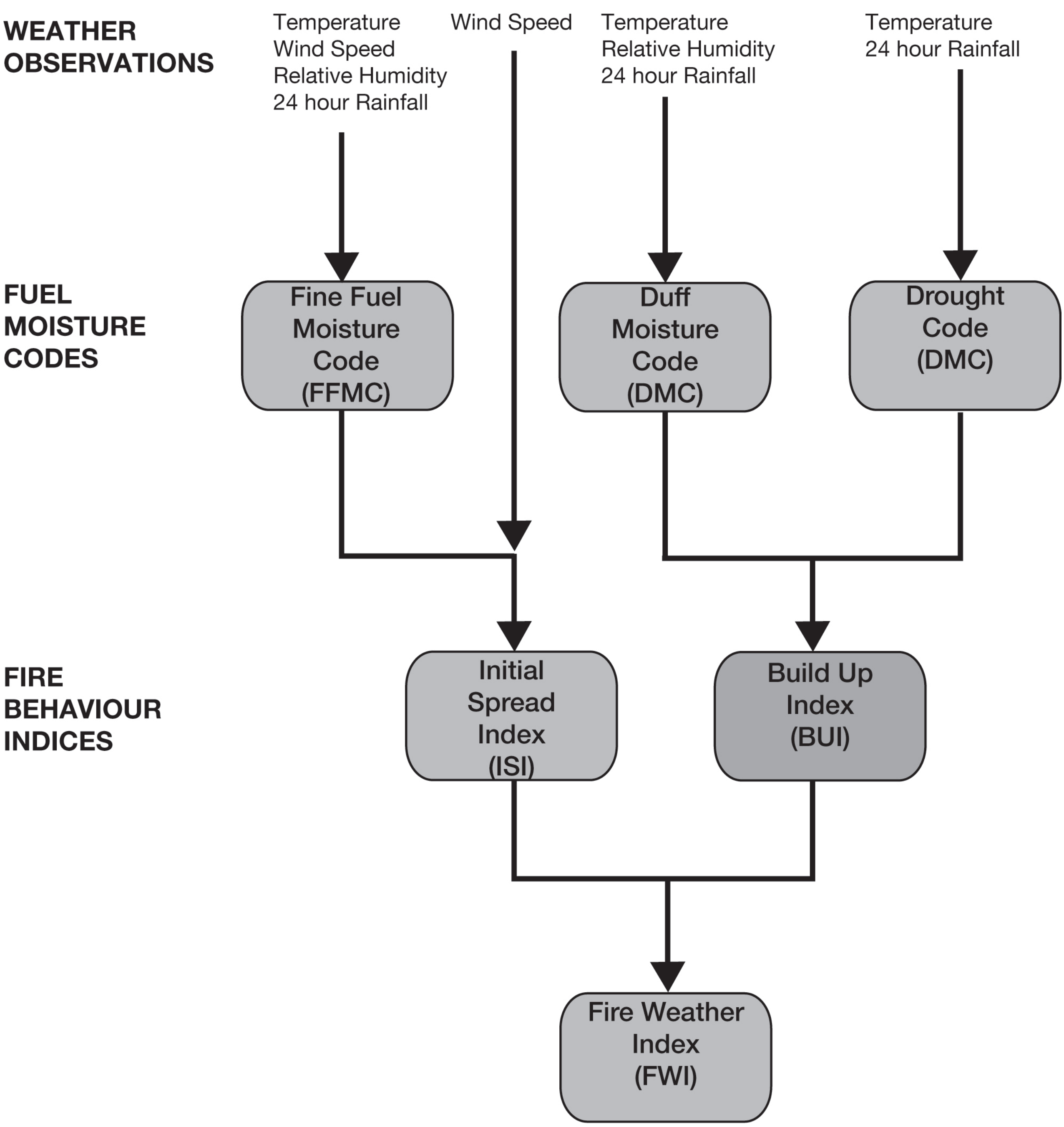
Six FWI Components

The diagram Fire Weather Index System on the next page shows the components that make up the calculation of the FWI.

NOTE

The FWI assesses the influence of weather conditions on fuel moisture and potential fire behaviour, providing information about the probability of a fire starting, spreading and doing damage.

FIRE WEATHER INDEX SYSTEM



The first three components of the FWI System are fuel moisture codes. They represent the moisture content of:

- Fine surface litter - Fine Fuel Moisture Code (FFMC) (0 – 5 cm)
- Loosely compacted duff - Duff Moisture Code (DMC) (5 – 10 cm deep)
- Deep compact organic matter – Drought Code (DC) (10 – 20 cm deep)

Fire behaviour indices

The other three components of the FWI System are fire behaviour indices, that are related to the level of fuel dryness.

The first of these is the Initial Spread Index (ISI) that is based on wind speed and the FFMC and reflects the potential rate of fire spread

- The second is the Buildup Index (BUI) that is based on the DMC and the DC and reflects the potential amount of fuel available to burn and persistence of burning
- The third index is the Fire Weather Index (FWI) that is based on the ISI and BUI values and represents potential fire intensity and difficulty of control.

Interpreting the Fuel Moisture Codes

The FWI System uses past and present weather effects on ground level fuels to evaluate fuel moisture content and potential fire behaviour.

The moisture codes reflect the effects of daily fuel moisture gains and losses.

NOTE

They act as a book-keeping system of fuel dryness that adds for each day’s drying and subtracts for wetting.

Fine Fuel Moisture Code (FFMC)

FFMC is a numerical rating of the moisture content of surface litter and other cured fine fuels. It indicates the relative ease of ignition and flammability of fine fuels.

The moisture content of fine fuels is very sensitive to the weather: the minimum rainfall required to affect the FFMC is 0.6 mm. Where there is canopy interception more than 0.6 mm is needed. The system uses a time lag of sixteen hours (two-thirds of a day) reflecting the rapid response of fine fuels to changes in weather conditions.

The FFMC rating is on a scale of 0 to 101.

NOTE

Generally ignition in fine fuels may occur at around an FFMC rating of 65-70. FFMC values in the mid-80s indicate easy ignition of fine fuels and values greater than 90 indicate very dry fine fuels that are extremely easy to ignite and provide for rapid fire development.

Duff Moisture Code (DMC)

DMC is a numerical rating of the average moisture content of loosely compacted organic layers of moderate depth. The code indicates the depth that fire will burn in moderate duff layers and medium size woody material.

Duff layers take longer than surface fuels to dry out but weather conditions over the past couple of weeks will significantly affect the DMC. The minimum rainfall required to affect the DMC is 1.5 mm (due to both canopy and litter layer interception). The system applies a time lag of 15 days to calculate the DMC.

NOTE

A DMC rating of more than 30 is dry, and above 40 indicates that intensive burning will occur in the duff and medium fuels. When the DMC rating is above 40, prescribed burning should be only be permitted after serious consideration.

Drought Code (DC)

DC is a numerical rating of the moisture content of deep, compact, organic layers. It is a useful indicator of seasonal drought effects on forest fuels, and amount of smouldering in deep duff layers and large logs.

The minimum rainfall required to affect the DC is 2.9 mm. A time lag of 53 days is used to calculate the DC, indicating that a long period of weather with low rainfall is needed to dry out these fuels and affect the Drought Code.

A DC rating of 200 is generally considered high, and 300 or more indicates that fire will involve deep sub-surface and heavy fuels.

NOTE

When the DC rating is above 300, prescribed burning should be only be permitted after serious consideration. In NZ DC can exceed 1000.

Interpreting the Fire Behaviour Indices

The three behaviour indices indicate what a fire is likely to do. They are relative to the fuel moisture codes.

The lower the fuel moisture content, the higher the Fuel Moisture Codes - the higher the Fire Behaviour Indices - the more active the fire will be.

Initial Spread Index (ISI)

ISI is a numerical rating of the expected rate of fire spread shortly after ignition. It combines the effects of wind and FFMC (Fine Fuel Moisture Code) on rate of spread without the influence of variable quantities of fuel.

The open-ended ISI scale starts at zero. A rating of 10 indicates a high rate of spread and a rating of 16 or more indicates an extremely rapid rate of spread.

SAFETY NOTE

A rating of 10 indicates a high rate of spread and a rating of 16 or more indicates an extremely rapid rate of spread.

Buildup Index (BUI)

BUI is a numerical rating of the total amount of fuel available for combustion that combines DMC (Duff Moisture Code) and DC (Drought Code).

It indicates control difficulty, including potential mop-up problems. The BUI scale starts at zero and is open-ended. A rating above 40 indicates that high levels of fuel become available for combustion. A rating above 60 indicates that fuel consumption will be very high and control of fire will be difficult.

SAFETY NOTE

A rating above 40 indicates that high levels of fuel become available for combustion. A rating above 60 indicates that fuel consumption will be very high and control of fire will be difficult.

Fire Weather Index (FWI)

FWI is a numerical rating of fire intensity that combines ISI and BUI. The FWI indicates the likely intensity of a fire and is suitable as a general index of fire danger.

SAFETY NOTE

A FWI over 30 is considered extreme

General Overview of thresholds for each component

Codes/Indices	Values	Example Triggers
Fine Fuel Moisture Code	0 – 101	0 – 73 Difficult to get fire ignitions
Time Lag = 16 hours		85 – 91 All fires will readily ignite
		92 + Expect extreme fire behaviour
Duff Moisture Code	0 ~ 150	0 – 10 Little mop-up required
Time Lag = 15 days		30 + Mop-up considered difficult
		40 + mop-up difficult & extensive. Consider suspending issue of permits
Drought Code	0 ~ 800	0 - 100 Little mop-up required
Time Lag = 53 days		300 + Difficult mop-up. Tighten conditions on permits
		350 + Prolonged mop up following fires
Initial Spread Index	0 ~ 100	0 – 3 Slow moving fires
		8 - 15 Rapid Spread of Fires
		16 + Extremely fast spreading fires
Buildup Index		0 ~ 200
		0 – 15 Fires considered easy to control
		40 + Fires are difficult to control
		60 + Extremely difficult to control. Consider suspending permits
Fire Weather Index	0 ~150	0 – 3 Low fire intensity. Easy to control
		30 + Extreme Fire Intensity. difficult to control

Summary table of a detailed breakdown of fire weather codes and indices

Ignition potential:	**Difficult**	**Moderately easy**	**Easy**	**Very easy**	**Extremely easy**
Fine Fuel Moisture Code (FFMC)	0 – 74	75 – 84	85 – 88	89 – 91	92 +
Rate of Spread:	**Slow**	**Moderately fast**	**Fast**	**Very fast**	**Extremely fast**
Initial spread Index (ISI)	0 – 3	4 – 7	8 – 12	13 – 15	16 +
Difficulty of control:	**Easy**	**Not difficult**	**Difficult**	**Very difficult**	**Extremely difficult**
Buildup Index (BUI)	0 – 15	16 – 30	31 – 45	46 – 59	60 +
Mop-up needs:	**Little**	**Moderate**	**Difficult**	**Difficult & extended**	**Difficult & extensive**
Duff Moisture Code (DMC)	0 – 9	10 – 19	20 – 29	30 – 39	40 +
Drought Code (DC)	0 – 99	100 – 175	176 – 249	250 – 299	300 +
Fire Intensity:	**Low**	**Moderate**	**High**	**Very high**	**extreme**
Fire Weather Index (FWI)	0 – 5	6 – 12	13 – 20	21 – 29	30 +

Note Exact triggers will vary in different parts of the country. Developed by Rod Farrow for central north island pine plantations.

Fuel Moisture Code

Example 1

FFMC= 86 DMC= 25 DC= 120

These numeric values indicate that:

- Fine fuels will ignite easily
- Fire will involve the fine fuels and to a limited extent the medium and duff layer fuels
- Fire will not become deep seated

Example 2

FFMC= 94 DMC= 45 DC= 320

These numerical values indicate that:

- Fine fuels will ignite extremely easily
- Fire will involve all fuel levels
- Extreme fire behaviour is likely
- Spot Fires

The fire behaviour indices (ISI, BUI and FWI) indicate the likely initial spread, total fuel availability and potential fire intensity.

Fire behaviour Indices

Example 1

ISI= 6 BUI=115 FWI=23

These numeric values indicate:

- Slow to moderate initial spread
- Very high volume of fuel available for combustion
- Potentially high level of fire intensity

In general terms a hot, but slow moving fire. The type of fire likely to occur on a windless day in mid summer after a long, dry period.

Example 2

ISI= 15 BUI= 30 FWI= 23

Note same FWI value as in Example 3. These numeric values indicate:

- Extremely fast initial spread
- Low to moderate volumes of fuel available for combustion
- Potentially high level of fire intensity

In general terms, a fast moving fire involving predominantly fine fuels only. Likely to be a fire in early spring or late autumn when heavy fuels have high moisture content and winds are strong.

ISI and BUI values

Because the FWI combines so many weather effects, the same FWI index value can be reached by many different combinations.

Note

Is an extreme FWI value mainly the result of a long stretch of dry weather (i.e. a high BUI) or from strong winds and a low relative humidity on the day in question (i.e. a high ISI)?

Example 1 - the key driver of the FWI value of 23 was the high BUI value of 115.

Example 2 - the key driver of the FWI value was the high ISI value of 15.

NOTE

An understanding of the sensitivity of the FWI system can only be gained by daily observation of the component values and changing weather conditions.

Grassland curing

Curing describes the annual or seasonal cycle of grasses dying and drying out. The degree of curing refers to the proportion of dead material in grasslands (indicated by a "curing value" and expressed as a percentage).

Why is curing important?

The degree of grassland curing has a significant effect on the vulnerability of grasses to ignite, a fire's rate of spread and suppression difficulty. The greenness and moisture content of grasses affects ignition potential, fire intensity and rate of fire spread. As fuel moisture content decreases, potential ignitability and fire intensity increase. The following are generalised guides, and it should be noted that ignitability and rate of spread are influenced strongly by weather and cover:

- Fuels cured less than 20% will be extremely difficult to ignite.
- Ignition is difficult in fuels cured less than 60%, and they are not likely to carry a continuous flame front, or intense fire.
- Ignition is moderately easy with slower spread when fuels are 60 – 80% cured.
- Ignition is easy and fires will spread in grasses cured more than 80%.

Grass curing is a crucial input into our fire danger and behaviour models. The percentage of dead (or cured) material in grasslands can have a dramatic effect on the fire danger. Currently, grassland curing is most commonly assessed by visual estimation which varies in accuracy due to observer subjectivity. Increasing the accuracy of grassland curing values will improve the accuracy of Fire Danger Ratings. Research into remote sensing, based on the reflective properties of grasses, provides an opportunity to improve the accuracy of curing estimates.

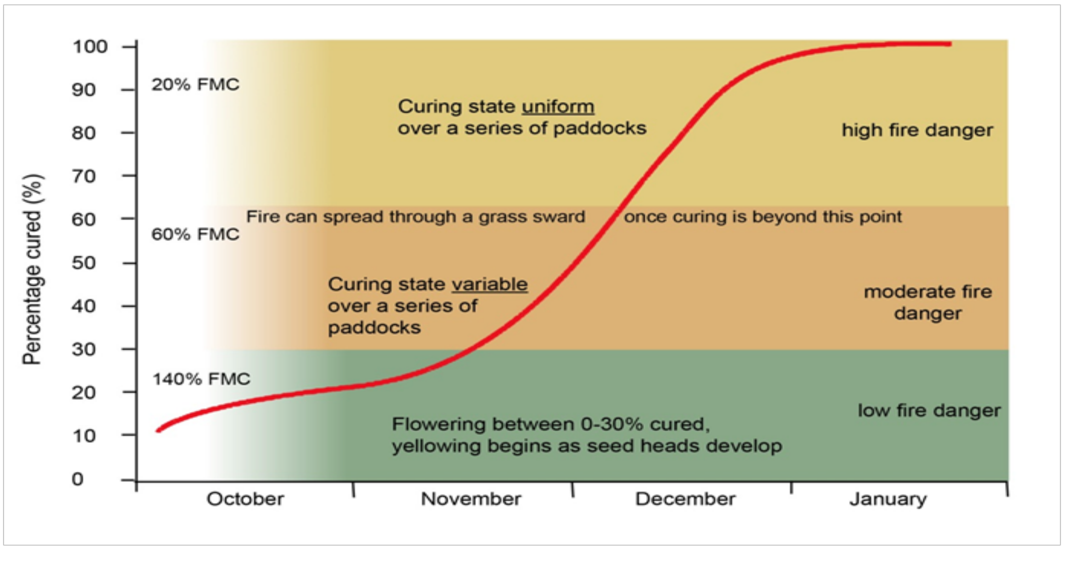


Figure. Generalized trend of grassland curing during the early fire season.
Reproduced from: CFA Grassland Curing Guide.

Hourly versus Daily FWI values

Hourly FWI values are different from the daily FWI values due to the way these are calculated.

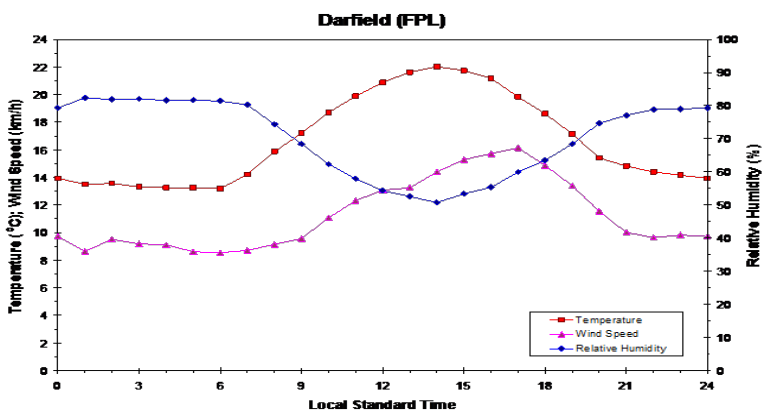
Hourly Fire Weather Index (FWI) values such as the hourly Fine Fuel Moisture Code (FFMCh), Initial Spread Index (ISIh) and Fire Weather Index (FWIh) are calculated for each hour of the day using up-to-date weather observations on temperature, relative humidity, wind speed and rainfall. As such, these provide the most accurate information on fire potential (ease of ignition, fire spread and fire intensity).

Daily values of DMC, DC & BUI (plus FFMC, ISI & FWI) are calculated from weather observations measured once a day at 1200 noon NZST. Daily values provide information on the general fire potential (ease of ignition, fire spread, fuel consumption and fire intensity) for the mid-afternoon peak burning conditions (around 1600-1700 hrs NZST) as well as trends in seasonal fuel dryness.

Daily Fire Weather Index (FWI) values such as the Buildup Index (BUI), Duff Moisture Code and Drought Code (DC) are used to provide information on the fuel dryness and fuel consumption associated with large woody fuels and soil organic layers. These slower responding fuels react more to weather conditions (rainfall, temperature, relative humidity and wind speed) at daily, weekly, monthly and seasonal timescales rather than short-term hourly fluctuations.

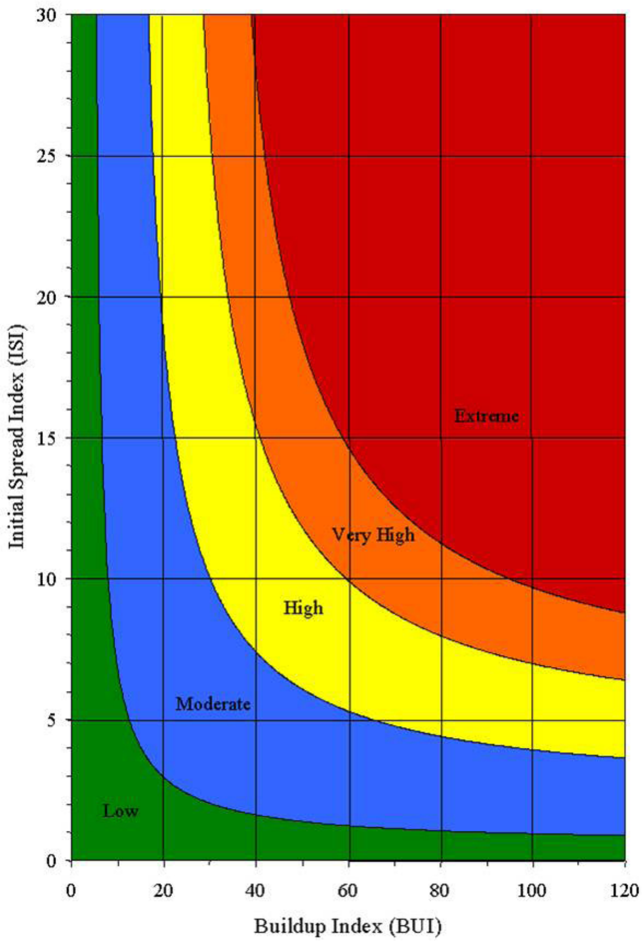
The daily FWI equations assumes a standard diurnal weather pattern, where temperature increases in a consistent trend throughout the day from dawn, to 1200 noon through to the mid afternoon peak burning period, and RH decreases consistently over the same period; wind speed is also assumed to increase to its peak.

If the weather for the day does not follow this standard diurnal pattern (e.g. due to a change in wind direction (e.g. sea breeze), cold front passage, or even heavy cloud cover), the hourly FWI's will be more accurate representation as they are utilising actual hourly weather.



Determining Fire Danger Class

Forest Fire Danger Class
This Forest Fire Danger Class Graph uses the ISI, reflecting the potential spread rate, and the BUI, reflecting the amount of fuel available to burn, to rate Forest fire danger and potential fire intensity



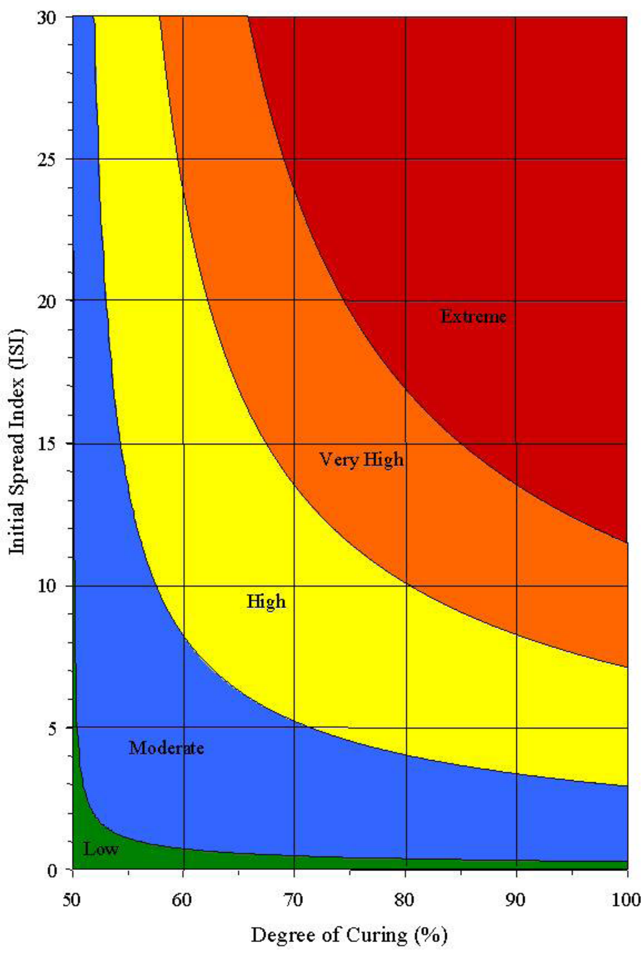
To use the graph

Take the ISI and BUI values and find the point where these intersect on the graph. This intersection indicates the level of fire danger based on fire intensity.

Grassland Fire Danger Class

In this Grassland Fire Danger Class Graph the fire danger rating is based on the ISI component and an assessment of the Degree of Curing (reflecting the percentage of the grass fuel that is cured and will burn). The same process of intersecting the ISI and Curing percentage is used to find the level of fire danger. **A grassland fuel load of 3.5 t/ha is used to determine potential fire intensity.**

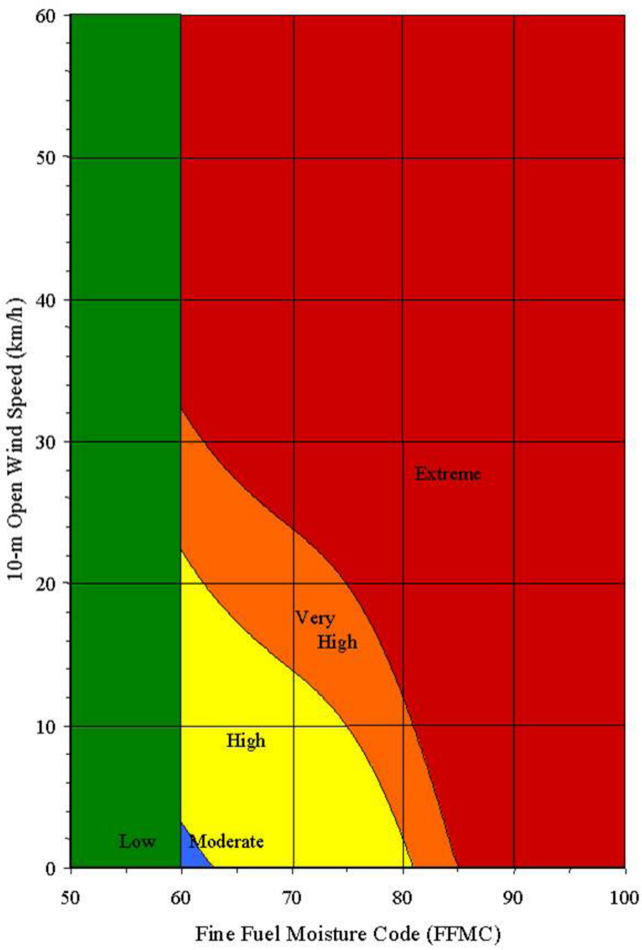
Note: The Degree of Curing must be supplied directly by the user and is usually based on a visual estimate.



It is important to remember that the level of fire intensity described by each fire danger class is the same no matter what the fuel type. Similarly, the general fire behaviour and control difficulty will also be much the same. (See Table of Suppression Interpretations,Green Book Section 6). However, the types and numbers of resources required to control a fire at the same level of fire danger in the various fuel types may be quite different due to variable fuel consumption and rates of fire spread.

Scrubland Fire Danger Class

In the Scrubland Fire Danger Class Graph the fire danger rating is based on the FFMC and 10 m open wind speed, which together reflect the potential rate of fire spread. **A scrubland fuel load of 20 t/ha is used to interpret potential fire intensity.**



Interpreting the codes and Indices-examples

The fuel moisture codes (FFMC, DMC and DC) indicate what fuels will be involved and their ease of ignition. This will vary during the season. Each code must be considered to assess its potential burning characteristics.

Section 3: Using the FWI Tables

You will need a set of the Fire Weather Index System Tables for New Zealand so that you can practice using them. They are available from the NRFA.

Introduction

The purpose of the FWI Tables is to provide a manual method of calculating daily FWI values for the prediction of fire danger conditions based on current or forecasted weather conditions. Learning these manual calculations is useful to help us grapple with the concepts and so understand them.

FWI Table Layout

The tables consist of five main section with each section separated with colour-coded tabs

Section 1 Tabs 1,3,5	Green Tab	Fuel Moisture Codes (Rainfall Tables for FFMC, DMC, DC)
Section 2	Yellow Tab	Fuel Moisture Codes (Drying Tables for FFMC)
Section 4,6	Yellow Tab	Fuel Moisture Codes (Drying Tables for DMC, DC)
Section 7,8	Red Tab	Fire Behaviour Indexes (ISI, BUI, FWI)
Section 10	Blue Tab	Relative Humidity Tables
	Final Section	Daily weather figures are entered into a Monthly Fire Weather Record Form, which is also used to calculate the Codes and Indices values.

The heading row sets out the Month, Year, Station Name and Elevation, and the Observer.

Month	Year	Station	Elevation	Observer

The next row is in two main columnar segments relating to the Daily Weather Readings and to Fuel Moisture and Fire Behaviour Index calculations.

Daily Weather Readings

	Temperature		RH	Wind		Rain
Day	(°C)	(°C)	(%)		(km/h)	(mm)
	Dry Bulb	Wet Bulb	Relative Humidity	Direction	Speed	24 hour

Fuel Moisture and Fire Behaviour Index Calculations

FFMC		DMC			DC			ISI	BUI	FWI
1	2	3	4		5	6		7	8	9
Rain code	Fine Fuel Moisture Code	Rain Code	Drying Factor	Duff Moisture Code	Rain Code	Drying Factor	Drought Code	Initial Spread Index	Build up Index	Fire Weather Index
	86			21			150			

The numbers in the Fuel moisture and Fire Behaviour columns refer to the FWI Table number used during the calculation process. Enter the value from the relevant table here.

The boxes hanging down from the FMC, DMC and DC columns are used to enter the starting values for the month. These will be the value of the last day of the previous month or, in the case of starting the calculations at the beginning of the fire season, the start-up values provided in the FWI Tables (see page vii of FWI Tables).

Enter the Weather Data - Step 1

Here is some weather data with information entered into the appropriate column (see below).

Day 1 On Monday *21.5°C, RH of 55 Enter the previous day FFMC, DMC, DC*

Daily Weather Readings

Fuel Moisture and Fire Behaviour Index Calculations

	Temperature		RH	Wind		Rain	FFMC		DMC			DC			ISI	BUI	FWI
Day	(°C)	(°C)	(%)		(km/h)	(mm)	1	2	3	4		5	6		7	8	9
	Dry Bulb	Wet Bulb	Relative Humidity	Direction	Speed	24 hour	Rain code	Fine Fuel Moisture Code	Rain Code	Drying Factor	Duff Moisture Code	Rain Code	Drying Factor	Drought Code	Initial Spread Index	Build up Index	Fire Weather Index
								86			21			150			
1	21.5		55		13	0.0											
2	18		65		8	3.1											
3	26		42		14	0.0											

In the absence of rain, it is often useful to record yesterday's moisture code values as today's Rain Code values to complete the chain of steps used in determining today 's FWI System values.

The next steps are more complex. However, by taking your time and following the instructions set out, you will soon learn the process.

Work through the following sections using the FWI System Tables to ensure that you arrive at the same values shown.

Book-keeping systems

Remember, the FWI System Fuel Moisture Codes act as “book-keeping systems” that add moisture at differing rates to different fuel profiles after rain and subtract moisture for each day’s drying.

Rain Code Value

It is very important to understand that when there has been sufficient rainfall to alter the value of the Fuel Moisture Codes, the calculation start value is modified by the amount of rain that has fallen. This is shown by the Rain Code Value. (See Rainfall Tables 1, 3 and 5 in the green section of the FWI Tables).

Using the FFMC,DMC, DC Tables

All of the Rain Codes are located together in the tables so that all of the Fuel Moisture Code values that are affected can be re-calculated at the same time the Rain Code values entered in to the appropriate Rain Code boxes on the Record Form (boxes 1, 3 and 5 as indicated by the highlighted boxes and arrows in the example below).

This is shown in the row for Day 2 when there was 3.1 mm of rain recorded.

STEP 2 Determine the FFMC. Go to Table 2

Go to the table with the temperature 21.5°C. Then go down to find the RH of 55% and wind speed of 13. Use yesterday FFMC of 86 today's FFMC is 86 record this. (shown in red)

Daily Weather Readings

	Temperature		RH	Wind		Rain
Day	(ºC)	(ºC)	(%)		(km/h)	(mm)
	Dry Bulb	Wet Bulb	Relative Humidity	Direction	Speed	24 hour

Fuel Moisture and Fire Behaviour Index Calculations

FFMC		DMC			DC		
1	2	3	4		5	6	
Rain code	Fine Fuel Moisture Code	Rain Code	Drying Factor	Duff Moisture Code	Rain Code	Drying Factor	Drought Code
	86			21			150

1	21.5		55		13	0.0		86	86	21	2	23			
2	18		65		8	3.1									
3	26		42		14	0.0									

STEP 3 Determine the DMC. Go to Table 4

Take the previous days DMC to the rain code. Go to table 4. Find the month of December go to the temperature of 21.5°C and RH of 55. Drying factor is equal to 2. Record this in column 4.

The DMC is then calculated by adding the Rain code and drying factor together.

DMC 21 + 2 = 23 (put this in DMC column)

SAFETY NOTE

It is very important to check that you are working in the correct temperature section of the FFMC Drying Tables. Most errors occur because the temperature table used is not the correct one.

STEP 4 Determine the DC

As there was no rain the previous day, use the previous days drought code as the rain code.

Daily Weather Readings

	Temperature		RH	Wind		Rain
Day	(°C)	(°C)	(%)		(km/h)	(mm)
	Dry Bulb	Wet Bulb	Relative Humidity	Direction	Speed	24 hour

Fuel Moisture and Fire Behaviour Index Calculations

FFMC		DMC			DC		
1	2	3	4		5	6	
Rain code	Fine Fuel Moisture Code	Rain Code	Drying Factor	Duff Moisture Code	Rain Code	Drying Factor	Drought Code
	86			21			150

1	21.5		55		13	0.0		86	86	21	2	23	150	7	157
2	18		65		8	3.1									
3	26		42		14	0.0									

STEP 5 Determine the Drying factor use Table 6

Use the month of December, temperature of 21.5°C gives a drying factor of 7. Put this in column 6 (in red above)

Step 6 Determine the Final DC

Add rain code and drying factor together to get the drought code.

150 + 7 =157. Put this in the drought code column.

Using the Fire Behaviour Tables

Tables 7, 8 and 9 of the FWI Tables relate to the Fire Behaviour Indices and are straightforward entries.

Finding the ISI

Use Table 7 with the daily weather readings from the table below both FFMC and Wind speed.

	Record the ISI in the column marked 7 on the sheet.

Finding the BUI

Use Table 8 with today's DMC and DC.

	Record BUI in the column marked 8 on the sheet.

Finding the FWI

Use Table 9 with today's ISI and BUI.

	Record FWI in the column marked 9 on the sheet.

Daily Weather Readings

	Temperature		RH	Wind		Rain
Day	(°C)	(°C)	(%)		(km/h)	(mm)
	Dry Bulb	Wet Bulb	Relative Humidity	Direction	Speed	24 hour

Fuel Moisture and Fire Behaviour Index Calculations

FFMC		DMC			DC			ISI	BUI	FWI
1	2	3	4		5	6		7	8	9
Rain code	Fine Fuel Moisture Code	Rain Code	Drying Factor	Duff Moisture Code	Rain Code	Drying Factor	Drought Code	Initial Spread Index	Build up Index	Fire Weather Index
	86			21			150			

1	21.5		55		13	0.0		86	86	21	2	23	150	7	157	5	34	10
2	18		65		8	3.1												
3	26		42		14	0.0												

Hint: The workbook has the completed table for you to check your calculations.

Section 4: Applications of FWI and Fire Danger Information

Overview

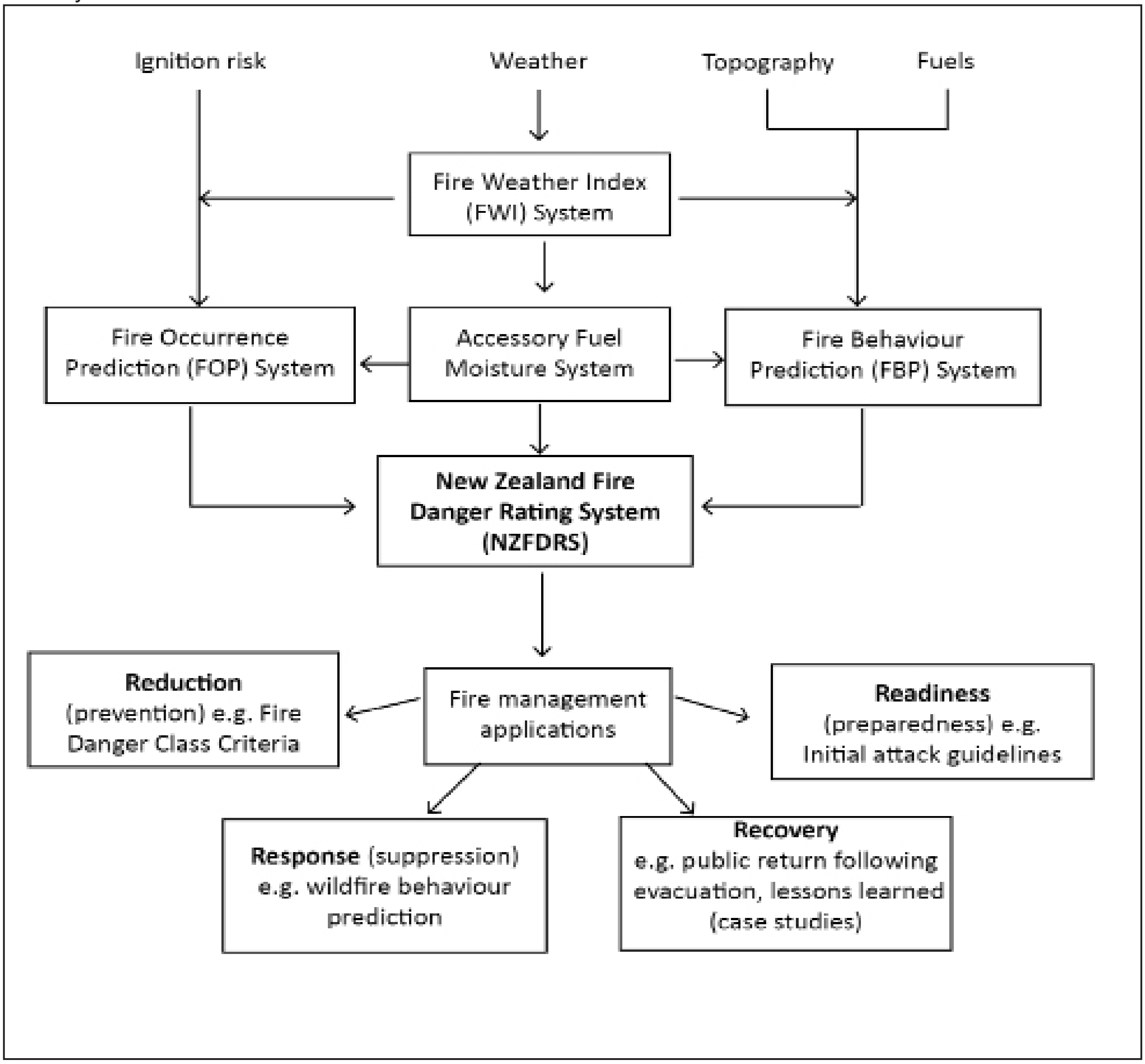
In this section our focus is on how to apply FWI System information and fire danger outputs.

What does a Fire Danger Rating System (FDRS) do?

It measures those elements that cause day-to-day changes in fire danger.

It enables you to interpret the information gained in a standard manner.

This means that you can identify the likelihood of a fire occurring and its likely characteristics.



What is fire management?

Successful fire management depends on effective reduction, readiness, response, and recovery.

Reduction - Fire prevention

Reduction refers to those activities that reduce the degree of long-term risk. In a fire management sense, reduction is generally regarded as ‘fire prevention’, which involves activities directed at reducing fire occurrence. Fire prevention aims to reduce the number of fires, therefore minimising area burned, fire suppression expenditure and other damages. In other words, fire reduction should lower the likelihood and consequence of fire. It may not be desirable, practical or possible to prevent all fire starts. If this is the case, reduction measures may be used to reduce the impact of fire across the landscape.

For example:

- Public notification of fire danger
- Publicity campaigns and education
- Fire season status
- Restrictions or closures
- Fire permit issue
- Fuels management
- Fuel reduction burning

Readiness - Fire detection and pre-suppression planning

Readiness refers to activities that develop operational capabilities for responding to an emergency event. In fire management terms, readiness activities are carried out before a fire occurs, to ensure rapid and effective fire suppression is achieved in the event of an incident. Readiness activities include planning and use of fire preparedness systems that aim to maximise successful initial attack.

For example:

- Fixed methods, such as fire lookout towers, lightning location systems and aerial or ground patrols
- Random methods such as reliance on commercial aircraft and the general public

Response - Fire suppression

Response refers to activities taken immediately before, during or directly after an emergency in an effort to minimise losses and improve recovery. In the fire management context, response refers to the 'fire suppression' phase, the fire fighting operations most of us are more familiar with. This includes the phases of detection, containment, mop-up, patrol and complete extinguishment that are sometimes represented using the chain of fire suppression.

For example:

- Fire behaviour prediction
- Fire growth and escape analysis: and
- Determination of resource requirements (including number and type of resources required)

Recovery

Recovery refers to the process of returning affected communities to social and economic normality, and includes immediate, medium and longer-term rehabilitation and restoration activities. In fire management, 'fire recovery' applies to re-instatement of fire response capability and rehabilitation of fire-affected individuals, properties and communities, and fire-damaged ecosystems.

For example:

- investigation and cost recovery
- public welfare
- damage assessment
- site rehabilitation
- debriefs and operational reviews

Summary

This table outlines the ways we use fire danger information to anticipate and plan for fire prevention and fire pre-suppression requirements.

Reduction	Define fire season status (Open, Restricted, Prohibited) Inform the public Make decisions on permitting, restricting or prohibiting a range of activities that have fire risk potential, including the issue or cancellation of permits for the use of fire
Readiness	Identify areas of concern with respect to potential for ignition Assess likely fire behaviour
Response	Plan for initial attack Identify resource requirements.
Recovery	Fire investigation, post fire rehabilitation of the area, reinstatement of fire equipment, post fire calculations, returning fire affected communities to normality to post fire rehabilitation of the fire area and reinstatement of fire equipment and post fire cost calculations. Fire investigation including return of fire affected communities to normality.

NOTE

To do any of this effectively it is essential to have meaningful information on current and predicted fire danger conditions.

Use of FWI Information as a decision support tool

Plan ahead

Prediction of fire danger conditions enables fire managers to plan ahead.

The FWI System is an excellent decision support tool. They can:

- Forecast what levels of preparedness they may need for their own area
- Determine what mitigation measures are appropriate
- Meet their own organisational requirements
- Support appropriate fire control measures

Fire season status

A key tool in Fire Prevention is our ability to define fire season status:

- Open, Restricted, Prohibited; and
- To let the public know when they must take extreme caution with fire.

We use this tool to make decisions on permitting, restricting or prohibiting a range of activities that have fire risk potential, including the issue or cancellation of permits for the use of managing fire.

Factors determining declaration of a prohibited fire season

If we have had an extended dry period (or weather forecasts are indicating that dry conditions are expected to prevail for some time)…

How and when do we decide to declare a "prohibited fire season"?

To help make a decision – we identify a trigger point.

To identify a trigger point, we look at the factors that combine to affect fire behaviour and identify the point where their levels meet to make conditions dangerous.

For example, some rural fire authorities declare a prohibited fire season when a degree of grassland curing is above 70%, or when a BUI goes above 40..

FWI System components

What is the relationship between fuel dryness (fuel availability) and the FWI System components? And where do we find this information?

In forest areas the key is fuel dryness levels and fuel availability.

Dryness level

The condition of the fuel, in particular its level of dryness is the key driver

Fuel availability

This dryness level reflects the amount of fuel that will burn in a fire - fuel availability

Buildup Index

In forest areas the key is fuel dryness levels and fuel availability i.e. Buildup Index (BUI)

Degree of Curing

In grasslands the dryness level is expressed as the Degree of Curing.

Your Fire Plan

Check your Fire Plan for trigger levels.

Fire season status - forests

Consider typical daily weather conditions in a dry summer period, say in December, January or February. At 1 pm Daylight Saving Time average conditions can be expected to be in the vicinity of the following values:

Air Temperatures around 20° – 25°C

Relative Humidity around 40 – 50%

Average Wind Speeds of around 22 km/h

Under these conditions the FFMC stabilises at around 89.

FFMC value of 89 + Wind Speed of 22 km/h make the corresponding ISI 11.

NOTE

Monitor the ISI as it changes hourly, daily and is directly influenced by wind speed.

Prohibition of fires

We need to consider that a prohibition of fires should be declared when it is likely that day after day of **Very High** or greater fire danger will be experienced, i.e. the level of fuel dryness has reached a dangerous level.

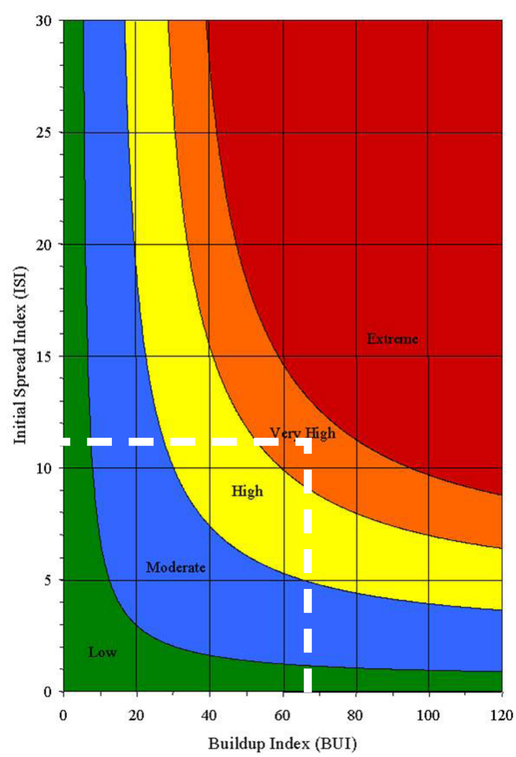
Trigger point

We determine a *trigger point* in terms of BUI. For an ISI of 11 the threshold value for Very High Fire Danger class is a BUI of 60 (graph).

Daily increase

At this time of the year under these conditions the BUI will increase by roughly 3 points per day, so the threshold could be regarded as being around BUI 50.

Forest Fire Danger Class



3 - 4 day cushion

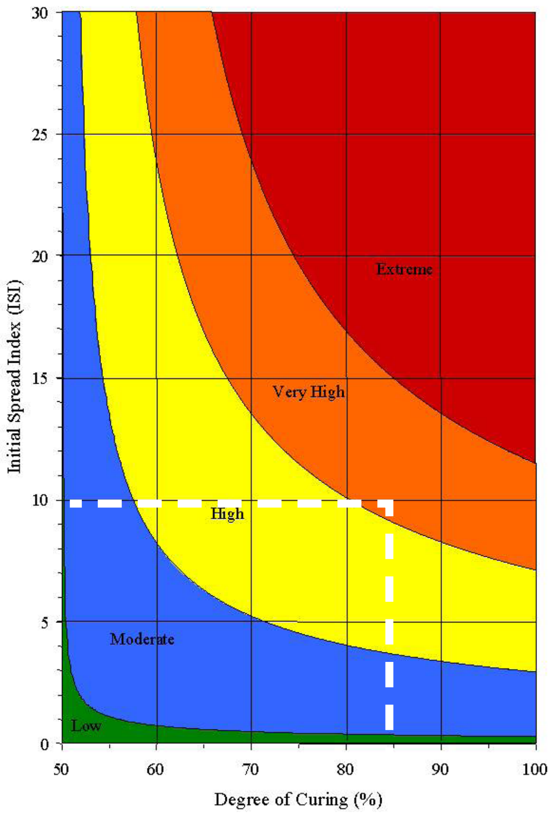
It is worth considering setting a “cushion” of 3 – 4 days by selecting the mid-point of the High Fire Danger Class as opposed to the lower end of the Very High class. The trigger point would then be about BUI 45.

This is the point at which a significant amount of ground or sub-surface fire activity can be expected. At the 3 points a day increase in the BUI this provides about a 3 - 4 day cushion.

It is also important to understand that during these conditions the difference between Very High and Extreme Fire Danger is an increase in wind speed of around 5 km/h to 27 km/h.

Fire Season Status - Grassland

The same methodology is used for Grasslands except that instead of BUI we use *Degree of Curing*. The threshold for Very High is around the 75 - 80% curing level.



Trigger point 80% curing

As there is unlikely to be considerable sub-surface fire activity in grassland a trigger point of 80% curing would be appropriate.

Informing the public - the Fire Danger Class

Once we've defined the fire season status (Open, Restricted, Prohibited) – we need to keep the public informed on a daily basis.

Use of the Fire Danger Class

The primary use of the fire danger class is for public notification of the prevailing fire danger conditions over a broad area and it is therefore primarily a fire prevention tool (i.e. reduction of ignitions).

Prevention focus

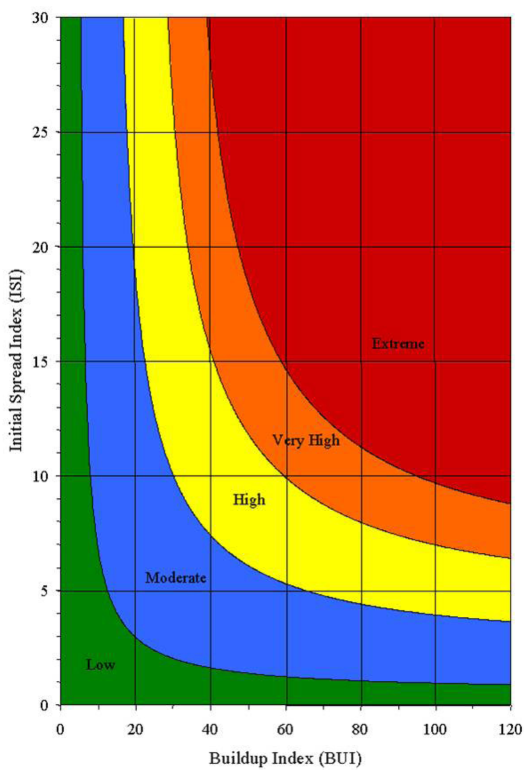
The primary focus of prevention is:

- On publicity of existing and predicted fire danger conditions for public awareness
- The impact of the activities that the public undertakes

Fire danger indicator signs

These must reflect the current level of fire danger. This means you must be able to identify the current fire danger rating (i.e. fire danger class) correctly.

Forest Fire Danger Class



Activity controls

We've defined the fire season status and we're keeping the public informed. Now we're also in a position to make informed decisions on permitting, restricting or prohibiting a range of activities that have known fire risk potential, including the issue or cancellation of permits for the use of fire.

Where do I find real examples?

You'll find examples of reduction (fire prevention) in the Fire Plans of most Rural Fire Authorities (RFA). Some of these provide a great amount of detail with respect to what is allowed and what must be carried out to meet the requirements set down. Others may provide a minimal amount of instruction and detail.

Different needs require different plans

A large plantation forest based RFA may have detailed requirements for:

- The provision of fire fighting tools and equipment for contractors working within forest areas
- Fire prevention requirements for heavy machinery such as spark arrestors, engine screens and shrouds and fire extinguisher requirements etc

An RFA with no plantation forest activities taking place, but with extensive use of fire within the district may have detailed requirements for:

- The management of fire and the issue of burning permits and restrictions on lighting-up times, e.g. burning of crop stubble

Or because of predominant conditions at the time, a RFA may have:

- A range of controls that are applied to various activities and are aimed at the prevention of fire that could start from them

On the next two pages you'll find examples that show how FWI System information can be used to identify triggering thresholds and action that may be taken for:

- The closure of Public Access to a grassland area
- The control of activities within a plantation forest

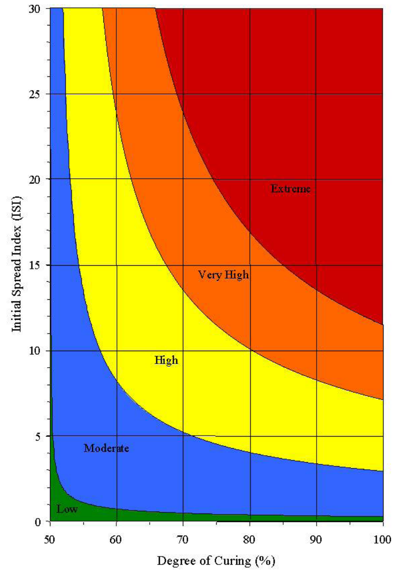
Reduction - Fire Prevention Measures

Example: Public access

The application of FWI System information to the development of a Public Access Control System.

This system is based on daily observations of weather and fuel factors (i.e., FWI System plus Degree of Curing of Grasslands) – and has 4 levels.

- Open Access
- Restricted Access Stage 1 – warnings issued related to fire hazard and fire danger
- Restricted Access Stage 2 – warnings issued as above with closure of the island at 1 pm
- Closed



This is an example of how this may be used.

Fire Danger Class	Degree of Grassland Curing		
	<60%	60-80%	>80%
Low	Open	Restricted Stage 1	Restricted Stage 1 or 2
Moderate	Open	Restricted Stage 1	Restricted Stage 1 or 2
High	Open	Restricted Stage 2	Closed
Very High	Open	Restricted Stage 2	Closed
Extreme	Open	Restricted Stage 2	Closed

This example shows how FWI System information can be used to identify triggering thresholds and action that may be taken for the closure of Public Access to Somes Island in Wellington Harbour.

Reduction - Fire Prevention Measures

Example Plantation Forest: Activity controls - The application of fire danger information to the development of Activity Controls for a Plantation Forest.

The tables on the next page is an extract from a Fire Plan for a plantation forest company.

This summary of activity controls is based on fuel availability represented by the Buildup Index values of the Fire Weather Index (FWI) System.

A fire occurring under high BUI values with an increase in wind speed will generate extreme fire intensity values beyond control by conventional means.

Hazard Levels	Fire Awareness	Public Access Restrictions	Restrictions on Forest Operations		Recreation and General Operations	
			Silviculture Operation	Harvesting and Heavy Machinery	Restrictions on Public Access	Other Operations
Level 1 (BUI 0-30) Low	Fire permits issued as per fire plan.	At discretion of landowner.	As per Fire Plan.	As per Fire Plan.	No restriction on public access	No restrictions on the use of any machinery
Level 2 (BUI 31-45) Moderate	Review fire permit issue.	As above.	Increase awareness of fire danger.	Increase awareness of fire danger.	No restriction on public access	No restrictions on the use of any machinery
Level 3 (BUI 46-60) High	Permits issued with strengthened conditions. Start public awareness campaign Maintain careful watch on drying trends	Prepare to restrict public access to high risk areas. Initiate fire patrols.	Initiate work site patrols. Continue work area inspections and fire danger awareness. Initial Attack crew located at fire depot	Initiate work site patrols. Continue work area inspections and fire danger awareness.	No restriction on public land	Consider increasing on site suppression equipment for spark hazardous operations such as railways grinding and welding operations. Use early part of the day. Care with chainsaw operations and mechanical equipment in contact with light fuels.
Level 4 (BUI 61-80) Very High	Maintain careful watch on drying trends. All permits issued with strengthened conditions and monitoring for compliance	Cancel all public access to production forests, including public easements.	Midday knock-off for all chainsaw operations. Restrict work to lower hazard areas. Initial Attack crew located at fire depot during burn part of the day	Midday halt of chainsaws in forest. Processing of logs on landings allowed until 2 pm.	Consider restricting Public walkways. Consider two stages (a) Restrict to certain hours or beyond certain points and maintain high levels of patrols (b) (b) Review complete closure of certain areas	Restrict chainsaw and other mechanical operations to low hazard areas and cease at mid-day if hot dry weather. No campfires once prohibition in place and gas barbeques only at approved sites

Level 5 (BUI 81-160) BUI> 100 not even Special Permits to be issued Extreme	Total Fire Ban Cancel any remaining fire permits Special Permits only by decision of PRFO. Public warnings Increased public awareness.	Consider closure of all high risk public areas and roads. Fire patrols and Initial Attack Crews only. Close production forest when BUI>100 FFMC >90 and ISI >5 or any 2 conditions met	Halt all chainsaw work. Place workers on standby for fire control operations When BUI>100 FFMC >90 and ISI >5 or any 2 conditions met no operations at all. Workers full time availability for fire control action. Locate Initial Attack Crews at strategic positions	Halt machine operations in high hazard areas such as cutover and scrub areas. When BUI>100 FFMC >90 and ISI >5 or any 2 conditions met no operations . All workers on fulltime availability for fire control action.	Consider restricting Public walkways. Consider two stages: (a) Restrict to certain hours or beyond certain points and maintain high levels of patrols (b) Review complete closure of certain areas	No Camp fires and no smoking in high hazard public places when BUI 120 and GC%95. Halt all chainsaw and spark hazardous operations including welding, grinding and trail bikes. Rail track and farm operations and contractor work involving roadside mowing on stony ground should cease Initiate preparation of emergency operations plans

Section 5: Readiness Measures

Hazard Levels Fire Awareness Public Access Restrictions on Forest Operations

Objective

Remember that we use fire danger information to anticipate and plan for readiness. This includes:

Reduction -Assess the likelihood of a fire occurring	• Identify areas of concern with respect to potential for ignition. • Assess likely fire behaviour.
Readiness- Determine fire suppression response and resources requirements	• Plan for initial attack. • Identify resource requirements.

One of the main objectives of any fire suppression organisation is to control and extinguish all unwanted fires while they are relatively small.

How do we achieve this?

The probability of this occurring can be significantly increased when the number, type and location of initial attack resources are systematically altered in response to changes in the fire environment and in accordance with organisational policy.

What does a preparedness plan include?

See appendix for example of preparedness plan. Readiness Triggers and Precautionary Measures, from Canterbury Conservancy

Readiness

In New Zealand, most unwanted fires are started by people.

A few of these are malicious lightings, but most probably result from escapes due to carelessness.

Identify - Assess - Plan

It’s crucial to identify serious situations before they occur so that fire managers can take action to increase the probability of controlling fires while they are small.

Most readiness systems are based on the idea that a rapid and aggressive initial attack will ensure that the majority of fires will not escape initial attack suppression action.

How do we achieve this?

In order to achieve this the following issues need to be considered:

1. The risk of fire ignitions and potential fire behaviour.
2. Protection and notification systems
3. Initial attack response measures that are appropriate for the values that are at risk from damage by fire.
4. Travel methods for Initial Attack crews (e.g. road or air).
5. Provision of guidelines for other pre-suppression activities.

Apply Fire Danger Information

The use and application of fire danger information is a critical in anticipating fire suppression resource requirements. Fire weather indicies indicate the degree of difficulty of control that is likely to be experienced at a vegetation fire.

Structured - Systematic - Flexible

Any preparedness system needs to be:

- Structured and systematic
- Flexible in order to allow for unique conditions.
- The preparedness system needs to take into account other factors that can influence preparedness levels such as:
- Extra human activity (e.g. long-weekends, hunting season etc)
- Agricultural burning gives rise to concentrated burn periods (double burning)
- Unrepresentative fire weather observations (usually caused by scattered rainfall)
- Potentially volatile fuels such as cured grass and scrubland fuels (drought conditions)
- Passage of a frontal system (weatehr changes)
- Limited availability of staff and resources

Readiness systems are able to:

- Assess the likelihood of fire occurrence
- Implement fire detection requirements and processes
- Determine initial attack dispatch requirements
- Determine fire suppression response strategies and tactics, and resource requirements

They are also very useful in determining the need for the implementation of, or stepping-up of, additional fire fighter training programmes.

SAFETY NOTE

Caution! The Fire Danger Class Interpretation Chart shows levels of fire danger rating based on the fire intensity.

Fire danger class

Some organisations may be tempted to try using the Fire Danger Class Interpretation Chart showing flame height, fire intensity, fire potential, and implications for suppression, for preparedness planning.

It is not appropriate to use the chart by itself for determining initial attack preparedness or for dispatching fire-fighting resources nor for suppression tactics and strategies at ongoing fires.

The fire danger class is only a reflection of fire intensity and does not by itself give any indication of how fast a fire is expanding in size.

To make appropriate decisions it is necessary to consider all of the other components of the NZ Fire Danger Rating System and the fire environment factors in the area of concern.

Basing preparedness for fire occurrences solely on the fire danger class that has been determined for the day, without collecting, evaluating, and recording fire intelligence data such as fuel type and fuel moisture conditions, topographic conditions including access routes and travel times, as well as other information related to water supply sources, detection requirements, and availability of fire suppression resources is likely to result in larger, more damaging and more costly fires.

The NZ Fire Danger Rating System is a management tool to assist managers to make sound decisions

Readiness Plans -Resource Standby Requirements

An example of Applying Fire Danger Rating System information to the development of Preparedness Levels and Personnel Standby Requirements for a Plantation Forest.

Below is an illustration only - not intended as definitive statements on what should or should not be included in any fire pre-suppression preparedness measures.

Preparedness Levels	
LOW Danger Levels	• Duty Officers to maintain continuous contact via message pager - respond to alarm via radio, cellphone or telephone within 10 minutes • A fire appliance and crew to be dispatched within 20 minutes of receipt of fire call
The objective is for the Initial Attack to be commenced within 60 minutes of report of fire.	
MODERATE Fire Danger level	• Duty Officer to maintain continuous contact via message pager – respond to alarm via radio, cellphone or telephone within 10 minutes • A fire appliance and crew to be dispatched within 20 minutes of receipt of fire call
The objective is for the Initial Attack to be commenced within 60 minutes of report of fire.	
HIGH Fire Danger Level	• Duty Officers will be available at all times. Continuous contact to be maintained via message pager - respond via radio, cellphone or telephone within 5 minutes • Outside of normal Monday to Friday work hours, the Duty Initial Attack crew is to maintain continuous contact via telepager - respond via radio, telephone or cellphone within 5 minutes, a fire appliance to be dispatched within 15 minutes of receipt of fire call
	Consider the following:
	• Aerial patrols • Additional manpower detailed to the Fire Depot • Advising key personnel and contractors of increasing fire danger conditions • Review forest access and fire permit issues • Standby requirements • Patrols of chainsaw and machinery operations • Bulldozer locations • Fire Danger Awareness advertising in local media
The objective is for Initial Attack to be commenced within 30 minutes of report of fire.	

VERY HIGH Fire Danger Level	• Duty Officers shall be immediately available at all times. Continuous contact by message pager. Respond immediately via radio, cellphone or telephone. • Outside of normal daily work hours, the Duty Initial Attack crew is to maintain continuous contact via telepager. Respond immediately via radio, telephone or cellphone. A fire appliance to be dispatched within 10 minutes of receipt of fire call. • PRFO or Deputy PRFO will be available. Continuous contact via message pager. Respond within 5 minutes via radio, cellphone or telephone. • Locate Initial Attack personnel at the Fire Depot. A fire appliance and crew to be dispatched immediately upon receipt of fire call.
	Consider the following:
	• Aerial and Highway patrols • Location, availability and ETA's for other helicopters and fixed wing fire-fighting aircraft • Location of transporters and bulldozers • Close public access to the forest • Cancel fire permits • Initiate standby requirements • Midday close down of Silvicultural chainsaw operations • Midday close down of Harvesting chainsaw operations with hauling of wood to, and processing of wood on landings allowed until 2 pm. • Patrols of chainsaw and machinery operational areas at cessation of work.
	The following actions may be implemented as the PRFO considers necessary:
	• Locate fire engines with fire-fighting crews at strategic locations within the forest • Place a fire-fighting helicopter on standby • Roster additional persons on duty. • Extended daily work hours for Fire Control, Duty Fire Officers, other personnel and fire-fighting crews. • Implementation of any other further precautions
The objective is for Initial Attack to be commenced within 15 minutes of report of fire.	

EXTREME Fire Danger Level	• Duty Officers, and PRFO or Deputy PRFO, shall be immediately available. Continuous contact via message pager. Immediate response via radio, cellphone or telephone. • The Duty Initial Attack crew shall be immediately available outside normal Monday to Friday work hours. Continuous contact via telepager. Immediate response via radio, telephone or cellphone. • Extended daily work hours for Duty Fire Officers, other personnel and Forestry silvicultural and fire-fighting crews shall be worked. • Precautions as in "VERY HIGH" fire danger level. • Implement Activity Controls for Hazard Level 5 • Fire engines with fire-fighting crews shall be located at strategic locations within the forest as required. • Transporters loaded with bulldozers shall be placed on standby. • A fire-fighting helicopter shall be placed on standby at the Helipad.
The objective is for Initial Attack to be commenced within 15 minutes of report of fire.	

An "EXTREME" fire danger rating relates to days with high wind speeds and an extremely high potential rate of fire spread. In the event of the Buildup Index (BUI) value of the FWI System exceeding 80-120 ALL silviculture, harvesting and other machinery operations to cease work in the forest. All workers to be on full time availability for fire control operations, this is dependent on the region.

This level is only likely to be reached under severe, prolonged drought conditions.

Standby levels

Dependent upon the level of fire danger, personnel may be required to standby after normal working hours.

Standby requirements will be determined as early as possible in order to schedule personnel as required prior to weekends or holiday periods.

Readiness Plans – Initial Attack System Guidelines

Applying Fire Weather Index System data to the development of Resource Readiness Deployment Tables for a Plantation Forest.

Below is an example of applying fire weather systems.

NOTE

This is an example only. Your RFA will have its own levels. Check in Fire Plan for these levels.

The table below needs to be used with the resource readiness deployment guidelines on the next page.

Table 1 Resource Readiness Deployment Table*

Wind forecast less than 20 km/h					**Wind forecast Greater Than 20 km/h**				
FFMC	**BUI**				**FFMC**	**BUI**			
	0 - 20	**21 - 40**	**41 - 80**	**>81**		**0 - 20**	**21 - 40**	**41 - 80**	**>81**
0 - 79	1	1	1	1	**0 - 79**	1	1	1	1
80 - 85	1	1	2	2	**80 - 85**	1	1	2	3
86 -89	1	2	3	3	**86 -89**	2	3	3	3
90 -91	2	3	4	5	**90 -91**	3	4	4	5
>91	3	4	4	5	**>91**	4	5	5	5

*NB this is a specific example for one part of the country, and will vary depending on the range of FWI conditions experienced locally (obtained from Historical Climatology)

Resource Readiness Deployment Guidelines

	Forest Companies	**General Fire Authorities**	
Forest Fire Danger Class	**Resource Deployment**	**Resource Deployment: Initial Attack (I/A) Predetermined response**	
Low Level 1	Normal forest operations with onsite forestry crew to deal with the fire	Dispatch	1 four person crew (includes leader 1 Initial attack trailer 1 personnel ranked logistic support
Moderate Level 2	2 person fire engine crew at Fire Depot Plus one additional fire truck driver	Dispatch these resources plus those listed in level one	1 Initial Attack Incident Controller (substitutes as Operations Manager level 3 or Sector Supervisor level four)
		Standby these resources	1 helicopter on standby
High Level 3	5 person Initial Attack crew based at Fire Depot 2 Additional Drivers deployed to Fire Depot Rostered weekend work for crews and standby	Dispatch these resources plus those listed in levels one and two	1 personnel ranked Incident Controller(substitutes as sector Supervisor Level four) 1 personnel ranked Air Support Supervisor 1 personnel ranked Logistics Manger (substitutes as logistics support level four 2 personnel ranked logistics support 1 four person crew (includes leader) 1 smoke-chaser unit 2 helicopters 1 four person heli-pad crew (includes leader) 1 heli box 1 Command unit 100 litres foam
		Standby these resources	Standby bulk foam/ retardant supplies

Very High Level 4	3 x 5 person Initial Attack crews with fire trucks pre-positioned at strategic locations in forest. Selected silvicultural crews on extended hours. To maintain listening watch 1200 hrs – 2000 hrs. 3 drivers deployed to Fire depot – extended hours worked. Rostered weekend work for crews and standby	Dispatch these resources plus those listed in levels one, two, and three	Fire Authority IMT or Regional IMT Includes Safety Advisor 4 personnel to support Planning and Logistics specialist functions 2 four person crews (includes leader)
		Standby these resources	2 four person crews(includes leader) 2 Helicopters 1 fixed wing
Extreme Level 5	4x 5 person Initial Attack crews with fire trucks pre-positioned at strategic locations in the forest. Selected silvicultural crews pre-positioned at selected areas in the forest. All other silviculture crews on extended hours. To maintain listening watch 1200 hrs - 2000 hrs. 3 drivers and additional personnel deployed to Fire depot- extended hours worked. Rostered weekend work for crews and standby All silviculture crews on standby	Dispatch these resources plus those listed in levels one, two, three, and four	Level four standby helicopters Level four fixed wing Level four standby personnel 1 Air Attack Supervisor 1 four person heli-pad crew (includes leader) 2 monsoon buckets and volume pumps 300 litres foam
		Standby these resources	1 fixed wing

Response Measures

Objectives

Determining response and resources requirements helps us:

- Plan for initial attack.
- Identify resource requirements

Fire suppression action follows three phases.

- Size-up
- Analysis
- Plan of action

Each of these can be made more accurate and effective by applying FWI information to the decision making process.

Review

Let's review the FWI System Codes and Indices to see how they provide key information for decision making on suppression action.

Rules of thumb

- The higher the Fuel Moisture Code values, the drier the fuel; the drier the fuel, the easier it is for it to ignite and burn, and the more available fuel.
- The higher the Fire Behaviour Index values, the more active the fire; the more active the fire, the more difficult it is to contain, control and extinguish the fire.
- When Drought Code (DC) exceeds about 300 and/or Buildup Index (BUI) is greater than around 40, one can generally expect ground or subsurface fires. Please note, however, these benchmark values are for moderately well-drained sites, but in actual fact will vary according to soil type and drainage conditions and should be determined locally on the basis of past wildfire suppression and/or prescribed burning experience.

FFMC and ISI

- Always monitor the FFMC value. It indicates ease of ignition in fine fuels. Fine fuel is where fires start and where they spread.

- Always remain aware of wind speed as this, in conjunction with the FFMC, drives the ISI, which indicates potential rate of spread

- The FFMC and ISI indicate the likelihood of spotting in fine fuels (a FFMC value greater than 92 indicates that burning material carried aloft and carried ahead by the wind will most probably start another fire). They help identify safety issues with respect to resource deployment.

DMC, DC, and BUI

- These indicate the likelihood of involvement of duff and deep organic material, and woody material such as small branches, limbs and logs, etc. in the burning process.

- They indicate the amount of resources and effort that is needed to gain and maintain control followed by the mopping up and extinguishment of a fire, once the initial fire front has passed through an area.

FWI

- This indicates the level of intensity of the fire front and indicates the energy released that has to be contended with during the suppression phase and the difficulty of control. Flame lengths are a very good indicator of fire intensity (see Fire Danger Class Criteria Table in section 1). Refer to the RFMH Handbook (the Green book section 6) for more information.

Fire Suppression Phases

Phases 1 and 2 - Size-up and Analysis Phases

Use the table below to answer the questions regarding size up and analysis phase

You will need to ask these questions...	About these key areas...	Using these key FWI values...
Where will the fire spread?	Fuels, wind direction, topography	ISI FFMC
Productivity of resources	Intensity and difficulty of control	BUI FWI
How much time will you need to contain the fire?	Difficulty of control, weather	FFMC, DMC, DC ISI, BUI, FWI
How much time do you require for resources to arrive?	Rate of spread	ISI

Phase 3 - Plan of action

Key Points

Rate of fire spread and fuel availability determines the amount of resource required to contain a fire at a certain size or within a specified time period

- Weather changes will affect fire behaviour – keep aware of these at all times
- Difficulty of control dictates the likely effort and time required required to contain, control and extinguish a fire
- Fire intensity – (as indicated by flame size) dictates resource effectiveness

You will need to ask these questions…	About these key areas…	Using these key FWI values…
Where and how to attack	Fuels, spread, intensity, safety	FFMC, ISI, FWI
What type of attack do you select?	Direct, dry, wet, indirect,aerial, etc.	BUI, FWI
How much time is needed to contain fire?	Spread, available fuel, intensity	ISI, BUI, FWI
What resources will you require?	Personnel+, machinery, aircraft, support, mop-up	ISI, BUI, FWI, DMC, DC

FWI Forecasting

Determining values for the codes and indices using hourly weather data or forecast information.

The FWI System has an in-built forecast capability – we use the 1200 noon NZST weather observations to predict the peak burning conditions occurring during the heat of the day, i.e. mid afternoon (between 1400-1600 hours).

Obviously weather conditions change from the standard noon observation time (different rates on different days) and it can be useful to update FWI calculations using mid-afternoon weather.

Typically only the FFMC, ISI and FWI components are affected, although these can have significant effects on the resulting fire danger class.

If detailed hourly weather observations are available (e.g. from automatic weather stations), you can use them to calculate hourly FWI System values using some of the FWI software packages available. Because they use more current weather information, they'll provide a more accurate assessment of prevailing fire danger conditions and fire behaviour potential.

You can also use forecasted weather information to predict FWI codes and indices for subsequent hours and days. Where detailed fire weather forecasts are available, you can predict FWI values out for several days. For more information on this use the Orange book.

Example: Forecasted weather for 1200 noon tomorrow (Day 2 below) can be used to calculate FWI conditions for tomorrow afternoon using the standard process of working through the FWI Tables and Fire Weather Record Form.

Month: FEBRUARY	Year:	Station Exercise: FIRE WEATHER FORECASTING	Elevation (m)	Observer

Day	Temperature (°C) Dry Bulb	Temperature (°C) Wet Bulb	RH (%) Relative Humidity	Wind Direction	Wind (km/h) Speed	Rain (mm) 24 hour	FFMC 1 Rain code	FFMC 2 Fine Fuel Moisture Code	DMC 3 Rain Code	DMC 4 Drying Factor	DMC Duff Moisture Code	DC 5 Rain Code	DC 6 Drying Factor	DC Drought Code	ISI 7 Initial Spread Index	BUI 8 Build up Index	FWI 9 Fire Weather Index	Forest Fire Danger Class
								87			35			194				

1	20		55		10	0		87	87	35	1	36	194	6	200	6	50	15	M
2	27		30		25	0		87	91	36	4	40	200	8	208	17	56	34	E

Long range weather forecasts provide an indication of likely temperatures and precipitation which can be used with the DMC and DC Drying Factor tables (tables 2 & 4) to provide an indication of how many points these values will increase by over the forecast period.

In the example above, in February with temperatures of around 20 °C (and RH of 50%), values of the DMC and DC will increase by around 2 and 6 points per day respectively, so that in the absence of significant rain:

NOTE

Use long range forecasts to estimate FWI values 10-15 days ahead

	DMC	**DC**	**BUI**
after 10 days (by day 12)	**60** (increase of 20 points)	**268** (increase of 60 points)	**75**
after 15 days (by day 17)	**70** (increase of 30 points)	**298** (increase of 90 points)	**85**

Glossary

Assessing fire danger	In assessing fire danger there are two key definitions specific to fire danger –“fire hazard” and “fire risk”.
Equilibrium Moisture code	Refers to the condition where the moisture content of the fuel is the same as that of the air around the fuel particle. It is this equilibrium moisture content towards which fuels are continually striving, through taking up moisture from the air (adsorption) or releasing moisture to the air (desorption). Fuels are always in a “catch-up” process of trying to attain equilibrium fuel moisture.
Fire Danger	A general term used to express an assessment of both fixed and variable factors of the fire environment that determine the: • Ease of ignition • Rate of spread (ROS) • Degree of difficulty of control • Fire impact.
Fire danger indices	Produce one or more indices of the potential for ignition and probable fire behaviour that are used as guides in a wide variety of fire management activities.
Fire danger potential	An assessment of expected fire behaviour and burning conditions, provided from fire danger ratings, including the likelihood of ignition, potential rate of fire spread, fire intensity, fire size and shape, and potential for damage.
Fire hazard	Assessment of fire hazard examines the potential fire behaviour for a given fuel type based on the physical fuel characteristics of fuel arrangement, fuel loading, and fuel condition.

Fire risk	Assessment of fire risk examines the probability or chance of a fire starting based on the presence of activities or ignition sources.
Fixed fire danger factors	Fixed fire danger factors are those that change only slowly over time but can vary from place to place. e.g. Topography, fuel types.
Fuel Moisture content (FMC)	Is very important to fire behaviour – affects ignitability, rate of combustion, amount of fuel consumed.
Time Lag	Values of dead fuels are important (the time required for dead fuels to lose about two-thirds of the difference between their initial moisture content and their equilibrium moisture content).
Variable fire danger factors	Variable factors are those that vary from time to time (throughout the day,and from day to day) at any given place. e.g. Temperature, relative humidity, wind, precipitation, fuel moisture.

Appendix

Attached are two publications

Fire Technology Transfer Note Number 7 January 1996. Published by New Zealand Forest Research Institute and National Rural Fire Authority)

An example of Readiness Triggers and Precautionary Measures from a Fire Plan

Fire Technology Transfer Note

Number - 7 January 1996

A summary and status of the "Proposed Revision of Fire Danger Class Criteria of Forest and Rural Fire Areas in New Zealand" by Martin Alexander.

Review by Liam Fogarty

Introduction

In New Zealand, most fires are started by people. A few of these are malicious lightings, but most probably[1] result from escapes due to carelessness (e.g., from cigarette butts, camp fires, and prescribed burn offs). To reduce the number of avoidable fires, fire managers need to influence people to make appropriate behavioural changes (e.g., care with the disposal of cigarette butts, adequate control of permitted fires) by increasing the level of public awareness about what the fire danger conditions actually are.

The aim of this *Fire Technology Transfer Note* is to discuss how fire prevention standards can be improved by implementing Alexander's (1994) proposed changes to the Fire Danger Class Criteria (FDCC) for forest and rural fire areas of New Zealand.

What do we use the FDCC for?

The Fire Danger Class Criteria (FDCC) are used by fire authorities and regional coordinating committees to send a standard message to the public about the *daily* fire danger conditions over a *broad area*. The FDCC are the basis of the daily fire danger levels (i.e., Low, Moderate, High, Very High and Extreme) displayed on the "half grapefruit" fire danger class display sign (see Figure 1), where each of the classes provide a general indication of the ease of suppression of a fire burning in the "standard" fuel types (i.e., Forest or Grassland fuels).

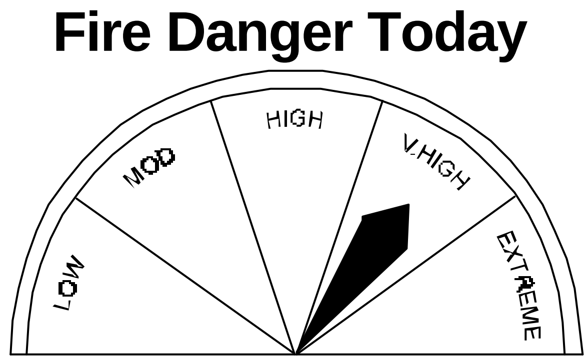
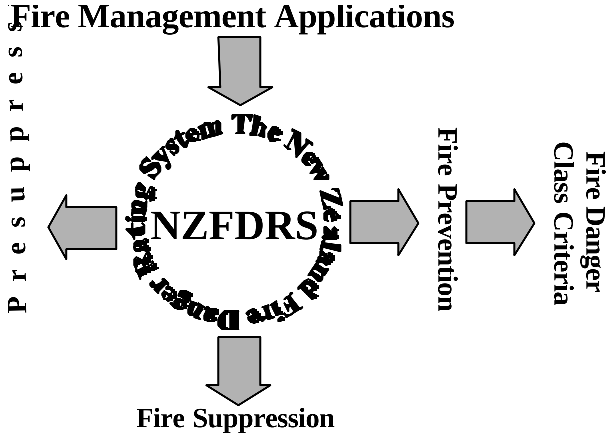


Figure 1. The standard "half grapefruit" fire danger class display sign.

Because daily fire danger levels reflect expected fire behaviour in the "standard" fuel types, they are determined by applying outputs from the Fire Weather Index (FWI) System to fuel types in the Fire Behaviour Prediction (FBP) System, which are both components of the New Zealand Fire Danger Rating System (NZFDRS). Therefore, public notification of daily fire danger using the FDCC (which is a fire prevention activity) is shown in Figure 2 to be another application of the NZFDRS.



[1] Approximately 70% of fires are attributed to unknown or miscellaneous causes, so its impossible to be more definitive.

Figure 2. Public notification of daily fire danger using the FDCC is another application of the NZFDRS.

Summary of revisions

The recommendations contained in NRFA Circular 1994/2 by Alexander (1994) are:

1. The recognition that the primary use of the fire danger class is for public notification of the prevailing fire danger conditions and it is therefore primarily a fire prevention tool (i.e., ignition mitigation).

2. Difficulty of control underpins the determination of the five fire danger classes. Hence, the system is based on fire intensity, and delineation of classes is based on the effectiveness of various types of resources as fire intensity increases (see Table 1), up to a point where fires are considered to be uncontrollable using conventional means (i.e., > 4000 kW/m). "Fire behaviour as a factor in forest and rural fire suppression" by Alexander (1992) provides a detailed discussion of the influence of fire behaviour on fire control and is recommended reading.3. There is a need for consistency, with the use of "MODERATE" rather than "MEDIUM" (which implies average), and the use of the "half grapefruit" style as the standard fire danger class display sign.

4. A change from 4 to 5 fire danger classes with inclusion of a "VERY HIGH" class, which recognises the transition between being able to suppress the fire using conventional suppression techniques and the likely occurrence of a campaign fire.

5. A Grassland fire danger model was incorporated in recognition of the fact that forest plantations make up 5% of NZ's land area only, while grasslands make up a large proportion of the remaining 95%. The model used is Natural (i.e., Standing) Grass fuel type (i.e., O-1b) developed by the Forestry Canada Fire Danger Group (1992).

6. The Grassland FDCC are based on an estimation of expected fire behaviour using the Initial Spread Index (ISI) and Degree of Curing (%), since curing has a significant effect on fire behaviour, particularly rate of spread (ROS) and therefore fireline intensity. Figure 3 shows that by interpreting these parameters, fire managers can begin to get an idea about fire shapes and sizes. The Degree of Curing also provides information on the ability of a fire to spread across the broader landscape and is an important input for the determination of fire season status.

7. In the new forest fire danger classification scheme, expected fire behaviour in the C-6 or Conifer Plantation fuel type (Forestry Canada Fire Danger Group 1992) is used to represent fire danger in exotic pine plantations, because this fuel type was considered to better represent forest fire danger on a broad aerial basis.

Table 1. The minimum fire suppression resources required to contain the head of a fire burning in each of the Fire Danger Classes (summarised from Alexander 1994)

Fire Danger Class	Fire Intensity Range (kW/m)	Minimum fire suppression resources for direct head fire attack
Low	0 - 10	Hand crew.
Moderate	10 -500	Hand crew and back-pack.
High	500 - 2000	Water under pressure and bulldozer.
Very High	2000 - 4000	Aircraft and long term retardants **may** be effective **but it may be too dangerous for ground crews.**
Extreme	> 4000	**Head fire attack will probably not be effective and is too dangerous for ground crews.**

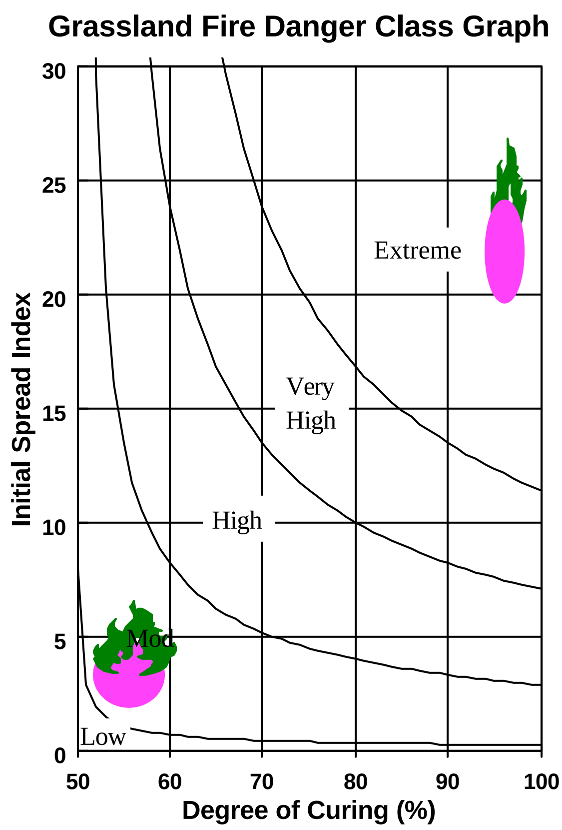


Figure 3. The Grassland Fire Danger Class Graph and expected fire shapes under different burning conditions.

8. The Buildup Index (BUI) and the ISI should be used for fire danger rating in forest areas because these provide a better estimate of fire intensity and suppression difficulty when compared to simply the FWI value (see Figure 4). The BUI combines the effects of soil and deep organic layer dryness (as represented by the Drought Code (DC)) and duff dryness (Duff Moisture Code (DMC)) to estimate surface fuel availability (which also has an effect on spread rate), and the ISI combines the effect of shorter term weather fluctuations on fine fuel moisture content (as represented by the Fine Fuel Moisture Code (FFMC)) and wind speed on the rate of fire spread. Fire spread and fuel availability are used to estimate head fire intensity and subsequent suppression difficulty using Byram's (1959) fire intensity equation:

I = H × W × R, where
I is Intensity (kW/m),
H is the heat of combustion (kJ/kg),
W is available fuel (kg/m^2) and,

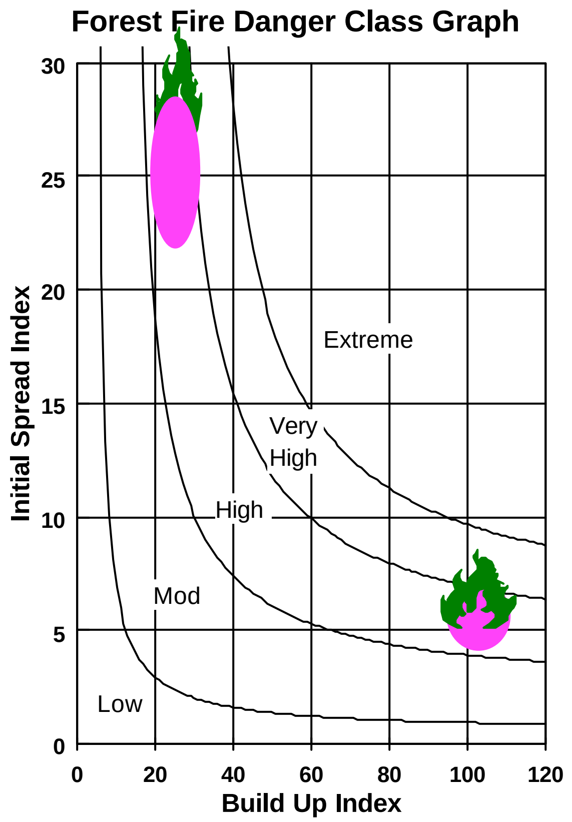


Figure 4. The Forest Fire Danger Class Graph and expected fire shapes under different burning conditions.

R is rate of spread (m/s).

9. The need for a Scrubland fire danger class criteria was recognised, but the lack of quantified fire behaviour data in relation to the FWI System precluded the derivation of a scheme. The development of scrubland fire behaviour models is recognised as a high priority for the NZ FRI Fire Research programme.

Status of the implementation of the proposed revisions

The aim of the FDCC developed by Alexander (1994) is to ensure a consistent message of daily fire danger over a broad area is presented to the public. By not understanding and adopting the philosophy and principles of the FDCC, the quality of the fire prevention effort is undermined because the message is confused and inconsistent. Some of the main problem areas are:

Fire Danger Class Display Sign Standards

There is a concern by some organisations that there would be a loss of corporate identity and public relations opportunity if the standard "half grapefruit" sign is adopted. This needs to be weighed against the need to present a unified message on daily fire danger conditions. Furthermore, Alexander suggests that the use of the standardised sign format does not preclude the identification of the corporate/organisation at the base of the "half grapefruit" sign (see Figure 5).

Daily Fire Danger Rating

The fire danger changes often during the day and from one day to the next. Some fire managers are concerned that moving the fire danger class up and down as the fire danger changes throughout the day will confuse the public. However, the aim of **daily fire danger** rating using the FDCC is to display the **expected worst case conditions over a broad area**, not to represent shorter term fluctuations in fire danger.

The use of forecasts of midday weather (which, in turn, forecast the worst expected daily fire danger level) to set the daily fire danger and changing the class on the display sign only if the forecast and midday weather values are significantly different will overcome this problem. Similarly, Alexander suggests that if the fire danger is significantly underestimated by the actual noon (NZ Standard Time weather readings), then the fire danger class can be altered. However, it is important that noon (NZST) weather is used to generate the FWI codes and indices from one day to the next.

When the fire danger is Low, but the DC is at a high level, some fire authorities are concerned that having the fire danger class display sign on Low will send the wrong message to the public about the fire season that is in effect (i.e., open, restricted or prohibited). This has lead to the ridiculous situation where the fire danger class on the display sign is kept on Very High or Extreme on cold and wet days when the daily fire danger has obviously been reduced.

To reduce confusion about daily and seasonal conditions, an additional panel sign depicting the current type of fire season (i.e., Open, Restricted or Prohibited) could be attached to the top of the "half grapefruit" style of fire danger class sign.

Figure 5. The standard "half grapefruit" or fire danger class display sign, plus additional plates for corporate identity and fire season status.

Declaration of fire season

There is no consistent approach to the determination of fire season status currently being used by all rural fire authorities. The widespread use of Remote Automatic Weather Stations (RAWS) has reduced (but not eliminated) the use of October 1 as the beginning of the fire season, which is a major fire prevention achievement.

On the negative side, the Drought Code (DC), which indicates deep drying only, is still often used to set the fire season status. When compared to the other moisture codes of the FWI System, the DC has the least effect on expected fire behaviour, and decisions on fire season status need to be based on an assessment of seasonal weather trends and how these interact with fire environment factors (as represented by the codes and indices of the FWI System) and expected fire behaviour. Failure to do so can result in fire managers being unprepared for wildfires which could have (or should have) been prevented.

To ensure that the fire season status is altered when the conditions warrant, "Trigger Points" (as discussed by Alexander (1994), pages 23 - 31) need to be developed. In forests, Alexander used the BUI and expected "average" weather conditions to conclude that in summer, there is a high probability that Very High or Extreme fire behaviour will occur when the BUI reaches 53. To build in a cushion before this point is reached he suggests that at a BUI of 40, a prohibited season should be invoked. This is also the point at which an extended mop-up is likely. Using the same rationale, a BUI of 25 indicates that High fire behaviour conditions may occur, necessitating the use of heavy machinery. This provides a trigger point for the instigation of a restricted fire season.

In pasture, the degree of grassland curing determines the likelihood that fire will spread over a broad area. When the average degree of curing has reached 80%, continuous fire spread is likely and a prohibited period should be declared. At 60% average curing, grasses will dry rapidly, and in divided areas drier aspects may be as high as 80% cured enabling fires to burn-out entire slope faces. This may requiring a larger scale suppression operation and warrants the instigation of a restricted period.

The fire season status in some Territorial Authority areas is based on a desire to avoid the need to issue burning permits and/or to allow the continued use of fire as a farm management tool (e.g., stubble burning). In many instances, this results in the fire season status later changing in response to a preventable fire incident[2](s). In some areas of Canterbury, for example, there are no restrictions placed on the burning of stubble, except that the burns must be conducted after 5 pm. This is in an area where gale force NW winds are common and, at times when grasses are highly cured, this could end up being a costly policy.

This approach reflects a poor understanding of fire behaviour and the FWI System. While there are many factors that need to be considered when making fire management decisions, conditions where the risks become unacceptable need to be identified and restricted or prohibited fire seasons must be used as a fire prevention tool.

Broad Fuel Typing For Fire Danger Class Purposes

Conflict over which is the appropriate FDCC (i.e., Forest, Grassland or the yet to be developed Scrubland criteria) for use in areas where forest, grass and scrub are intermixed. Most conflict occurs in areas where DOC or a forest company has assets interspersed with marginal farmland where scrub fuels predominate.

In these areas, the fuel type used need not necessarily be the one that provides the greatest level of fire danger, because the aim is to present a *broad picture of the probability that a fire will start, spread and do damage*. For example, if the Forest fire danger is Low, it is not likely that significant areas of forest can be easily burnt, so having Extreme fire danger in small pockets of scrub may not be a concern. If the fire danger in forests increases to High, then it is more likely that a developed fire will spread and do damage.

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[2]An example of fires prompting the declaration of a restricted fire season are the 1994 Hurunui District Council fires, which both started from permitted burning operations. The McDonnell Downs and Mt Noble Fires each burnt 800 ha of high country tussock and scrubland and the latter threatened a plantation and involved 2 near miss incidents. The fires occurred on the August 27, when the FWI codes and indices where approximately as follows (based on Ashley and Balmoral data):

FFMC: 88 - 89, DMC: 24 - 19, DC: 51 - 140, ISI: 5, BUI: 24 - 29, FWI: 9.

Tussock and scrub fuels are able to carry a fire soon after rain due to the high loading of elevated dead fuel that is aerated and exposed. Fires in scrub/tussock fuels can run for great distances at nearly any time of the year, and fire season status should be based on similar reasoning to that described by Alexander (1994), where historical weather data should be analysed to determine when, say, High to Very High fire danger conditions are probable, and a prohibited season declared when days of Very High to Extreme fire danger are likely.

Therefore, rural fire coordinating committees need to follow the recommendation made by Alexander, to map fuels and determine fuel type zones for fire danger rating in that region. The National Rural Fire Authority could assist with this process by using the vegetation maps of New Zealand (Newsome 1987) to produce regional vegetation maps that could be updated by the committees for their use. Once this has been done, some criteria can be set to logically represent broad fire danger conditions in these zones.

Fire Danger Class Display Sign Location

Fire danger class display signs should be placed in locations that reflect the level of fire danger over a broad area. Alexander (1994) suggests that by consulting a fuel type map, coordinating committees could place double-sided display signs between the boundary of major fuel types (e.g., between a grassland area and a large-to-medium sized forest area) so that motorists going from one fuel type zone to another are notified of the changes.

When deciding where to place signs, coordinating committees also need to identify accessible areas so that signs are easily changed. Travel to some existing signs can take more than an hour, which has meant that changes in the fire danger are not being adequately reflected. Worst still, some organisation have signs that are rarely changed; in these areas, coordinating committees would achieve a better level of fire prevention if these signs where removed.

The FDDC as an Application of the New Zealand Fire Danger Rating System

Some fire managers have suggested that the Fire Danger Class Criteria do not adequately reflect the fire management needs in specific areas and fuel types. This may be because they have confused the FDCC with the other applications of the NZFDRS. The FDCC cannot cater for all aspects of fire management, including forest closures and initial attack planning, because the FDCC provide a broad aerial assessment of the general fire danger only. Initial attack plans, for example, should be based on a more detailed analysis of the fire environment so that the resources initially sent to suppress a wildfire can adequately cater for the anticipated fire intensity and rate of perimeter growth. The fire behaviour information available from the FDCC graphs will not enable a fire manager to adequately respond to a fire in logging slash or gorse on a 30^{o} slope.

Conclusion

Alexanders (1994) "Proposed Revisions of the Fire Danger Class Criteria of Forest and Rural Fire Areas in New Zealand" have not yet been fully implemented. This may be because of one, or all, of the following reasons:

- fire authorities, particularly some Territorial Authorities, see the implementation of the FDCC as an additional cost only.
- fire managers have an insufficient level of knowledge of the NZFDRS, and of how the FWI System and the Fire Behaviour Prediction System relate to the fire environment and fire behaviour respectively; and
- fire managers do not fully understand that the FDCC are one of many applications of the NZFDRS, and that the FDCC provide an estimate of the expected fire behaviour over a broad area only.

Hopefully, the information provided in this *FTTN* and from further reading of the Alexander (1994) report, will convince fire managers of the value of presenting a unified message to the general public. It is also hoped that fire managers will take the training opportunities offered by NZ FRI and the NRFA to improve their level of understanding of fire behaviour and the NZFDRS.

Suggested Further Reading

Alexander, M.E. 1994 Proposed revision of fire danger class criteria for forest and rural fire areas in New Zealand. National Rural Fire Authority, Wellington, New Zealand. Circular 1994/2. 73p.

Alexander, M.E. 1992. Fire behaviour as a factor in forest and rural fire suppression. Pages 64-103 *in* Proc. Forest and Rural Fire Association of New Zealand 2nd Annual Conference (August 5-7, 1993, Christchurch). FRFANZ, Rotorua.

Readiness Triggers and Precautionary Measures

Contents

1. Introduction

The trigger points contained in this section have been derived using the New Zealand Fire Danger Rating System. In particular the report on the "*Proposed revision of the fire danger class criteria of forest and rural fires areas in New Zealand*"[1] has been used in conjunction with advice from New Zealand Forest Research Institute (now known as Scion) in a letter to the regional committee titled Prohibited Fire Seasons and Duff Fires[2].

Assessment of average conditions from the weather analysis for Christchurch Aero taken from *"A fire danger climatology for NZ, 30 May 2003"*[3] has also been used. The average over the period December through March indicates that after a couple of days without rain the FFMC will be 86.6 (all ignition threshold) and the ISI 7.8 (fast initial spread). Because it is a fine line between the Alexander[1] average day and the Christchurch Aero average day, a range of ISI: 8 – 11 has been used as a trigger.

It must be kept in mind that to meet the average ISI trigger as noted here, a spell of drying following rain is needed. Conversely, if conditions exceed the average, more elevated fire danger will result, and fire officers will need to use their discretion in re- evaluating prevailing or predicted fire danger conditions.

The preparedness levels have been set in relation to the five fire danger classes of Low, Moderate, High, Very High and Extreme. The lowest numerical level corresponds to the lowest fire danger class.

Rural Fire Officers will maintain situational awareness of prevailing and predicted fire dangers for their area. They will ensure the appropriate fire season status, and the required precautionary measures are in place. Decisions will be made following an assessment of the prevailing and predicted fire dangers, in association with local conditions on appropriate preparedness level, and on the ground validation of fuel condition and weather. When initiating a response refer to *Initial Attack Response Level Guidelines* on page A5 for resource dispatch requirements. Any resources that are on standby will be utilised first unless situation information dictates less is required.

2. Readiness levels

The Conservancy operates a 24 hour 7 day Duty Conservancy Fire Coordinator who will receive emergency fire calls from the New Zealand Fire Service Communications Centre and pass them immediately to the relevant Area Office. The Fire Coordinator is usually the Technical Support Officer (fire) (TSO fire) or the acting TSO fire.

The Conservancy will have a Fire Coordinator (DPRFO) available throughout the year, to assess and advise on likely and prevailing fire dangers, thereby ensuring adequate readiness levels and response capability is maintained. The Conservancy maintains five (5) remote automatic weather stations (RAWS), and monitors with agreement up to nineteen RAWS throughout Canterbury for fire danger purposes. There are five readiness and response levels relating directly to the expected or prevailing fire dangers. Area Managers are accountable for readiness and response levels, and the level is usually set after discussion between the Conservancy Fire Coordinator and the Area Fire Programmer (RFO).

The Conservancy operates a coordinated approach to standby, which affects the staffing level required from each area for readiness. Two aerial response crews (heli-attack crews) are maintained, one in Twizel utilising staff from there and Aoraki, and one in Christchurch utilising staff from Mahaanui and Waimakariri area offices, Conservancy and Christchurch City Council. The crew competency and personnel numbers are based on the DOC national response crew requirements. The crews are available to all Areas in the Conservancy, as an initial attack response. If they are required to be on standby then a request must be made to the Conservancy Fire Coordinator.

3. Alert procedures for Very High and Extreme Fire Danger

1. If the FWI readings are High and expected to rise, the Fire Co-coordinator will begin FWI forecasting as early as possible in the week. Area programmers will then be advised of possible stand-by requirements for weekends and public holidays. A final decision on standby levels would be made as close as practicable to the beginning of the standby period, following Fire Coordinator and Area Fire Programmer discussions.

2. To ensure readiness and response levels rise with increased levels of fire danger, the following points will be mandatory during Very High and Extreme fire dangers.
   - Conservancy Duty Officer and Conservancy Fire Co-coordinator will be contactable at all times.
   - The appropriate level of standby for the prevailing conditions is set following Fire Coordinator and Area Fire programmer discussions.

- Areas and Conservancy carryout an assessment of the availability of backup personnel to ensure key CIMS roles and fire crews can support the initial attack standby crews (availability sheet) and thereby meet Initial Attack Response Level Guidelines.
- Vehicles are fuelled and available for immediate response.
- Smoke chaser units are fitted to vehicles and filled with water for immediate response.
- All fire fighting personnel will carry their fire kits with them during working hours, which will include at least a litre of drinking water as well as food for the first four hours of work e.g. energy food bars.
- All radio equipment will be charged and available for immediate response.

3. The skill sets required to fill an Incident Management Team (IMT) for level two and three fires, have been distributed Conservancy wide. Coordination is needed to bring the required skill sets together when forming an IMT. Further to this.

4. A Canterbury regional multi-agency incident management team, and a national multi-agency incident management team, are available and can be requested through the Conservancy Fire Coordinator. If one of these teams is engaged on a fire then an Area Manager will need to undertake the role of DOC liaison to the incident controller. A formal delegation of authority must occur using the specific DOC form.

5. When conditions are such that all rural fire authorities in Canterbury have imposed Prohibited Fire Seasons, the regional emergency coordinating centre (ECC) at Environment Canterbury in Christchurch will activate at its level two (fire danger monitoring and forecasting). This information will be used to help set response levels).

6. When the situation arises, where the region is in an extended period of very high and extreme fire danger, or response activities have been continuous over an extended duration, then the Department's national fire response plan should be activated to ensure personnel receive the required rest and stand down periods (contact the National Fire Co-coordinator).

[1] Alexander, M.E. 1994. Proposed revision of the fire danger class criteria of forest and rural fires areas in New Zealand. National Rural Fire Authority, Wellington. Circular1994/2. 73p

[2] Liam G Fogarty New Zealand Forest Research Institute, Prohibited Fire Seasons and Duff Fires advice letter March 1997.

[3] A fire danger climatology for NZ, 30 May 2003 by Pearce, Douglas and Moore

4. Fire season status: trigger points

Grassland Curing (%)	Buildup Index (BUI)			
	0-25	25-50	50-80	>80
0-60	Restricted[1]	Restricted[1]	Restricted	Restricted
60-80	Restricted[1]	Restricted	Restricted	Prohibited
>80	Restricted	Restricted	Restricted	Prohibited
Adopted at the Canterbury/West Coast Regional Rural Fire Committee meeting of 3rd November 1997.[1] Other authorities normally open.				

5. Response readiness levels:
These are minimum requirements.

OFFICERS/PERSONNEL	READINESS LEVELS 1 – 5, AS RELATED TO FIRE DANGER RATING				
	Low (1)	Moderate (2)	High (3)	Very High (4)	Extreme (5)
Deputy Principal Rural Fire Officer	Pager and/or cell Phone.	Pager and/or cell Phone.	Pager and/or cell Phone.	On standby. Pager and 100% Phone.	On standby. Pager and 100% Phone.
Duty Officer receives emergency fire reports: gathers situational information: advises Area or dispatches fire crew:	Pager and/or cell Phone.	Pager and/or cell Phone.	Pager and/or cell Phone.	Pager and 100% Phone.	Pager and 100% Phone.
Rural Fire Officer is advised of the emergency situation by Duty Officer and responds:	Not required.	Not required.	Area RFO. On standby. Pager/cell.	Area and Field Centre RFOs on standby. Pager/cell.	Area and Field Centre RFOs on standby. Pager/cell.
Standby Crews fast initial attack response:	Not required.	Not required.	Not Required.	Nth & Sth heli-attack crews. EOC logistics. Regional Fire Depot. Fire Coordinator	As for Very High (4) with the following for extended periods. Area four person crew plus logistics person. Discretionary National standby (NFC).
Fire Patrols prevention and detection:	Not required.	Not required.	Not required.	Consider Scheduling.	Scheduled.

6. Fire weather index trigger points for precautionary measures during low to extreme fire dangers

6.1 Fire danger level one, low.

Fire Danger Level One LOW	Permit Issue	Standby	Patrols/ Resource type	Access Restrictions	Restrictions on Activities		Response Times
					Conservation Operations	Recreational Activities	
Trigger Points. The Canterbury regional fire season average ISI is between 8 and 11. BUI: ≤ 15 G/C% ≤ 50% FWI: ≤ 5	Issue permits.	No standby. Resources located at home location. Areas monitor staff availability during weekdays. Friday or last day before public holiday, staff availabilities are to be completed and sent to the TSS Fire by 12:00 hrs. Fire Coordinator (DPRFO) contactable	No additional resources	No.	No.	No.	Normal operations
Note: Any time the ISI is above 11 you will need to recalculate the fire danger level and apply the appropriate preparedness level.							

6.2. Fire danger level two, moderate

Fire Danger Level Two MODERATE	Permit Issue	Standby	Patrols	Access Restrictions	Restrictions on Activities	
					Conservation Operations	Recreational Activities
Trigger Points. The Canterbury regional fire season average ISI is between 8 and 11. BUI 15 to 30 G/C% 50 to 60 FWI ≤ 6 to 12	Issue permits.	No standby. Areas monitor staff availability during weekdays. Friday or last day before public holiday, staff availabilities are to be completed and sent to the TSS Fire by 12:00 hrs. Fire Coordinator (DPRFO) contactable	No.	No.	No.	No.
Note: Any time the ISI is above 11 you will need to recalculate the fire danger level and apply the appropriate preparedness level.						

6.3. Fire danger level three, High.

Fire Danger Level Three	Permit Issue	Standby	Patrols/ Resource Level	Access Restrictions	Restrictions on Activities		Response times
					Conservation Operations	Recreational Activities	
Trigger Points. The Canterbury regional fire season average ISI is between 8 and 11. BUI: 30 to 55 G/C% 60 to 75 FWI: ≤ 13 to 20	Issue permits but maintain a watch on drying trends with a mind to tightening special burning conditions. Ensure publicity of safe burning practices across the range of fire types.	As for level one PLUS Area RFO on standby. Closer monitoring of fire danger trend. Resources located at home location.	As per normal work. No additional resources	Forest Owners and other use their procedures or discretion. No restriction to public land.	Consider increasing onsite suppression equipment during spark hazardous operations or restricting them to the earlier part of the day.	No.	Normal Operations
Note: Any time the ISI is above 11 you will need to recalculate the fire danger level and apply the appropriate preparedness level.							

6.4. Fire danger level four, very high.

Fire Danger Level Four VERY HIGH	Permit Issue	Standby	Patrols/ Resource type	Access Restrictions	Restrictions on Activities	
					Conservation Operations	Recreation Activities
Trigger Points The Canterbury regional fire season average ISI is between 8 and 11 BUI: 55 to 90 G/C% 75 to 100 FWI: ≤ 21 to 29	Prohibited Fire Season at BUI 80 and G/C% 80. Once the prohibited benchmark is meet permits will be cancelled and no more issued until condition ease. Cancel land clearing fires at 60 BUI and G/C% 75 Issue permits for other fires but with strong special conditions Increase publicity	As for level three **Plus** Field Centre RFO on standby Northern & Southern heli-attack crews on standby for their respective response areas EOC logistics and Regional Fire Depot persons on standby Fire Coordinator on standby. National Fire Coordinator advised Resource location at home location but on standby	High awareness of field workers to fire issues Consider patrols in high hazard areas or trouble spots and at peak fire danger times	Consider Restricting. Public Walkways. Consider two stages: (a) Restrict to certain hours or beyond certain points, and maintain high level of patrols. (b) Review complete closures of selected areas. Forest Owners and others use their own procedures. Advice may need to be given to them.	Chainsaw and other spark hazardous operations in low hazard areas only. Adequate suppression equipment and water supply available. Midday knockoff to be considered.	Regular checks by RFO. No Camp Fires once prohibition in place.

Note: Any time the ISI is above 11 you will need to recalculate the fire danger level and apply the appropriate preparedness level.

6.5. Fire danger level five, extreme.

Fire Danger Level Five EXTREME	Permit Issue	Standby	Patrols	Access Restrictions	Restrictions on Activities		Response Times
					Conservati on Operati	Recreation Activities	
Trigger Points The Canterbury regional fire season average ISI is between 8 and 11 BUI: > 90 G/C% 100% FWI: > 29	Prohibited fire season in place. Fire permits are cancelled and no more issued until condition ease.	As for level four PLUS the following for extended periods of extreme danger or severe regional weather events. Area four person crew and logistics person on standby. National Fire coordinator activates required national response level, either availability and/or standby.	Maintain a high level of patrols Introduce aerial patrols.	Consider closing Public Walkways and other access Consider two stages: (a) Restrict to certain hours or beyond certain points, and (b) review complete closures of selected areas. Forest Owners and others use their own procedures. Advice may need to be given to them.	When BUI 120 and G/C%95. Halt all chainsaw and spark hazardous operations. No smoking in the bush. Initiate Preparation of local emergency plan. Nearest Water. Evacuation. Crew Training. Safety plan. No smoking in the Bush.	Regular checks by RFO. No Camp Fires. No smoking in the Bush.	Ready to respond within 10 minutes of call.

Note: Any time the ISI is above 11 you will need to recalculate the fire danger level and apply the appropriate preparedness level.

7. Guidelines for fire weather codes and indices

Ignition Potential		Difficult	Moderately Easy	Easy	Very Easy	Extremely Easy
Fine Fuel Moisture Code	FFMC	0–74	75–84	85–88	89–91	92
Rate of Spread		Slow	Moderately Fast	Fast	Very Fast	Extremely Fast
Initial Spread Index	ISI	0–3	4–7	8–12	12–15	16
Control		Easy	Not Difficult	Difficult	Very Difficult	Extremely Difficult
Buildup Index	BUI	0–15	16–30	31–45	46–59	60
Mop-Up Needs		Little	Moderate	Difficult	Difficult and Extended	Difficult and Excessive
Duff Moisture Code	DMC	0–10	11–20	21–30	31–40	41
Drought Code	DC	0–99	100–175	176–250	251–300	301
Fire Intensity		Low	Moderate	High	Very High	Extreme
Fire Weather Index	FWI	0–5	6–12	13–20	21–29	30+

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8. Fire Danger Class for forests and grasslands

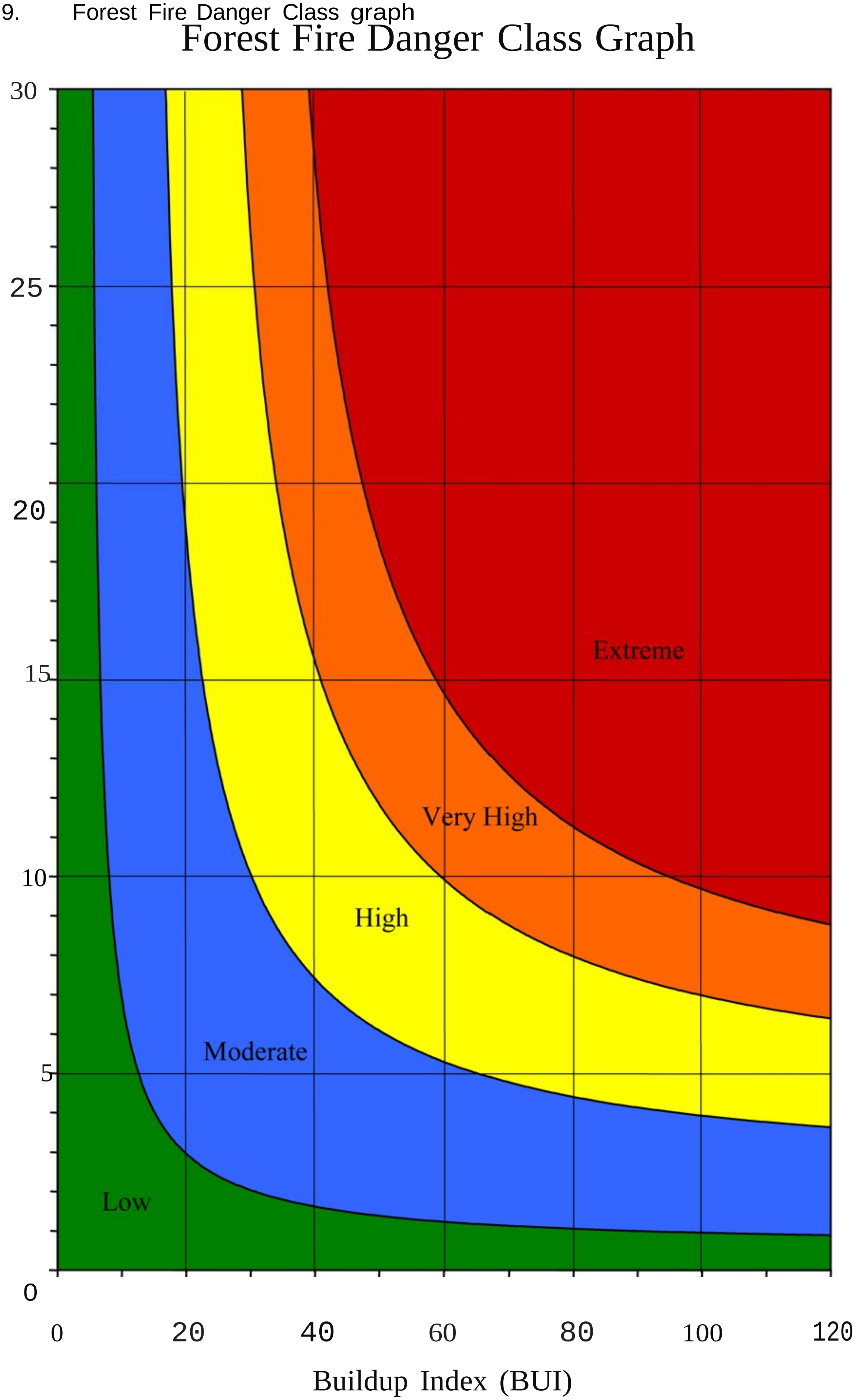
8.1. Fire danger classification for forests based on Initial Spread Index (ISI) and Build Up Index (BUI).

Forest Fire Danger Class					
	Build Up Index Level				Initial Spread Index Level
	BUI <20	BUI 21–40	BUI 41–80	BUI >81	
Low	ISI <3	ISI <1	ISI <1	ISI <1	
Moderate	ISI 3–10	ISI 1–6	ISI 1–4	ISI 1–3	
High	ISI 10–20	ISI 6–13	ISI 4–9	ISI 3–7	
Very High	ISI 20–25	ISI 13–17	ISI 9–13	ISI 7–10	
Extreme	ISI >25	ISI >17	ISI >13	ISI >10	

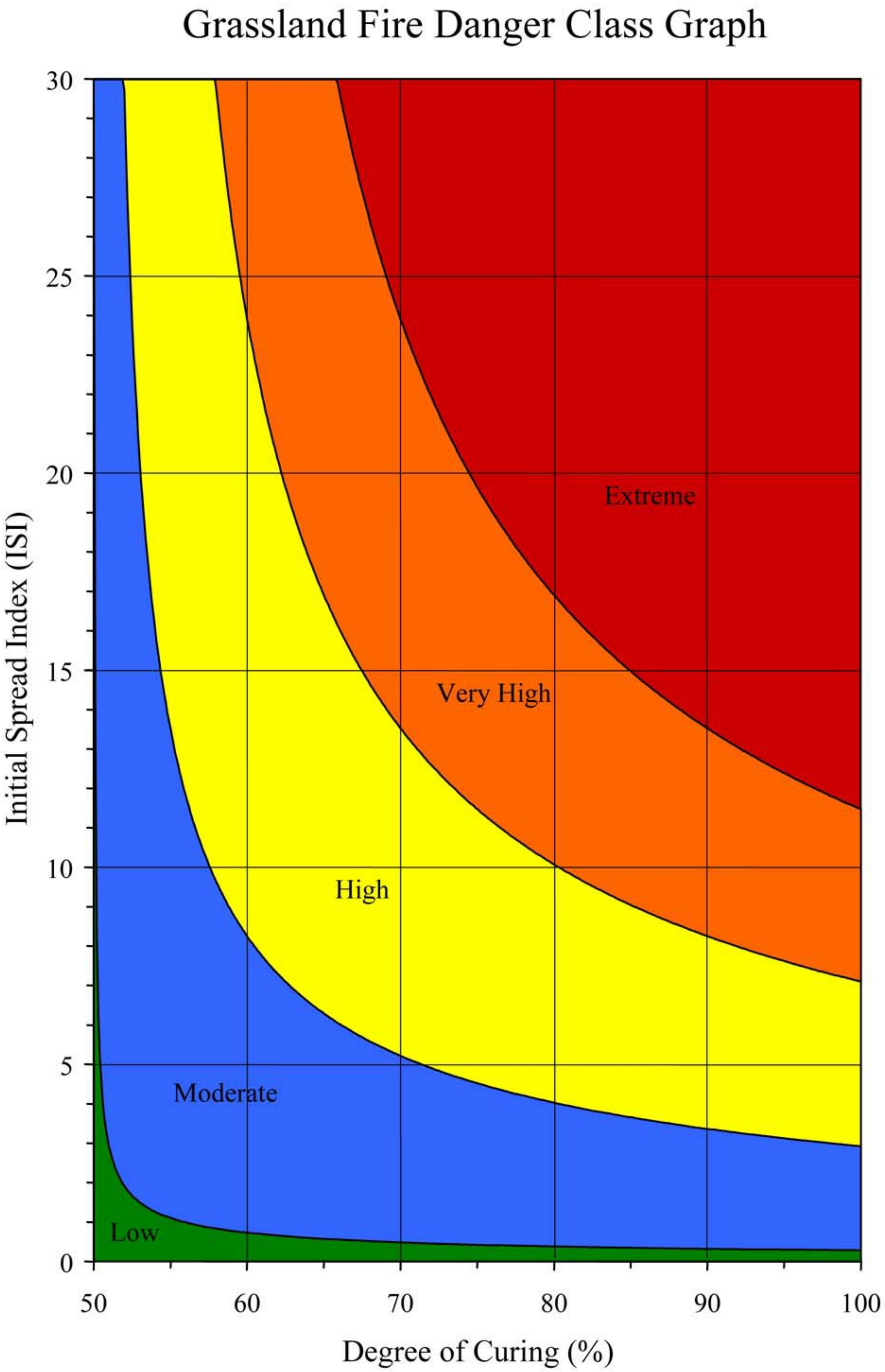
8.2. Fire danger class classification for grasslands based on Initial Spread Index (ISI) and degree of grass curing.

Grassland Fire Danger class						
	60%	70%	80%	90%	100%	Initial Spread Index Level
Low	ISI <1	ISI <0.1	ISI <1	ISI <1	ISI <1	
Moderate	ISI 1–8	ISI 1–5	ISI 1–4	ISI 1–3	ISI 1–3	
High	ISI 7–23	ISI 5–13	ISI 4–10	ISI 3–8	ISI 3–7	
Very High	ISI 24-30+	ISI 13–24	ISI 10–17	ISI 8–13	ISI 7–11	
Extreme	ISI >30+	ISI >23	ISI >17	ISI >13	ISI >11	

9. Forest Fire Danger Class graph



10. Grassland Fire Danger Class Graph



11. Fire Danger Class Interpretation

Fire Danger Class Interpretation

Fire Danger Class	Description of Probable Fire Potential and Implications for Fire Suppression l	Nominal Max. Flame Height
EXTREME	The situation should be considered "explosive". The characteristics associated with the violent physical behaviour of conflagrations or firestorms is a certainty (e.g., rapid spread rates, crowning in forests, medium- to long-range mass spotting, firewhirls, towering convection columns, great walls of flame). As a result, fires pose an especially grave threat to persons and their property. Breaching of roads and firebreaks occurs with regularity as fires sweep across the landscape. Direct attack is rarely possible given the fire's probable ferocity except immediately after ignition and should only be attempted with the utmost caution. The only effective and safe control action that can be taken until the fire run expires is at the back and along the flanks.	3.6+ metres
VERY HIGH	Burning conditions have become critical as the likelihood of intense surface fires is a distinct possibility; torching and intermittent crowning in forests can take place. Direct attack on the head of a fire by ground forces is feasible for only the first few minutes after ignition has occurred. Otherwise, any attempt to attack the fire's head should be limited to helicopters with buckets or fixed-wing aircraft, preferably dropping long-term chemical fire retardants. Until the fire weather severity abates, resulting in a subsidence of the fire run, the uncertainty of successful control exists.	2.6 to 3.5 metres
HIGH	Running or vigorous surface fires are most likely to occur. Any fire outbreak constitutes a serious problem. Control becomes gradually more difficult if it's not completed during the early stages of fire growth following ignition. Water under pressure (from ground tankers or fire pumps with hose lays) and bulldozers are required for effective action at the fire's head.	1.4 to 2.5 metres
MODERATE	From the standpoint of moisture content, fuels are considered to be sufficiently receptive to sustain ignition and combustion from both flaming and most non-flaming (e.g., glowing) firebrands. Creeping or gentle surface fire activity is commonplace. Control of such fires is comparatively easy but can become troublesome as fire damages can still result and fires can become costly to suppress if they aren't attended to immediately. Direct manual attack around the entire fire perimeter by firefighters with only hand tools and back-pack pumps is possible.	up to 1.3 metres
LOW	New fire starts are unlikely to sustain themselves due to moist surface fuel conditions. However, ignitions may take place near large and prolonged or intense heat sources (e.g., camp fires, windrowed slash piles) but the resulting fires generally do not spread much beyond their point of origin and, if they do, control is easily achieved. Mop-up or complete extinguishment of fires that are already burning may still be required provided there is sufficient dry fuel to support smouldering combustion.	no visible flame

THE ABOVE SHOUL.D NOT BE USED AS A GUIDE TO FIREFIGHTER SAFETY, AS FIRES CAN BE POTENTIALLY DANGEROUS OR LIFE-THREATENING AT ANY LEVEL OF FIRE DANGER!

From:

Alexander, M.E. 1994. Proposed revision of fire danger class criteria for forest and rural fire areas in New Zealand. National Rural Fire Authority, Wellington. Circular 1994/2. 73 p.

Anon. 1995. New Zealand Fire Danger Classes. (Revised edition). National Rural Fire Authority, Wellington, in association with the New Zealand Forest Research Institute, Rotorua. Poster (with suppression interpretations).

12. Staff availability tracking

FIRE EMERGENCY - Weekend staff availability –Area Name						
✓ = available for call out X = not available for call out ? = not here to ask						
Staff availability for: *Date* DOC Duty Officer: *Name*						
Name	Phone	Friday	Saturday	Sunday	Monday	Comment
		x	x	x	x	Duty officer
		✓	✓	✓	✓	Fire Coordinator
		?	?	?	?	
		✓	✓	✓	✓	
		✓	✓	✓	✓	
		x	x	x	x	
		✓	✓	✓	✓	
		x	x	x	x	
		✓	✓	✓	✓	
		x	x	x	x	
		✓	✓	✓	✓	
		✓	✓	✓	✓	
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