Fire Technology Transfer Note

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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).

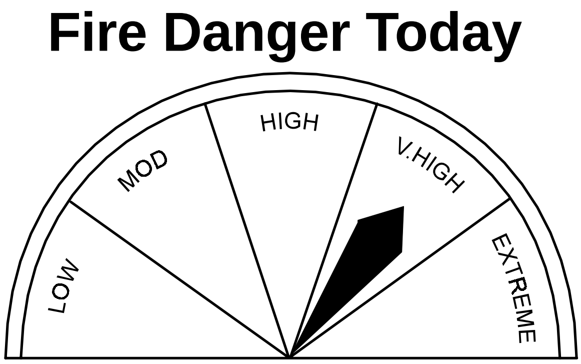

Figure 1. The standard "half grapefruit" fire danger class display sign.

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.

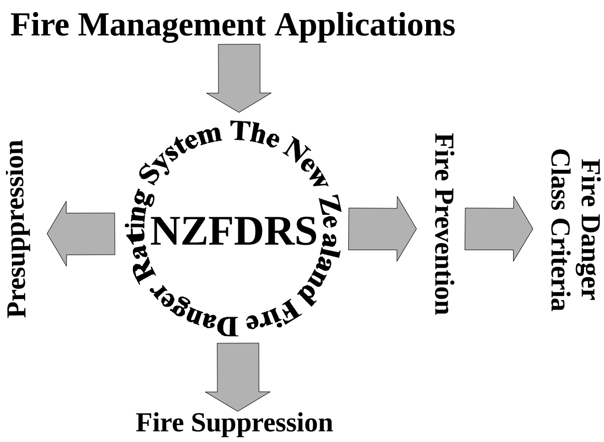

Figure 2. Public notification of daily fire danger using the FDCC is another application of the NZFDRS.

Summary of revisions

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

New Zealand Forest Research Institute

National Rural Fire Authority

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.**

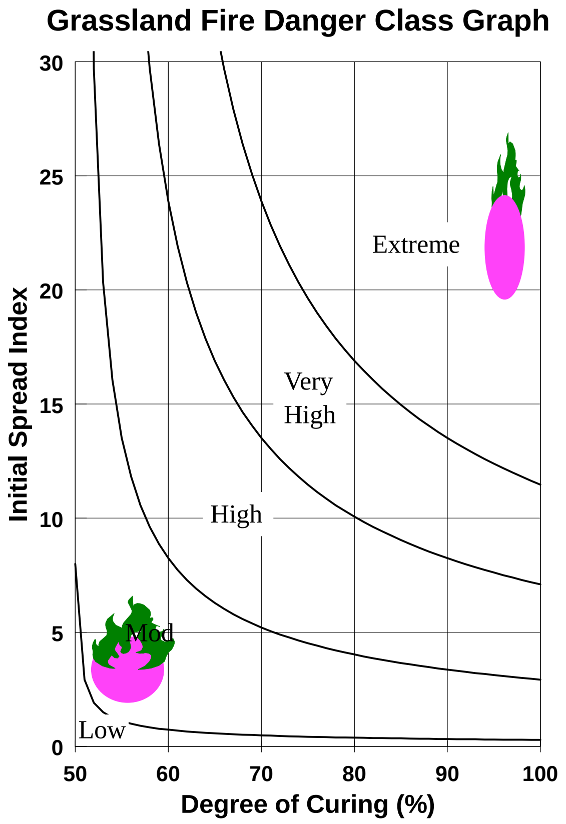

Figure 3. The Grassland Fire Danger Class Graph and expected fire shapes under different burning conditions.

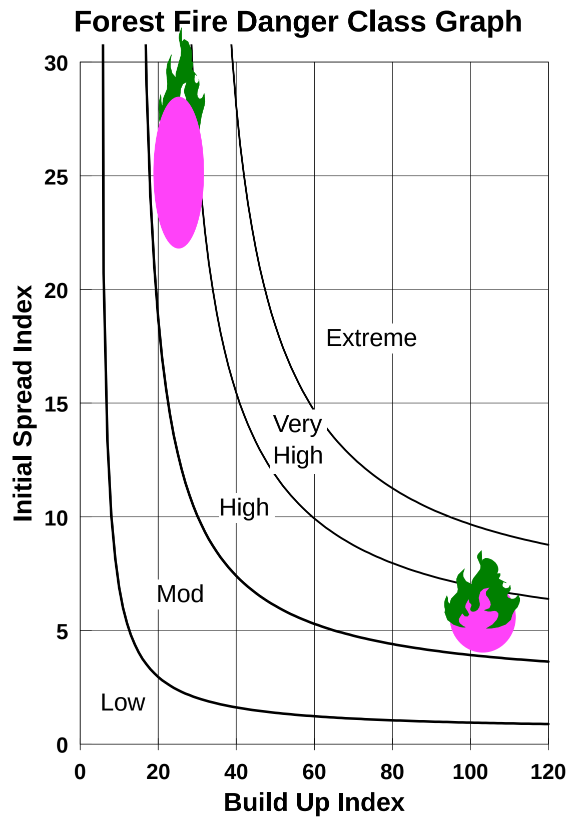

Figure 4. The Forest Fire Danger Class Graph and expected fire shapes under different burning conditions.

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:

   $\mathbf{I = H \times W \times R}$, where
   I is Intensity (kW/m),
   H is the heat of combustion (kJ/kg),
   W is available fuel (kg/m^2) and,
   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 30º 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.