## Fire Behaviour Tools

The Scion Rural Fire Research Group has released two exciting new tools to assist fire managers in calculating and predicting fire behaviour. These tools were designed to present fire behaviour information in an easily accessible manner; whether in the field, office or Incident Management Team.

The first tool is a paper-based field manual and the second is a user-friendly software package. Both tools are based on the current state of knowledge of fuels and fire behaviour in New Zealand and should be considered as aids in fire management decision-making.

The information from these tools will inform and guide fire managers with a range of actions across the 4 Rs of fire management:

- **Reduction** – fire mitigation, wildfire threat analysis, risk assessment and planning, and fuels management.

- **Readiness** – setting fire suppression preparedness levels, adequate resourcing of Rural Fire Authorities, and managing fire season status and activities.

- **Response** – responding to fires with adequate resources, safe and effective fire suppression, accurate predictions of fire behaviour, and decisions around evacuation or asset protection.

- **Recovery** – understanding events and learning from them to prevent these events reoccurring in the future.

## New Zealand Fire Behaviour Prediction Manual

The *Manual for Predicting Fire Behaviour in New Zealand Fuels* represents the current state of knowledge with respect to predicting fire behaviour in New Zealand. Previous draft versions used at fire behaviour training courses in the last few years have helped develop the current version into an effective format. This Manual comes in a durable ring binder that is easy to navigate and allows for replacement of content as new information becomes available.

The Manual contains a number of sections related to different fuel and fire behaviour characteristics. These include:

1. Step-by-step instructions for fire behaviour calculations and forecasts
2. Wind speed estimation
3. Fire Weather Index System adjustments
4. Determining available fuel loads in New Zealand fuels
5. Determining rate of spread in New Zealand fuels
6. Calculating slope and the Slope Correction Factor
7. Determining fire intensity and calculating flame length/heights manually
8. Interpreting fire intensities

10. Determining fire size and growth
11. Appendices containing conversion factors, fire danger graphs and blank forms

The Manual also contains a "quick guide" card that guides the user through the steps and tables for fire behaviour calculations, and a copy of the "Grassland field Guide" pocket card[1].

### Availability and distribution

Rural Fire Authorities will be contacted when new information on fire behaviour becomes available. New or reprinted sections of the manual will be available for download from the Scion website (**www.scionresearch.com/fire**).

One complimentary copy will be provided to each Rural Fire Authority through the NRFA, and further orders can be placed with Scion at a cost of $45 plus postage.

To place orders please contact: **publications@scionresearch.com**

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The Field Manual contains a "quick guide" card to help users through the calculations, and a copy of the "Grassland field guide" for easy reference.

### A Simple Field Guide for Estimating the Behaviour and Suppression Requirements of Fires Driven by Winds Coming From a Constant Direction, in Open, Fully Cured Grasslands at Low Fuel Moisture.

**Caution:** Flame heights at the fire's head will be greater than 2.5 metres. Under NO circumstances should direct attack be mounted on the head fire. Any containment action must begin from a secured anchor point and progress along the flanks toward the head as the fire edge or perimeter is "knocked down".

| Beaufort Wind Force[a] | Forward **spread distance/perimeter length/ maximum breadth** versus elapsed time since ignition kilometres | | | | Head fire intensity kW/m | Head fire flame length metres | Minimum firebreak width required to stop head fire[b] metres | |
|---|---|---|---|---|---|---|---|---|
| | 0.5 hour | 1 hour | 1.5 hours | 2 hours | | | Trees absent | Trees present |
| 0-1 | 0.7/2.4/0.4 | 1.3/4.9/0.7 | 2.0/7.3/1.1 | 2.6/9.8/1.4 | 2300 | 2.7 | 5 | 12 |
| 2 | 1.0/2.7/0.4 | 2.0/5.5/0.7 | 2.9/8.2/1.1 | 3.9/10.9/1.5 | 3450 | 3.3 | 6 | 13 |
| 3 | 1.6/3.7/0.4 | 3.2/7.4/0.8 | 4.8/11.1/1.2 | 6.3/14.8/1.6 | 5550 | 4.1 | 7 | 15 |
| 4 | 2.7/5.7/0.6 | 5.3/11.5/1.1 | 8.0/17.2/1.7 | 10.7/22.9/2.2 | 9350 | 5.2 | 8 | 30+ |
| 5 | 4.4/9.1/0.8 | 8.7/18.2/1.5 | 13.1/27.3/2.3 | 17.5/36.4/3.1 | 15 300 | 6.5 | 10 | 30+ |
| 6 | 6.1/12.5/1.0 | 12.2/25.0/1.9 | 18.2/37.5/2.9 | 24.3/50.0/3.8 | 21 300 | 7.6 | 12 | 30+ |
| 7 | 7.2/14.8/1.0 | 14.5/29.5/2.0 | 21.7/44.3/3.1 | 28.9/59.1/4.1 | 25 300 | 8.2 | 13 | 30+ |
| 8 | 7.5/15.2/1.0 | 15.0/30.5/2.1 | 22.5/45.7/3.1 | 30.0/60.9/4.1 | 26 200+ | 8.4+ | 14+ | 30+ |

[a] See reverse side for details on the Beaufort Wind Scale.

[b] The "Trees absent" and "Trees present" classes refer to the absence or presence of trees/scrub within 20 metres of the windward side of the firebreak. The presence of trees or scrub has a significant influence on the firebreak effectiveness because they supply woody material for firebrands which can spot across the break.

**Note:** Fire behaviour predictions in this guide are based on head fire rate of spread in fully cured standing grasslands (Fire Behaviour Prediction System Fuel Type O-1b) on flat to undulating terrain, assuming a fuel load of 3.5 t/ha, a Fine Fuel Moisture Code of 93.2, and the midpoint of the wind speed range associated with each Beaufort Wind Force. Use of the guide is at the reader's sole risk.

### ... wind speed over land

| | | | Observed wind effects |
|---|---|---|---|
| | | | Smoke rises vertically. |
| | | | ...tion of wind shown by smoke drift but not by wind vanes. |
| 2 | Light breeze | 8 to 11 | Wind felt on face; leaves rustle; ordinary vanes moved by wind. |
| 3 | Gentle breeze | 12 to 19 | Leaves and small twigs in constant motion; wind extends light flags. |
| 4 | Moderate breeze | 20 to 29 | Wind raises dust and loose paper; small branches are moved. |
| 5 | Fresh breeze | 30 to 39 | Small trees in leaf begin to sway; crested wavelets form on inland waters. |
| 6 | Strong breeze | 40 to 49 | Large branches in motion; whistling heard in telephone wires; umbrellas raised with difficulty. |
| 7 | Moderate gale | 50 to 61 | Whole trees in motion; inconvenience felt when walking against wind. |
| 8 | Fresh gale | 62 to 74 | Breaks twigs off trees; generally impedes progress. |
| 9 | Strong gale | 75 to 87 | Slight structural damage occurs (e.g., TV antennas and tiles blown off). |
| 10 | Whole gale | 88 to 101 | Seldom experienced inland; trees uprooted; considerable structural damage. |

**Note:** Fire behaviour predictions in this guide are based on head fire rate of spread in fully cured standing grasslands (Fire Behaviour Prediction System Fuel Type O-1b) on flat to undulating terrain, assuming a fuel load of 3.5 t/ha, a Fine Fuel Moisture Code of 93.2, and the midpoint of the wind speed range associated with each Beaufort Wind Force. Use of the guide is at the reader's sole risk.

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### Fire Behaviour Prediction Quick Guide

Guide to determining fire behaviour using the "Manual for Predicting Fire Behaviour in New Zealand Fuels" and Fire Behaviour Prediction Worksheet (see *Section A-3*).

Fill in the **incident details** (date, time and name of fire incident the prediction is being made for).

Obtain the standard daily (1200 noon) **starting FWI System values** for the nearest weather station. If the prediction time is before 1200 NZST, use yesterday's noon daily FWI values; if after 1200 NZST, use today's FWI values.

Enter the **prediction time(s)** that predictions are being made for.

Obtain the actual or forecasted **weather conditions** for these prediction times (from RAWS or hand-held observations).

If weather conditions for the time of prediction are different to those for the 1200 FWI calculation, determine the **adjusted FFMC and/or ISI values** (*Section C*).

Select the appropriate **fuel type(s)**.

| Pine plantation | Indigenous forest | Pasture grassland | Crop stubble | Tussock grassland | Scrubland |
|---|---|---|---|---|---|

Record any necessary fuel modifiers (e.g., fuel height, cover, curing) and determine the **Available Fuel Load (AFL) (t/ha)** for the selected fuel type (*Section D*):

| Fuel Type (AFL) | Need | Page |
|---|---|---|
| Pine plantation | BUI | D-3 |
| Logging slash | BUI | D-3 |
| Indigenous forest | BUI | D-4 |
| Pasture grassland | Height and cover | D-5 |
| Crop stubble | Height | D-6 |
| ...d | Height and Cover | D-6 |
| | Height | D-7 |

...uilibrium Rate of Spread (ROS) (m/h) on level terrain (*Section E*):

| | Need | Page |
|---|---|---|
| | ISI and BUI | E-2 |
| | ISI and BUI | E-3 |
| | ISI and BUI | E-4 |
| | ISI and Degree of curing (DoC%) | E-5 |
| | ISI and DoC% (use cut/matted grass model) | E-5 |
| | ISI (use natural/standing grass model, with 100% curing) | E-5 |
| | ISI | E-6 |

...eepness and **Slope Correction Factor (SCF)**, if applicable (*Section F*).

...e the **slope-adjusted ROS (m/h)** = ROS (level terrain) x SCF

...fire intensity from I = (w x r)/2 (*page G-1*) or table (*page G-2*)]
...e flame length, firebreak width, crown fire initiation (*Section H*)]

...e, area, perimeter, length-to-breadth ratio, or perimeter growth rate (*Section I*)

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[1] Alexander, M.E.; Fogarty, L.G. 2002. *A pocket card for predicting fire behaviour in grasslands under severe burning conditions.* New Zealand Forest Research, Forest and Rural Fire Research Programme, Christchurch. Fire Technology Transfer Note 25 (June 2002). 8 p.

## New Zealand Fire Behaviour Toolkit

The *New Zealand Fire Behaviour Toolkit* offers a significant improvement in the level of tools that are available to assist decision-making for fire managers across the country. The user-friendly software package incorporates current knowledge on fuels and fire behaviour in the New Zealand fire environment. It is based on the fuel and fire behaviour models that are contained in the field manual. The Toolkit was developed in conjunction with Scion's ATLAS Technology Group, and was co-funded by the New Zealand Fire Service Commission's Contestable Research Fund.

### Features

The Toolkit is comprised of a number of separate modules, each of which was developed for different purposes and levels of use:

1. **Fire Behaviour Calculator** - designed for quick and easy determination of fire potential in any New Zealand fuel type.

2. **Fire Behaviour Worksheet** - based on the paper worksheet contained in the field manual. This is used for predicting fire behaviour over a period of time for a specific fire, and/or to evaluate effects on fire behaviour of different conditions (i.e. changes in weather conditions, fuel types or slope).

3. **Firebreak Effectiveness** - allows the user to determine either the probability of an existing firebreak being breached by a fire of known intensity, or the width of a firebreak required to contain a head fire of known intensity.

4. **Fire Intensity** - calculates fire intensity based on an observed flame length, or flame length from a known fire intensity.

5. **Fire Behaviour Rules of Thumb** - a list of "rules of thumb" for quick and easy reference.

6. **Resource Productivity** - provides general guidelines for resource productivity in New Zealand fuel types.

Additional features include:

- The ability to save files as scenarios and reload for later use.

- The creation of PDF reports from the Calculator and Worksheet modules that can be used as the basis for the preparation of fire behaviour forecasts or included in Incident Action Plans (IAPs), fire investigation reports, and prescribed burn plans.

- A comprehensive "Help" section, with detailed information on the use and features of the Toolkit. A *User Guide and Technical Report* that also contains this information is available for download (in PDF) from the Scion website.

This version of the Toolkit is the first version to be released, and we will update relevant modules in the future as new information becomes available. We also intend to improve subsequent versions as the Toolkit becomes extensively used, and a need for new features or enhancements is identified.

We would welcome any feedback or suggestions for improvements. Please contact Stuart Anderson on +64 3 364 2987 extn 7827 or email: **stuart.anderson@scionresearch.com**

### Availability

The *New Zealand Fire Behaviour Toolkit* along with the *User Guide and Technical Report* is available for download (free of charge) from the Scion website (**www.scionreseach.com/fire**). Updates and subsequent versions will also be posted on the website when they become available.
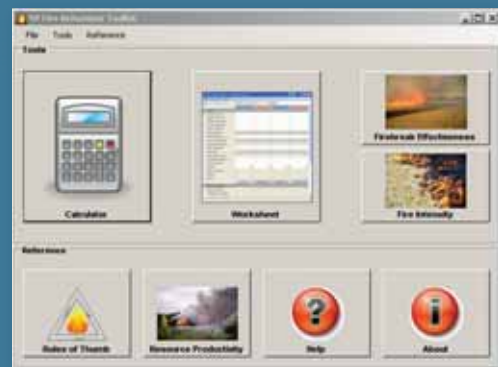


**The user-friendly software package incorporates current knowledge on fuels and fire behaviour in the New Zealand fire environment.**

## Assumptions

It is assumed that users applying the outputs of both the Field Manual and Toolkit Calculator have a reasonable level of understanding of fire behaviour and fire danger rating, and have the underlying knowledge and experience to confidently use and apply these outputs correctly. This also applies to selection of appropriate fuel models for calculating available fuel load and fire rate of spread. Users must also be careful not to apply model outputs beyond their useful range. Fire behaviour models that are incorporated into both of these tools are based on several basic assumptions, and it is recommended that users familiarise themselves with these assumptions before using and applying the outputs from these tools. A listing of these assumptions can be found in either the "Help" section of the Toolkit, the *Toolkit User Guide and Technical Report* or the *New Zealand Fire Behaviour Prediction Field Manual*.

## Caution

Fire behaviour predictions represent a combination of art and science. They are intended to assist in fire management decision making, and are not a substitute for experience, sound judgement, or observations of actual fire behaviour. Fire behaviour can change rapidly due to changes in fuel conditions, slope and exposure to wind; and no model can ever fully account for all the variables that affect fire behaviour. Operational personnel must be aware of the limitations of the models that form the basis of these tools. They must be able to recognise unique or unusual situations, as fires can be potentially dangerous at any level of fire danger (e.g., Bucklands Crossing Fire, Pearce et al. 2004)[2]. It is therefore essential to combine one's local knowledge and experience with outputs from these models to better reflect conditions at the fire location.

[2] *Pearce, H.G.; Hamilton, R.W.; Millman, R.I. 2004. Fire behaviour and firefighter safety implications associated with the Bucklands Crossing Fire burnover of 24 March 1998. Forest Research Bulletin No. 197, Forest and Rural Fire Scientific and Technical Series, Report No. 4. 63 p.*

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