BEFORE THE HEARINGS PANEL
FOR THE QUEENSTOWN LAKES PROPOSED DISTRICT PLAN

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of Hearing Stream 12 – Upper Clutha Annotations and Rezoning Requests

---

REBUTTAL EVIDENCE OF GLENN DAVIS
ON BEHALF OF QUEENSTOWN LAKES DISTRICT COUNCIL

ECOLOGY

5 May 2017

Simpson Grierson
Barristers & Solicitors

S J Scott / C J McCallum
Telephone: +64-3-968 4018
Facsimile: +64-3-379 5023
Email: sarah.scott@simpsongrierson.com
PO Box 874
SOLICITORS
CHRISTCHURCH 8140

TABLE OF CONTENTS

1. INTRODUCTION

1.1 My full name is Glenn Alister Davis. I am a Principal Environmental Scientist and Director and have been employed by Davis Consulting Group Limited since 2008.

1.2 My qualifications and experience are set out in my statement of evidence in chief dated 20 March 2017.

1.3 I confirm that I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2014 and that I agree to comply with it. I confirm that I have considered all the material facts that I am aware of that might alter or detract from the opinions that I express, and that this evidence is within my area of expertise except where I state that I am relying on the evidence of another person.

2. SCOPE

2.1 My rebuttal evidence is provided in response to the following evidence filed on behalf of various submitters:

(a) Dr Kelvin Lloyd for Allenby Farms Limited (502);

(b) Dr Judith Roper-Lindsay for Glendhu Bay Trustees Limited (583); and

(c) Mr Mike Kelly for Lake McKay Station (439) (483 and 484).

2.2 **Appendix 1** to my evidence contains an overlay of the proposed residential development onto Schedule 1A from an Environment Court Enforcement Order.[1] **Appendix 2** contains a Flammability Report by Fogarty (2001).

1 *Queenstown Lakes District Council v Allenby Farms Limited* [2017] NZDC 3251. See also Mr Barr's Group 2 s42A report at paragraph 5.7.

3. FRINGE

Kelvin Lloyd for Allenby Farms Limited (502)

3.1 Dr Kelvin Lloyd has filed evidence in relation to the Mt Iron SNA C. Dr Lloyd states at paragraph 18 that he considers no site visit was undertaken by me, and continues to imply a lack of site visit in subsequent paragraphs of his evidence.

3.2 I confirm that I completed a site visit of the Mt Iron SNA C area on 17 November 2011 with Mr Ralph Henderson. I have not taken a more recent site visit because I am aware that the SNA continues to contain kanuka woodland that is consistent with the vegetation encountered in my 2011 site visit. My knowledge of the current state of the vegetation is based on work undertaken by Mrs Rebecca Teele a Senior Ecologist and work colleague of mine who provided ecological evidence on behalf of the Council in the vegetation clearance prosecution of Allenby Farms in 2016. In this prosecution Mrs Teele completed a site visit and walked through Mt Iron SNA C to describe the vegetation that had been unlawfully removed.

3.3 I also do not agree with any inference within Dr Lloyd's evidence that the assessment was not 'best practice', and that only the Threatened Environment Classification (**TEC**) was used to classify the site as an SNA.

3.4 Dr Lloyd states at paragraph 17 and 46 that the TEC should not be the sole basis for identification of SNAs. I agree with Dr Lloyd, which is why the Mt Iron SNA C was not classified solely on the basis of the TEC. The SNA assessment was completed utilising the methodology set out in my evidence for the Rural Hearing Stream 02 (dated 6 April 2016) the site visit completed to confirm the vegetation present, scientific research of the local ecology, as well as the TEC.

3.5 Dr Lloyd states at paragraph 30 that the TEC can be used in 'defining areas where it is important to address the effects of additional indigenous vegetation clearance' and 'prioritising areas where legal protection of indigenous biodiversity should be targeted'.

3.6 I agree with Dr Lloyd and I consider it is also helpful to clarify that the TEC was used in such a manner to assist in identifying the Mt Iron SNA C. The TEC was not used in isolation, it guided the process of identifying Mt Iron SNA C, which was then assessed via site visits and existing scientific research.

3.7 Dr Lloyd states at paragraph 40 that he has used the Land Cover Data Base (**LCDB**) and the TEC to estimate the percentage of indigenous cover in land environment N4.1d within a five kilometre radius of the site.

3.8 The five kilometre boundary is arbitrary and different distances could give very different results. For this reason, the Mt Iron SNA C was not classified solely based on the LCDB or TEC.

3.9 Dr Lloyd states at his paragraph 22 that "*kānuka woodland does not represent the original vegetation*". Kanuka is representative of the original vegetation, as it formed part of the pre-settlement native woodlands, along with matagouri, small-leaved Coprosma and Olearia species, and kowhai; modelling also suggests kanuka may have been one of the main species present (Leathwick et al., 2003; Walker et al., 2003).[2]

3.10 The criteria for identifying significant indigenous vegetation includes 'Representativeness', which in Wildland Consultants' 2013 report[3] includes "*Representative vegetation and habitats are those that are typical of those that would have been present at a baseline of 1840, i.e. prior to the bulk of European settlement*." An example provided includes "*any indigenous vegetation assemblages on the Canterbury Plains, especially those that contain indigenous woody species, e.g. kanuka and kowhai*". While the example is from Canterbury, vegetation modelling undertaken by Walker et. Al in 2003 indicates that kanuka was one of the main species present within the pre-settlement vegetation of Mt Iron and surrounding area. While I accept

2 Leathwick, J., Wilson, G., Rutledge, D., Wardle, P., Morgan, F., Johnston, K., McLeod, M., & Kirkpatrick, R. (2003). Land Environments of New Zealand. Auckland: David Bateman Ltd. Walker, S., Lee, W. G., & Rogers, G. M. (2003). The woody vegetation of Central Otago, New Zealand: its present and past distribution and future restoration needs. Wellington: Science for Conservation 226.

3 Wildland Consultants 2013. Guidelines for the Application of Ecological Significance Criteria for Indigenous Vegetation and Habitats Of Indigenous Fauna in Canterbury Region. Contract Report No. 2289i.

the kanuka woodland has been modified and lacks the diversity of the original woodland community, it clearly meets the criteria for Representativeness.

3.11 Dr Lloyd states at paragraph 50 his consideration of residential development within the Mt Iron SNA C and his proposed 'alternative SNA' is detailed in paragraphs 51 to 55.

3.12 Further context is required to understand the requested 'alternative SNA', as this includes the illegal clearing of native vegetation within the SNA that occurred in May 2016. This clearance not only included clearance adjacent to existing tracks and fence lines, but notably four distinct areas located within the area seeking to be excluded from the SNA. As a result of the clearance, there are Court Enforcement Orders requiring replanting.[4] **Appendix 1** shows an overlay of the proposed residential development onto Schedule 1A of the Court Enforcement Order. Area B (indicated by the green triangle at 042) lies within proposed building platform 10. I also note that the illegal clearing occurred along the proposed access to Platforms 10 and 11 (see purple circles on **Appendix 1**). Four distinct areas are required to be replanted by the Enforcement Order, indicated by green triangles at 043 (A), 042 (B), 042 (C), and 039 to 040 (D), which Allenby Farms Limited 'must not harm, disturb or damage' once replanted.

3.13 I consider that it is also helpful to identify that, as evidenced by Dr Lloyd's Attachment 10, there are indigenous invertebrate and lizard values within the Mt Iron SNA C. Of note is the At Risk – Declining Kawarau gecko located where building platform 10 is proposed to be situated. Attachment 10 discounts this fact, due to a lesser degree of good quality rocky habitat in the area to be excluded. However, the Kawarau gecko is clearly also utilising this habitat.

3.14 Furthermore, the native brown creeper was noted in Attachment 10 as being present on site and as having 'substantial gaps in their distribution' and 'generally present only in areas with extensive'

4 *Queenstown Lakes District Council v Allenby Farms Limited* [2017] NZDC 3251. See also Mr Barr's Group 2 s42A report at paragraph 5.7.

vegetation. Therefore, allowing the fragmentation of the kanuka woodland by proposed building platforms 10, 11 and 12 appears counterintuitive to protecting their habitat.

3.15 Dr Lloyd has filed evidence in relation to the values within his alternative SNA. Dr Lloyd states at paragraph 20 that the 'alternative SNA' 'would include <u>all</u> ecologically significant values'.

3.16 The above statement is in contradiction to Dr Lloyd's subsequent evidence in Attachment 10, that states the addition of the values to the south of the current SNA boundary would be 'at the expense of losing some kanuka woodland' in the northern section, as well as paragraph 68 that states the alternative SNA would include 'almost all' of the populations of plants, invertebrates and lizards. Dr Lloyd also requires four conditions in Paragraph 63 of his evidence to be instituted if kanuka woodland clearance is to occur. The contradiction, and requirements placed on clearance, highlight the significant values of the kanuka woodland.

3.17 Dr Lloyd has filed evidence in relation to an extension to the southern boundary of the Mt Iron SNA C. Dr Lloyd states at paragraph 51 that an extension to the southern boundary of Mt Iron SNA C would incorporate further ecological values present on Mr Iron.

3.18 I agree with Dr Lloyd that the area identified to the south of the current SNA also has ecologically significant values and hence why I have previously supported, and continue to agree with, an adjustment to extend the southern boundary to include these values.

3.19 Dr Lloyd states at paragraph 68 that he proposes an alternative SNA to the notified Mt Iron SNA C.

3.20 Based on my knowledge of the site (informed by site visits and existing scientific research), the relevant parts of Dr Lloyd's evidence, the local ecological environment, as well as my experience as a consulting ecologist, from an ecological perspective I oppose the proposed 'alternative SNA' as it does not accurately reflect the area of significant value. I specifically oppose the inclusion of building platforms 10, 11 and 12 within the Mt Iron SNA C. I could support the inclusion of only the platform boundaries 3 to 9, 13 and 15 within the SNA, although some of the platform boundaries could be more sympathetic to the existing kanuka woodland, and the following conditions would need to be met:

(a) all development be contained within these platform boundaries and controls over vegetation within the platforms;

(b) the extension of the SNA's southern boundary occurs;

(c) forest restoration of the area shown in Attachment 9 of Dr Lloyd's evidence successfully occurs and is monitored; noting that on its own the proposed restoration of this area would not be compensation enough for removal of existing kanuka woodland;

(d) the removal and ongoing control of all woody weeds within Mt Iron SNA C;

(e) the removal of platforms 10 to 12; and

(f) the control of pest animal species on Mt Iron.

3.21 I consider that it is also helpful to identify that many of the matters and outcomes raised by this submission would be better dealt with through the resource consent process. I also note that parts of this submission conflict with an already issued Environment Court enforcement order.

3.22 Finally, I note that in Mr Paddy Baxter's landscape evidence for Allenby Farms Limited, at paragraph 39, he refers to "*a Fire Service requirement for indigenous planting within 10 metres of any dwelling to be in green fleshy leaved plants for safety reasons*." While I am not a landscape nor fire expert, in my ecological opinion all plants are flammable to different extents, with kanuka being known as a particularly flammable species. In terms of green fleshy leaved plants that have low flammability, this is outside my area of expertise but I include a report by Fogarty (2001) which lists the flammability for 42 native New Zealand trees and shrubs,[5] see **Appendix 2**. This list

5 Fogarty, L.G. 2001. A flammability guide for some common New Zealand native tree and shrub species. Forest Research, Rotorua, in association with the New Zealand Fire Service Commission and National Rural Fire

notes kanuka as having high flammability, and five of the proposed species suggested for planting within the building platforms as having either Low, Moderate, or Low/Moderate flammability.

3.23 Regarding the species proposed by the submitter for building platform revegetation, listed in proposed Rule 27.7.13.1(iv)(e)(iv) of Appendix B to Mr White's evidence, broadleaf, pittosporum, fierce lancewood and matai may be difficult to establish in my view. Even with irrigation these plants would struggle to establish. There are other smaller leaved natives that would be better suited to the site conditions alongside kowhai. Any plantings would also require rabbit protection and will require continued rabbit control.

4. RURAL

Judith Roper-Lindsay for Glendhu Bay Trustees Limited (583)

4.1 In my evidence in chief I noted that the Revegetation Strategy referred to in the submitter's proposed Glendhu Station Zone (**GSZ**) provisions, had not been provided with the submission. Dr Roper-Lindsay clarified the situation by stating at paragraph 88 that the "*Revegetation Strategy is linked to the specifically consented works and not the rezoning, but would appropriately form the basis of a Revegetation Strategy under the Zone rule*".

4.2 While the Environment Court required Revegetation Strategy is provided with Dr Roper-Lindsay's evidence, this strategy relates specifically to the previous Environment Court decision conditions[6] for a select area of the proposed GSZ. It does not cover the entire area proposed to be rezoned.

4.3 Dr Roper-Lindsay's evidence addresses how the Revegetation Strategy applies within Activity Areas of the proposed GSZ. Dr Roper-Lindsay at paragraph 50 sets out the Revegetation Strategy objectives *a* to *g* (from Condition 6 of consent RM070044). In her paragraph 55, she states that these seven objectives are repeated in

---

Authority, Wellington. Forest Research Bulletin No. 197, Forest and Rural Fire Scientific and Technical Series, Report No. 6. 18 p.

6 The relevant resource consents and Environment Court decision are described at paragraph 13.11 and footnote 12 of Mr Barr's s42A report for Group 3 - Rural.

Zone Rule 44.5.4, and that this rule will require resource consent applications for all activities, except for buildings, in the Golf (G), Lake Shore (LS), Residences (R) Activity Areas to include a Revegetation Strategy. I understand that while this Rule may extend into Activity Areas G, GS(OS/F) and LS the Rule only applies to Activity Area R. If this Rule was extended to all Activities and all Activity Zones within the GSZ and Activity Area specific measures were drafted, then provision for a revegetation strategy over the GSZ would be provided for. Providing Rule 44.5.4 was extended to all Activities and Activity Areas I could support the GSZ from an ecological perspective.

4.4 At paragraph 53, Dr Roper-Lindsay states that within the Zone Purpose (44.2) "*revegetation with indigenous species is noted as a feature of each of the Golf, Lake Shore, Residences and Open Space Farm activity areas*". However, I note that the term "indigenous revegetation" is missing from proposed Zone Purpose 44.2(b) for the Lake Shore Activity Area. This may be an oversite given "indigenous revegetation" is referred to in all other Activity Areas listed.

4.5 Dr Roper-Lindsay states at paragraph 71 that it would be of benefit to biodiversity values in the GSZ to extend the Revegetation Strategy to the Farm Homestead (FH) and Camping (C) Activity Areas. I agree with this statement and that these areas could be included into a redraft of Rule 44.5.4 as discussed in paragraph 4.2 above.

4.6 Dr Roper-Lindsay states at paragraph 74 that activities proposed in the large OS/F Activity Area will be carried out under the Revegetation Strategy, and in paragraph 84 states that the balance of this Activity Area will be subject to the District-wide indigenous clearance rules of Chapter 33.

4.7 The Revegetation Strategy is not a requirement to support consent applications within Activity Areas other than Activity Area R. This again highlights a requirement for a Revegetation Strategy to be required for all Activities within all Activity Zones as set out in paragraph 4.3 above.

4.8 Dr Roper-Lindsay's evidence addresses how the overlays on the proposed Structure Plan were achieved at her paragraphs 93 and 95. She states that the overlays were identified largely based on landscape features and not directly on ecological values.

4.9 However, Mr Ferguson states in his evidence at paragraph 7.8 that the Landscape Protection Area overlays were removed/relabelled as "*it has subsequently been identified that these are not actually based on landscape values*". Furthermore, in paragraph 7.9 he states that for two of the overlays, "*the nature of these areas is about farm management and ecological values*".

4.10 Given the confusion as to reasons why certain areas were identified within the overlays, I think this highlights that provision for a revegetation strategy across the whole GSZ is required.

4.11 Dr Roper-Lindsay supports in part my evidence regarding the need to address indigenous biodiversity values on public access as part of Council discretion. At her paragraph 97 she states that "*it would be appropriate for indigenous biodiversity values to be considered in specific route design and formation*."

4.12 Despite our agreement on this issue, the amended proposed GSZ still only has recreation values listed as a matter for Council's discretion.

Mike Kelly for Lake McKay Station (439)

4.13 Mr Mike Kelly has provided evidence on behalf of Lake McKay Station (**LMS**) regarding the five significant indigenous vegetation and habitat areas (SNAs E30A, E30B, E30D, E30F and E18G) identified on Lake McKay Station.

4.14 Based on Mr Kelly's evidence I understand LMS does not oppose the identification of the five SNAs. Rather, LMS is concerned about the implications of maintenance and construction of farm tracks that are present within the SNAs.

4.15 LMC proposes that 20 metre wide farm track corridors are excluded from four SNAs (E30A, E30D, E30F and E18G) in order to provide certainty that farm track maintenance/construction works can be completed.

4.16 I do not consider this is necessary, as provision for the maintenance of existing farm tracks is already provided for under Rule 33.3.4.2 of the PDP **[CB22]**. Although the exemption in Rule 33.3.4.2 does not provide for expansion of farm tracks; it exempts their operation and maintenance, but specifically states *'but excludes their expansion'*.

4.17 I consider the provision of a 20 metre wide corridor has the potential to fragment the SNAs and provide an expectation that disturbance within the 20 metre wide corridor can be undertaken. In my view the SNAs have inherent values that are worthy of protection and a consent process is the appropriate mechanism for determining if clearance can be undertaken. Importantly the consent process would require that all efforts are undertaken to avoid, minimise and mitigate effects on the SNA.

4.18 I note that Mr Kelly at his paragraph 3.5 is concerned with the expense associated with obtaining consent for clearing within an SNA. I note that even with the corridors excluded from the SNAs, clearing of vegetation within the identified areas would be a discretionary activity under the PDP because the SNAs are for the most part situated within a Land Environments of New Zealand (**LENZ**) Level IV environment where the remaining indigenous vegetation cover is less than 20%. Provision of a 20 metre wide corridor is unlikely to remove the requirement for resource consent under the indigenous vegetation clearing rules.

4.19 As noted at paragraphs 4.9-4.11 of my Rural evidence **[CB48]**, LENZ is a national classification of environments mapped across New Zealand's landscape. LENZ environments are mapped on the basis of 15 climate, landform and soil parameters that were chosen for their roles in driving geographic variation in biological diversity. LENZ has been presented at four levels of detail containing 20, 100, 200 and 500 environments to facilitate use at a range of scales.

4.20 Walker *et al.*, (2006) combined the LENZ Level IV database (500 environments) with the New Zealand Landcover Database (LCDB2 – based on 2001/02 imagery; Terralink 2004) and a spatial database of private and public land managed for conservation. This work estimated the percentage of remaining indigenous vegetation cover and the percentage of each unit formally protected. Based on these two criteria, five categories of TEC were established. The "Chronically threatened" category applies where there is 10-20% indigenous vegetation cover remaining.

Mike Kelly for Lake McKay Station Limited (483, 484) Rural Residential and Rural Lifestyle Rezoning

4.21 I have read the evidence of Mr Kelly relating to the rezoning of two areas to Rural Lifestyle Zone and an area to Rural Residential Zone. I understand there are no changes to the proposal or new evidence relating to ecological matters and I maintain my opinion as set out in my evidence in chief.

Glenn Alister Davis
5 May 2017

APPENDIX 1

Overlay of proposed residential development onto Schedule 1A from Environment Court Enforcement Order

PATERSONPITTSGROUP
Your Land Professionals
www.ppgroup.co.nz
0800 PPGROUP

Job No: W4743
Scale: 1:1500 @ A1 1:3000 @ A3
Sheet & Revision: 06 Rev F
Date: 05/04/2017

Title: **Building Platforms**
Mt Iron Park Rural Lifestyle Zone

APPENDIX 2

Flammability Report (Fogarty, 2001)

Fire Research Report

A Flammability Guide for Some Common New Zealand Native Tree and Shrub Species

FOREST RESEARCH

November 2001

Abstract

Information about the flammability of selected New Zealand native species was collated by means of two surveys. Fire managers were asked to place each species into one of four classes according to observations of flammability at wildfires and prescribed burns under different fire danger conditions. The original classes were modified in the light of comments by respondents and again by statistical procedures. A final list was produced containing 42 species ranked and classified on the basis of flammability characteristics. Information about the suitability of each species for green breaks and as components of vegetation near homes and buildings is included. Problems encountered in deriving useful guidelines from the survey responses are discussed. The list/guide is presented as a "state of our knowledge" summary that can and should be refined as a result of future suggestions and observations.

The report summarises the methodology used to produce the brochure *Flammability of Native Plant Species: a guide to reducing fire hazard around your home.*

Liam G. Fogarty

New Zealand Fire Service Commission Research Report Number 20
ISBN Number 0- 908920-63-6

A flammability guide for some common New Zealand native tree and shrub species

Liam G. Fogarty

Forest Research Bulletin No. 197
Forest and Rural Fire Scientific and Technical Series
Report No. 6

NEW ZEALAND FIRE SERVICE COMMISSION Whakaratonga Iwi

forest research

NATIONAL RURAL FIRE AUTHORITY Te mana ahi matua o te motu

Other reports printed in the *Forest and Rural Fire Scientific and Technical Series* (Forest Research Bulletin No. 197) include:

1. Fogarty, L.G. 1996. Two rural/urban interface fires in the Wellington suburb of Karori: assessment of associated burning conditions and fire control strategies.

2. Rasmussen, J.H.; Fogarty, L.G. 1997. A case study of grassland fire behaviour and suppression: the Tikokino Fire of 31 January 1991.

3. Fogarty, L.G.; Jackson, A.F.; Lindsay, W.T. 1997. Fire behaviour, suppression and lessons from the Berwick Forest Fire of 26 February 1995.

4. Pearce, H.G.; Hamilton, R.W.; Millman, R.I. 2001. Fire behaviour and firefighter safety implications associated with the Bucklands Crossing Fire burnover of 24 March 1998.

5. Alexander, M.E. 2000. Fire behaviour as a factor in forest and rural fire suppression.

Cover Photograph: Rural/urban interface fire on Bluff Hill, Napier, 23 November 1994.

Peer reviewed

A flammability guide for some common New Zealand native tree and shrub species[*]

Liam G. Fogarty

(Forest Fire Management Consultant, Berau Forest Management Project, Balikpapan, Kalimantan Timur, Indonesia)

At the time this research was conducted, the author was the Fire Technology Transfer Specialist with the Forest and Rural Fire Research Programme at the New Zealand Forest Research Institute, Rotorua, New Zealand.

This research report is a product of the *Forest Research* (formerly NZ FRI) forest and rural fire research programme. Funding and "in kind" support for this project is jointly provided by the following organisations:

- **Foundation for Research, Science and Technology**
- **New Zealand Fire Service Commission**
- **National Rural Fire Authority**
- **New Zealand Forest Owners Association**
- **Department of Conservation**
- **New Zealand Defence Force**
- **members of Local Government New Zealand**

[*] Correct citation: Fogarty, L.G. 2001. A flammability guide for some common New Zealand native tree and shrub species. Forest Research, Rotorua, in association with the New Zealand Fire Service Commission and National Rural Fire Authority, Wellington. Forest Research Bulletin No. 197, Forest and Rural Fire Scientific and Technical Series, Report No. 6. 18 p.

Published with the assistance of:

Forest and Rural Fire Association of New Zealand

National Rural Fire Authority

New Zealand Fire Service Commission
Contestable Research Fund

Disclaimer:

The contents of this publication are not intended to be a substitute for specific specialist advice on any matter and should not be relied on for that purpose. The New Zealand Forest Research Institute Ltd. and the authors of this publication shall not be liable for any loss, damage or liability incurred as a direct or indirect result of reliance by any person upon information contained, or opinions expressed in this work.

Additional copies of this publication are available from:

Publications Officer
Forest Research
Private Bag 3020
Rotorua
New Zealand

National Rural Fire Authority
PO Box 2133
Wellington
New Zealand

Contents

Abstract

Information about the flammability of selected New Zealand native species was collated by means of two surveys. Fire managers were asked to place each species into one of four classes according to observations of flammability at wildfires and prescribed burns under different fire danger conditions. The original classes were modified in the light of comments by respondents and again by statistical procedures. A final list was produced containing 42 species ranked and classified on the basis of flammability characteristics. Information about the suitability of each species for green breaks and as components of vegetation near homes and buildings is included. Problems encountered in deriving useful guidelines from the survey responses are discussed. The list/guide is presented as a "state of our knowledge" summary that can and should be refined as a result of future suggestions and observations.

The report summarises the methodology used to produce the brochure *Flammability of Native Plant Species: a guide to reducing fire hazard around your home*.

Introduction

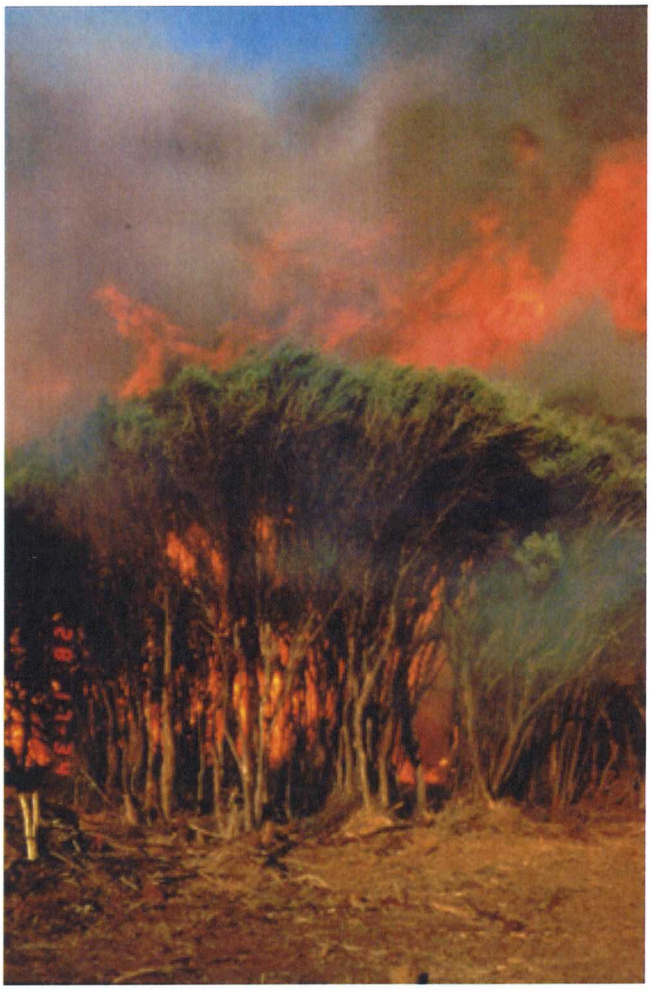
The flammability[1] of a vegetation fuel complex significantly affects fire intensity which has a strong influence on: (i) fire control (Cheney 1981, Alexander 2000), (ii) chance of homes or buildings being destroyed or damaged by fire (Wilson 1984, 1988), and (iii) the degree of damage to timber resources (Nicholls and Cheney 1974, Buckley 1990). High flammability fuels have chemical and physical characteristics which greatly assist fire spread. These characteristics often include heavy fuel loads (McArthur 1967) with a high proportion of dead material (Sneeuwjagt and Peet 1985), as well as aerated and continuous arrangements (Cheney *et al.* 1992) which dry rapidly and provide ladder fuels or fuel bed bulk densities that promote combustion (Rothermel 1972). The individual fuel particles that comprise a fuel array may have one or more properties that enhance ignition and combustion such as a high surface area to volume ratio, low mineral content (Rothermel 1972), the presence of volatile oils or extractives and low foliar moisture contents.

Fuel is the only component of a fire environment that can be altered to reduce the probability of occurrence of extreme wildfires (McArthur 1962). Reduction of fuel quantity by burning (McArthur 1962, Underwood *et al.* 1985), and modification of other characteristics by mechanical alteration (e.g., pruning and thinning) are commonly and successfully used to reduce local and regional fire hazard[2]. A promising, but less commonly used alternative, is the use of low flammability species in *green breaks* (Johnson 1975) positioned to divide flammable landscapes, or to reduce fire hazard in the immediate vicinity of property and settlements (Simpfendorfer 1989).

[1] For the purpose of this study, fuel flammability is defined as the ease by which part or all of a fuel complex is ignited. This determines whether a fire will spread through a stand as a surface or crown fire and subsequently, the level of exposure to the gradient wind, the rate and relative amount of fuel consumption, and in turn, the rate of head fire spread and intensity.

[2] Fire hazard is the exposure or vulnerability to injury or loss due to the effect a fuel complex has on ease of ignition, fire behaviour and suppression difficulty (Luke and McArthur 1978).

Photo 1. Fires in manuka (*Leptospermum scoparium*) or kanuka (*Kunzea ericoides*) scrub typically burn with high intensities, and provide an example of High flammability species.



Selection of species for green breaks is difficult because plants are variable in form and composition. Genetic and physiological factors including provenance, age, and response to environmental influences (soil fertility, aspect, elevation, climate) contribute to this variability.

Published lists of species with high and low flammability exist (e.g., Evans 1983, Moore 1991, Hutt City Council 1996), but some of the information available is limited and can be misleading. Rigorous scientific assessment of the flammability of species is likely to be costly and time consuming, making the development of comprehensive lists difficult. For example, lists based on an estimate of green leaf flammability will not indicate how a species will respond to fire in drought conditions and is likely to ignore features of the whole fuel complex that contribute to flammability (e.g., the proportion of dead material, the arrangement of fine fuels). Assessment based on the knowledge and experience of fire managers is likely to be subjective (i.e., influenced by personal opinion, infrequent observation and sometimes inaccurate recall). However, fire managers do possess a wide range of valuable and practically useful knowledge that can be quickly and cheaply accessed. Wilson (1992, 1993) has used interpretations of fire manager experience in the production of photo guides relating scrub and bark fuels to fire hazard in Australian eucalypt forests.

An ideal flammability guide would combine the best elements of systematic scientific approach with the best elements of a fire manager assessment and would remain open to further incorporation of field observations and rigorous scientific testing. This report describes the compilation of a ranked list of New Zealand native tree and shrub species derived from scientific examination of fire manager assessments of relative flammability. In doing so, it outlines the methodology used to produce the species flammability list contained in the brochure *Flammability of Native Plant Species: a guide to reducing fire hazard around your home* previously released by the Forest and Rural Fire Research Programme (NZ Fire Research 2000). The intention of this research was to provide a state-of-our-knowledge summary of the flammability of native New Zealand plant species in the form of an interim guide that can be updated as more information becomes available.

Methodology

An initial questionnaire listing 25 species was sent to 250 fire managers throughout New Zealand. The mailing list was compiled from the National Rural Fire Authority Rural Fire Management Directory and the membership roll of the Forest and Rural Fire Association of New Zealand. Ex-New Zealand Forest Service personnel who had been involved in many land clearing burns were also asked to respond. The species list was compiled from results of two previous surveys identifying species that do not easily carry fire (Evans 1983) and those that suppress or replace other vegetation with a higher fire risk (Moore 1991). In total, 59 responses were received. This survey was used to identify additional species that warranted assessment. A second questionnaire listing 25 species was sent out to the 59 original respondents, of whom 36 replied. In both surveys, most respondents categorised at least 75 % of the species, but some categorised as few as 8%.

In both surveys, respondents were asked to classify species on the basis of observations during or after burns and wildfires. The criteria were as follows:

- *High flammability*: burns readily in Low to Moderate fire danger conditions.
- *Moderate flammability*: partially ignites in Moderate conditions and burns readily in High to Very High fire danger conditions.
- *Low flammability*: partially ignites in High to Very High fire danger conditions and burns readily in Extreme conditions.
- *Not flammable*: will not burn even under Extreme fire danger conditions.

Respondents were asked to isolate species from the vegetation communities in which they commonly grow, and to try to remember individual species being burnt by a head fire, or remaining after a high intensity burn-off. The fire danger conditions were based on the Forest Fire Danger Class Criteria (Alexander 1994), because this has been the forest fire danger rating and fire management decision support system used in New Zealand since 1980/81 (valentine 1978, Fogarty *et al.* 1998).

Sixteen of the respondents found that the flammability classes where too broad and often used composite classes such as Low/Moderate. To adequately account for the variation of the responses for each species and the numerous comments received, 7 flammability classes were needed to define species flammability. The following criteria were used to categorise species according to the revised flammability classes:

- *Not-flammable*: greater than or equal to 75% of all responses in the Not-flammable category.

- *Not-flammable/Low*: greater than or equal to 50% but less than 75% in Not-flammable category, and greater than or equal to 75% in Not-flammable and Low categories.
- *Low*: greater than or equal to 75% in Not-flammable and Low categories.
- *Low/Moderate*: greater than or equal to 50% but less than 75% in the Not-flammable and Low categories, and greater than or equal to 75% in Not-flammable, Low and Moderate categories.
- *Moderate*: greater than or equal to 75% in Not-flammable, Low and Moderate categories.
- *Moderate/High*: greater than or equal to 50% but less than 75% in the Not-flammable, Low and Moderate categories and greater than or equal to 75% in the Not-flammable, Low, Moderate and High categories
- *High*: greater than or equal to 75% in the Not-flammable, Low, Moderate and High categories.

These selection criteria were applied starting from Not-flammable criteria and ending with High flammability criteria (i.e., each species was initially tested against the Not-flammable criteria, then the Not-flammable/Low criteria and so on). The minimum acceptable number of responses per species set for inclusion in the study was 14. On this basis, 8 species had to be omitted from the final assessment. For each of the remaining 42 species, frequency of response to each flammability category was determined from a scoring system in which 0 = Not-flammable, 1 = Low flammability, 2 = Moderate flammability, and 3 = High flammability.

When species were ranked using the average flammability score, they formed a continuum, with few clear divisions between groups of species. To test whether the revised flammability classes could be regarded as statistically robust groupings, the Least Significant Difference (LSD) (Snedecor and Cochran 1972) value was calculated using the species scores. Where the difference in the weighted score of two species exceeds an LSD value of 0.37, the separation between them was significantly different at the 95% level of confidence. The calculated LSD value was used to refine the boundaries of the classes in borderline cases. The range of scores within each of the final classes was approximately equal to the LSD range.

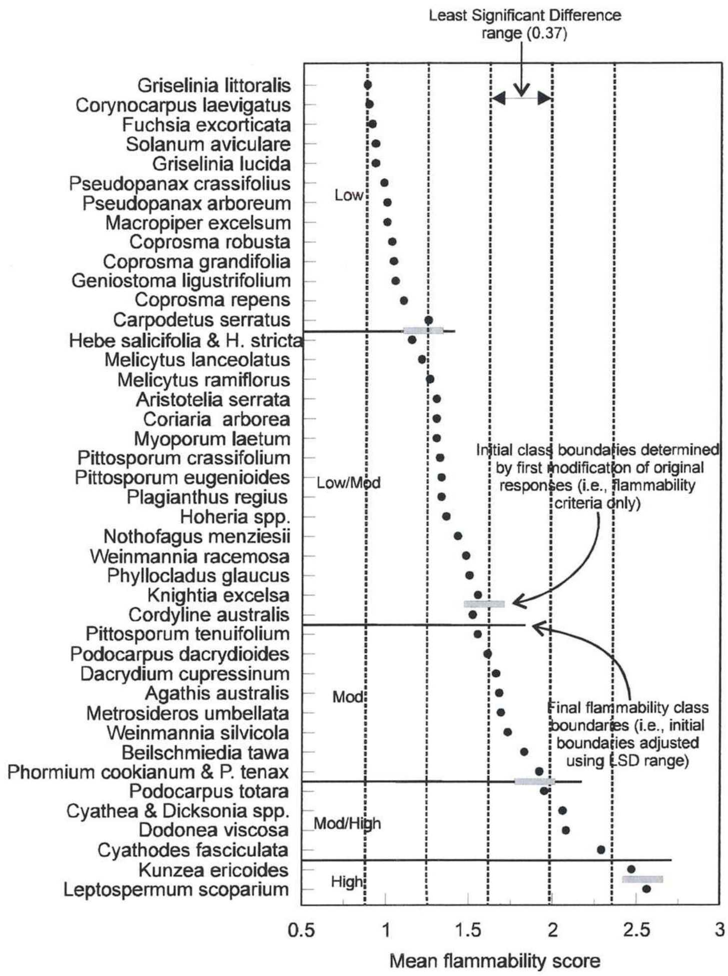
Results

Figure 1 shows the mean score for each species, boundaries of the revised flammability classes, the LSD range boundaries for flammability scoring and the final class boundaries. In general, the flammability classes were close to the boundaries assigned using the LSD range. Two species that were initially borderline were re-classified so that the final classes corresponded better with the LSD boundaries. These were:

- ti kouka/cabbage tree (*Cordyline australis*), which was transferred from the Moderate to the Low/Moderate flammability class; and
- kanuka (*Kunzea ericoides*) which was transferred from the Moderate/High to the High flammability class.

The status of *Carpodetus serratus* was reviewed because its flammability score was close to the LSD boundary. It was decided that the Low flammability rating should be retained because 12 out of 16 people had given it a Low flammability rating.

Figure 1. Determination of final flammability classes for 42 native New Zealand shrubs and trees.



Ranking by species score and final classification compared favourably. All species in each flammability class were contiguous in the rankings (for example, the Low flammability species ranked from 1 to 14, and no Low/Moderate species were interspersed among them). Most importantly, the boundaries assigned to the revised set of flammability classes, and those of the LSD ranges were found to be in close proximity, with re-classification required for only 2 species that had been regarded as borderline. Many respondents provided reasons for placing species in a particular flammability class and commented on flammability changes with age and situation. Using these comments and the final classification, flammability classes used to describe the species can be interpreted as follows:

- *Not-flammable*: dense stands will not burn, even in Extreme forest fire danger conditions. Suitable for green breaks or defensible space[3].
- *Not-flammable/Low flammability*: dense stands will partially burn in Extreme forest fire danger conditions, especially during drought. Suitable for green breaks or defensible space, but when in the immediate vicinity of structures, a distance greater than 3 m between crowns[4] is needed to reduce continuity and prevent crown fires under Extreme fire danger conditions.

---

[3] *Defensible space* is a low fuel or low fire hazard area around a house or other structure, that allows heat and embers from a wildfire to dissipate before they reach the structure (see Figure 2).

[4] As a rule of thumb, crown cover should be reduced to less than 35% with a minimum of 3 m (10 feet) of open space between crowns (Dennis 1983, Schmidt and Wakimoto 1988).

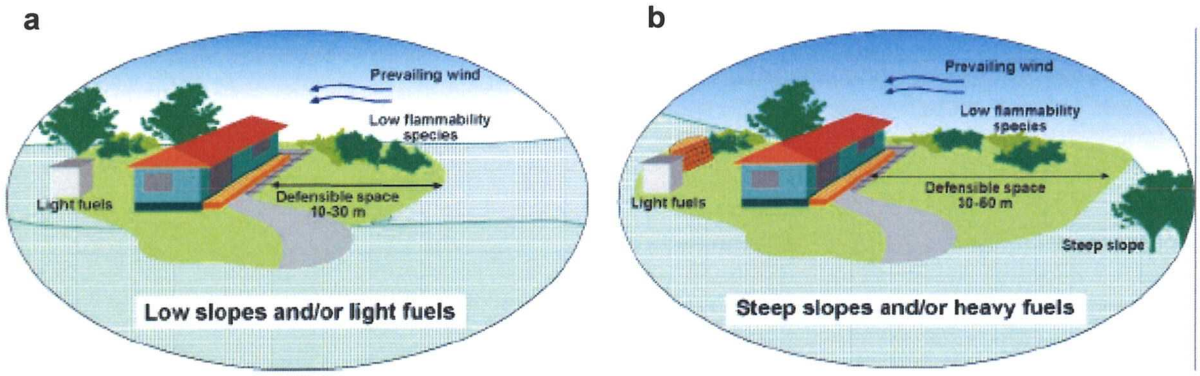


Figure 2. Defensible space requirements around a house in **(a)** low slopes and/or light fuels, and **(b)** steep slopes and/or heavy fuels.

- *Low flammability*: dense stands established as green breaks on moist or fertile sites will usually reduce a crown fire in adjacent forest or scrub to a surface fire under High to Very High forest fire danger conditions, but will burn readily in Extreme conditions. Suitable for green breaks or defensible space, but when in the immediate vicinity of structures, a distance greater than 3 m between crowns is needed to reduce continuity and prevent crown fires under Extreme forest fire danger conditions.
- *Low/Moderate flammability*: dense stands will burn readily in Very High to Extreme forest fire danger conditions especially on dry and/or infertile sites. Surface fires will be sustained in Moderate to High fire danger conditions. Not recommended for green breaks. If present in defensible space, elevated dead material and litter should be removed regularly. Crowns should be more than 4 m apart and a minimum of 10 m from any structure.
- *Moderate flammability*: dense stands will partially ignite under Moderate forest fire danger conditions, and burn readily in High to Very High fire danger conditions. Species may have flammable green foliage, or produce heavy accumulations of litter or elevated dead material. Not recommended for green breaks or defensible space.
- *Moderate/High flammability*: dense stands burn readily in Moderate to High forest fire danger conditions, and partially ignite in Moderate conditions. Species may have flammable green foliage, or produce heavy accumulations of litter or elevated dead material. Not recommended for green breaks or defensible space.
- *High flammability*: burn readily at Low to Moderate forest fire danger conditions. Not recommended for green breaks or defensible space.

The name(s), relative ranking, class and any additional comments for each species are presented alphabetically and in the order of lowest to highest flammability in Appendices 1 and 2 respectively. Comments by respondents are summarised in Appendix 2.

Photos 2-5, clockwise from top left. Lancewood (*Pseudopanax crassifolius*) is a Low flammability species which will only carry fire if planted on dry, infertile sites or amongst other more flammable species; flaxes (*Phormium* spp.) are classified as having Moderate/High flammability which increases with age due to the build up of dead material, and have been observed to "explode" when burnt; the cabbage tree (*Cordyline australis*) is a Moderate flammability species which increases with age due to retention of elevated dead material; tree ferns (*Cyathea* and *Dicksonia* spp.) are Moderate/High flammability due to hanging dead fronds and accumulations of flammable litter.

Discussion

Ranking and classification of species flammability provides fire managers and home owners with a list of species that can be used to reduce the risk of injury or loss by wildfire. The flammability of species in Appendix 1 is considered to range between Low and High. None of them were classified as Not-flammable or Low/Not-flammable.

Only species in the Low category are recommended for planting in green breaks or defensible space. Vegetation types normally considered to be impervious to fire will often burn with higher intensity under drought or other critical fire weather conditions (Kiil and Grigel 1969). It is expected that use of species in the Low flammability class will reduce, but not eliminate the probability of fire spread in Extreme fire danger conditions.

Species in the Low/Moderate flammability class are not recommended for use in green breaks, but can be planted in defensible space provided that spacing is adequate and any debris is removed regularly. They should not be planted within 10 m of a house or structure. Species in the Moderate and Moderate/High flammability categories are not recommended for use in green breaks or defensible space. The flammability of many of the species in these classes often increases to High with age.

Many respondents remarked that flammability is increased by unsuitable sites, mixture with other more flammable species, and sparse planting. Species growing outside their preferred environmental range may have different characteristics that influence flammability (e.g., lower foliar moisture content and increase litter accumulation). The suitability of a species for a given site needs to be determined from one of the many bushland revegetation manuals available (e.g., Pollock 1986, Porteous 1993). Selection of trees and shrubs for planting in areas adjacent to flammable vegetation will require particular care. Scrub dominated by gorse (*Ulex europaeus*) or manuka (*Leptospermum scoparium*) (see Photo 1) has High flammability and could generate a fire intensity capable of overriding the normal flammability classification of nearby vegetation. This effect is likely to occur along the edges of green breaks.

The final classification cannot be regarded as definitive in all situations since the initial assessment by the respondents contained considerable variability, reflecting a wide range of knowledge and experience. For example, although some species in the Low flammability class (i.e., *Fuchsia excorticata* and *Pseudopanax crassifolius*) were considered by a relatively small proportion of respondents to have Moderate rather than Low flammability, the final classification conforms with the majority of experience. The flammability classes undoubtedly require further testing and refinement in the light of future observations made at experimental, prescribed and accidental fires.

The species listed in the guide include those published previously and others recommended by respondents to the first survey. It is by no means extensive and the following commonly planted species should receive priority in any future upgrade of the guide:

- pohutukawa (*Metrosideros excelsa*).
- pukatea (*Laurelia novae-zelandiae*).
- Olearia spp.
- puriri (*Vitex lucens*).
- kowhai (*Sophora tetraptera*).
- pigeonwood (*Hedycarya arborea*).
- tanekaha/celery pine (*Phyllocladus trichomanoides*).
- red beech/tawhairaunui (*Nothofagus fusca*).

Toetoe (*Cortaderia* spp.), although neither trees nor shrubs, also warrant inclusion because of widespread use in shelterbelts.

Conclusion

The flammability of New Zealand native vegetation is perceived by fire managers to vary between species, and also within species when environmental differences are taken into account. Some species are considered to be suitable for green breaks and defensible space; others are not recommended near forests, buildings or areas of highly flammable scrub.

A list is presented as the current "state-of-our-knowledge" summary of information about the flammability of some New Zealand native shrub and tree species. It requires improvement based on testing, observation and comparison, but in the meantime can be used for fire management and landscape design purposes with some degree of confidence.

Acknowledgments

Thanks are extended to the many forest and rural fire managers who responded to the surveys. The comments and contributions of Ruth Gadgil, Grant Pearce and Ken Klitscher (***Forest Research***) are also acknowledged. The assistance of Mark Kimberley (***Forest Research***), who carried out the Least Significant Difference test and developed the format of Figure 1 is particularly acknowledged.

References

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

Alexander, M.E. 2000. Fire behaviour as a factor in forest and rural fire suppression. Forest Research Bulletin No. 197, Forest and Rural Fire Scientific and Technical Series, Report No. 5. Forest Research, Rotorua. 28 pages.

Buckley, A. 1990. Fire behaviour and fuel reduction burning - Bemm River Wildfire, October 1988. Department of Conservation and Environment, Research Report No. 28. Fire Protection Branch, Victoria. 24 pages.

Cheney, N.P.; Gould, J.S.; Knight, I. (Editors). 1992. A prescribed burning guide for young regrowth forests of Silvertop ash. Forests Commission of New South Wales, Research Paper No. 16. Research Division, Sydney, New South Wales. 87 pages.

Cheney, N.P. 1981. Fire behaviour. Pages 151-175 *in* Gill, A.M.; Groves, R.H.; Noble, I.R. (Editors). Fire and the Australian Biota. Australian Academy of Science, Canberra, Australian Capital Territory.

Dennis, F.C. 1983. Fuelbreak guidelines for forested subdivisions. Colorado State Forest Service, CSFS 102-1083. Colorado State University, Fort Collins, Colorado. 16 pages.

Evans, B. 1983. Revegetation manual: a guide to revegetation using New Zealand native plants. Queen Elizabeth the Second National Trust, New Zealand.

Fogarty, L.G.; Pearce, H.G.; Catchpole, W.R.; Alexander, M.E. 1998. Adoption vs. adaptation: lessons from applying the Canadian Forest Fire Danger Rating System in New Zealand. Pages 1011-1028 *in* Viegas, D.X. (Editor). Proceedings of the 3rd International Conference

on Forest Fire Research and 14th Fire and Forest Meteorology Conference, Luso, Coimbra, Portugal, 16-20 November, 1998. University of Coimbra, Portugal.
Hutt City Council. 1996. Fire resistant plants for fire-prone areas. Hutt City Council, Home Gardening in the Hutt Series, No. 5. (August 1996). (Pamphlet).
Johnson, V.J. 1975. Hardwood fuel-breaks for north eastern United States. Journal of Forestry 73(9): 588-589.
Kiil, A.D.; Grigel, J.E. 1969. The May 1968 forest conflagrations in central Alberta - a review of fire weather, fuels and fire behaviour. Canadian Department of Fisheries and Forests, Forestry Branch, Information Report A-X-24. Forest Research Laboratory, Calgary, Alberta. 36 pages.
Luke, R.H.; McArthur, A.G. 1978. Bushfires in Australia. First edition. Australian Government Publishing Service, Canberra, Australian Capital Territory. 359 p.
McArthur, A.G. 1962. Control burning in eucalypt forests. Commonwealth of Australia, Department of National Development, Forestry Timber Bureau, Leaflet No 80. Forestry Research Institute, Canberra, Australian Capital Territory. 31 pages.
McArthur, A.G. 1967. Fire behaviour in eucalypt forests. Commonwealth of Australia, Department of National Development, Forestry Timber Bureau, Leaflet No 107. Forestry Research Institute, Canberra, Australian Capital Territory. 36 pages.
Moore, J. 1991. On the edge: management options for plantation edges. Ministry of Forestry, New Zealand. 20 pages.
Nicholls, J.W.P; Cheney, N.P. 1974. Effect of experimental and wildfires in pine plantations on wood characteristics. Australian Forestry 36(3): 164-177.
NZ Fire Research. 2000. Flammability of native plant species: a guide to reducing fire hazard around your home. Forest Research, Christchurch in association with the New Zealand Fire Service Commission and National Rural Fire Authority, Wellington. (Pamphlet).
Pollock, K.M. 1986. Plant materials handbook for soil conservation. Volume 3: Native Plants. Water and Soils Miscellaneous Publication No. 95. Department of Scientific and Industrial Research, Lincoln.
Porteous, T. 1993. Native Forest Restoration: a practical guide for landowners. Queen Elizabeth the Second National Trust, Wellington.
Rothermel, R.C. 1972. A mathematical model for predicting fire spread in wildland fuels. U.S. Department of Agriculture, Forest Service, Research Paper INT-115. Intermountain Forest and Range Experiment Station, Ogden, Utah. 40 pages.
Schmidt, W.C.; Wakimoto, R.H. 1988. Cultural practices that can reduce fire hazards to homes in the interior west. Pages 131-141 *in* Fischer, W.C.; Arno, S.F. (Compilers). Protecting People and Homes from Wildfire in the Interior West: Proceedings of the Symposium and Workshop, October 6-8, 1987, Missoula, Montana. U.S. Department of Agriculture, Forest Service, General Technical Report INT-251. Intermountain Research Station, Ogden, Utah.
Simpfendorfer, K.J. 1989. Trees, farms and fires. Department of Conservation, Forest and Lands, Lands and Forests Bulletin No. 30. Lands and Forest Division, Victoria. 55 pages.
Snedecor, G.W.; Cochran, W.G. 1972. Statistical Methods. Sixth edition. The Iowa University Press. 593 pages.
Sneeuwjagt, R.J.; Peet, G.B. 1985. Forest fire behaviour tables for Western Australia. Third edition. Department of Conservation and Land Management, Perth, Western Australia. 59 pages.
Underwood, R.J.; Sneeuwjagt, R.J.; Styles, H.G. 1985. The contribution of prescribed burning to forest fire control in Western Australia: case studies. Pages 153-170 *in* Ford, J.R. (Editor). Symposium on Fire Ecology and Management in Western Australian Ecosystems, May 1985.

Valentine, J.M. 1978. Fire danger rating in New Zealand - review and evaluation. New Zealand Forest Service, Forest Establishment Report No. 123. Forest Research Institute, Production Forestry Division, Rotorua. 53 pages. (unpublished).

Wilson, A.A.G. 1984. Assessing the bushfire hazard of houses: a quantitative approach. National Centre for Rural Fire Research, Technical Paper No. 6. Chisholm Institute of Technology, Melbourne. 16 pages.

Wilson, A.A.G. 1988. A simple device for calculating the probability of a house surviving a bushfire. Australian Forestry 51(2): 119-123.

Wilson, A.A.G. 1992. Assessing fire hazard on public lands in Victoria: fire management needs, and practical research objectives. Department of Conservation and Environment, Research Report No. 31. Fire Management Branch, Melbourne, Victoria. 16 pages.

Wilson, A.A.G. 1993. Elevated fuel guide. Department of Conservation and Natural Resources, Research Report No. 35. Fire Protection Branch, Victoria. 22 pages.

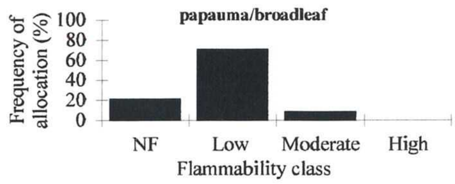
Appendices

Appendix 1. Flammability guide for 42 native New Zealand trees and shrubs – alphabetical list of species with flammability class.

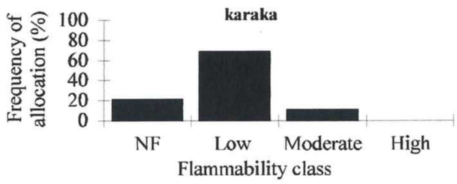
Botanical Name	Maori/European Name	Flammability class
Agathis australis	kauri	Moderate
Aristotelia serrata	makomako/wineberry	Low/Moderate
Beilschmiedia tawa	tawa	Moderate
Carpodetus serratus	putaputaweta	Low
Coprosma grandifolia	raurekau, kanono	Low
Coprosma repens	taupata	Low
Coprosma robusta	karamu	Low
Cordyline australis	ti kouka/cabbage tree	Low/Moderate
Coriaria arborea	tutu	Low/Moderate
Corynocarpus laevigatus	karaka	Low
Cyathea and *Dicksonia* spp.	tree ferns	Moderate/High
Cyathodes fasciculata	mingimingi	Moderate/High
Dacrydium cupressinum	rimu	Moderate
Dodonea viscosa	ake ake	Moderate/High
Fuchsia excorticata	kotukutuku/fuchsia	Low
Geniostoma ligustrifolium	hangehange	Low
Griselinia littoralis	papauma/broadleaf	Low
Griselinia lucida	puka	Low
Hebe salicifolia and *H. stricta*	koromiko	Low/Moderate
Hoheria spp.	houhere/hoheria/lacebark	Low/Moderate
Knightia excelsa	rewarewa	Low/Moderate
Kunzea ericoides	kanuka	High
Leptospermum scoparium	manuka	High
Macropiper excelsum	kawakawa/pepper tree	Low
Melicytus lanceolatus	mahoe wao	Low/Moderate
Melicytus ramiflorus	mahoe/whiteywood	Low/Moderate
Metrosideros umbellata	southern rata	Moderate
Myoporum laetum	ngaio	Low/Moderate
Nothofagus menziesii	tawhai/silver beech	Low/Moderate
Phormium cookianum and *P. tenax*	flax/harakeke	Moderate/High
Phyllocladus glaucus	toatoa	Low/Moderate
Pittosporum crassifolium	karo	Low/Moderate
Pittosporum eugenioides	tarata/lemonwood	Low/Moderate
Pittosporum tenuifolium	kohuhu	Moderate
Plagianthus regius	manatu/ribbonwood	Low/Moderate
Podocarpus dacrydioides	kahikatea/white pine	Moderate
Podocarpus totara	totara	Moderate/High
Psuedopanax arboreum	five finger	Low
Pseudopanax crassifolius	horoeke/lancewood	Low
Solanum aviculare	poroporo	Low
Weinmannia racemosa	kamahi	Low/Moderate
Weinmannia silvicola	tawhero/towhai	Moderate

Appendix 2. Flammability guide for 42 native New Zealand trees and shrubs – list of species ranked by flammability class, with summaries of factors relating to their flammability characteristics. Graphs show frequency of allocation to flammability class (%) by respondents.

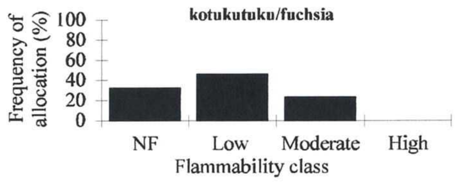
Species Name: *Griselinia littoralis*
Relative ranking: 1
Flammability class: Low
Comments: Broad, succulent leaves do not ignite easily. Flaky bark may burn and provide embers for spot fires under Extreme fire danger conditions.



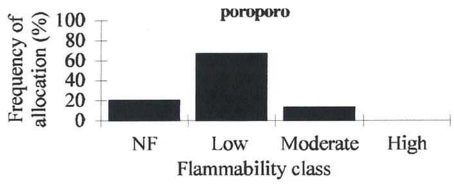
Species Name: *Corynocarpus laevigatus*
Relative ranking: 2
Flammability class: Low
Comments: None received.



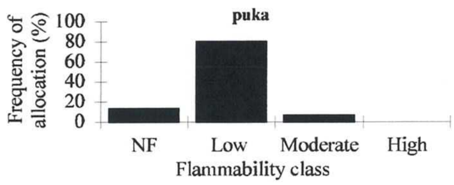
Species Name: *Fuchsia excorticata*
Relative ranking: 3
Flammability class: Low
Comments: Flaky bark is flammable. Deciduous. Litter may need to be removed in spring, but the surface litter is often damp and difficult to ignite on favourable sites.



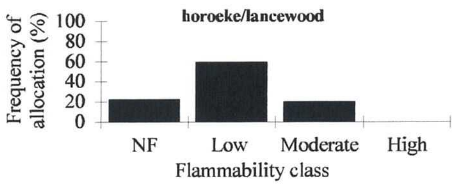
Species Name: *Solanum aviculare*
Relative ranking: 4
Flammability class: Low
Comments: None received.



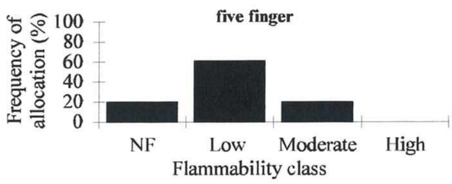
Species Name: *Griselinia lucida*
Relative ranking: 5
Flammability class: Low
Comments: Broad, succulent leaves do not ignite easily. Flaky bark may burn and provide embers for spot fires under Extreme fire danger conditions.



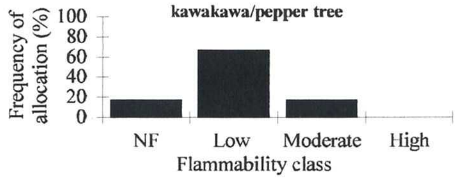
Species Name: *Pseudopanax crassifolius*
Relative ranking: 6
Flammability class: Low
Comments: Will carry a fire if planted on dry infertile sites, or in mixed scrub.



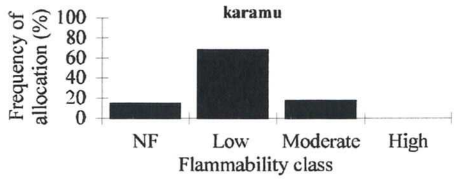
Species Name: *Pseudopanax arboreum*
Relative ranking: 7
Flammability class: Low
Comments: None received.



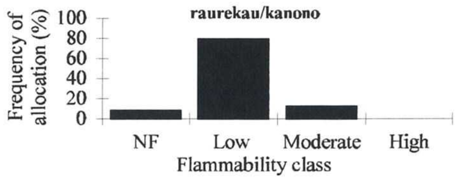
Species Name: *Macropiper excelsum*
Relative ranking: 8
Flammability class: Low
Comments: None received.



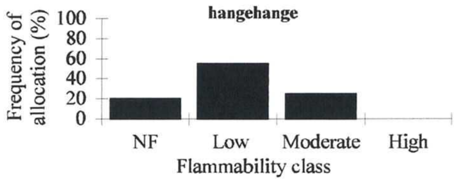
Species Name: *Coprosma robusta*
Relative ranking: 9
Flammability class: Low
Comments: Can produce large amounts of surface litter.



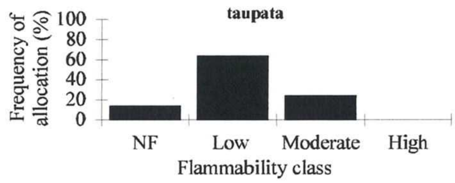
Species Name: *Coprosma grandifolia*
Relative ranking: 10
Flammability class: Low
Comments: None received.



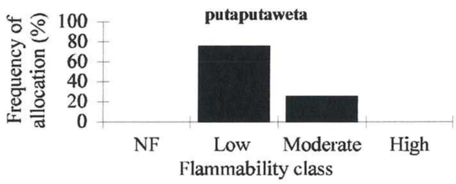
Species Name: *Geniostoma ligustrifolium*
Relative ranking: 11
Flammability class: Low
Comments: None received.



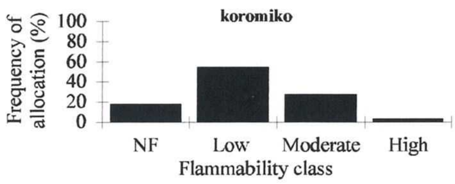
Species Name: *Coprosma repens*
Relative ranking: 12
Flammability class: Low
Comments: None received.



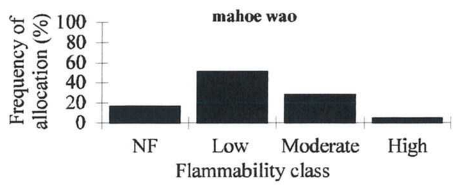
Species Name: *Carpodetus serratus*
Relative ranking: 13
Flammability class: Low
Comments: None received.



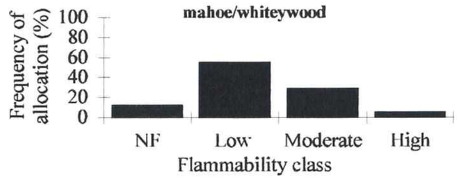
Species Name: *Hebe salicifolia* and *H. stricta.*
Relative ranking: 14
Flammability class: Low/Moderate
Comments: Must be planted densely to maintain moisture in surface litter layers. Will burn readily at Moderate to High fire danger conditions on dry sites or when sparsely mixed with more flammable scrub.



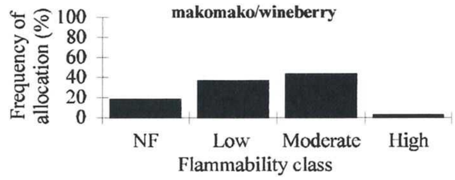
Species Name: *Melicytus lanceolatus*
Relative ranking: 15
Flammability class: Low/Moderate
Comments: None received.



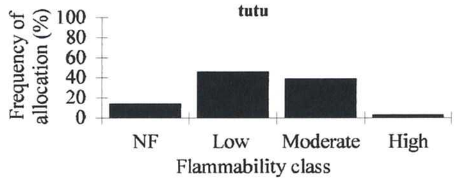
Species Name: *Melicytus ramiflorus*
Relative ranking: 16
Flammability class: Low/Moderate
Comments: Becomes more flammable with age.



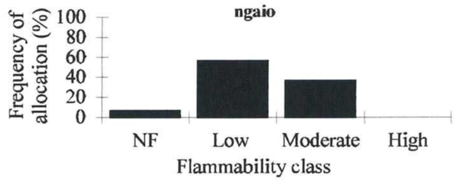
Species Name: *Aristotelia serrata*
Relative ranking: 17
Flammability class: Low/Moderate
Comments: Produces elevated dead material that should be removed annually near homes and structures. Partially deciduous in colder climates. Litter may need to be removed in spring.



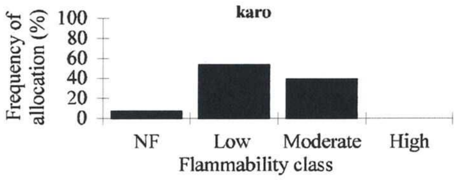
Species Name: *Coriaria arborea*
Relative ranking: 18
Flammability class: Low/Moderate
Comments: Surface litter accumulation can be heavy. Old plants may have Moderate to High flammability.



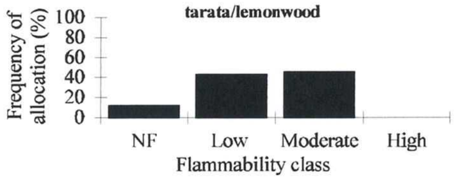
Species Name: *Myoporum laetum*
Relative ranking: 19
Flammability class: Low/Moderate
Comments: None received.



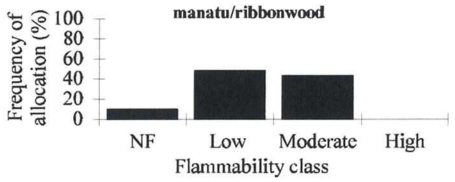
Species Name: *Pittosporum crassifolium*
Relative ranking: 20
Flammability class: Low/Moderate
Comments: None received.



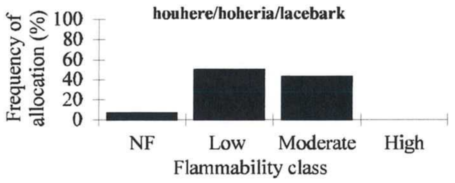
Species Name: *Pittosporum eugenioides*
Relative ranking: 21
Flammability class: Low/Moderate
Comments: Old plants may have Moderate flammability.



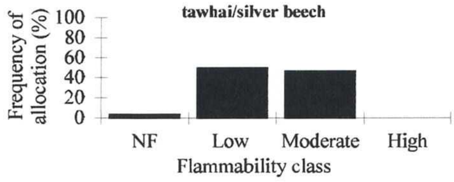
Species Name: *Plagianthus regius*
Relative ranking: 22
Flammability class: Low/Moderate
Comments: Deciduous. Litter may need to be removed in spring.



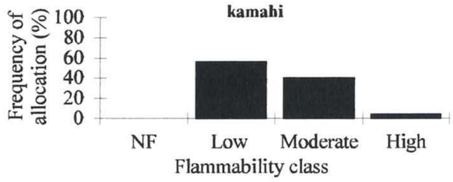
Species Name: *Hoheria* spp.
Relative ranking: 23
Flammability class: Low/Moderate
Comments: None received.



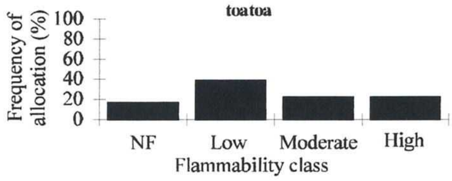
Species Name: *Nothofagus menziesii*
Relative ranking: 24
Flammability class: Low/Moderate
Comments: More flammable when immature. Mature trees often have dead branches that ignite easily and provide embers for spot fires.



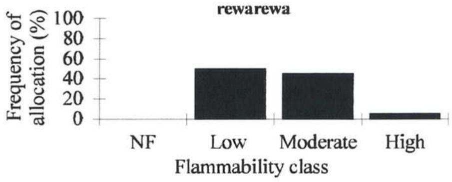
Species Name: *Weinmannia racemosa*
Relative ranking: 25
Flammability class: Low/Moderate
Comments: Mature stands may be less flammable.



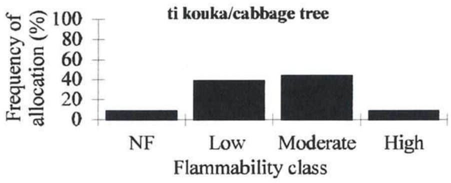
Species Name: *Phyllocladus glaucus*
Relative ranking: 26
Flammability class: Low/Moderate
Comments: None received.



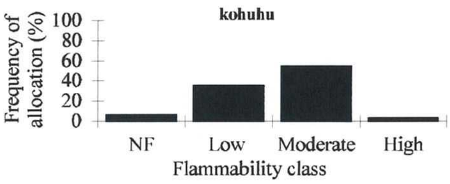
Species Name: *Knightia excelsa*
Relative ranking: 27
Flammability class: Low/Moderate
Comments: Large quantities of litter (leaves and twigs) often accumulate. Near houses or in "green breaks", this material must be removed.



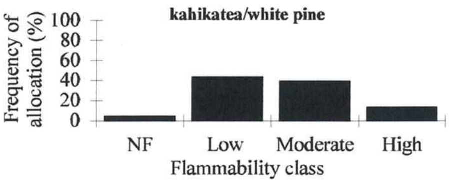
Species Name: *Cordyline australis*
Relative ranking: 28
Flammability class: Low/Moderate
Comments: Flammability increases with age due to elevated dead material. Old trees have High flammability. Near houses or in "green breaks", flammable material must be removed.



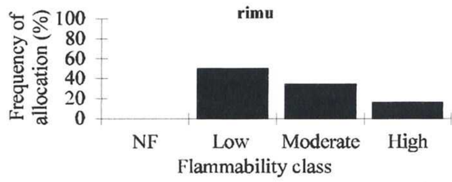
Species Name: *Pittosporum tenuifolium*
Relative ranking: 29
Flammability class: Moderate
Comments: None received.



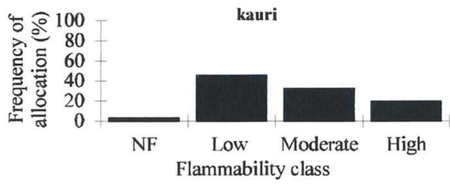
Species Name: *Podocarpus dacrydioides*
Relative ranking: 30
Flammability class: Moderate
Comments: Flammability may decrease with age. Mature trees often have dead branches that ignite easily and provide embers for spot fires.



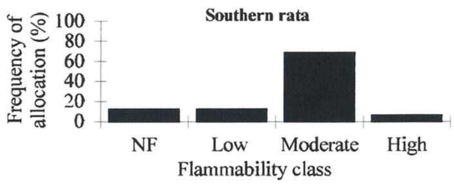
Species Name: *Dacrydium cupressinum*
Relative ranking: 31
Flammability class: Moderate
Comments: Flammability changes with age, and may be Moderate/High when very young; Low/Moderate when mature. Dead stem and branch material in overmature trees is susceptible to ignition from airborne embers.



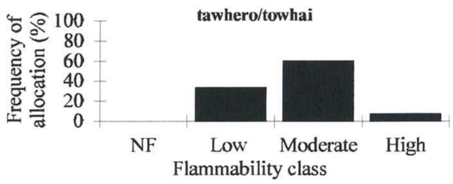
Species Name: *Agathis australis*
Relative ranking: 32
Flammability class: Moderate
Comments: None received.



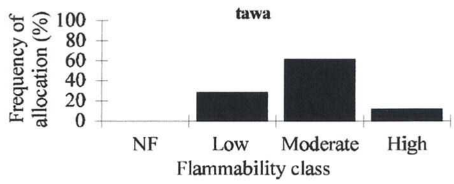
Species Name: *Metrosideros umbellata*
Relative ranking: 33
Flammability class: Moderate
Comments: None received.



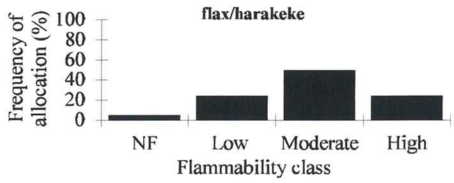
Species Name: *Weinmannia silvicola*
Relative ranking: 34
Flammability class: Moderate
Comments: None received.



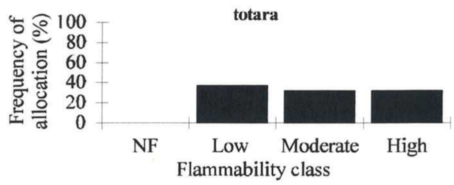
Species Name: *Beilschmiedia tawa*
Relative ranking: 35
Flammability class: Moderate
Comments: Large quantities of litter often accumulate. Near houses or in "green breaks", this material must be removed.



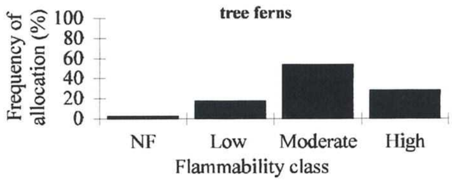
Species Name: *Phormium cookianum* and *P. tenax*
Relative ranking: 36
Flammability class: Moderate/High
Comments: Becomes more flammable with age due to build up of dead material. Has been observed to "explode" when burnt in Very High and Extreme fire danger conditions. Flammability increases in drought conditions.



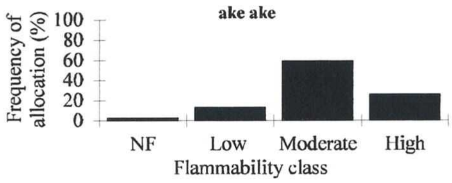
Species Name: *Podocarpus totara*
Relative ranking: 37
Flammability class: Moderate/High
Comments: Flammability changes with age, and may be Moderate/High when young; Low/Moderate when mature. Dead stem and branch material in overmature trees is susceptible to ignition from airborne embers.



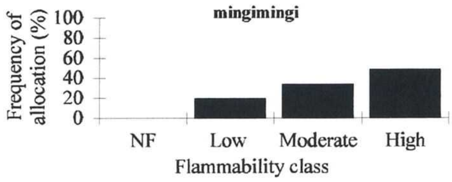
Species Name: *Cyathea* and *Dicksonia* spp.
Relative ranking: 38
Flammability class: Moderate/High
Comments: Carries elevated dead material that assists fire spread, and increases fire intensity.



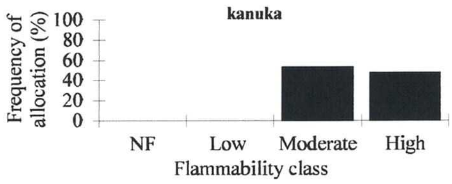
Species Name: *Dodonea viscosa*
Relative ranking: 39
Flammability class: Moderate/High
Comments: Flaky bark and flammable foliage.



Species Name: *Cyathodes fasciculata*
Relative ranking: 40
Flammability class: Moderate/High
Comments: None received.



Species Name: *Kunzea ericoides*
Relative ranking: 41
Flammability class: High
Comments: Flammability changes from High when young to Moderate when mature. Mature stands with a flammable understorey that can provide a "ladder" for fire spread into the crowns have High flammability.



Species Name: *Leptospermum scoparium*
Relative ranking: 42
Flammability class: High
Comments: Flammability changes from High when young to Moderate when older.