# Department of Conservation fire research needs analysis

## Report on a project to implement Recommendation 7 of DOC's Fire Management Systems Audit

Department of Conservation
*Te Papa Atawhai*

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## Report on a project to implement Recommendation 7 of DOC's Fire Management Systems Audit

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Report on a project to implement Recommendation 7 of DOC's Fire Management Systems Audit:

*Recommendation 7: That the Director General tasks the General Manager of Research, Development & Improvement Division to carry out a fire research needs analysis to determine the gaps in DOC's knowledge by June 06. The analysis should focus on:*

- *What research is needed to support management's decisions toward achieving fire management objectives, taking into account the fire research undertaken by Ensis (formally Forest Research).*
- *Determining whether fire ecology research has a place in New Zealand (DOC), or not.*

(DOC 2005b)

Cover: View of the Mount Benger research burn, Otago (31 March 2006).
*Photo: Stephen Jaquiery, Otago Daily Times.*

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# 1. Executive summary

## 1.1 CONTEXT

In 2005, an internal audit report of the Department of Conservation's (DOC's) fire management was published (DOC 2005b). It identified issues and made recommendations for improvements to support DOC's desired national and regional direction for fire management. Recommendation 7 of this audit stated:

> *That the Director General tasks the General Manager of Research, Development & Improvement Division to carry out a fire research needs analysis to determine the gaps in DOC's knowledge by June 06. The analysis should focus on:*
>
> - *What research is needed to support management's decisions toward achieving fire management objectives, taking into account the fire research undertaken by Ensis (formally Forest Research).*
> - *Determining whether fire ecology research has a place in New Zealand (DOC), or not.* (DOC 2005b)

Since then, through the preparation of two national policy documents—General policy for National Parks (NZCA 2005) and Conservation General Policy (DOC 2005a)—DOC has had a major change in focus with regard to fire, with an emphasis now on 'fire management' rather than 'fire suppression'. As a result, DOC is adopting a much broader approach to its fire management responsibilities, for both research and management.

## 1.2 GENERAL IMPRESSIONS

There is considerable direct and indirect fire research being carried out in New Zealand. Major players are Ensis (formerly Forest Research), Landcare Research, AgResearch and DOC. In addition, this report draws on the results of Australian research, in particular that by the Bushfire Cooperative Research Centre (CRC).

Little information has been collected and collated in a form that can be easily understood by DOC managers, however, especially those who implement fire management. The analysis of gaps has revealed a lack of decision-making tools for managers; an ineffective transfer of technical knowledge; incomplete field testing to validate research; and gaps in the social and ecological research available to inform decisions.

The response to the question of whether DOC has a role in researching fire ecology was a resounding 'yes'. Many people believe that, because of DOC's mission and vision statements, and its responsibility for so much of New Zealand's landmass, DOC should lead fire ecology research in New Zealand. This sentiment is consistent with the shift in DOC's policies to fire management (which includes such issues as managing fire risk, fire regimes and prescribed burns for ecosystem management). Information gathered in preparing this report supports the view that understanding fire ecology (i.e. fire's impact on ecosystems and species) is fundamental to nature conservation and will enable DOC to make better conservation management decisions.

## 1.3 ISSUES

The analysis revealed several issues that DOC must consider before Recommendation 7 of the fire management audit can be fully addressed. The most significant of these are:

- An assessment of the implications of the new General Policies for the Conservation Act and National Parks Act
- An assessment of the implications of the outcome of the Department of Internal Affairs' review of fire legislation and the delivery of fire and rescue services
- An assessment of the implications of the Land Tenure Review process, which will bring vast tracts of land (> 600 000 ha by 2009) in fire-prone regions under DOC responsibility
- The need for DOC to formulate long-term fire management policies and approaches, supported by good science
- The role of the conservancies' 10-year Conservation Management Strategies, which are due for review, in helping guide DOC's on-the-ground fire management and research
- The need for succession planning to cover key departmental fire positions where current incumbents are approaching retirement
- The need for a methodology to effectively transfer the considerable amount of existing and pending technical information and fire-related research to departmental managers and staff

DOC must also work on its own and in collaboration with other agencies to plug important gaps in knowledge and tools

## 1.4 OPPORTUNITIES

Some good models for fire management and research are available, or are being developed, that can help direct future work. These include decision-making tools and frameworks for analysing issues and identifying future needs and directions.

This report presents a model derived from common themes raised during interviews—the model's 13-part structure was used to identify:

- Research that already exists or is underway
- Further research that is needed

To enable the findings of this report to be implemented, it is critical that a strategic management document be developed to address the issues identified and to guide DOC through the implications of new fire legislation, including any impacts on staffing and resources. The strategic document also needs to address policy issues, particularly:

- DOC's philosophy on fire as part of land management
- Social research
- Ecological research
- Establishing fire management principles

## 1.5 OPPORTUNITIES FOR SIGNIFICANT IMPROVEMENT

The author believes that DOC will achieve significant improvement in its fire management if it focuses on two national goals:

- Set and maintain a framework outlining DOC's philosophy on fire management, and use this to guide the development of a national strategy direction regarding fire
- Establish strong links between researchers and practitioners within DOC and other relevant agencies to help ensure that research is coordinated, opportunities to collaborate are identified and acted on, and technical information and research outcomes are effectively transferred to practitioners

## 1.6 RECOMMENDATIONS

The following recommendations for the General Manager of Research, Development & Improvement Division (GM RD&I) are derived from the two areas for improvement outlined above and the key findings in section 3:

1. That the GM RD&I receives this report, and discusses the findings with the two General Managers Operations, the Chief Scientist, the Terrestrial Conservation Unit Manager and the National Fire Coordinator.
2. That the GM RD&I tasks the Terrestrial Conservation Unit Manager to establish a Senior Technical Support Officer (Fire) role to support the National Fire Coordinator in implementing the recommendations of this report and the 2005 internal audit of fire management systems. Key tasks are to:
    - Ensure that there are links between fire researchers and other researchers to promote the benefits of fire management to decision makers
    - Ensure that there are links between fire researchers and all levels of management in DOC
    - Coordinate research and its technical transfer
    - Oversee the development and implementation of strategic planning

3. That the GM RD&I tasks the Terrestrial Conservation Unit Manager to:
   - Continue to support and complete current fire research (this includes the 'Actions' identified in section 4)
   - Seek opportunities to collaborate with other DOC staff and researchers—for example, by including fire ecology in the Natural Heritage Management System (NHMS) and DOC's inventory and monitoring programme, and by undertaking social research related to fire
   - Actively participate in the Fire Research Advisory Group
4. That the GM RD&I tasks the Terrestrial Conservation Unit Manager to prepare a departmental 'Fire Research Plan'.
5. That the GM RD&I tasks the Terrestrial Conservation Unit Manager to support the Rural Fire Research Advisory Committee to convene, manage and fund a national workshop on fire management to debate fire ecology in New Zealand. Participation should be required from research providers and key DOC staff (including scientists).
6. That the GM RD&I tasks the Terrestrial Conservation Unit Manager to set and maintain a framework outlining DOC's philosophy on fire that will enable DOC to undertake proactive fire management.
7. That the GM RD&I agrees with the schedule of other recommendations in the body of this report and tasks the relevant DOC staff to action, as per the attached summary of recommendations in section 3.2.1, Table 3. This includes collaboration between General Managers and other organisations in New Zealand with an interest in fire management and research.

# 2. Introduction

The Department of Conservation (DOC) is the major land management agency in New Zealand. Through the Minister of Conservation, it is the Fire Authority for about 30% of the country's landmass, and is responsible for safeguarding life and property by preventing, detecting, controlling, restricting, suppressing and extinguishing fire in forest and rural areas, and other areas of vegetation (Forest and Rural Fires Act 1977).

Fire has played a major part in shaping New Zealand ecosystems, especially over the past 800 years. Many ecosystems have been exposed to some form of disturbance, with many natural processes severely modified by human activity, including fire. Even today, change remains a constant, with new land uses bringing new pressures. For example, high-country lands that were retired as part of the Land Tenure Review process form 'dryland' tussock grasslands and have new use issues, as do the lowland wetlands drained for farmland.

These modified ecosystems are often seen as 'natural' by the public of New Zealand, but what is natural? Philosophical questions that DOC faces as it seeks to clarify its role in managing fire include:

- Are these modified ecosystems to be maintained in their current state?
- If they are to be maintained in a certain state, what techniques, such as fire, should be used to maintain them?

This report, an analysis of DOC's fire research needs, fulfils Recommendation 7 of the internal audit of fire management systems carried out in March 2005:

> *Recommendation 7: That the Director General tasks the General Manager of Research, Development & Improvement Division to carry out a fire research needs analysis to determine the gaps in DOC's knowledge by June 2006. The analysis should focus on:*
>
> - *What research is needed to support management's decisions toward achieving fire management objectives, taking into account the fire research undertaken by Ensis (formally Forest Research).*
> - *Determining whether fire ecology research has a place in New Zealand (DOC), or not.* (DOC 2005b)

In accordance with that recommendation, the analysis focused on:

- What research DOC needs to carry out to support management decisions to achieve its fire management objectives—taking into account fire research undertaken by Ensis (formally Forest Research)
- Determining whether DOC should engage in fire ecology research

Specifically, a Terms of Reference (Hilliard & Hunt 2005) asked the analysis to complete a fire management research needs analysis for DOC, taking into account the findings of the internal audit into fire management systems. This included:

- Identifying the current and future fire research needs of DOC
- Considering the current and future fire research being carried out in New Zealand and the Australian Bushfire Cooperative Research Centre (CRC) that directly relates to DOC
- Assessing the 'gap' between DOC's needs and the current research environment
- Identifying approaches DOC can use to ensure adequate and appropriate fire research (including fire ecology) is undertaken that can be applied to fire management

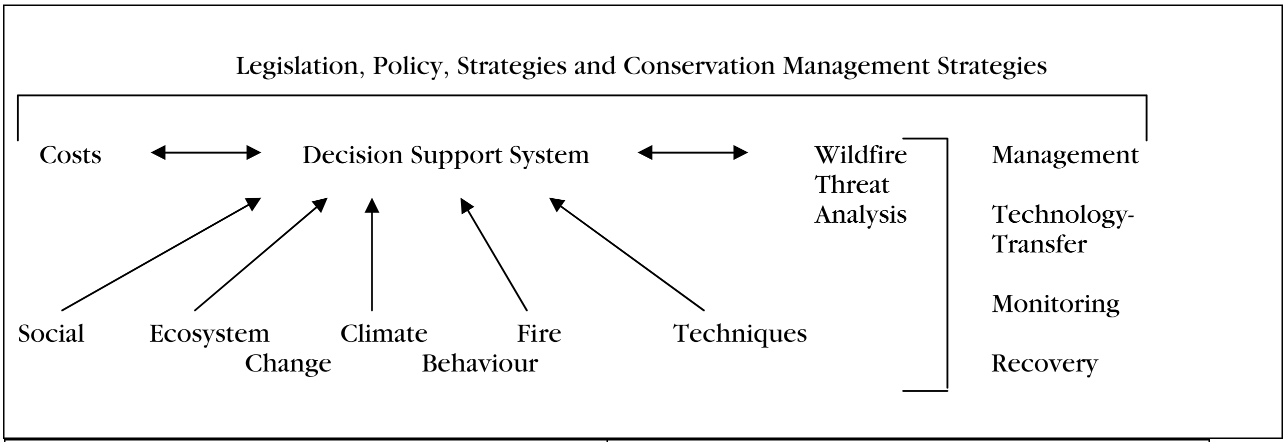
To deliver the analysis, the author interviewed a wide range of staff in DOC and several other agencies. The latter included the National Rural Fire Authority (NRFA) and science providers engaged by DOC to deliver research on ecosystem and conservation management (see Appendix 1 for a glossary of terms used in this report). The methodology for this project is described in Appendix 2.

To facilitate the collating of interview responses, a 13-part model of fire management was developed and the responses were analysed according to the model's 13 themes (see Fig. 1). This resulted in a list of 64 specific actions that the author believes will address DOC's research needs and gaps. These actions have been analysed to determine their priority and urgency. The research organisations capable of carrying out the necessary research have also been identified.

The author appreciates the cooperation and openness of all people interviewed during the development of this report.

The report's structure is as follows:

- Section 3 overviews the main findings, thus addressing the questions raised in the 2005 internal audit about research gaps and the place of fire ecology research, and provides a national overview of what DOC can do to improve fire management
- Section 4 lists the 64 specific actions that the author believes will help meet DOC's fire research needs
- Section 5 introduces the main agencies involved in fire management and fire research in Australia and New Zealand, and summarises their current and planned activities
- Section 6 is the Acknowledgements, and Section 7 lists the References
- The appendices provide background detail to inform the report and its findings, such as a glossary, the methodology of the interview process, an outline of the model, and summaries of current funding in fire research




**Legislation, Policy, Strategies & Conservancy Conservation Management Strategies**
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- Conservation Management Strategies

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**Monitoring**
**Recovery**

Figure 1. Model of fire management—the analysis tool underpinning this report. (To help make sense of the information gathered from the 80 people interviewed, the author identified the components of the framework that DOC calls 'Fire management'. Analysis led to the 13-part model shown. Information gathered during interviews has been collated and grouped according to its headings, including the suite of 64 actions described in section 4.1.)

# 3. Key findings

This section presents the key findings that address the questions raised in the 2005 internal audit relating to identifying DOC's research needs and gaps, and establishing whether there is a need for research into fire ecology:

- 3.1 Provides the context of fire management in New Zealand today
- 3.2 Summarises the research needs and gaps
- 3.3 Makes the case for DOC's involvement in research into fire ecology

## 3.1 THE CONTEXT

### 3.1.1 Managing fire

Because it manages approximately 30% of New Zealand's landmass, DOC has a significant role as a Fire Authority in managing wildfires[1]. To that end, it spends a considerable amount of money each year on fire management—about NZ$7.05 million. The size of DOC's role, and its budget, is shown in Table 1. (Refer to Appendix 1 for the definitions of some of the terms used.)

The NRFA is responsible for coordinating rural fire management activities throughout New Zealand. Activities include:

- Regional rural fire control
- Monitoring, evaluating and auditing regional Rural Fire Authorities
- Setting national standards
- Monitoring fire danger conditions throughout the country
- Administering the Rural Fire Fighting Fund
- Providing technical advice
- Providing grants to regional Rural Fire Authorities
- Promoting and encouraging research into matters relating to rural fire control
- Promoting and encouraging training and education of personnel engaged in rural fire control

The NRFA coordinates two committees that have a bearing on fire research: the National Rural Fire Advisory Committee and the Rural Fire Research Advisory Committee. The former involves the NRFA, the New

[1] Under the Forest and Rural Fires Act 1977, the Minister of Conservation is the Fire Authority for each State area. All the Minister's powers are delegated to the General Managers Operations (North and South), Conservators and Deputy Principal Rural Fire Officers.

TABLE 1. SIZE OF DOC'S ROLE AND BUDGET IN MANAGING WILDFIRES, 1 JULY 2000 – 30 JUNE 2005.

| FIRE MANAGEMENT | TOTALS |
|---|---|
| Number of fires | 621, as follows:<br>• 323 within the fire safety margin<br>• 223 within the DOC State area<br>• 75 on DOC land within Rural Fire District |
| Area burnt | 4388 ha, as follows:<br>• 914 within the fire safety margin<br>• 3129 within the DOC State area<br>• 345 on DOC land within the Rural Fire District |
| Amount spent on fire suppression | NZ$6,819,791 on fire suppression, as follows:<br>• $1,256,337 within the fire safety margin<br>• $4,766,284 within the DOC State area<br>• $797,170 on DOC land within the Rural Fire District<br>This is a best estimate, as DOC identifies around $4 million of operational funds for fire control each year (including fire suppression), but the figure does not include salaries or wages. |
| Amount spent on training (annually) | $120,000 |
| Amount spent on research contributions (annually) | $60,000, with about $50,000 on in-kind support. This funding goes mainly to Ensis and Otago Conservancy projects. |

Zealand Fire Service, DOC (represented by the National Fire Coordinator), the New Zealand Defence Force, Local Government New Zealand, the New Zealand Forest Owners Association and Federated Farmers of New Zealand (Inc).

### 3.1.2 Research

Four main groups are involved in fire research in New Zealand. Fire science research is undertaken by Ensis. Ecological research is conducted by Landcare Research, AgResearch and DOC. DOC also has some involvement in Australian fire research carried out by the Bushfire CRC (see Appendices 3 and 4 for more detail) and can access its results. There is some collaboration between all the above groups and other organisations.

Considerable fire-related research has been undertaken in New Zealand with several major projects currently underway. These include two experimental burns, fuel type and fuel load maps (Opperman & Coquerel 2005). Some projects, such as the Wildfire Threat Analysis, have been completed and require validation. The findings and recommendations from these projects need to be distributed and tested by practitioners, and improvements identified, if required.

An ongoing problem is inadequate transfer of the results from these and other projects, both within DOC and to DOC.

While ongoing and consistent funding of research has been difficult to obtain, recently some stabilisation funding has been both applied for and received from the Foundation for Research, Science and Technology (FRST) (see Appendices 4 and 5 for more information on FRST).

## 3.2 NEEDS AND GAPS

To fulfil Recommendation 7 of the 2005 internal audit of DOC's fire management, this project was asked to identify:

> *What research is needed to support management's decisions toward achieving fire management objectives, taking into account the fire research undertaken by Ensis* (DOC 2005b)

Table 2 summarises the identified national gaps. Some gaps are due to an absence of actual research and information, whereas others are gaps in DOC's strategic and management frameworks. The latter must be filled to enable DOC to gather the relevant information and use it effectively.

These needs are presented according to a 13-part fire management model (see Fig. 1) developed to facilitate the analysis of the large amount of information gathered during the preparation of this report.

### 3.2.1 Author's views

Fire research needs to fit with, support and help DOC deliver on its legal, policy and strategic mandates. Although a DOC strategy on fire management is in preparation, at present the strategic part of this framework is lacking. It is not yet clear how changes to the Conservation General Policy[2] will influence the role of the conservancies' 10-year Conservation Management Strategies (CMSs) in providing for fire management. This needs to be established.

There are various approaches DOC can take to ensure that adequate fire research is undertaken, that the research supports DOC's strategic and policy directions, and that the results are effectively communicated to staff.

While much of this relies on recognition and raised awareness of the need for fire research, it also relies on DOC having the necessary tools, techniques, models and relationships with other agencies to deliver relevant research, and to effectively transfer the outcomes to operational practitioners.

Therefore, besides needing to clarify its strategic and policy directions, DOC also needs some infrastructure changes. In particular, it needs to:

- Put in place appropriate management structures and establish positions to manage contracts and staff, and provide legal advice.
- Adopt or develop models to help define management processes and key relationships.

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[2] See Section 4.3 (a and b) of the Conservation General Policy (DOC 2005a) and see Appendix 6.

TABLE 2. IDENTIFIED GAPS AND NEEDS IN THE NATIONAL FIRE MANAGEMENT MODEL.

| 13-PART FIRE MANAGEMENT MODEL | NEEDS AND GAPS |
|---|---|
| 1. Policy and strategies | No clear policy on ecosystem management with regard to disturbance and long-term outcomes.<br>No policy direction that would promote acceptance of fire research, especially on lands administered by DOC.<br>National ecosystem models not completed.<br>Strategic direction not set.<br>Social acceptance work required. |
| 2. Decision support systems | Some tools already developed and in use, but require application nationally. For example, a wildfire threat analysis is required to assist in decision making by line managers. |
| 3. Costings | Ongoing work is required to improve the cost-effectiveness of fire management. |
| 4. Wildfire threat analysis | Model established; it needs to be applied nationally and analysis validated. |
| 5. Social | Work begun on staff health.<br>Public perception of DOC's fire management needs to be studied.<br>Tools and techniques required. |
| 6. Ecosystems | Considerable work started in some areas.<br>Threatened ecosystems, especially those highly prone to fire, need to be studied.<br>Studies begun on fire regimes, ecosystem disturbance, fire–plant–invertebrate relationships. Key actions are to complete current projects (e.g. Otago grasslands). |
| 7. Climate change | Identify how fast it is changing and the impacts. |
| 8. Fire behaviour | Complete and validate fuel loading, fuel mapping work.<br>Improve and broaden fire behaviour models. |
| 9. Techniques | Develop biosecurity management of fire-fighting techniques. |
| 10. Management | Research burns (Mt Benger and Torlesse Range) have not been completed, nor has associated fire–plant–invertebrate work. |
| 11. Technical transfer | Current information not being transferred to DOC staff, or the transfer is variable (e.g. information about ecosystems). |
| 12. Monitoring | Not established; a national approach to post-fire monitoring of changes in ecosystems is required. |
| 13. Recovery | No nationally developed policies and procedures for managing social and ecosystem recovery after fires. Some models available (e.g. fencing carried out after the Mt Somers fire of 2004). Variable post-fire recovery work undertaken in New Zealand (e.g. ecosystem restoration and pest plant management). |

- Improve the transfer of technology and information to ensure that research findings are transmitted effectively to all levels of the organisation.
- Improve monitoring—such as by measuring changes in social attitudes to how fire disturbance is managed, and to changes in ecosystems.
- Improve ecosystem recovery after fires—such as by using a team of specialists to begin managing restoration and rehabilitation during the mop-up phase of an incident. They would assess the scale and consequences of the damage from the fire (for more information see Department of the Interior National Interagency BAER Team 2006).

Table 3 provides an overview of the greatest opportunities for DOC to improve its capability in fire management. It should be noted that DOC has received reports on how it can improve its fire management over the years (see Appendix 6) but few of the findings have been followed up. To make the most of the opportunities identified in this report, a commitment is required to follow priority actions through.

TABLE 3. OPPORTUNITIES TO IMPROVE DOC'S FIRE MANAGEMENT CAPABILITY.

| AREA OF OPPORTUNITY | COMMENTS |
|---|---|
| Strategy | 1. DOC needs to develop a long-term (20-year) fire management strategy, with emphasis on identifying key ecosystems for fire management, which includes prescribed burns. The strategy needs to establish clear policy directions, including appropriately recognising and implementing the Conservation General Policy for fire management. |
| | 2. As part of its wider fire management strategy, DOC needs a long-term (10- to 20-year) fire research plan. The plan should help ensure that all DOC fire research supports DOC's fire management strategic directions and policies. It should establish and use models—such as the proposed 13-part fire management model herein, or the Wildland Fire Management Policy adopted in the USA (see strategy 11). |
| Structure and roles | 3. A new position is needed, 'Senior Technical Support Officer (Fire)', to support the National Fire Coordinator in implementing the findings of this report and the recommendations from the internal audit into fire management systems (DOC 2005b).<br>Key tasks are to:<br>• Ensure that there are links between fire researchers and other researchers to promote the benefits of fire management to decision makers<br>• Ensure that there are links between researchers and between researchers and all levels of management in DOC<br>• Coordinate research, and the technical transfer of the results and findings<br>• Oversee the development and implementation of strategic planning |
| Tools | 4. A decision support system is needed to help managers identify ecosystems that require intensive fire management, and those where less intense management is appropriate (such as only for the safeguarding of life and property). These tools will help operational managers assess whether fires should be suppressed or managed (see Appendix 7). |

*Continued on next page*

*Table 3—continued*

| AREA OF OPPORTUNITY | COMMENTS |
|---|---|
| | 5. DOC should continue researching and improving fire fighting techniques and methods. In particular, it should:<br>• Develop fire management plans for lands administered by DOC that are at risk of fire or have a history of fires<br>• Prepare restoration plans to manage sites after fires have burnt through areas of significant conservation value, or when communities request these<br>• Monitor recovery after fires in areas of conservation significance on land administered by DOC |
| Information gathering | 6. DOC should complete a wildfire threat analysis in collaboration and research with all other Rural Fire Authorities.<br>7. DOC should undertake social research on community awareness, especially those communities adjoining the current research burns.<br>8. DOC should promote fire ecology research and advance research identified through the Rural Fire Research Programme and this document. This includes:<br>• Supporting and assisting the completion of fuel accumulation and fuel type research that has begun<br>• Completing and reporting on the current research burns<br>• Further investigating prescribed burns for fuel management, especially on the Tenure Review process lands<br>• Continuing and completing studies of fire-adapted and fire-prone ecosystems and species<br>• Establishing ecosystem monitoring—including DOC research on various aspects of fire management (e.g. post-fire colonisation by pest plants and ecosystem restoration techniques)<br>• Continuing and increasing research on the relationship between pest plants and ecosystem disturbance, especially fire<br>9. The transfer of technology and information associated with current projects to DOC managers and researchers needs to be increased. |
| Collaboration | 10. DOC needs to actively participate on the Fire Research Advisory Group, ensure it is actively involved in the FRST Outcome Based Investment (OBI) programme (see Appendix 5) and become involved in collaborative research, such as supporting the Rural Fire Research Programme, mapping fuel types and fuel loads, and using the Landcover Database 2 (LCDB II) information for fire management purposes.<br>11. Opportunities to undertake collaborative fire ecology and fire-related social research should be sought. To that end, DOC should maintain and increase its role in the Rural Fire Research Programme by:<br>• Contributing funding to the research programme<br>• Providing governance on the direction of the research<br>• Providing departmental resources during research-prescribed burning operations and other specific research work<br>• Providing sites for research-prescribed burning operations<br>12. DOC should convene, manage and fund a national workshop on fire management and debate fire ecology in New Zealand. Participation is required from research providers, the Rural Fire Research Advisory Committee, key DOC staff and scientists. |

## 3.3 FIRE ECOLOGY RESEARCH

The second part of Recommendation 7 that this project was asked to address was:

> *Determining whether fire ecology research has a place in New Zealand (DOC), or not.* (DOC 2005b)

Fire has played a major part in disturbing, modifying and shaping New Zealand ecosystems and landscapes, especially over the last 800 years since the arrival of people (Allen et al. 1996; Rogers et al. 2005). Fire has had a role in spreading pest plants and pest animals, removing forests (with the ensuing problems of hillside erosion and sedimentation of coastal areas), and modifying grasslands and wetlands.

This has created a landscape of fragmented ecosystems in many different stages of disturbance—including lowland tussock grasslands, shrublands and regenerating forest.

The period of changes that began 800 years ago continues as New Zealanders' land uses continue to change, bringing with them new pressures and new issues for those responsible for managing fire. One example is the retirement of high-country lands as part of the Land Tenure Review process. This process is increasing the area of tussock grassland for which DOC is responsible, much of which was induced by fire and maintained by fire and grazing. While not the original and natural environment for these areas, many are now regarded as iconic landscapes of the South Island and there is public pressure to preserve them. On top of this, as grazing ceases and the tussock grows, these lands will be covered with highly flammable fuel, increasing the fire risk (M. Clare & R. McNamara, DOC, pers. comm. 2005). Table 4 shows the amount of new land estimated to come under DOC's management by 30 June 2009 as a result of the Land Tenure Review process.

TABLE 4. LAND TENURE REVIEW—ESTIMATE OF LAND FALLING UNDER DOC MANAGEMENT IN THE SOUTH ISLAND.

| YEAR | CUMULATIVE AREA (ha) |
|---|---|
| 2005–2006 | 309 000 |
| 2006–2007 | 394 000 |
| 2007–2008 | 508 000 |
| 2008–2009 | 600 000 |

Sitting within this context of fragmented ecosystems, constant change and public perceptions, are the recently released General Policies for National Parks[3] and the Conservation General Policy[4]. These policies have shifted DOC's focus from fire suppression to fire management—that is, managing fire risk, fire protection and fire regimes, and prescribed burns for ecosystem management. DOC managers need good science to help them apply these policies.

This shift in DOC's approach is also being driven by the Department of Internal Affairs' current review of fire legislation and the delivery of fire services. This review is likely to bring about a significant change

[3] Section 4.7 Fire Management, in the General policy for national parks (NZCA 2005: 27–28).

[4] Section 4.3 Fire Management, in the Conservation General Policy (DOC 2005: 24).

in how urban and rural fire services are managed and delivered in New Zealand. DOC needs to support its own policies with sound science to ensure that fire management principles and techniques are taken up to enhance biodiversity.

### 3.3.1 Author's views

The author is firmly of the view that fire ecology research has a place in New Zealand, and that DOC should take a lead role in formulating long-term fire management policies and approaches.

Conservation and ecosystem management are human constructs and value systems, so it is critical that DOC understands people's social wants, needs and desires for New Zealand's landscape. This understanding must be based on good social research. However, it is also critical that DOC balances these human needs and desires with an understanding of ecosystem principles and processes, including fire ecology.

Understanding fire ecology as a 'disturbance' of ecosystems and species is fundamental to nature conservation. Research on fire ecology that aims to improve our understanding of natural heritage management will enable DOC to make better conservation management decisions in the future about matters such as fuel reduction burning, letting some fires burn and encouraging succession of fire-resistant vegetation. The need for information resulting from fire- and ecosystem-related research is vital to the public of New Zealand, especially at the local and community level. Thus, DOC needs to gain and employ communication and consultation techniques with communities, and the outcome will be an increase in the general public's understanding of fire ecology on the landscape.

# 4. Meeting DOC's fire research needs

This section details what is required to help fill the knowledge and capability gaps and meet DOC's research needs for fire management. It is a suite of 64 actions.

- Section 4.1 lists the 64 specific actions which, when completed, will deliver DOC's fire research needs
- Section 4.2 gives the author's views on which of the actions need to happen first

## 4.1 SIXTY-FOUR WAYS TO MEET DOC'S FIRE RESEARCH NEEDS

This section presents 64 actions distilled from interviews, which the author believes will help fill the knowledge and capability gaps and meet DOC's current and future research needs to support its role and responsibilities for fire management. They are presented under the 13 headings of the fire management model presented in Fig. 1. (See Appendix 8 for further details of the interviewees' responses.)

Twenty-six of the actions relate to general research that will provide information also useful to fire management, and 38 relate to fire-specific research. Both categories of research are intermingled, as there is considerable overlap, especially when fire management raises both policy and land-management issues. An example is management of tussock grasslands—it entails not only fire management, but also pest plant and pest animal management.

To provide some context for each of the actions, the original need has been written as a research question, and the actions are presented as solutions (i.e. as the tasks that need to be completed in order to address the need).

For each action, the organisations that should lead and/or be involved in the research work have been identified. A key to their various acronyms is provided in Table 5.

TABLE 5. COMMON ACRONYMS FOR ORGANISATIONS INVOLVED IN FIRE RESEARCH.

| ORGANISATION | DIVISION/ACRONYM |
|---|---|
| Department of Conservation | DOC<br>Specific divisions within DOC are:<br>• Natural Heritage Management System (NHMS)<br>• Research, Development & Improvement (RD&I)<br>• Conservancies<br>• Business Management Division (BMD)<br>• People and Organisational Development (POD) |
| Landcare Research | LCR |
| AgResearch | – |
| National Rural Fire Authority | NRFA |
| Ensis | – |

For each of the 64 actions arising, the following have also been identified:

- Status:
  - To be done
  - Underway and ongoing
- Urgency of research or management action:
  - A. Within 1–2 years
  - B. In the medium term (5 years)
- Importance of research or management action[5]:
  1. Research action essential for proceed to management
  2. Research or management action can proceed, but will be sub-optimal without research
  3. Research or management action can proceed, but will be sub-optimal without research
- General or specific research:
  - G General research
  - S Fire-specific research

Actions to be started immediately are denoted by an asterisk '*' alongside the word (e.g. 'Action 12*').

The status, urgency and importance of each research or management action is summarised in the following sections. Several of the actions depend on budgets being assigned to them and on programmes being undertaken from 2006/07, such as the development of NHMS.

[5] From Hilliard & Timmins (1998).

### 4.1.1 Legislation, policy, strategy and conservation management strategies

> These are the national, overarching structures that both define and establish DOC's direction regarding fire management and fire-associated research. They address questions such as: should experimental burning be used for extensive ecosystem management and, if so, where? The Conservation General Policy (DOC 2005a) requires interpretation and development of models and procedures to enable CMSs to be prepared and NRFA Minimum Standards for Fire Authorities to be actioned. The minimum standards include:
>
> - Training, equipping and clothing Fire Officers
> - Achieving timely responses to fires
> - Observing fire weather
> - Assessing fire hazards

#### *1(a) Policies*

i. Should DOC be managing successional processes at all sites it is responsible for, a range of sites, or just those with threatened ecosystems or species?

| ACTION 1: DOC (NHMS) | | | |
|---|---|---|---|
| Identify how DOC will undertake management of successional processes, and the types of sites on which this will occur | Underway and ongoing | A1 | G |

ii. What are the management outcomes on lands administered by DOC?

| ACTION 2: DOC (NHMS) | | | |
|---|---|---|---|
| Identify the processes DOC will use to define management on lands it administers | Underway and ongoing | A1 | G |

#### *1(b) Strategies*

i. What is the strategy for deciding where and how DOC uses fire as a management tool?

| ACTION 3: DOC (NHMS) | | | |
|---|---|---|---|
| Develop and establish models of ecosystem successional processes that are supported by nationally standardised mapping of ecosystems and successional stages | Underway and ongoing | A1 | G |

ii. Where will DOC let fires burn, and under what conditions?

| ACTION 4: DOC | | | |
|---|---|---|---|
| Establish guidelines to determine under which circumstances fires should be left to burn | To be done | B2 | S |

iii. What is the direction for DOC's fire management over the next 20 years?

| ACTION 5: DOC | | | |
|---|---|---|---|
| Prepare a strategy to identify DOC's fire directions for the next 20 years | To be done | A2 | G |

iv. How does DOC maintain fire management as part of its culture?

| ACTION 6: DOC (POD, RD&I) | | | |
|---|---|---|---|
| Identify appropriate tools to encourage and support staff interest in fire management | To be done | B2 | G |

v. What is the effect of landscape fire on social and ecological communities?

| ACTION 7: NRFA, DOC (RD&I), ENSIS | | | |
|---|---|---|---|
| Identify appropriate tools and techniques to better understand the effect of fire on social and ecological communities | Underway and ongoing | B2 | S |

vi. What is the national approach to managing recovery activities (social and ecological) on DOC-administered lands after a fire event?

| ACTION 8: NRFA, DOC (RD&I) | | | |
|---|---|---|---|
| Establish the direction and approaches required to promote recovery of social and ecological processes after a fire event | To be done | A1 | G |

### 1(c) *Conservation management strategies*

i. What tools and techniques are required to develop integrated fire management plans that include recovery (social and ecological) of, and prescribed burning for, ecosystem management?

| ACTION 9: DOC (RD&I, CONSERVANCIES) | | | |
|---|---|---|---|
| Develop and enhance current tools and techniques to enable integrated fire management plans to be developed | To be done | B2 | G |

### 4.1.2 Decision support system

A decision support system brings together 'hard' technical data with social research and values to help managers make appropriate, sound decisions on fire management. An example is the NRFA's *Position on wildfires and community safety* (NRFA 2005a). Research is required to develop and verify tools for supplying data to fire managers and improve their understanding of using decision support systems for fire management. A key decision is whether to directly intervene to suppress a fire, or to let it burn under supervision to boundaries (thus removing pest plants, or providing easier supervision of the fire, for example). Once that decision is made, processes can be established. One example from the USA is the US Federal Fire Policy (provided in Appendix 9).

i. What is required to build a decision support system for fire management by and in DOC?

| ACTION 10: DOC (RD&I, NHMS) | | | |
|---|---|---|---|
| Identify, test and apply the components of a decision support system to assist DOC's fire management capability | To be done | A1 | S |

### 4.1.3 Costings

Cost-effective fire management is an important part of DOC's business. Identifying costs and seeking efficiencies is one of the easiest parts of fire management to closely study and research. The new broader approach to fire management requires that this work be done. Analysis of the costs of suppressing a fire compared with the costs of monitoring it (letting it burn) is a key area requiring study.

i. What are the current costs of fire control and management?

| ACTION 11: DOC (BMD, RD&I) | | | |
|---|---|---|---|
| Identify and analyse the costs of current and future fire control and management | Underway and ongoing | A1 | G |

### 4.1.4 Wildfire threat analysis

The process for wildfire threat analysis in New Zealand has been tried and tested in parts of the country (a diagram of this model is provided in Appendix 7). Wildfire threat analysis is 'a systematic method to identify the level of threat a particular area faces from wildfire. The level of threat is generally related to a combination of ignition potential, potential fire behaviour and the values threatened' (NRFA 2005b).

i. Can a nationally consistent wildfire threat analysis be prepared for DOC, to support DOC's decision support system?

| ACTION 12*: DOC (RD&I, CONSERVANCIES) | | | |
|---|---|---|---|
| Investigate and prepare a national wildfire threat analysis for DOC | To be done | B2 | S |

### 4.1.5 Social research

Social research includes studies on people's perception of fire; public awareness of fire messages and prevention; volunteers; people's feelings about past fires; fire-fighter health; and cultural issues. It includes research into community resilience to fire and community restoration after a fire. DOC needs to promote fire awareness in communities. An outcome of social research could be the development and use of approaches to gain community support for specific activities, such as using fire as a management tool.

#### *5(a) Cultural*

i. What is the level of understanding of cultural concerns relating to fire management?

| ACTION 13: DOC, ENSIS, NRFA | | | |
|---|---|---|---|
| Investigate the cultural concerns of key cultural communities in relation to fire management | To be done | B2 | S |

#### *5(b) Health of firefighters*

i. What are the risks affecting firefighters, including the impacts of smoke inhalation while undertaking strenuous work?

| ACTION 14: CRC (PROGRAMME D), NRFA, DOC (RD&I) | | | |
|---|---|---|---|
| Continue to investigate the health of those involved in fire fighting | Underway and ongoing | B2 | S |

### 5(c) *Perception and public awareness of fire management*

There is an increasing need to empower communities to do things for themselves in times of emergencies, especially the implementation of the '4Rs' of emergency management (Reduction, Readiness, Response and Recovery). Perception and public awareness studies are ways to ensure that appropriate techniques are used and taken up by communities (Fitzgerald & Fitzgerald 2005). The NRFA Advisory Committee is currently identifying the New Zealand strategy on 'stay and defend' in the event of a rural wildfire (NRFA 2005a).

Some community members are known to start fires for their own reasons, such as clearing sites for hunting.

i. What is the public perception of DOC's policies on fire management, especially the use of fire as a means of landscape and ecosystem management?

| ACTION 15: DOC, NRFA, ENSIS, UNIVERSITIES | | | |
|---|---|---|---|
| Study public perception of DOC's policies on fire management | To be done | B2 | S |

ii. What is the community perception of fires deliberately lit for management purposes? ('Community' referring to both the immediately affected community and those in surrounding areas.)

| ACTION 16: DOC, ENSIS, NRFA UNIVERSITIES | | | |
|---|---|---|---|
| Study the awareness of key communities, and that of the neighbouring communities, of fire. For example, communities that are adjacent to the research burns at Lake Taylor, Torlesse Range, Deep Stream and Mt Benger. | To be done | A2 | S |

iii. What causes individuals in some communities to deliberately start fires?

| ACTION 17: NRFA, UNIVERSITIES | | | |
|---|---|---|---|
| Study communities known to have individuals that deliberately start fires, investigate the reasons behind the behaviour, and then devise ways to minimise such activities | To be done | B2 | S |

### 5(d) *Prevention of fires*

Much of this requires the transfer of researchers' technical findings to managers in DOC.

i. What is the profile of an arsonist?

| ACTION 18: CRC (PROGRAMME C), NRFA | | | |
|---|---|---|---|
| Support investigation into arson | Underway and ongoing | B2 | S |

vii. How effective are fire prevention strategies and the methods and timing of their delivery (e.g. mid-summer or late summer)?

| ACTION 19: CRC (PROGRAMME C), NRFA, ENSIS | | | |
|---|---|---|---|
| Study the effectiveness of fire prevention strategies, methods and timing | Underway and ongoing | B2 | S |

### 5(e) *Volunteers*

i. Why do people volunteer to fight fires? Where do volunteers come from? What methods can be used to keep them interested in fire management? This is especially important for areas with infrequent fires.

| ACTION 20: CRC (PROGRAMME D), NRFA | | | |
|---|---|---|---|
| Study the recruitment and retention of volunteers | Underway and ongoing | B1 | S |

### 5(f) *Effectiveness of incident management teams*

Incident management teams are commonly being used for fire management nationally. Post-operational reviews are carried out, but a more social science and behavioural approach could also be investigated.

i. How effective are incident management teams?

| ACTION 21: NRFA, DOC | | | |
|---|---|---|---|
| Investigate the effectiveness of incident management as used in New Zealand and inform fire managers of the findings | Ongoing | B2 | S |

## 4.1.6 Ecosystems

Ecosystem management is a key DOC activity. Fire is just one disturbance regime that affects ecosystems. Ecosystem research includes both biotic and abiotic investigations. These include modelling ecosystems, threatened species management, and the response of pest plants and pest animals after disturbance by fire over numerous sites nationally. The development of techniques for restoring ecosystems is an important aspect of DOC's work. This topic drew the most responses from staff interviewed.

### 6(a) *Ecosystems studies*

i. What are the fire regimes in New Zealand terrestrial ecosystems—for example, what are the periodicities and intensities of fires in wetlands, tussock grasslands and shrublands?

| ACTION 22: ENSIS, LCR | | | |
|---|---|---|---|
| Study the fire regimes in New Zealand | Underway and ongoing | B1 | S |

ii. What are the ecosystem disturbance regimes in New Zealand and where does fire fit within these? What ecosystems have recently been established and maintained by fire—e.g. is lowland tussock grasslands an example?

| ACTION 23: DOC, ENSIS, LCR | | | |
|---|---|---|---|
| Study ecosystem disturbance regimes in New Zealand and the role of fire in developing and maintaining ecosystems | Underway and ongoing | A1 | S |

iii. What are the impacts of fire on ecosystems and biodiversity? Addressing this question includes research on the changes in nutrients, hydrology and species composition of flora and fauna, especially invertebrates before and after fires.

| ACTION 24: DOC, LCR, AGRESEARCH, ENSIS | | | |
|---|---|---|---|
| Continue the current vegetation and invertebrate work | Underway and ongoing | A1 | S |
| ACTION 25: DOC, LCR, ENSIS | | | |
| Identify the community and ecosystem changes in fire-induced systems | Underway and ongoing | B1 | S |
| ACTION 26: DOC, LCR | | | |
| Study recent and old fires (such as those occurring 200–800 years BP). Investigate the rates of change, especially in tussock grasslands and seral shrublands subsequent to fires. This is important due to the rapid change in land use resulting from the Land Tenure Review process. | Underway and ongoing through the OBI programme; managed by M. McGlone & S. Wiser at LCR | B1 | S |

iv. What is the current literature on fire ecology in relation to ecosystem management (e.g. Allen et al. 1996)?

| ACTION 27*: DOC | | | |
|---|---|---|---|
| Review literature biennially on the use of fire to manage ecosystems as described in Allen et al. (1996) | To be done | A2 | S |

v. What rehabilitation techniques are required to enhance ecosystems and ecosystem processes after disturbance by fire?

| ACTION 28*: DOC, LCR, AGRESEARCH | | | |
|---|---|---|---|
| Investigate post-fire ecosystem rehabilitation techniques | Underway and ongoing | A2 | G |

## 6(b) *Management of ecosystems (apart from pest plants)*

i. Can fire be used as a management tool to alter or modify ecosystems for a particular purpose, such as maintaining tussock grasslands, modifying coastal forests and specific wetland associations such as *Donatia novae-zelandiae*, or recreating specific ecosystem processes (e.g. shrublands)?

| ACTION 29: DOC, LCR, AGRESEARCH | | | |
|---|---|---|---|
| Investigate how indigenous species and ecosystems respond to fire for ecosystem management | Underway and ongoing | A2 | G |

ii. What ecosystems are most vulnerable to modification by fire?

| ACTION 30: DOC, LCR | | | |
|---|---|---|---|
| Map known, vulnerable ecosystems and identify if there may be any loss of species due to a lack of disturbance by fire or other sources | To be done | A2 | G |

## 6(c) *Modelling*

Modelling can assist interpretation of the environment. It can identify likely trends and establish scenarios—such as identifying probable pest plant dispersal patterns and identifying microclimates for restoration.

i. What are the ecological trajectories of ecosystems (e.g. beech forest, wetland, tussock grasslands and shrublands, Northland kauri gumlands and East Coast drylands) after disturbance by fire?

| ACTION 31: DOC (NHMS, PEST PLANTS), LCR | | | |
|---|---|---|---|
| Build and use ecosystem models to interpret ecosystem trajectories after a fire, with a focus on threatened species recovery and pest plant dynamics | To be done | A2 | G |

## 6(d) *Threatened species*

Several of New Zealand's threatened plant and animal species can reproduce only in recently disturbed or seral ecosystems (e.g. *Corybas carsii*). Many New Zealand species are adapted to disturbed or seral communities (e.g. wetland plants). The converse applies for other threatened species, where a lack of disturbance over decades or centuries is required to establish suitable habitats for their establishment (e.g. species associated with mature kauri forest or dryland woodlands). DOC's threatened species specialists will undertake this work.

i. What is the scale (frequency and size) of disturbance required to ensure protection of acutely threatened plant species that are seral community specialists (where fire is one part of a disturbance regime affecting these species)?

| ACTION 32: DOC, LCR | | | |
|---|---|---|---|
| Study and map the ecosystems of acutely threatened plant species that require disturbance-induced sites for their reproduction and growth. Competition from other plant species needs to be taken into account. | Underway and ongoing | A2 | G |

ii. What is the potential loss of threatened species due to ecosystems not being disturbed by fire or some other cause?

| ACTION 33: DOC (RD&I) | | | |
|---|---|---|---|
| Investigate the potential loss of threatened species due to a lack of disturbed sites that would allow colonisation and establishment | Underway and ongoing | B1 | G |

iii. Where are the recent fire-induced ecosystems that contain threatened species?

| ACTION 34: DOC, LCR | | | |
|---|---|---|---|
| Model and map new or similar ecosystems and sites that are naturally or human induced | Underway and ongoing | B2 | G |

### *6(e) Pest plants*

Pest plants, due to their reproductive ecology, have a major influence on ecosystems after fire (Allen et al. 1996; Johnson 2004). Increased knowledge of pest plants is required to better understand their role in disturbance regimes and establish appropriate management of pest plants after fire.

i. What is the ecological trajectory of ecosystems with and without different pest plant species? How important is the location of a seed source, such as pampas, to such sites?

| ACTION 35: DOC, LCR, ENSIS | | | |
|---|---|---|---|
| Establish the relationship between fire disturbance and pest plant species, with a focus on threatened ecosystems | Underway and ongoing | A1 | S |

ii. Can fire be used to manage pest plants such as pines, hakea and willows (where fire is one of many forms of pest plant management that includes spraying, mechanical clearing)?

| ACTION 36: DOC, ENSIS | | | |
|---|---|---|---|
| Study the possible use of fire to manage pest plants. For example, undertake experimental burns on sites that have had pest plants sprayed. | To be done | A1 | S |

### 4.1.7 Climate change

> Climate change has been identified as a long-term impact on the New Zealand environment (Pearce et al. 2005).

i. What is the speed, impact and potential effect of climate change on ecosystems? What are the changes in pest plant populations, threatened species, and threatened ecosystems' species composition (especially ecosystems and species that are rare or on the edges of their 'range')?

| ACTION 37: DOC, LCR | | | |
|---|---|---|---|
| Undertake further investigation and modelling of the influence of climate change on pest species, threatened species and ecosystems | Underway and ongoing | A2 | G |

### 4.1.8 Fire behaviour studies

> While considerable work has been carried out on fire research in New Zealand, there is only limited understanding of the Ensis Bushfire Research Programme among several DOC staff responsible for fire management. Fire behaviour studies identified by DOC staff addressed topics including fire behaviour, experimental burns, fuel mapping (types and loadings), ignition points, modelling of fire behaviour, prescribed burning, weather, and technical transfer of findings. Although there is information about fire and post-fire ecosystem changes in particular, little information is available on the specific fire behaviour that produced the post-fire ecosystems.

#### *8(a) Fire behaviour*

i. Can the number of fuel models for indigenous fuels be increased and the current models improved, especially for shrubland and grasslands? Can 'slope-equivalent wind speed' models of fuels (which are easier to use and provide more relevant calculations) be prepared using the input of wind direction and speed to predict fire direction and rate of spread? Can the number of models be increased to improve fire behaviour predictions and to increase human safety?

| ACTION 38: DOC, ENSIS, LCR | | | |
|---|---|---|---|
| Develop and validate fire behaviour models for New Zealand fuel types through collaborative experimentation | Underway and ongoing | B1 | S |

## 8(b) *Experimental burns*

Experimental burns provide data to develop and validate models. The results are useful in supporting the analysis and understanding of wildfires and ecosystem response (which requires monitoring), and supporting fire behaviour models. Allen et al. (1996) have identified a method to establish the priorities for experimental burns to maintain ecosystems.

i. Can the validation of the current fuel models be proved? Can new indigenous fuel models be prepared to enable better management of ecosystems by DOC?

| ACTION 39: DOC, ENSIS | | | |
|---|---|---|---|
| Undertake experimental burns and analyse the fire behaviour and ecosystem responses, especially the responses of pest plants | Underway and ongoing | A2 | S |

## 8(c) *Fuel types*

Any work on fuel types will support the wildfire threat analysis. Key fuel types include grasslands and shrublands, such as kauri gumlands and wetlands. There is also a need to study fire-resistant species that can be used for protection plantings to reduce or minimise fire spread. Work has already begun on this (Opperman & Coquerel 2005).

i. What are the different fuel types in New Zealand? What is the potential impact of fire on them and can they be mapped?

| ACTION 40: ENSIS, DOC, LCR | | | |
|---|---|---|---|
| Continue improving the available fuel type analysis and mapping | Underway and ongoing | A1 | S |

## 8(d) *Fuel loadings*

Knowledge of both the short- and long-term change in fuel loadings, such as retirement of pasturelands, is required for effective fire management planning. Fuel loads are important in understanding the intensity and difficulty of controlling fires. Some changes in fuel loads can be quite rapid—for example, the Land Tenure Review process can result in extensive areas of retired land with increased vegetation growth. Work has already begun on this (Opperman & Coquerel 2005). Priority areas of study are fuels found on ‘drylands’ as defined by Walker et al. (2005).

i. What are the fuel loadings in New Zealand? How fast are they changing given recent land use changes? How do they recover following fire or other disturbances, such as grazing, mowing or retirement?

| ACTION 41: ENSIS, DOC, LCR | | | |
|---|---|---|---|
| Continue work on fuel loadings analysis and mapping. Link this work with the National Carbon Monitoring Project, and the changes in fuel loadings. | Underway and ongoing | A1 | S |

## 8(e) *Ignition point investigations*

There are many ignition sources. DOC needs to have the sources that are important for compliance and law enforcement, particularly in the case of arson, identified. Some work has already been done on this by Ensis (Opperman 2005).

i. What are the key ignition sources of fire in New Zealand and how can they be minimised?

| ACTION 42*: DOC, ENSIS, NRFA | | | |
|---|---|---|---|
| Study ignition sources, such as lightning strikes and human-induced sources | Underway and ongoing | B2 | S |

## 8(f) *Modelling fire behaviour*

i. What was the fire behaviour of recent fires in New Zealand?

| ACTION 43*: DOC, ENSIS | | | |
|---|---|---|---|
| Investigate and model previous fires and use the results to support current and future fire fuel models. Further investigate work undertaken by Johnson (2004) and Williams et al. (1990). | Underway and ongoing | B2 | S |

ii. What models can be used to demonstrate the use of fire as an ecosystem management tool? Priority ecosystems for study include indigenous grasslands, shrublands and priority pest plants (such as pines, wattles and pampas).

| ACTION 44: DOC, ENSIS | | | |
|---|---|---|---|
| Use models to identify the appropriate techniques for using fire as an ecosystem management tool | Underway and ongoing | B1 | S |

## 8(g) *Prescribed fire*

i. Can prescribed fire techniques be improved, especially as tools for managing ecosystems?

| ACTION 45: DOC, ENSIS | | | |
|---|---|---|---|
| Develop guidelines for prescribed burning and then undertake prescribed burning (e.g. hot and cold burns as described in Allen et al. (1996); Department of Sustainability and Environment (2005); and Fire Ecology Working Group (2004)). | Underway and ongoing | B1 | S |

## 8(h) *Weather*

i. Can the fire weather indices be improved?

| ACTION 46: ENSIS | | | |
|---|---|---|---|
| Increase understanding and validation of the fire weather indices | Underway and ongoing | B1 | S |

### 4.1.9 Techniques for managing fire in New Zealand

> The techniques for managing fire in New Zealand have been based on models developed by previous agencies, for example the New Zealand Forest Service. There is still considerable research required on biosecurity practice, cost effectiveness, protection of specific flammable sites, the use of different retardants, retardants and their possible impacts on ecosystems, and the current techniques employed in fire management.

#### *9(a) Biosecurity*

Biosecurity can be described as the prevention of organisms becoming established (DOC 2005a).

i. Can pest species (plant or animal) be transferred during fire management activities?

| ACTION 47*: DOC (BIOSECURITY) | | | |
|---|---|---|---|
| Identify the risk of pest species transfer through fire suppression activities (e.g. using water sources containing didymo or using machinery that is harbouring pest animals, such as invertebrates, and pest plant species) | Underway and ongoing | A1 | G |

#### *9(b) Protection of specific flammable sites*

These include historic structures and culturally important sites.

i. What techniques can be used to protect historic sites?

| ACTION 48*: DOC, ENSIS, LCR | | | |
|---|---|---|---|
| Identify the techniques that protect and conserve historic sites (e.g. those that protect the fabric of a pa site once a fire has removed the vegetation from it, or those that adequately fire-proof historic structures) | To be done | B2 | G |

#### *9(c) Retardants and suppressants (e.g. foam concentrate, hydro-blender soap capsules)*

Retardants or suppressants added to water increase the effectiveness of fire management.

i. Can the current use of retardants or suppressants be improved?

| ACTION 49*: ENSIS, NRFA | | | |
|---|---|---|---|
| Investigate the most effective and efficient retardants and suppressants for a range of fire management activities (e.g. prescribed burning, managing a wildfire in a rural–urban interface) | Underway and ongoing | B2 | S |

## 9(d) *Impacts of retardants and suppressants on ecosystems*

The retardants currently available in New Zealand have a high concentration of phosphate in their formulae. Suppressants are high-grade surfactants that readily mix with water. In some fragile ecosystems, the use of retardants or suppressants could affect plant and animal species owing to the rapid injection of nutrients. There is some debate over which ones to use and where to use them.

i. What is the effect of the currently used retardants and suppressants on ecosystems?

| ACTION 50*: DOC, ENSIS, NRFA | | | |
|---|---|---|---|
| Investigate the impact of retardants and suppressants on ecosystems (e.g. wetlands, low fertility systems) and threatened animals (e.g. mudfish) | To be done | B2 | G |

ii. What is the impact on ecosystems of using salt water to manage a fire on an offshore island or coastal wetland, e.g. the Kaimaumau wetland?

| ACTION 51*: DOC | | | |
|---|---|---|---|
| Investigate the use of salt water on ecosystems. Identify those ecosystems that can sustain salt water being used as a suppressant. | To be done | B2 | G |

## 9(e) *Fire management techniques in use*

Techniques need to be socially, ecologically and economically sustainable (see sections 4.1.3 Cost effectiveness, 4.1.5 5(a) to 5(f) Social research, and 9(b) Protection of specific flammable sites).

i. What are the most appropriate techniques for managing fires?

| ACTION 52*: ENSIS | | | |
|---|---|---|---|
| Review the efficiency and effectiveness of current tools and methods used in fire management and plan for future fire management (e.g. air attack methods and fire breaks) (see Action 11) | Underway and ongoing | B1 | S |

### 4.1.10 Management

> Management includes staff capacity, training, managing research contractors and researchers (e.g. liaison between organisations), legal advice, and data management.

#### 10(a) *Staff capacity*

Considerable fire-related research has been undertaken by DOC. If capacity is lacking to support, coordinate and transfer this information to operational staff, DOC is at risk of not using the most appropriate techniques or methods for managing fire. Thus, there are two types of capacity required: fire management staff (to implement the recommendations and advice) and research staff (to transfer information in the most appropriate way to fire management staff).

i. What is the appropriate staff capacity for the support, coordination, management and transfer of fire research within DOC?

| ACTION 53*: DOC | | | |
|---|---|---|---|
| Investigate the current and planned staffing capacity for fire research, coordination, management and transfer | To be done | A2 | G |

#### 10(b) *Managing science contractors and researchers*

There are a number of fire management research projects being undertaken by four organisations in New Zealand (see section 5 and Appendices 3–5). The results of these will enhance our knowledge of how specific sites respond to a fire event.

i. Can the current research projects be completed while undertaking new research initiatives?

| ACTION 54*: DOC, LCR, AGRESEARCH, ENSIS | | | |
|---|---|---|---|
| Continue the studies relating to the research burns (e.g. invertebrate and flora studies) | Underway and ongoing | A1 | S |

#### 10(c) *Human resources*

Any organisation needs to ensure continuity of human resources with each staff member being able to undertake several roles.

i. What is DOC's capacity to attract and maintain fire management experience?

| ACTION 55: DOC | | | |
|---|---|---|---|
| Investigate DOC's capacity to maintain staff with fire management and incident management experience over the next 20 years | To be done | A2 | G |

| ACTION 56: DOC | | |
|---|---|---|
| Identify what motivates staff to become involved in fire management at all levels of the organisation | To be done | B2 S |

## 10(d) *Literature review*

There is considerable literature on fire management in New Zealand and Australia. The most recent literature review to advise DOC on ecological management relating to fire was by Allen et al. (1996). There has yet to be a review of the social research activities and techniques that could be used to manage social concerns.

i. What is the current literature on fire management and fire ecology in New Zealand and Australia?

| ACTION 57*: NRFA, ENSIS, CRC | | |
|---|---|---|
| Undertake and distribute a fire management literature review of work completed and reported in New Zealand and relevant Australian work once every 2 years | To be done | B2 S |

## 10(e) *Standard operating procedures*

Both DOC and the NRFA have specific standard operating systems—for example, the Fire Service Amendment Act 2005 requires the NRFA to set, in consultation with Fire Authorities, minimum standards for Fire Authorities in relation to the following matters:

*(i) The training, equipping, and clothing of Fire Officers and any other persons required by a Fire Authority to attend a fire:*

*(ii) Achieving timely responses to fires:*

*(iii) Fire weather observation:*

*(iv) Assessing fire hazards:*

(section 14A(2)(k) of the Fire Service Act 1975)

i. Are research findings actively incorporated into DOC's standard operating procedures?

| ACTION 58*: DOC (RD&I) | | |
|---|---|---|
| Integrate research findings into DOC's standard operating procedures | To be done | A2 G |

### *10(f) Data management*

The need for sound data management has already been identified by Opperman (2005). Accessible data can help predict fire occurrence and behaviour, assist in the positioning of suppression resources, develop fire prevention programmes and prioritise fuel treatments and research programmes.

i. What systems and processes are required to adequately manage fire-related data?

| ACTION 59*: DOC (RD&I—INVENTORY AND MONITORING) | | | |
|---|---|---|---|
| Collect, store and manage fire-related data under DOC's Biodiversity, Inventory and Monitoring framework | To be done | A2 | G |

## 4.1.11 Technology transfer

Information is worthless if it is not transferred to the end users. There has been considerable research undertaken relating to fire management in New Zealand. This must be passed on to the DOC staff who are required to manage fires. Appropriate, clear and concise methods are needed to transfer information to the relevant people to ensure they are working in the best and safest way.

i. How can the technical transfer of research findings be improved?

| ACTION 60*: DOC (RD&I), NRFA, ENSIS | | | |
|---|---|---|---|
| Identify and undertake the most appropriate and effective ways of transferring technical fire management and research information to departmental staff and the public (e.g. DOC could instigate a national workshop to debate fire management and fire ecology in New Zealand) | To be done | A1 | G |

| ACTION 61*: DOC, LCR, ENSIS | | | |
|---|---|---|---|
| Continue, complete and publicise the results of the current grassland and shrubland research burns at Lake Taylor, Mt Benger, Deep Stream and the Torlesse Range | Underway and ongoing | A1 | S |

ii. How can the public be informed about current and future fire risks?

| ACTION 62*: NRFA, DOC (RD&I), ENSIS | | | |
|---|---|---|---|
| Identify how best to notify the public about fire risk and raise public awareness (e.g. establishing appropriate thresholds of when to warn the public about fire risk) | Underway and ongoing | A1 | S |

### 4.1.12 Monitoring

The monitoring of ecosystems and fire management techniques has been variable nationally, with a few sites being tracked specifically for the long-term effects of fire on ecosystems (e.g. Johnson 2004; Walker et al. 2005). Prior to humans arriving in New Zealand, fire regimes for some drylands in New Zealand had a return time of more than 100 years. Monitoring may be required for some of these ecosystems for over 200 years to study changes and trends (Rogers et al. 2005).

i. What are the most appropriate and effective monitoring techniques to measure the effectiveness of fire management in key ecosystems in New Zealand?

| ACTION 63*: DOC (NHMS), LCR, ENSIS, NRFA | | | |
|---|---|---|---|
| Undertake monitoring of fire management and associated ecosystem management (e.g. flora and fauna changes after a fire, effects of prescribed burns and impact on waterways). Study the changes in fuel loadings and fuel types with time. Monitor land management changes. | To be done | A1 | S |

### 4.1.13 Recovery

Recovery is the restoration and rehabilitation of a site following fire. The Principal Rural Fire Officer (PRFO) shall deploy a team of specialists to assess the site and prepare recommendations for its future management.

i. What techniques and approaches are required to implement appropriate recovery after a fire?

| ACTION 64: DOC, ENSIS, LCR | | | |
|---|---|---|---|
| Investigate the techniques and procedures that enable effective and efficient recovery of a site after a fire. Include social, economic and environmental studies. | To be done | B2 | G |

## 4.2 TIMING THE ACTIONS—THE AUTHOR'S VIEWS

Timing is important to help DOC achieve its responsibilities and objectives for fire management, and to effectively deliver the 64 actions. A suggested rationale and priority order for actions is provided below.

### 4.2.1 Rationale

Five outcomes were sought, as follows:

1. DOC needs to be clear on where it is going with its ecosystem management, especially regarding the lands it administers as a result of the Land Tenure Review process. This will require mapping of ecosystems and linking fire behaviour models to these ecosystems.
2. Completing experimental burns and associated fuel model, fuel type and fuel load work will increase the safety for staff and increase the understanding of fire behaviour to provide better forecasting.
3. A national wildfire threat analysis will provide a context for planning social, ecosystem, fire behaviour and fire management techniques. Its preparation, in collaboration with other organisations, will provide a cohesive basis of fire management in New Zealand.
4. Continuity of skilled fire managers through training and exposure to fire management is required.
5. Technical transfer of information is vitally important, especially for linking other areas of ecosystem management (pest plants, invertebrates) and social science (messages on fire management).

### 4.2.2 Priority order

Of the 64 actions described in section 4.1, those that have priority in helping to achieve the five outcomes are listed below.

Priority: Fire modelling is required for outcome reporting, to help estimate what was saved. Both Treasury and the Fire Service Commission Chairperson want this to happen.

| NEED | RELEVANT ACTIONS |
|---|---|
| Complete current fire behaviour and fuel model work | Action 24: Research burns<br>Action 40: Fuel types<br>Action 41: Fuel loadings<br>Action 54: Management of research burns |
| Establish technical transfer of this information to fire behaviour specialists | Action 62: Technology transfer |

Priority: Priorities need to be established for fire management that aims to conserve biodiversity. DOC will then be able to identify which ecosystems it should apply all its available resources to in order to suppress fires, and when it should use less expensive approaches to merely contain a fire to protect life and property[6]. Effective prioritisation requires setting of policy directions; wildfire threat analysis; understanding of social impacts, ecosystem management and fire behaviour; techniques for managing fire; and databases.

| NEED | RELEVANT ACTIONS |
|---|---|
| Establish policy and strategies | Actions 1 & 2: Departmental land management<br>Actions 3, 4 & 5: Strategies for managing ecosystems processes |
| Identify how fire management plans will be prepared for inclusion into CMSs | Action 9: Develop tools and techniques for integrated fire management plans |
| Prepare and use a national wildfire threat analysis to identify important sites | Action 12: Prepare a wildfire threat analysis |
| Support the wildfire threat analysis | Actions 13, 15 & 16: Social research<br>Actions 23, 29, 30, 32 & 34: Ecosystem studies<br>Actions 38, 40 & 41: Fire behaviour (fuel models)<br>Action 49: Techniques for managing fires<br>Action 62: Technology transfer<br>Action 63: Monitoring |

Priority: DOC needs to investigate its use of pre-emptive fire management—that is, which ecosystems it will protect and conserve by using fire breaks and control burns. Because New Zealand ecosystems have not co-evolved with fire, pre-emptive fire management raises some issues that need to be resolved.

| NEEDS | RELEVANT ACTIONS |
|---|---|
| Resolve the relationship between 'landscape management' and 'risk'<br><br>Resolve the compromise between protecting biodiversity and the frequency and intensity of burns—that is high frequency, low intensity, and low frequency, high intensity | Most relevant actions have been identified above, with the addition of:<br>Action 16: Social research |

6 LENZ and LCDB II are tools that will help assess 'island management' on the mainland—such as for the Cromwell Chaffer Beetle Reserve.

# 5. Who's involved and what are they doing?

This section introduces the main agencies involved in fire management and research. Collaboration between them will help complete the actions needed to fill the research gaps and meet DOC's research needs.

- 5.1 summarises the agencies
- 5.2 summarises their current planned activites

## 5.1 FIRE RESEARCH AGENCIES AND THEIR ACTIVITIES

### 5.1.1 Overview

Considerable research that is of value to fire managers has been carried out in New Zealand and Australia, and several major projects are currently underway. Four agencies are involved in fire research in New Zealand: fire science is undertaken by Ensis, and ecological research by Landcare Research, AgResearch and DOC.

Ensis has just begun social research on communities and fire, including a project to assess community resilience to wildfires (Fitzgerald & Fitzgerald 2005). Ensis has also recently joined with Australia's main player, the Bushfire CRC (see Appendices 3, 4 & 10).

There is some collaboration between all these groups and other organisations on various projects. For example, Otago tussock grassland burning trials at Deep Stream and Mt Benger involve DOC managing the burns, Ensis managing the fire behaviour modelling, Landcare Research managing the vegetation studies and AgResearch managing the invertebrate studies (this project is profiled in Appendix 11). Another example is a joint report by Ensis and the National Institute of Water and Atmospheric Research (NIWA) on the impact of climate change on long-term fire danger (Pearce et al. 2005).

Recent support from FRST is helping to plug information gaps by providing ongoing and consistent funding for fire research.

Current research by each of these agencies is summarised below, and covered in more detail in Appendices 3, 4 and 5.

An ongoing issue that should be noted is the lack of effective transfer of the technical results of these and other projects within DOC and to DOC staff from outside agencies. This lack is in part because fire research is carried out by several different agencies, and research results are not shared as well as they could be.

### 5.1.2 Fire research in Australia

The Australian Commonwealth Government's Cooperative Research Centres Programme runs the Bushfire CRC. Its objectives are to provide research that enhances the management of bushfire risk for the community in an economic and ecologically sustainable way. There are five programmes funded over 6 years, finishing on 30 June 2010:

A: Safe prevention, reparation and suppression (of fire)

B: Management of fire in the landscape

C: Community self-sufficiency for fire safety

D: Protection of people and property (from fire)

E: Education

New Zealand researchers are involved in aspects of programmes A and C. Further detail of the programmes is provided in Appendices 3 and 10.

### 5.1.3 Ensis

Fire research in New Zealand was intermittent up to 1992; that year, a major fire research capability was established within the former Forest Research Institute, now called Ensis (see Appendices 4 & 10). Ensis has three full-time researchers, one technician, and employs others when required. The researchers have strong international links with fire research organisations around the world, in particular Australia and Canada.

Ensis is now involved in two major fire research programmes:

- The New Zealand Forest and Rural Fire Research Programme
- The Ensis Bushfire Research Programme—a cooperative venture with the Australian CRC programme

#### *5.1.3.1 New Zealand Forest and Rural Fire Research Programme*

The major aim of the New Zealand Forest and Rural Fire Research Programme is to understand fire behaviour in the New Zealand fire environment and develop tools to assist in fire management. This includes reducing the incidence and consequence of wildfires, and to provide for the safe and effective use of fire as a land management tool, where appropriate (Pearce & Anderson 2004).

The programme is aligned with the '4Rs' of emergency management (Reduction, Readiness, Response and Recovery).

Understanding the New Zealand fire environment is addressed through a New Zealand Fire Danger Rating System (NZFDRS) to support fire management decision making. Key components of the NZFDRS include:

- A Fire Behaviour Prediction (FBP) system made up of models that predict fire behaviour in different vegetation types. Collecting and analysing fire behaviour data from prescribed burning trials and wildfires is essential to developing an FBP. A considerable amount of work has been done on this, but some aspects require refining, one of which is general fire ecology of New Zealand fuels.

- Models describing the effectiveness of various fire-fighting resources in relation to fire behaviour and other fire environment factors (e.g. vegetation, terrain).

The New Zealand Forest and Rural Fire Research Programme includes work on:

- Describing the fire weather and fire climate of New Zealand
- Developing techniques for assessing the degree of curing of grasslands (how dry and flammable grasslands are)
- Assisting New Zealand fire managers to develop management applications using outputs from the NZFDRS
- Quantifying the effect of slope on fire behaviour in New Zealand fuel models

The research programme has also identified 15 activities that need to be continued or begun. Those that affect DOC are:

Ongoing:

- Work with the Australian Bushfire CRC on shrublands and grasslands
- Develop a standard methodology to monitor the impact of fire on flora, fauna, nutrient cycling, water quality and sustainability
- Quantify the effect of the fire environment factors on the risk of fire occurrence and damage in tussock grasslands
- Conduct burning trials to assess the impact of season and frequency of burning on tussock grassland ecosystems

Needed:

- Establish study sites to monitor fire effects
- Develop an expert decision support system
- Produce guidelines on the use of fire as a management tool in tussock grassland ecosystems
- Develop ignition models
- Model fire break effectiveness
- Develop spatial fire growth models
- Assess resource productivity and effectiveness
- Assess fuel types, fuel loads, fire climate mapping and fire behaviour potential
- Conduct social research related to wildfire—this covers social and economic factors affecting wildfire risk, communication of fire danger warnings, and community resilience and recovery following wildfire events
- Provide fire behaviour training and support to fire managers
- Develop capability to draw on Australian expertise to support New Zealand research questions

#### *5.1.3.2 Ensis Bushfire Cooperative Research Centre*

Ensis' New Zealand Forest and Rural Fire Research programme has recently joined with the Australian five-part fire research programme, the Bushfire CRC (see Appendix 4).

The combined research programme is called 'Ensis Bushfire Research' and it is partly funded by the New Zealand Government through FRST, and a 'fire industry collaborative' made up of the New Zealand Fire Service, the NRFA, the New Zealand Forest Owners' Association, DOC, New Zealand Defence Force and Local Government New Zealand.

In addition to direct cash funding, considerable 'in-kind' support for research activities is received from Rural Fire Authorities throughout New Zealand and the Federated Farmers of New Zealand. This is in the form of help with research burning (location of sites, site preparation and suppression), field sampling programmes and notification of wildfires.

Ensis Bushfire Research's objective is to provide research that enhances the management of bushfire risk to the community in an economic and ecologically sustainable way. This provides an opportunity to expand the scope and amount of research that can be undertaken. A major gap is the lack of fire ecology research in New Zealand.

As stated, the Bushfire CRC has established five programmes. New Zealand researchers are involved in two of these:

Programme A: Safe prevention, preparation and suppression (of fire)

- A1.1: Fire behaviour modelling for shrub and heathland fuels
- A1.4: Improved methods for the assessment and prediction of grassland curing (see below)

Programme C: Community self-sufficiency for fire safety.

Ensis has recently expanded its work to include social research (e.g. Fitzgerald & Fitzgerald 2005).

While Ensis oversees implementation of the Bushfire Programme, strategic direction is provided by the Rural Fire Research Advisory Committee. This committee includes groups with an interest in managing fires as safely and cost effectively as possible by promoting and maintaining a research capability to support fire management decision making. They are the:

- NRFA
- New Zealand Fire Service
- DOC
- New Zealand Defence Force
- Local Government New Zealand
- New Zealand Forest Owners' Association
- Federated Farmers of New Zealand (Inc)

In 2004, the New Zealand Rural Fire Research Working Group, in a joint exercise with the Research Advisory Committee, produced its Rural Fire Research Strategy (Pearce & Anderson 2004) and a priority ranking for research topics. The priority rankings were calculated by weightings based on funding contributions from different organisations, multiplied by a range of scores that had been summed. This process produced a transparent approach to managing research. Since then the Ensis Rural Fire Researchers have focused on seeking continued funding from FRST and establishing a role in the Australian Bushfire CRC collaborative work. This has resulted in the priority ranking not being updated to include the recent changes to the programme. Details about the Ensis Bushfire Research Programme are provided in Appendices 4 and 10.

### 5.1.4 Research within DOC

Because fire can impact on the management of pest plants, pest animals, threatened species, recreation resources and the public (especially public safety), DOC conservancies and Head Office units are working on the management and research needs of these areas of work.

DOC undertakes fire research (e.g. Smale & Fitzgerald 2004). It also addresses national monitoring (e.g. Lee et al. 2005), and biodiversity management projects (NHMS).

DOC has carried out a considerable amount of work to identify its fire research needs and fire management direction. Between 1996 and 2005, seven documents on various aspects of this work were produced (these are summarised in Appendix 6). However, while much of this has been written in a clear, directive manner, few recommendations have been actioned, which suggests an unwillingness to take up and apply this information.

The recent publication of Conservation General Policy (DOC 2005a) has considerably broadened DOC's mandate in ecosystem management by 'enabling' fire management (Policy 4.3). This will require increased understanding of ecosystems, which is an activity also identified in the policies on 'Terrestrial and freshwater species, habitats and ecosystems' (Policy 4.1) and 'Biosecurity and management of threats to indigenous species, habitats and ecosystems' (Policy 4.2). Much of this understanding will come from detailed ecological research and mapping, being common to all three policies (4.1, 4.2 and 4.3).

### 5.1.5 Landcare Research

Landcare Research (Manaaki Whenua) specialises in sustainable management of land resources, enhancing biodiversity, and conserving and restoring natural assets.

Landcare Research have several projects with an element of fire ecology. Considerable effort has gone into seeking funding for ecosystem research from FRST, through its OBI programme, as well as other funding streams (e.g. the Marsden Fund). Projects under the intermediate outcome of 'biodiversity response to global change' include climate change, fire, wetlands and the effect of climate change on Tuhoe forests (Appendix 5).

Other relevant Landcare Research projects include palynology studies; investigations into the impacts of burning by Maori and the effect of fire on wetlands in the New Zealand landscape; Otago grassland research burns at Deep Stream and Mt Benger; research burns in the Marlborough Sounds; and a study comparing seed and vegetative re-growth after fire.

### 5.1.6 AgResearch

AgResearch, as well as providing support to the agricultural sector, also has a very strong entomological base. This has been used to support fire research through a project looking at 'Tussock grassland invertebrate community structure and function, and impact of habitat disturbance by fire' (see Appendix 11). Again, considerable effort has been put into seeking funding for ecosystem research from FRST through the OBI programme.

## 5.2 SUMMARY OF CURRENT AND PLANNED FIRE RESEARCH

The organisations introduced in section 5.1 are all involved in some aspect of fire research in New Zealand and Australia. The following sections summarise their current and future work according to the 13-part fire management model developed for this report to provide a quick overview of what is being done, for whom, and who is paying for it (for more detail see Fig. 1 for the model and Appendices 3–5 for the research programme).

### 5.2.1 Research underway

Table 6 summarises current research initiatives.

### 5.2.2 Research needs and gaps

Table 7 summarises identified research needs and gaps.

TABLE 6. FIRE-RELATED RESEARCH UNDERWAY IN NEW ZEALAND AND AUSTRALIA.

| AREA OF RESEARCH | AGENCY | | | | | |
|---|---|---|---|---|---|---|
| | DOC | ENSIS BUSHFIRE RESEARCH | LCR | AGRESEARCH | NRFA | OTHERS (e.g. HSE UNIVERSITIES) |
| Legislation, policy, strategies and conservation management strategies | | | | | | |
| • Legislation | a, b, c | | | | | |
| • Policy | a, b, c | | | | | |
| • Strategies | a, b, c | | | | | |
| • Conservation management strategies | a, b, c | | | | | |
| Decision support system | a | a, b, c | | | | |
| Costings | a, b, c | | | | | |
| Wildfire threat analysis | a, b, c | | | | a, b | |
| Social research | | | | | | |
| • Cultural | a, b, c | | | | | |
| • Health | a | b, c | | | a, c | a |
| • Perception | a | a, b, c | | | | a |
| • Prevention | a | c | | | a | |
| • Volunteers | a | a, b, c | | | a | |
| Ecosystems | | | | | | |
| • Ecosystem studies | a, b, c | a, b, c | b | b | | b |
| • Management of ecosystems | a, b, c | | b, c | b | | |
| • Modelling | a, b, c | b, c | b | | | |
| • Threatened species | a, b, c | | b | | | b |
| • Pest plants | a, b, c | b | b | | | |
| Climate change | a, b, c | a, b, c | | | a, b | |

a Who wants it?
b Who is doing it?
c Who is paying for it?

TABLE 7. FIRE-RELATED RESEARCH NEEDS AND GAPS IN NEW ZEALAND AND AUSTRALIA.

| AREA OF RESEARCH | AGENCY | | | | | |
|---|---|---|---|---|---|---|
| | DOC | ENSIS BUSHFIRE RESEARCH | LCR | AGRESEARCH | NRFA | OTHERS (e.g. HSE UNIVERSITIES) |
| Fire behaviour | | | | | | |
| • Fire behaviour | a | a, b, c | | | a, b | |
| • Experimental burns | a, b, c | a, b, c | | | a | |
| • Fuel types | a | a, b, c | | | a | |
| • Fuel loading | a | a, b, c | | | a | |
| • Modelling fire behaviour | a | a, b, c | a | a | a | a |
| • Prescribed burning | a, b, c | a, b, c | | | a | |
| • Weather | a | a, b, c | | | a | |
| • Technical transfer of fire behaviour | a, b, c | a, b, c | a | a | a | a |
| Techniques for managing fire in New Zealand | | | | | | |
| • Biosecurity | a, b, c | | | | | |
| • Cost-effectiveness | a, b, c | a, b, c | | | a | |
| • Protection of specific flammable sites | a, b, c | b | b | | a | |
| • Retardants and suppressants | a | a, b, c | a | | a | |
| • Impacts of retardants and suppressants on ecosystems | a, b, c | a, b | a,b | | a | |
| • Fire management techniques in use | a | a, b, c | a | | a | |
| Management | | | | | | |
| • Staff capacity | a, b, c | | | | | |
| • Managing science contractors and researchers | a, b, c | b, c | b | b | b | b |
| • Human resources | a, b, c | | | | | |
| • Legal | a, b, c | | | | | |
| • Incident management teams | a | | | | a,b,c | |
| • Literature review | a, b, c | a, b, c | | | a | |
| • Standard operating procedures | a, b, c | | | | | |
| Technology transfer | a | b, c | | | | |
| Monitoring | a, b, c | b, c | a, b | a, b | a | a, b |
| Recovery | a, b, c | a, b, c | b | b | a | a, b, c |

a Who wants it?
b Who is doing it?
c Who is paying for it?

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# Appendix 1

## GLOSSARY OF TERMS

**Class A foam**

A chemical concentrate added to water that combines foaming and wetting agents specifically formulated for extinguishing vegetation.

**CIMS**

Coordinated Incident Management System. A structure to systematically manage incidents.

**Conservation area**

Has the same meaning as in the Conservation Act 1987, and includes land being managed under section 61 or section 62 of the Act; but does not include any marginal strip as defined in section 2(1) of that Act.

**Control**

The overall direction of response activities in an emergency situation. Authority for control is established in legislation or by agreement and carries with it the responsibility for tasking and coordinating other agencies. Control relates to situations and can operate at either the single agency level or horizontally across agencies. (See 'CIMS'.)

**Ecosystem**

The interacting system of a biological community, including the plants and animals, and its non-living surroundings.

**Extreme fire behaviour**

A level of fire behaviour that ordinarily precludes methods of direct suppression. One or more of the following characteristics is usually involved: high rates of spread and fire intensity; prolific crowning and/or spotting; presence of fire whirls; a strong convective column.

**Fire**

Simultaneous release of heat, light and flame, generated by the combustion of flammable material.

**Fire authority** (taken from the Forest and Rural Fires Act 1977)

Means:

(a) In relation to a rural fire district, the rural fire committee in which the administration of the district is vested or, as the case may be, the Minister of Conservation or the Minister of Defence.

(b) In relation to a territorial area, the territorial authority having jurisdiction in respect of that area.

(c) In relation to any State area, the Minister of Conservation.

(d) In relation to the fire safety margin of any State area, the Minister of Conservation to the extent provided by section 14(5) of this Act.

(e) In relation to any land or other property subject to any agreement or arrangement made pursuant to subsection (1) or subsection (2) of section 14 of this Act, the party thereby appointed to act.

   Provided that the power and duties of that party as a Fire Authority shall extend only as far as is provided by that agreement or arrangement.

(f) In relation to any land or other property in respect of which a local authority exercises the functions of a Fire Authority pursuant to section 9(b) of this Act, that local authority to the extent approved under that section by the New Zealand Fire Service Commission.

**Fire behaviour**

The manner in which fuel ignites, flame develops and fire spreads and exhibits other related phenomena as determined by the interaction of fuels, weather and topography.

**Fire break**

A natural or artificial physical barrier against the spread of fire from or into any area of continuous flammable material.

**Fire climate**

The composite pattern or integration over time of the fire weather elements that affect fire occurrence and fire behaviour in a given area.

**Fire control** (taken from the Forest and Rural Fires Act 1977)

In relation to forest, rural and other areas of vegetation, it means:

(a) The prevention, detection, control, restriction, suppression and extinction of fire.

(b) The safeguarding of life and property from damage and risk of damage by or in relation to fire.

(c) All measures conducive to or intended to further or effect such prevention, detection, control, restriction, suppression, extinction or safeguarding and 'fire control measure' has a corresponding meaning.

**Fire danger**

A general term used to express an assessment of both fixed and variable factors of the fire environment that determine the ease of ignition, rate of spread, difficulty of control and fire impact. (See 'Fire hazard', 'Fire risk'.)

**Fire danger rating**

The process of systematically evaluating and integrating the individual and combined factors influencing fire danger represented in the form of fire danger indices.

**Fire ecology**

The study of the relationships between fire, the physical environment and living organisms.

**Fire environment**

The surrounding conditions, influences and modifying forces of topography, fuel and fire weather that determine fire behaviour.

**Fire hazard**

A general term to describe the potential fire behaviour, without regard to the state of weather-influenced fuel moisture content and/or resistance to fireguard construction for a given fuel type. This may be expressed in either the absolute (e.g. 'cured grass is a fire hazard') or comparative (e.g. 'clear-cut logging slash is a greater fire hazard than a deciduous cover type') sense. Such an assessment is based on physical fuel characteristics (e.g. fuel arrangement, fuel load, condition of vegetation, presence of ladder fuels). (See 'Fire danger', 'Fire risk'.)

**Fire hazard reduction**

Treatment of living or dead forest fuels to diminish the likelihood of a fire starting and to lessen the potential rate of spread and resistance to control.

**Fire management**

All activities associated with the management of fire-prone land, including the use of fire to meet land management goals and objectives.

**Fire plan**

A statement compiled and issued by a Fire Authority defining policy, chain of command and procedure, in relation to fire control by that Authority.

**Fire prevention**

Activities directed at reducing fire occurrence; includes public education, law enforcement, personal contact and reduction of fire hazards and risks.

**Fire protection**

All activities designed to protect an area (including human life, property, assets and values) from damage by fire.

**Fire regime**

The history of fire use in a particular vegetation type or area including the frequency, intensity and season of burning. It may also include proposals for the use of fire in a given area.

**Fire retardant**

A chemical substance that, when mixed with water and applied to vegetation, retards fire ignition. Retardants are applied to unburnt vegetation ahead of a fire. (See 'Fire suppressant'.)

**Fire risk**

The probability or chance of fire starting determined by the presence of activities or causative agents (i.e. potential number of ignition sources). (See 'Fire hazard', 'Fire danger'.)

**Fire safety margin**

*Any land (not being the whole or part of a defence area within the meaning of the Defence Act 1990) that:*

> *In relation to a State area, is outside that area but within 1 kilometre (or such less distance as may be approved by the Minister of Conservation, after consultation with the National Rural Fire Officer, and notified in the Gazette) of the boundary of that area.*
>
> *In relation to a forest area, is situated outside that area but within such distance (not exceeding 1 kilometre) of the boundary thereof as is approved by the Fire Authority of that area.*
>
> *But does not include any land that, by notice in the Gazette under section 14(5A) of the Forest and Rural Fires Act 1977, is excluded from the fire safety margin of any State area.* (DOC 2000)

**Fire season**

The period(s) of the year during which fires are likely to occur, spread and do sufficient damage to warrant organised fire control. There are three types of status—Open, Restricted and Prohibited fire seasons.

**Fire Service**

The New Zealand Fire Service as constituted by section 3 of the Fire Service Act 1975.

**Fire services**

Collective term for urban, rural, industrial or defence fire brigades, or fire services, airport rescue services and the New Zealand Fire Service.

**Fire suppressant**

An additive designed to reduce the surface tension of water and/or to hold water in suspension thus increasing water's efficiency as a fire extinguishing agent. Suppressants are applied directly to the burning fuels. (See 'Fire retardant'.)

**Fire suppression**

All the work and activities connected with fire-extinguishing operations, beginning with discovery and continuing until the fire is completely extinguished.

**Fire weather**

Collectively, those weather parameters that influence fire occurrence and subsequent fire behaviour (e.g. dry-bulb temperature, relative humidity, wind speed and direction, precipitation, atmospheric stability, winds aloft).

**Fire weather index (FWI) system**

The FWI system provides numerical ratings of relative vegetation fire potential. The first three components are fuel moisture codes that follow daily changes in the moisture contents of three classes of forest fuel with different drying rates. The higher values represent lower moisture contents and hence greater flammability. The final three components are fire behaviour indices, representing rate of spread, amount of available fuel and fire intensity; their values increase as fire weather severity worsens.

The system is dependent on weather only and does not consider risk, fuel or topography. It provides a uniform method of rating fire danger throughout New Zealand. The components are described below.

*Fine Fuel Moisture Code (FFMC)*: A numerical rating of the moisture content of litter and other cured fine fuels. This code is an indicator of the relative ease of ignition and flammability of fine fuel.

*Duff Moisture Code (DMC)*: A numerical rating of the average moisture content of loosely compacted organic layers of moderate depth. This code gives an indication of fuel consumption in moderate duff layers and medium-size woody material.

*Drought Code (DC)*: A numerical rating of the average moisture content of deep, compact, organic layers. This code is a useful indicator of seasonal drought effects on forest fuels, and amount of smouldering in deep duff layers and large logs.

*Initial Spread Index (ISI)*: A numerical rating of the expected rate of fire spread. It combines the effects of wind and FFMC on rate of spread without the influence of variable quantities of fuel.

*Buildup Index (BUI)*: A numerical rating of the total amount of fuel available for combustion that combines DMC and DC.

*Fire Weather Index (FWI)*: A numerical rating of fire intensity that combines ISI and BUI. It is suitable as a general index of fire danger throughout the forested and rural areas of New Zealand.

**Firefighter**

A person whose principal function is fire suppression.

**Flammability**

The relative ease with which a substance ignites and sustains combustion.

**Foam**

See 'Class A foam'.

**Fuel**

Any material such as dead and live vegetation that can be ignited and sustain a fire.

**Fuel load**

The dry weight of combustible materials per unit area. Measured in kilograms per square metre ($kg/m^2$) or tonnes per hectare (t/ha).

**Fuel management**

Any manipulation (including lopping, mowing, burning and changing of species) for the purpose of reducing their flammability.

**Fuel type**

An identifiable association of fuel elements of distinctive species, form, size, arrangement or other characteristics that will exhibit characteristics fire behaviour under specified burning conditions.

**Ignition**

The beginning of flame production or smouldering combustion; the starting of a fire.

**Local authority**

Any territorial authority within the meaning of the Local Government Act 1974.

**Monitor**

To check, supervise, observe critically or record the progress of an activity, action or system on a regular basis in order to identify change.

**National Rural Fire Authority (NRFA)**

The National Rural Fire Authority constituted under section 14A(1) of the Fire Service Act 1975.

**New Zealand Fire Danger Rating System (NZFDRS)**

The meaning is set out in section 63 of the Forest and Rural Fires Act 1977.

**Retardant**

A substance that by chemical or physical action reduces the flammability of combustibles and remains effective after application, even after water content has evaporated. Long-term retardants depend on certain flame-inhibiting chemicals for their effectiveness.

**Risk**

The chance of something happening that will have an impact on objectives. Measured in terms of consequences and likelihood.

**Rural Fire Management Code of Practice**

The code of practice published under section 14A(2)(e) of the Fire Service Act 1975.

**Shrublands (= scrub)**

Indigenous shrub species manuka, kanuka, non-merchantable species and may include gorse, bracken, fern, broom, blackberry or other introduced species. May contain regenerating native bush.

**Social research**

Social research includes research and studies of people. Its subjects can include perception of fire, public awareness and fire prevention, volunteers, historic work into past fires, firefighter health, and cultural issues. It also includes community resilience to fire and restoration of communities after a fire event.

**State area**

An area of land defined under the Forest and Rural Fires Act 1977, Section 2

**Suppress a fire**

Extinguish a fire or confine the area burning within defined boundaries.

**Threat**

The comparative level of the combined effects of risk, hazard and values.

**Urban–rural interface**

The line, area or zone where structures and other human development adjoin or overlap with undeveloped bush-land.

**Values (= values at risk)**

The specific or collective set of natural resources and man-made improvements and/or developments that have measurable or intrinsic worth and that could or may be destroyed or otherwise altered by fire in any given area (includes social, economic, cultural and environmental values).

**Vegetation**

*Includes:*

*(a) All plants and the produce thereof, live or dead, standing, fallen, windblown, cut, broken, pulverised, sawn, or harvested, natural or disturbed, in use or as waste, rubbish, refuse or debris, stump, stubble, or otherwise*

*(b) Fossil fuel exposed at or lying within 20 metres of the surface of any land*

*(c) Peat in any form.*

*But it does not include wood forming part of a structure or in an otherwise processed form.* (Forest and Rural Fires Act 1977, Section 2)

**Wildfire**

An unplanned fire. A generic term that includes grass fires, forest fires and shrubland fires.

**Wildfire threat analysis**

A systematic method of identifying the level of threat a particular area faces from wildfire. The level of threat is generally related to a combination of ignition potential, potential fire behaviour and the values threatened. These factors may themselves be derived from other combinations of factors, for instance, potential fire behaviour can be determined from a combination of climate, topography and fuels.

# Appendix 2

## PROJECT METHODOLOGY

### A2.1 Introduction

A Terms of Reference for this project was prepared in July 2005 (Hilliard & Hunt 2005). The agreed process was to visit and interview DOC staff and people working in other agencies. Following a request from a wider group of DOC staff wishing to take part in face-to-face discussions, the original number of localities to visit was expanded from 9 conservancies to include all 13. The RD&I offices in Hamilton, Wellington and Christchurch were also visited.

Eighty DOC staff were interviewed and 46 questionnaires completed. These included 2 written 'interviews', 5 telephone interviews, 14 one-on-one sessions, and 15 group sessions. The positions of DOC staff extended from Rangers to Conservators and Principal Business Analysts (see Table A2.1 below). Ten questionnaires were also completed during six one-on-one interviews and four group sessions with staff working for other agencies.

TABLE A2.1. COMPOSITION OF INTERVIEWEES.

| DOC STAFF POSITIONS | NUMBER | NON-DOC ORGANISATIONS | NUMBER |
|---|---|---|---|
| Conservator | 4 | Landcare Research (scientists) | 7 |
| Technical Support Manager | 7 | National Rural Fire Authority | 4 |
| Technical Support Officer (Advisory Scientist) | 6 | Ensis (fire scientists) | 3 |
| Technical Support Officer[a] (Fire) | 12 | AgResearch | 2 |
| Technical Support Officer[a] (Pests and Threats, etc.) | 25 | **Total non-DOC people** | **16** |
| Information Management Unit[b] staff | 3 | | |
| Area Manager | 4 | | |
| Programme Manager | 6 | | |
| Ranger | 1 | | |
| Scientist | 8 | | |
| Principal Business Analyst | 2 | | |
| Internal Auditor | 1 | | |
| National Fire Coordinator | 1 | | |
| **Total DOC staff** | **80** | | |

[a] A Technical Support Officer is a specialist who provides support to the conservancy staff.
[b] Information Management Units are staffed by geospatial specialists who use GIS.

## A2.2 Interviews with DOC staff

*Selection*: On 12 July, Conservators were notified of the project and that initial contact would be made through the Technical Support Managers. All Technical Support Managers were rung and meeting times were set, based on people's availability. The Technical Support Officer (Fire) (or representative) in each conservancy was also contacted.

*Outcome*: Some conservancies publicised the project well and interested staff programmed the time into their diaries. Other conservancies appeared to select only a few key staff and, when the meeting times were set, a number could not attend, which limited the meeting's effectiveness. Some key individual staff were difficult to contact. Also, in some conservancies, fire management appears to be seen as just fire suppression, and staff were considered to be adequately trained. Any further work on fire research was not seen as important.

## A2.3 Interviews with non-DOC organisations

*Selection*: Because there are only a few organisations directly managing rural fires and fire research, getting in contact with them was easy.

*Outcomes*: Key known individuals and organisations were contacted and dates and times for meetings set. There were no issues with this process and the participants were interested and willing to be involved.

## A2.4 Names of people interviewed

The people interviewed are listed in Table A2.2.

TABLE A2.2. NAMES, ROLES AND LOCATIONS OF INTERVIEWEES.

| NAME | ROLE | LOCATION |
|---|---|---|
| Chris Jenkins | Conservator | Whangarei |
| Don McKenzie | Technical Support Manager | Whangarei |
| Tony Beauchamp | Conservancy Advisory Scientist | Whangarei |
| Tony McCluggage | Technical Support Officer (Weeds) | Whangarei |
| Lisa Forester | Technical Support Officer (Plants) | Whangarei |
| Lynnell Greer | Technical Support Officer (Recreation) | Whangarei |
| Peter Anderson | Technical Support Officer (Species) | Whangarei |
| Terry Conaghan | Information Management | Whangarei |
| Trevor Bullock | Technical Support Officer (Fire) | Bay of Islands |
| Alan MacRae | Ranger | Kaitaia |
| Jan Coates | Technical Support Manager | Auckland |
| Chris Green | Technical Support Officer (Invertebrates) | Auckland |
| Bec Stanley | Technical Support Officer (Plants) | Auckland |
| Daniel Breen | Conservancy Advisory Scientist | Auckland |
| Nobbie Reekie | Technical Support Officer (Fire) | Auckland |
| Peter de Lange | Scientific Officer | RD&I Auckland |
| John Gumbley | Technical Support Manager | Waikato |
| Avi Holzapfel | Conservancy Advisory Scientist | Waikato |
| Michael Green | Technical Support Officer (Fire) | Waikato |

*Continued on next page*

*Table A2.2—continued*

| NAME | ROLE | LOCATION |
|---|---|---|
| Andrea Brandon | Technical Support Officer (Plants) | Waikato |
| Ian Imrie | PM Service | Hauraki |
| Tracie Dean | Manager (Freshwater) | RD&I Hamilton |
| Natasha Grainger | STSO | RD&I Hamilton |
| Simon Kelton | Principal Business Advisor | RO Hamilton |
| Brendon Christensen | Technical Support Officer (Monitoring) | Bay of Plenty |
| Ralph Turner | Technical Support Officer (Fire) | Bay of Plenty |
| Bob Boardman | Technical Support Officer (Fire) | Bay of Plenty |
| Harry Keys | Conservancy Advisory Scientist | Tongariro |
| David Lumley | Area Manager | Tongariro |
| Nick Singers | Technical Support Officer (Plants) | Tongariro |
| Trevor Mitchell | Technical Support Officer (Fire) | East Coast |
| Chris Ward | Technical Support Officer CAS | East Coast |
| Ken Hunt | Area Manager | Napier |
| Ed Te Kahika | Field Supervisor | Napier |
| Paul Baker* | Rural Fire Manager | Napier |
| Bill Fleury | Technical Support Manager | Wanganui |
| Lindsay Golding | Technical Support Officer (Fire) | Palmerston North |
| Bill Carlin | Conservator | Wanganui |
| Amy Hawcroft | Technical Support Officer (Ecology) | Wanganui |
| Robert Bennett | Area Manager | Stratford |
| Phil Mohi | Area Manager | Palmerston North |
| Graeme La Cock | Technical Support Officer (Plants) | Wanganui |
| Kerry Hilliard | National Fire Officer | Palmerston North |
| Jim Campbell | Programme Manager (Biodiversity) | Wanganui |
| Rod Smillie | Programme Manager (Biodiversity) | Wanganui |
| John Mangos | Land Management Officer | Defence Department, Waiouru |
| Colin Miskelly | Technical Support Manager | Wellington |
| Rachael Thorp | Technical Support Officer (Fire) | Wellington |
| John Sawyer | Technical Support Officer (Plants) | Wellington |
| Hilary Aikman | Technical Support Officer | Wellington |
| Paul Hughes | Information Management | Wellington |
| Don Newman | Science Manager | Wellington |
| Susan Timmins | Scientific Officer | Wellington |
| Kate McAlpine | Scientific Officer | Wellington |
| Mike Davies* | Manager Legislation/Operations | NRFA Wellington |
| Karl Majorhazi* | Information Management | NRFA Wellington |
| Murray Dudfield* | National Rural Fire Officer | NRFA Wellington |
| Martin Heine | Technical Support Manager | Nelson |
| Mike Rodgers | Technical Support Officer (Fire) | South Marlborough |
| Shannel Courtney | Technical Support Officer (Plants) | Nelson |
| Cathy Jones | Technical Support Officer (Plants) | Nelson |
| Ian Miller | Technical Support Officer (Invertebrates) | Nelson |
| Harri Rautjoki | Auditor | Nelson |
| Elaine Wright | Terrestrial Sites Manager | Christchurch |
| Rod Hay | Science Manager Threats | Christchurch |
| Graeme Ayres | Principal Business Advisor | Christchurch |

*Continued on next page*

*Table A2.2—continued*

| NAME | ROLE | LOCATION |
|---|---|---|
| Dave Wilkins | Acting Technical Support Manager | Christchurch |
| Sjaan Charteris | Technical Support Officer (Freshwater) | Christchurch |
| Tony Teeling | Technical Support Officer (Fire) | Christchurch |
| Andy Grant | Conservancy Advisory Scientist | Christchurch |
| Nick Head | Technical Support Officer (Plants) | Christchurch |
| Norm Thornley | Information Management | Christchurch |
| Richard McNamara | Programme Manager Fire/Compliance and Law Enforcement/Historic, etc. | Twizel |
| Matt McGlone* | Scientist | LCR Christchurch |
| Janet Wilmhurst* | Scientist | LCR Christchurch |
| Peter Bellingham* | Scientist | LCR Christchurch |
| Ian Payton* | Scientist | LCR Christchurch |
| Grant Pearce* | Scientist | Ensis Christchurch |
| Stuart Anderson* | Scientist | Ensis Christchurch |
| Tonja Opperman* | Scientist | Ensis Christchurch |
| Ingrid Grunner | Conservancy Advisory Scientist | Hokitika |
| Jim Staton | Technical Support Officer (Fire) | Hokitika |
| Philipe Gerbeaux | Technical Support Officer (Freshwater) | Hokitika |
| Phil Knightbridge | Technical Support Officer (Plants) | Hokitika |
| Tom Belton | Technical Support Officer (Weeds/WAC) | Hokitika |
| Jeff Connell | Conservator | Dunedin |
| Marcus Simons | Technical Support Manager | Dunedin |
| Brin Barron | Technical Support Officer (Fire) | Alexandra |
| John Pearce | Programme Manager (Biodiversity Threats) | Dunedin |
| Theo Stephens | Scientific Officer | Dunedin |
| Geoffrey Rodgers | Scientific Officer | Dunedin |
| Bill Lee* | Scientist | Landcare Dunedin |
| Susan Walker* | Scientist | Landcare Dunedin |
| Peter Johnson* | Scientist | Landcare Dunedin |
| Barbara Barrett* | Scientist | AgReaearch Dunedin |
| Colin Fergusson* | Scientist | AgResearchDunedin |
| Alan Jackson* | Rural Fire Manager | NRFA Dunedin |
| Brian Rance | Technical Support Officer (Plants) | Southland |
| Peter Lowen | Programme Manager (Biodiversity) | Southland |
| Andrea Goodman | Technical Support Officer (Fauna) | Southland |
| Lynn Sheldon-Sayer | Ranger Weeds | Southland |
| Mike Grant*,† | Principal Rural Fire Officer | Southland |
| Chris Hodder | Fire Operations Officer | Victoria, Australia |

* Non-DOC personnel.

† Manages Southland Conservancy's fire responsibilities.

## A2.5 Fire research needs questions for DOC staff

| | |
|---|---|
| Name | Location |
| Date | Time in position |

*Introduction*

The objectives of this review are to complete a Fire Management fire research needs analysis for the Department of Conservation taking into account the findings of the internal audit into fire management systems. This includes:

1. Identifying the current and future fire research needs of the Department;
2. Consider the current and future fire research being carried out in New Zealand and the Australian Bushfire CRC that directly relates to the department;
3. Assessing the 'gap' between the Department's needs, 'awareness' and the current research environment;
4. Identifying approaches the Department can use to ensure adequate and appropriate fire research, including fire ecology, is undertaken that can be applied to fire management;
5. Identify, describe and recommend future technical advice requirements relating to fire ecology for the DOC to manage its obligation in Protected Natural Areas.

| | |
|---|---|
| 1. What type of Interview? | Telephone:<br>One on One:<br>Group: |
| 2. What is your role within the Department and what is your relationship with fire management? | |
| 3. Do you know of any fire research projects in New Zealand?<br>If Yes which ones?<br>What is the intent? | |
| 4. Two questions, current and future research needs.<br>What do you consider are the current fire research needs for the Department?<br>How can these be addressed? | Current needs<br><br><br>Addressed by |
| 5. What do you consider are the future fire research needs for the Department?<br>How can these be addressed? | Future needs<br><br>Addressed by |
| 6. What ecosystems in your conservancy (or area of work) are most prone to fire? | |
| 7. What research, if any, do you need to support management of these ecosystems? | |

8. Do you monitor ecosystem recovery after fires?
   If yes how?

9. Can you identify three aspects of fire research you would like to see that would make the biggest difference to the Department's fire management?

10. What future technical advice on fire ecology is needed by the Department?

    How do you see this being implemented?

11. Anything else you would like to say?

## A2.6 Fire research needs questions for non-DOC personnel

| | |
|---|---|
| 1. What type of Interview? | Telephone:<br>One on One:<br>Group: |
| 2. What is your organisation's role in fire management? | |
| 3. Do you know of any fire research projects in New Zealand?<br>If Yes which ones?<br>What is the intent?<br>Attach notes/papers if necessary | |
| 4. What national social, ecological or physical research relating to fire management, needs to be undertaken in New Zealand? | National needs: |
| How will these be addressed and by whom? | Addressed by |
| 5. Can you identify three aspects of fire research that would make the biggest difference to national fire management in New Zealand? | |
| 6. What future technical advice on fire management do you feel is needed by the Department of Conservation? | |
| How do you suggest this should be implemented? | Implemented by: |
| 7. Anything else you would like to say? | |

# Appendix 3

## GOVERNMENT FUNDING FOR RESEARCH IN AUSTRALIA

(Material taken from the Bushfire CRC website, www.bushfirecrc.com, viewed July 2007.)

**Wildfire research—science for safer communities**

The Bushfire Cooperative Research Centre (CRC) was established under the Australian Commonwealth Government's CRCs Programme. The objective is to provide research that enhances the management of the bushfire risk to the community in an economically and ecologically sustainable way.

**Aims of the Bushfire CRC**

- To develop an internationally renowned centre of excellence to lead and coordinate bushfire research in Australia
- To provide a research framework that will improve the effectiveness of bushfire management agencies
- To increase the self-sufficiency of communities in managing the risks from bushfires

The Bushfire CRC runs four separate research funding programmes. Each of the research programmes is described below:

A: Safe prevention, preparation and suppression

B: Management of prescribed and wild fires in the landscape

C: Community self-sufficiency for fire safety

D: Protection of people and property

It also has an education and training programme, which provides scholarships (Programme E), as well as a knowledge networking programme (Programme F).

**Programme A: Safe prevention, preparation and suppression**

This category of research aims to increase understanding of, and ability to manage, bushfires in order to reduce the risk to firefighters and the community.

Accurate, high-resolution fire weather and fire behaviour predictions are key to taking effective management action before and during fires. There is a need to more accurately describe the fire environment and the level of uncertainty in predictions, so that fire managers can better understand the consequences of their actions, and of their interaction with natural events.

Reliable predictions of different elements of fire behaviour and fire danger are critical in suppression strategies. Diurnal, short-term (up to 4 days), seasonal and long-term predictions of potential fire occurrence and severity are also critical for allocating fire-fighting resources, implementing prescribed burning programmes and for public warning and fire migration programmes.

The duty of care principles constraining bushfire and prescribed fire management across a widening range of social and environmental issues requires that the fire manager uses reliable prediction tools that make the best use of emerging technology. Advances in computing and knowledge-based systems will greatly facilitate the integration of more of the critical variables that determine the development of either wildfire or controlled prescribed bushfire. The challenge will be to determine which are the most relevant factors from all the available sources and then subject these to rigorous field testing.

Programme A is divided into five major research themes. Each has a range of research projects, postdoctoral research fellows, postgraduate studies, end-user collaboration and national and international links. The five themes are:

A1. Fire behaviour modelling, with sub-themes:

- 1.1 Fire behaviour modelling (because of its relevance, this sub-theme is described more fully below)
- 1.2 Bushfire observer's handbook
- 1.3 Fuel classification and availability
- 1.4 Improved methods for assessment and prediction of grassland curing

A2. Fire weather and fire danger

A3. Suppression technology

A4. Bushfire risk management

A5. Computer simulation modelling

Projects aligned with these themes are led by researchers from CSIRO, the Commonwealth Bureau of Meteorology, and the Universities of Melbourne, New South Wales and Western Australia. Programme A has established an end-user advisory committee to strengthen the important link between researchers and users.

### *Programme A1-1.1: Fire behaviour monitoring*

The need to improve firefighter and community safety in the management of bushfires has been a growing concern in recent years. This project aims to address this need by providing better knowledge and understanding of the interactions between fire, fuel, weather and topography.

The project plans to integrate existing and new fire behaviour models into a national fire behaviour prediction system. Factors include rate of spread, flame height, intensity and spotting for wildfires and controlled prescribed fires. The research includes experimentation and validation of fire behaviour models, documentation, training, and the production and delivery of fire behaviour systems to end users.

Specifically, research includes field validation of the findings from Project Vesta to southeastern fuels in Maragle State Forest, NSW. Project Vesta was a comprehensive research project between CSIRO, Department of Conservation and Land Management in Western Australia that investigated the behaviour of bushfires burning fuel of different ages and structures under dry summer conditions. Experimental burning and the collection of fire behaviour information from major wildfires is a key component of the research. (See website: www.ffp.csiro.au/nfm/fbm/vesta, viewed 8 October 2006.)

A highlight of the work was a large-scale experimental burn named 'Operation Tumbarumba', which was conducted in Maragle State Forest, adjacent to Kosciusko National Park in February 2004. This was the first experimental burn conducted in the life of the Bushfire CRC and was notable because it was linked with other research projects, such as the Fuel Classification and Tanker Systems projects. The experiment involved more than 20 researchers and 60 personnel from the NSW Rural Fire Service (staff and volunteer firefighters), Country Fire Authority Victoria (staff and volunteer firefighters), state forests of New South Wales, New South Wales National Parks and Wildlife Service, Department of Sustainability and Environment Victoria, Department of Conservation and Land Management, Western Australia, and New Zealand Ensis.

A postgraduate scholarship at the University of New South Wales (ADFA) was also established as part of this project to investigate the weather and fuel moisture parameters affecting the behaviour of fires in heathland fuels in the greater Sydney Basin Region.

***Project synopsis***

The programme will link with other research to integrate both physical and empirical models to develop operational fire behaviour models for varied vegetation types. The projects will give managers better operating models to implement prescribed burning programmes, suppression resources, risk and biodiversity management programmes. These models will be integrated into a national fire behaviour prediction system consisting of four primary components (fuel models, fuel moisture models, wind models and spot fire models) to predict fire behaviour, including rate of spread, flame height, fireline intensity and residence time.

High-resolution fire behaviour prediction is crucial to taking effective fire management action before and during fires. Models need to accurately describe the fire environment—and indicate the uncertain level of predictions—so fire managers can better understand the likely consequences of their actions. Predictions of different elements of fire behaviour, including emissions, are vital when deciding on suppression strategies.

The first of three core projects involves extending the forest fire behaviour model derived from the Project Vesta fire experiments in WA to suit conditions in southeast Australia. Researchers will compare fuels of different ages in selected eucalypt forests in southeast Australia with those from the WA fire experiment sites. Wind data from the Bureau of Meteorology weather prediction models will be compared with observations taken below the forest canopy to calibrate and validate the fire behaviour models. Techniques will be developed to collect wildfire data to extend the fire behaviour datasets into very high and extreme fire danger conditions. Field validation fire experiments will be carried out in the Margle State Forest.

The second focus will be on extending a preliminary model for predicting fire behaviour in heathland, shrubland and woodland. This vegetation makes up a considerable proportion of the remaining natural vegetation in the most heavily populated parts of Australia, and is a major component of the urban interface around Sydney. Carefully designed experimental fires will isolate the effects of vegetation type, structure and age, and will examine fire behaviour at low moisture contents. The effects of slope and head fire width will also be determined. Bushfire data must be collected to validate the model for high intensity conditions.

The third research goal is to determine a prescribed burning protocol for forest plantations. The Plantations for Australia 2020 vision (www.plantations2020.com.au, viewed August 2006) of trebling the plantation estate to 3 million hectares will significantly change the nature and load of flammable fuels and consequently alter regional fire risk and fire behaviour. Researchers will develop prescribed burning guides for different plantations in the north coast region of NSW, and will create new fire behaviour models to help fire and plantation managers plan for pre-suppression and suppression activities.

Project Leader: Jim Gould, CSIRO, Ph: (02) 6281 8341.

**Programme B: Management of fire in the landscape**

Managing fires on a landscape scale is a difficult task in a continent where fire is a central component of both the ecology and the biophysical 'structure' of the environment. This programme focuses on the use of prescribed fires to prevent loss of life and property, and to retain key ecological attributes such as biodiversity. Embracing prescribed fire as a central plank in maintaining biodiversity has been one of the major shifts in government policy in recent years and a testament to the work of many scientists over many years. However, the job is not finished and progress in Programme B during the first year of the CRC's operation has largely been the continuation of research already underway.

The CRC looks forward to further dialogue on how to best integrate the outputs and learning from Programme B into practice. Recent launches of books and research projects in Sydney and Darwin have attracted broad media and community interest.

Another important outcome in this early part of the CRC's life has been the recruitment of key postdoctoral researchers. New young researchers in Programme B include Matthias Boer, Roy Witkuhn, Maria Taranto, Karen King and Kate Parr. It is significant that two are international—Matthias Boer from Spain, and Kate Parr from South Africa.

Literature reviews will feature highly as outputs of several current research projects. These are eagerly awaited by both the CRC research committee and the stakeholders. Programme B research spans Australia—from Darwin to Perth to Adelaide to the entire eastern seaboard. It also spans nearly every imaginable type of Australian ecosystem, and includes research conducted within long-term fire regime experiments, as well as that conducted 'opportunistically'. Some of the NSW and WA research aiming to develop landscape-scale use of fire history data in conjunction with biodiversity and other ecological data offers exciting prospects for CRC's stakeholders. Equally exciting are the prospects of a world-class facility for analysis of bushfire smoke, and the related development of a database.

**Programme C: Community self-sufficiency for fire safety**

Some members of these communities may also create risk by starting fires through carelessness or arson. Through individual and community action people can reduce their own vulnerability, and reduce the probability of fires, and substantially reduce fire's impact. Communities need support to achieve this, and agencies involved with bushfire risk management need to know how best to provide it. They need to be confident that programmes work and that they are cost effective.

Programme C has started to address these issues through projects on:

- Understanding communities
- Risk communication
- Negligent and deliberate fire lighting
- The economics of bushfire
- The 'stay-or-go' policy
- The evaluation of community safety policies and programmes

Projects in this programme draw primarily on social science and economics. Each project or project area is working towards two basic aims:

- A state of the art methodology, or guidelines for the specific topic
- The evaluation of selected existing practices through case studies

The projects are closely linked to other CRC activities, in particular parts of Programme D on building safety, Programme A on aerial fire fighting, and all areas with an interest in bushfire risk modelling. Initial reports and presentations have been produced in the first year and next steps include finalising reports for publication, and commencing primary data collection and analysis, which will involve case studies and collation of disparate datasets.

This work has attracted considerable international interest. Collaboration has commenced in the economics area and is also expected soon in the 'stay-or-go' project.

Programme C aims to increase community resilience through self-sufficiency in managing bushfire risk. People living and working in bushfire-prone areas bear the fire risk and also, through their lifestyles and locations, help create the risk.

### Programme D: Protection of people and property

The risk to people and the destruction of property by bushfires in Australia are major political issues. Community expectations change with time and so does the impact of bushfires. Living in the high-risk urban interface is now a much sought after lifestyle for a large proportion of Australians, and the ability of new arrivals to cope with bushfires is often inadequate. In addition, community expectations for the health and safety of firefighters are now higher than they were even a decade ago. Working conditions on the fireground are now expected to be as safe as those in a normal work place.

#### *The need for a risk model*

A key focus of this programme is developing a risk model for assessing the impact on houses and thence the cost effectiveness of various recommendations related to safety. The numerous factors under study that affect safety include climate factors, the terrain and vegetation landscape within a kilometre or so of houses, local urban planning and building regulation requirements, details of house construction, local fire fighting policies and the preparations and actions of the building occupants themselves. In addition, laboratory studies will be undertaken to develop methods for the design of various building components, such as decking and glazing, to resist attack by bushfires.

#### *Firefighter health and safety*

The largest part of this programme targets the health and safety of firefighters. Both short-term risks and long-term health hazards will be investigated. Initially, the demographics and data on the physiology of Australian firefighters will be obtained. These will be used to map out strategies for work routines, which will then be checked by field measurements under operational conditions. Of particular concern is the health impact of air toxics in the fireground, where many potentially hazardous chemicals are detected. Improvements in fire-fighting equipment are also being investigated as part of the safety drive. One such project has assessed the performance of fire-fighting trucks that have been modified to provide protection in the event of an accidental burn-over from a moderate forest fire. A project is also underway to assist firefighters in making safe decisions, particularly when subjected to the stress of operational situations.

#### *Volunteerism*

The recruitment and retention of volunteer firefighters is seen as a major issue in the protection of people and property. Currently Australia is serviced by about 300 000 highly effective volunteers and their services, which if paid for, would cost several billion dollars each year. The indications are that the size and nature of this volunteer work force will change in the future owing to changes in the demographics and culture of those living in rural and peri-urban areas. Accordingly, research is underway to assess the changes and to develop strategies for dealing with them.

# Appendix 4

## ENSIS BUSHFIRE COOPERATIVE RESEARCH CENTRE PROJECTS

This appendix provides supporting information to section 5 of this report. It summarises three funding streams that provide opportunities for a range of fire management research projects in New Zealand. It also summarises projects underway at October 2005.

The three funding providers are the:

- Foundation for Research, Science and Technology (FRST) research programme (see Appendix 5 for further detail of the FRST programme)
- Australian Bushfire Cooperative Research Centre (CRC) programme
- New Zealand Rural Fire Research Group projects

## A4.1 FRST research programme

This 6-year research programme began in 2005. The programme has four themes, which are listed below.

***Reduction of wildfire hazard***

These projects aim to quantify factors contributing to wildfire risk by providing:

- Better definition of the rural fire hazardscape and the physical and human/social processes contributing to vegetation wildfires, leading to improved wildfire risk assessments
- Quantification of the physical/environmental factors (fuels, weather, topography) that contribute to rural fire risk
- Assessment of the social/political/economic factors that may contribute to the fire hazardscape in rural areas
- Analysis of data on fire frequency, causes, area burned and costs

***Application of fire danger rating to enhance readiness***

These projects focus on developing a New Zealand Fire Danger Rating System (NZFDRS), modelling fire behaviour and communicating fire danger through the:

- Development and validation of the FWI (Fire Weather Index), FBP (Fire Behaviour Prediction) and FOP (Fire Occurrence Prediction) modules of the NZFDRS
- Development of models to predict rate of fire spread and fuel consumption in a range of vegetation types
- Determination of the effectiveness of communication of fire danger warnings in reducing fire hazard and ensuring the safety of communities in rural areas

### *Tools to support wildfire response*

These projects aim to develop practices and tools that promote safe and effective decision making during rural fire incidents, with particular emphasis on improving firefighter and community safety, through the:

- Quantification of resource productivity and fire suppression effectiveness during wildfires and research burning trials
- Production of models and guidelines for predicting the productivity and effectiveness of fire suppression resources
- Development of models and guidelines for predicting the effectiveness of fire breaks in different fuel types
- Development of spatial tools to model fire growth to support fire suppression decision-making

### *Social research on improved community recovery mechanisms*

These projects seek to quantify the effectiveness of existing recovery processes following wildfires, and investigate methods for enhancing community resilience through the:

- Evaluation of community resilience and recovery mechanisms following major fire events (e.g. Blenheim and Alexandra), and documentation of case studies and lessons learned
- Evaluation of relevant international research results and social recovery practices
- Recommendations on best practices to lessen social impacts and improve recovery process following significant wildfires

## A4.2 Bushfire CRC projects (Year 3 of 7)

The Australian Bushfire CRC was established in December 2003 to bring together state agencies, research organisations and universities across Australia. It has been allocated A$110 million for bushfire research over 7 years. The New Zealand Fire Research programme has been invited to participate and this carries significant benefits both for its projects and for fire management in general. Benefits include:

- Some funding for research and travel costs
- Access to the education programme and student scholarships
- Access to all research results and outcomes from across the Bushfire CRC

The Bushfire CRC has four research programmes, plus an education programme:

Programme A: Safe prevention, preparation and suppression

Programme B: Management of fire in the landscape

Programme C: Community self-sufficiency for fire safety

Programme D: Protection of people and property

Programme E: Education

New Zealand provides an in-kind contribution to several programmes via existing activities:

- Within Programme A, led by Ensis Bushfire Research (J. Gould)
- Contributing to research on fire behaviour modelling via research burning (A1.1, Project FuSE, further described below)
- Leading research on grassland curing assessment (A1.4, further described below)
- Recently joined Programme C—social research

***Bushfire CRC research in 2005***

- Wildfire risk, fire occurrence and statistics.
- Description of the New Zealand fire environment—fuels (fuel type definition and mapping) and weather (fire climate description and mapping, and effects of climate change).
- Review of factors affecting wildfire risk (including social/economic factors); review of available information sources and databases; development of work plan for subsequent research.

***Project A1.1: Fire behaviour modelling for shrub and heathland fuels***

Also known as Project FuSE—'fire behaviour experiments in scrub, with attention to wind (*u*) and slope'.

- Modelling heath/scrub fire behaviour
  —In similar shrub/heath types across Australia and New Zealand
  —In New Zealand, 15–20 burns in manuka/kanuka and gorse scrub at 2–3 sites
- Effects of slope on rate of spread
  —New Zealand sites on steep slopes critical to research
  —5–10 burns at 1–2 sites, initially in scrub but also potentially other fuel types (such as tussock)
- First New Zealand burn experiments at Lake Taylor site completed (March 2005)
  —International research team: CSIRO, CALM-WA, DEH-SA, USFS (Riverside) and the New Zealand Fire Researchers (Ensis)
  —Three burns in manuka/kanuka scrub on steep slopes (25° to 35°)
  —Two burns in manuka scrub/wilding pine mix on lesser slopes (5° to 15°)
  —Included point and line ignition comparisons
  —Measurements of rate of fire spread, flame lengths, fuel consumption, weather, fuel moisture, in-fire temperatures; and recording of ground and aerial infra-red and visual video
- Further New Zealand burn experiments planned at the Torlesse site
  —8–10 burns in manuka/kanuka and gorse scrub on range of slopes and aspects
  —Multi-year burn programme; set up in spring 2005 (from September), first burns proposed summer 2006 (November/December)

***Project A1.4: Improved methods for the assessment and prediction of grassland curing***

This project began in 2004 to test the degree of curing, i.e. the 'proportion of cured and/or dead material in a grassland fuel complex'. It is providing critical input for Australian and New Zealand models of grassland fire behaviour and fire danger. The project is revealing inaccuracies and inconsistencies with current methods.

Objective: To develop improved methods for the assessment and prediction of grassland curing as an input into fire danger rating systems and fire behaviour models.

Deliverables:

- Accurate curing input into fire danger rating and fire behaviour models
- Systems applicable across a range of grass types, and management and environmental influences
- Assessement of current and prediction of future levels of curing
- Prediction of the onset and progression of curing, and green-up
- Data for use in maps, climatology
- Systems that are easy to use and implement operationally

Research methods:

- Remote sensing
- Pasture growth modelling and soil moisture relationships
- Australasian field sampling programme

## A4.3 Rural Fire Research Group projects

These projects are undertaken as part of the FRST research programme.

***Fuel type and fuel load mapping***

An improved fuel type and fuel loadings project has begun. A Fire Technology Transfer Note on this has been published (Opperman & Coquerel 2005). It is a GIS-based project using Landcover Database 2 data.

***New Zealand fire climate and fire behaviour mapping***

This maps the fire climate using climate station information, then uses these data to map fire behaviour potential. This is done by combining fuel types and fuel loadings (above), and fire climate models.

### *Research on wildfire risk, fire occurrence and statistics*

This project has two foci:

1. Description of the New Zealand fire environment:

- Fuels: studies of fuel chemistry, fuel type field guide
- Weather: fire climate updating, fire season severity prediction
- Topography: modelling of slope/aspect effects on Finefuel Moisture Code

2. Review of fire occurrence statistics:

- Analysis of data on fire frequency, cause, area burned and costs
- Recommendations on fire occurrence databases and reporting
- Analysis of total costs of wildfires to New Zealand
- Development of the FOP module

### *Fire behaviour modelling—2004/05 experimental burning*

- Focus on Bushfire CRC experiments: completion of Lake Taylor scrub burns, establishment of Torlesse site
- Mt Benger tussock fire ecology burns
- Completion of stubble burns, Canterbury, in conjunction with firebreak breaching studies
- Wildfire documentation: significant fires of 2004/05

### *Fire behaviour modelling—future*

Development of a New Zealand FBP system:

- Observation and documentation of fire behaviour in different vegetation types: experimental burning trials and opportunistic wildfires
- Validation of existing international models: mature pine, logging slash, pasture grasslands
- Development of models for unique New Zealand fuel types: gorse and manuka scrub, tussock grasslands, crop stubble

### *Grass curing—future*

The focus is on two aspects of improved methods for the assessment and prediction of grassland curing.

Investigation of alternative approaches:

- Remote sensing, pasture growth modelling, soil moisture relationships
- Expanded Australasian field sampling programme

Accurate curing inputs for fire danger and fire behaviour models:

- Current and predicted curing; curing onset, the progress of greening-up
- Models/systems for range of grass types, and management and environmental influences

### *Fire response tools (1)*

This looks at resource productivity and effectiveness. It is led by the Centre for Human Factors and Ergonomics (Scion-based research team) and involves:

- A literature review, a work plan and the development of methods for research
- Data collection from experimental burns, wildfires and simulated exercises
- Validation of international resource productivity studies
- Assessment of the effectiveness of firefighters, hand tools, pumps and hose, and heavy machinery

A New Zealand Fire Service Commission Collaborative Research Fund proposal for a project looking at fire suppression workload and firefighter fatigue was unsuccessful.

### *Upgrading of New Zealand Fire Danger Rating System*

This is looking at upgrading and developing NZFDRS modules via:

- FWI system validation
- Ongoing FBP development, including fire behaviour models and grass curing investigations
- FOP and AFM (Accessory Fuel Moisture) system development

It is also looking at developing and improving NZFDRS guides and systems such as those related to fire danger class criteria, the FWI system, the FBP system and the FOP system.

### *New fire response tools (2)*

Firebreak effectiveness studies involve developing a research methodology for firebreak breaching trials via a literature review, and the development of a workplan and a methodology. It is hoped this will be undertaken as student project. A pilot study in crop stubble was carried out during the 2004–05 season. The initial focus is on crop stubble, and the intention is to extend the work to other fuel types (scrub, forest).

The aim is to produce models and guidelines for operational use and to validate international models and guides (e.g. those for grass).

### *Fire response tools—future*

This project to develop spatial fire growth models involves a review of international GIS-based fire spread/growth models via a technical review of the GIS components of available models, and a review of fire behaviour modelling aspects of the available models. It will begin in 2005/06.

It will deliver recommendations on how best to progress New Zealand fire growth models. Its aim is to adopt and/or adapt existing models rather than re-invent them. The completion date is 2009/10 (or earlier).

### *Social wildfire research*

New social fire research is underway in a range of areas:

- Social and economic factors affecting wildfire risk: review of databases, workplan development.
- Communication of fire danger warnings: new research for 2005/06; review of international approaches; investigation of fire manager as compared to public perspectives.
- Community resilience and recovery following wildfire events: two studentships were obtained during 2004/05; reviews of Australian and North American literature; case studies of affected communities planned from 2005/06.

### *Technology transfer*

This has three components:

- Developing fire behaviour training and materials:
  —Intermediate fire behaviour courses
  —Fire behaviour forecasting course (under development)
- Publications:
  —Forest Research Bulletin series
  —Newsletters (Fire Technology Transfer Notes, Fire Research Overview)
  —Other (Fire Behaviour Field Guide)
- Fire Research website:
  —Adding pages on fire background and on publications
  —Updating project pages

# Appendix 5

## GOVERNMENT FUNDING FOR RESEARCH IN NEW ZEALAND

Organisations, including government departments, can fund and carry out their own research. There is also a government-funded agency that funds research by other organisations—the Foundation for Research, Science and Technology (FRST).

FRST must show measurable returns to New Zealand from its investments. It has determined to do this in part by creating an Outcome Based Investment (OBI) programme where:

- There is clear identification of long-term outcomes
- Long-term investment stability is targeted at areas of national importance
- Science outputs are taken up, applied and the benefits of the research captured
- There is engagement and coordination with research users to achieve practical outcomes
- The research contribution to the delivery of outcomes is monitored and measured

An OBI is an investment tool that focuses on contracting for outcomes (rather than outputs per se). It does this through the delivery of Intermediate Outcomes. FRST defines an Intermediate Outcome as a 'direct, measurable result of successful implementation or uptake of research outputs'.

An OBI is associated with an 8–12-year funding period (rather than the usual 3–5 years), meaning more security for the science provider agencies and a greater opportunity to deliver meaningful natural ecosystem research products. The investment amounts are large (up to NZ$6.2 million per year for 12 years in the most extreme case) and a contestable process is run to select the best providers or mix of providers.

A due diligence round is run on each likely provider to ensure that its capability claims are justified and that the provider is likely to be able to deliver results.

Each OBI is managed under strict project management protocols and is the responsibility of a governing body (a board or a council) to ensure that strategic directions are maintained and priorities actioned. Moreover, each OBI is supported by advisory committees to ensure that the detailed research directions and projects are aligned with governance body expectations. End-user engagement in both governance and advisory levels is mandatory.

Research on four government goals are undertaken by FRST. These are:

- Economic research for industry
- Environmental research
- Knowledge
- Social

Within each goal are Portfolios, each of which has Target Outcomes.

Four Portfolios exist under 'environmental research':

1. Understanding and adapting to global environmental and earth processes change
2. Resilient, functioning and restored natural ecosystems
3. Building sustainable cities and settlements
4. Maintaining environmental integrity for sustainable resource use

Eight Target Outcomes have been identified and funded under Portfolio (2): Resilient, functioning and restored natural ecosystems (Table A5.1).

TABLE A5.1. EIGHT TARGET OUTCOMES UNDER PORTFOLIO (2).

| CODE | TARGET OUTCOME | ANNUAL FUNDING (NZ$) |
|---|---|---|
| TO1 | Define New Zealand's biota | $6–9 million |
| TO2 | Reverse the decline in New Zealand's biota | $7 million |
| TO3 | Biosecurity—incursion management | $2.5 million |
| TO4 | Biosecurity—management of existing pests | $4 million |
| TO5 | Protection of the unique ecosystems of the Southern Ocean and Antarctica | $0.25 million |
| TO6 | Sustainable use of aquatic and terrestrial biota | $5 million |
| SPS | Sustainable systems for production, use and harvest in aquatic systems | $2 million |
| SRU | Effective biosecurity systems across sectors | $2 million |

FRST called for research proposals to address priority issues relating to biodiversity and other topics. Two of Landcare Research's proposals that were accepted as OBIs relate directly to DOC's management of terrestrial ecosystems. They are:

- Ecosystem resilience, addressing Target Outcomes 2 and 4
- Sustaining and restoring biodiversity, addressing Target Outcome 2

Both OBIs have Intermediate Outcomes that contribute to the achievement of the Target Outcomes.

Ecosystem resilience has five Intermediate Outcomes:

- Reducing threats to forest ecosystem processes (protection against introduced herbivores)
- Reducing threats to forest ecosystem processes (prioritising pest species for control)
- Increasing natural ecosystem resilience to weeds
- Biodiversity response to global change
- National Vegetation Survey Databank

Sustaining and restoring biodiversity also has five Intermediate Outcomes:

- Reducing extinction risk by sustaining genetic diversity
- Sustaining critical functional species interactions
- Increasing effectiveness of conservation flagships
- Maintaining threatened rare ecosystems
- Restoring dryland biodiversity through woody dominance

DOC has been involved in the OBI process by providing:

- Accountability for provision of resources
- Accountability for implementation (uptake) of OBI products
- Accountability for OBI governance

This involvement has resulted in significant success in funding and establishing the direction of research.

# Appendix 6

## RECENT DOC REPORTS ON FIRE MANAGEMENT

This appendix summarises seven key documents on fire management completed for or by DOC. They are:

- The use of fire for conservation management in New Zealand (Allen et. al 1996)
- Fire ecology and control research plan 1997/2006 (Hilliard & Timmins 1998)
- Fire ecology and management information transfer from Western Australia to New Zealand (Burrows 1999)
- Brief statement on strategic priorities for research 1999 (Timmins et al. 1999)
- Report on the fire management systems audit (DOC 2005b)
- General policy for national parks (NZCA 2005) and Conservation General Policy (DOC 2005a)
- Long-term approach to fire management (Hilliard et. al 2005)

### A6.1 The use of fire for conservation management in New Zealand

Landcare Research provided DOC with a summary of previous scientific reviews of fire ecology in New Zealand. It reviewed international and New Zealand literature on the use of fire for managing grasslands, shrublands and wetlands for conservation purposes. Techniques for monitoring fire impacts on ecosystem recovery and recommendations for use of fire in ecological management were also prepared.

Landcare Research suggested that prescribed fire be used to meet management objectives in New Zealand's protected natural areas. However, knowledge of the effects of fire on many ecosystem components is scarce or lacking. Caution was advised in the planning and application of fire as a management tool (Allen et al. 1996).

### A6.2 Fire ecology and control research plan 1997/2006

This internal DOC document provides a list of the fire research topics that require attention in the next 10 years, ranking the following highly in terms of urgency and importance:

- The impact of fire on native communities and species
- Fire behaviour
- Fire as a management tool
- Fire control
- Monitoring and information transfer

However, this document was not formally accepted by DOC and no recommended actions have been undertaken.

## A6.3 Fire ecology and management information transfer from western Australia to New Zealand

This is the most recent formal summary of DOC's approach to fire ecology and management information. The document contrasted aspects of western Australian fire management with New Zealand fire ecology. This work identified various principles. It also recommended establishing a national Wildfire Threat Analysis, incorporating this into each level of land management planning and broadening it to include fire ecology. For example, Conservation Management Strategies (CMSs) detail fire management and strategies for special areas.

The document contained a warning that:

> 'The Department's reluctance to use fire as a management tool in relation to conservation of flammable vegetation types, and political and agency disagreement over the primary objective and best course of action or confusion about fire management could lead to a major fire crisis, causing damage to property and conservation values and possibly loss of human life.' (Burrows 1999: 26)

This would be alleviated by:

> 'Recognition and definition of fire issues, the formulation of clear fire management policies and objectives underpinned by sound science, and a well trained and well equipped fire fighting force will reduce the risk and impact of a major fire.' (Burrows 1999: 26)

## A6.4 Brief statement on strategic priorities for research: fire ecology and control

Timmins et al. (1999) developed eight strategic priorities for fire research for DOC. These were:

1. Comprehensive research programme on fire ecology and ecosystems
2. Study of the effect of fire on different native communities
3. Investigation of the long-term impacts of fire on ecosystems
4. Development of a fire behaviour prediction system for a range of fuels
5. Risk assessment of fire to indigenous species and safer working conditions for firefighters
6. Investigation of the behaviour of fire regimes under different climatic regimes
7. Study of the effect of prescribed fire on indigenous species
8. Investigation of the synergy of fire with other management practices to maximise biodiversity

The eight priorities were not acted upon by DOC.

## A6.5 Report on the fire management systems audit, March 2005

The internal audit provides the background to issues facing fire managers in DOC, and suggestions for a way forward. It does this by:

- Helping to clarify DOC's strategic direction for fire management
- Providing a basis for a response to the Department of Internal Affairs' review
- Identifying the issues and making recommendations for improvement to support DOC's desired national and regional direction

The audit team advocated for DOC to make the most of opportunities to substantially change the way it manages fire by:

- Being much clearer on its strategic direction for fire management
- Clarifying roles and creating a consistent national approach
- Rethinking how DOC is involved in New Zealand's overall fire management

The team also recommended that a fire research needs analysis be undertaken (in Appendix 2 of the report).

## A6.6 General policy for national parks and Conservation General Policy

These government policy documents guide, and in some cases direct, Ministerial decisions. They will similarly guide and direct decisions of the Director-General of DOC and other decision makers under the legislation. In particular, they will shape a new round of CMSs and Conservation Management Plans over the next few years, as well as revised national park plans. The scope of the policies are broad, reflecting the wide spectrum of conservation areas administered under the legislation and the many conservation tasks to be performed. Relevant text from the Conservation General Policy is below:

> *4.3 Fire management*
>
> *4.3 (a) Conservation management strategies and plans should make provision for fire management, covering fire risk, fire protection, fire control, fire regimes, and the use of prescribed burning for ecosystem management.*
>
> *4.3 (b) Conservation management strategies and plans may provide for small-scale prescribed burning where it is clearly necessary to:*
>
> *i. manage fuel loadings where this addresses a significant risk and is ecologically justified; or*
>
> *ii. preserve specified indigenous species, habitats or ecosystems.*
>
> *4.3 (c) Fires may be allowed to burn where the Principal Rural Fire Officer considers that the risks to people, places and property can be managed in accordance with predetermined fire plans, which should take into account planned conservation outcomes.*
>
> (DOC 2005a: 24)

*4.7 Fire management*

*4.7(a) A national park management plan may provide for prescribed burning where necessary to:*

*i) manage fuel loadings where this addresses a significant risk and is ecologically justified; or*

*ii) preserve specified indigenous species, habitats and ecosystems.*

*4.7(b) Fires may be allowed to burn where the Principal Rural Fire Officer considers the risks to people, places and property to be manageable in accordance with predetermined fire plans that should take into account national park values.* (NZCA 2005: 27)

## A6.7 Long-term approach to fire management by DOC

This is an unpublished, internal DOC report presented to the General Manager of RD&I, 21 July 2004.

The paper describes the context of the legislative fire management changes and discusses how DOC needs to be able to anticipate and account for these changes. DOC must also be able to implement new ways of managing fire supported by sufficient and robust information.

It identified that DOC needs to be proactive in formulating long-term fire management policies and approaches. It went on to say that DOC is at risk of having to attend increasing numbers of fires owing to changes in land tenure, acquisition of land (particularly grasslands), changes in land use and increased recreational use. Currently there is also a review of the national structure of fire-fighting authorities, including rural areas, and fire funding.

The document identifies some changes, opportunities and risks relating to DOC's fire management. It recommends that DOC invests in developing a long-term strategy (10–20 years) for fire management that includes and addresses the following:

- Build on, support, initiate and contribute to fire research projects.
- Develop specific fire management plans for high-risk or important conservation areas. Reflect and include this in conservancies' CMSs.
- Become more proactive in monitoring recovery after fires, undertaking restoration of significant sites, and learning more about fire ecology.
- Develop decision support tools for line managers to use when assessing whether fires should be left to burn or suppression activities undertaken.
- Use fire as a management tool to sustain desirable habitat types for specific biodiversity or recreational values.

# Appendix 7

## DECISION SUPPORT SYSTEMS FOR OPERATIONAL MANAGERS

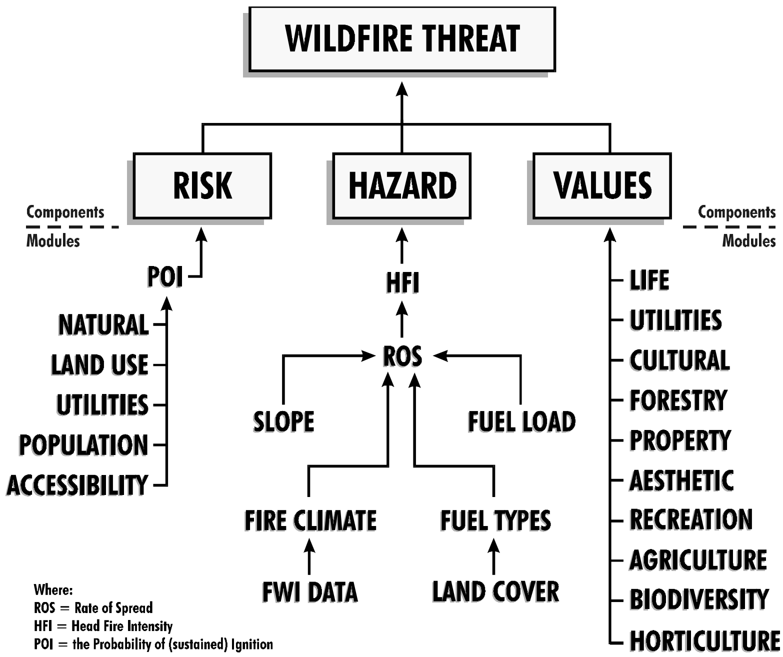
An essential part of DOC's ability to manage fire and to direct associated research is the development of a decision support system for operational line managers. This will help managers assess the key question of whether fires should be left to burn or actively suppressed.

A decision support system is a computer-based decision support tool including a spatial display of the fire environment factors, as well as the social and ecological values of importance to DOC. The system can draw heavily on:

- Existing knowledge of fire behaviour
- Wildfire threat analyses (see Fig. A7.1)
- Detailed research and mapping of ecosystems and the social environment

In the wildfire threat analysis diagram below (Fig. A7.1), ignition potential is described as RISK, potential fire behaviour is described as HAZARD, and values threatened are described as VALUES. The results of a Wildfire Threat Analysis can have multiple uses for a Rural Fire Authority's management activities—including fire prevention, fire mitigation and resource allocation. It can also be used to establish benchmarks to determine appropriate fire control measures.

Figure A7.1. Wildfire threat analysis diagram. From NRFA (2005b). Note: FWI is the 'Fire Weather Index'.



# Appendix 8

## INTERVIEWEES' RESPONSES RE: DOC'S CURRENT AND FUTURE RESEARCH NEEDS

The 80 people interviewed as part of this project identified the research needs presented below. Their feedback is in two parts:

- General research, non-specific to fire, that they believe will usefully support DOC's fire management
- Specific fire-related research

This information led to the 64 specific actions identified in Section 4.1.

### A8.1 General research

The general, non-fire-specific research that respondents said would provide useful technical information to support DOC's role and responsibilities for fire management needs to:

1. Align DOC fire research with the purpose of the Forest and Rural Fires Act 1977 for the 'safeguarding of life and property' in DOC's fire jurisdiction.
2. Manage fire research and organisational links within DOC through the establishment of one new position, a 'Senior Technical Support Officer (Fire)'.
3. Undertake research to support the recent Conservation General Policy on fire management.
4. Ensure technical transfer of information from 'researchers to department managers' and 'researchers to researchers', which is key to increasing understanding and awareness of fire management.
5. Continue supporting the current Forest and Rural Fire Research Programme and seek completion of outstanding projects.
6. Undertake and support additional research outcomes from experimental burns (e.g. invertebrate studies).
7. Establish a decision support system to assist managers deciding on whether to actively suppress a fire or manage it for 'safeguarding of life and property' only.
8. Complete a national wildfire threat analysis for all lands administered by DOC in collaboration with all Rural Fire Authorities.
9. Model fuel types, fuel loadings and fire behaviour for:
    a) Achievement reporting to estimate 'what difference was made by the actions taken'. A national wildfire threat analysis is required for this.
    b) Enhancing fire suppression tactics and safety of staff.
10. Prioritise fire management for conservation of biodiversity and appreciation assets.

11. Establish a clear management philosophy and hierarchy of landscape, ecosystem and site management. This needs to come from DOC's 'Sites group'

12. Pre-emptively manage fire to minimise future losses. There are two key actions required by DOC in order to undertake this effectively: gaining social acceptance for the use of fire as a management tool; and clearly defining ecosystem management policy and practice.

13. Develop social research to improve relations with rural communities and the wider public.

14. Convene, manage and fund a national workshop on fire management and the place of fire ecology in New Zealand.

## A8.2 Research specific to fire

The following list identifies the technical information respondents believe that DOC needs to manage fire.

***1. Policy and planning***

1.1 Investigate the benefits of DOC's carbon credits accumulating through current land management. Identify potential loss of carbon credits by fire in a range of ecosystems and the impacts of these.

1.2 Identify a national approach to managing specific sites across the New Zealand landscape. Incorporate this into the review of the Conservation Management Strategy (CMS) process.

***2. Decision support systems***

2.1 Develop a decision support system and train managers in its use.

***3. Wildfire threat analysis***

3.1 Complete and validate a national wildfire threat analysis for DOC in collaboration with all Rural Fire Authorities.

***4. Social***

4.1 Encourage social research on fire and fire ecology within DOC and other agencies. Emphasis needs to go on dryland ecosystems.

4.2 Promote the importance of public awareness of the threat of fire to features of importance to them and DOC (e.g. people living in the rural–urban interface; Medbury Scientific Reserve; disposal of ashes around huts).

***5. Ecological***

5.1 Study disturbance regimes and identify the role of fire in them.

5.2 Identify appropriate techniques to minimise the impacts of pest plants after fire.

5.3 Identify inventory and monitoring techniques that apply to sites that have been burnt.

5.4 Study recovery rates of ecosystems after fire and identify techniques to rehabilitate ecosystems post-fire.

5.5 Identify ecosystems and species that could benefit from prescribed fires to maintain them.

5.6 Model ecosystem recovery using data from historic burns and current research.

5.7 Acquire information on changes in invertebrates after fire.

5.8 Establish and apply guidelines on management of tussock grasslands, especially lands under DOC jurisdiction as a result of the Land Tenure Review process. The role of fire must be included in this.

### *6. Climate change*

6.1 Study the changes in fire behaviour under climate change scenarios.

### *7. Fire behaviour*

7.1 Build geospatial fuel models. More experimental burns are required to increase the knowledge of fire behaviour and assist in monitoring the effects of ecosystems post-fire.

7.2 Undertake experimental burns on conservation lands for credibility and continuity of management, especially ecosystem monitoring.

7.3 Map and monitor fuel types, fuel loading, fire climate and potential fire behaviour for a range of conditions.

7.4 Establish and apply prescribed burning guidelines.

### *8. Techniques*

8.1 Improve the information on retardants, especially those applied in or near wetlands and streams. Also investigate the use of salt water as a retardant.

### *9. Management*

9.1 Establish a Senior Technical Support Officer (Fire) to undertake technical transfer from researchers (inside and outside DOC) to DOC managers, coordinate research and oversee the development and implementation of strategic planning, and implementation of the strategies.

9.2 Employ, train and retain staff with fire management experience in DOC.

9.3 Integrate fire management within DOC's organisational structure.

9.4 Establish a Technical Advisory Group (TAG) for fire management decisions, to include both social and ecosystems specialists.

9.5 Collect information on fire ecology for Natural Heritage Management System (NHMS) reporting, for fire management and for a research database.

### *10. Technical transfer*

10.1 Transfer of fire research management techniques to DOC staff as required.

10.2 Prepare technical papers and conduct workshops on fire research and management findings.

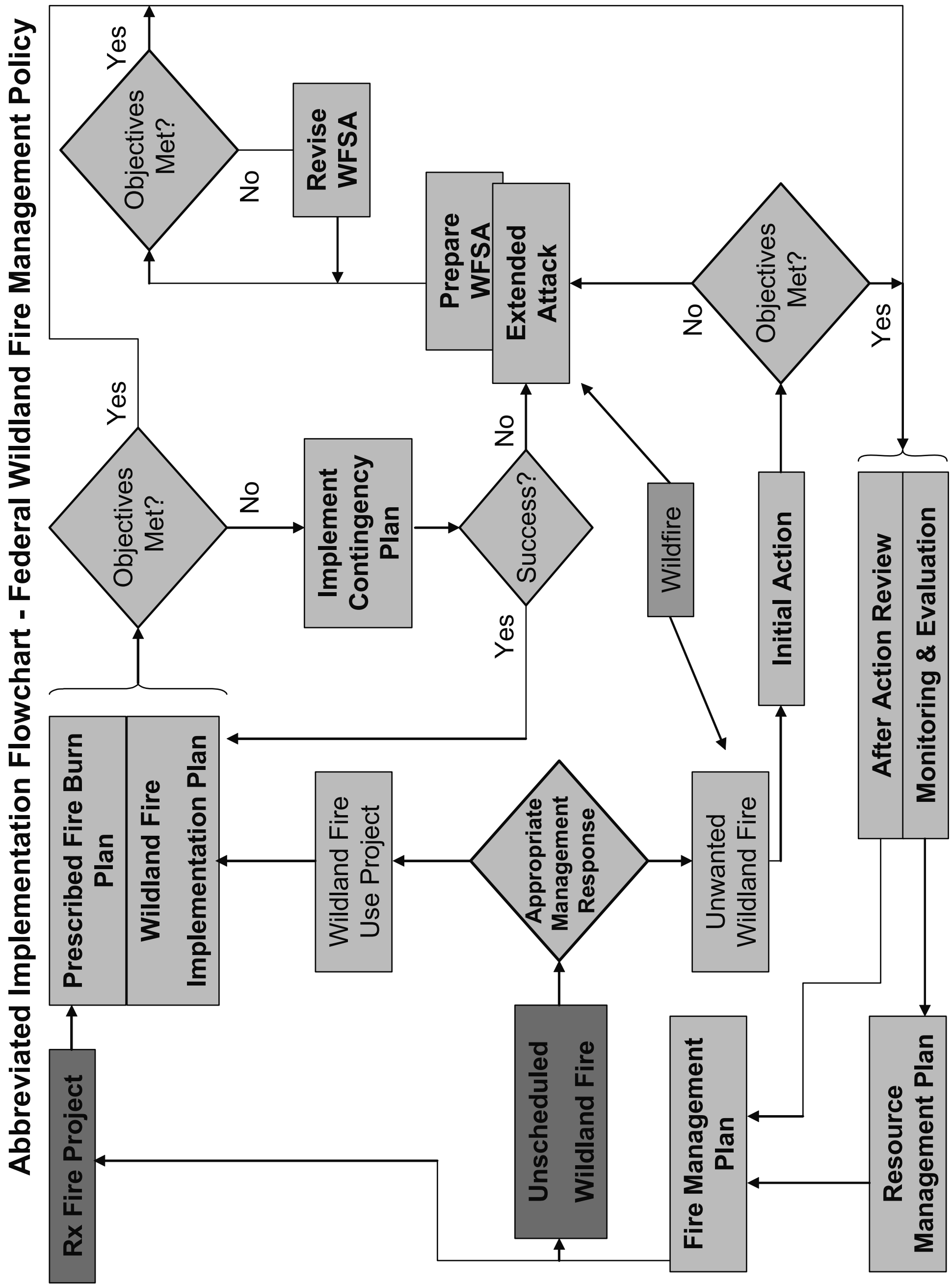
10.3 Undertake a literature review of fire research and management in New Zealand.

10.4 Run a biennial fire management workshop to include staff of DOC and other relevant agencies.

# Appendix 9

## US FEDERAL FIRE POLICY

Taken from National Fire & Aviation Executive Board, Policy Directives Task Group (2004).



# Appendix 10

## ENSIS RURAL FIRE CONTROL: FIRE BEHAVIOUR AND RISK MANAGEMENT

| Department of Conservation *Te Papa Atawhai* | | | | ***Investigation Summary: 200/06*** | |
|---|---|---|---|---|---|
| **Investigation Number** | **34851** | **Key Output** | | **Agreed Completion Date** | 30 June 2010 |
| | | | | **Reporting Date** | March 2006 |
| **Title** | Rural Fire Control: Fire behaviour and risk management | | | | |
| **Agency** | **Ensis** | | | **Investigation Leader** | **Grant Pearce** |

### *Objectives*

Every year, significant areas of New Zealand either experience or are threatened by wildfire, and the reality is that the risks from rural fire are growing. This programme aims to protect life, property, and economic and conservation resources from wildfire in New Zealand's rural environments. This goal will be achieved through providing land managers, Rural Fire Authorities (RFAs) and policy makers with information and tools that will help reduce the number and consequences of wildfires.

The research programme aims to improve understanding of fire behaviour in the New Zealand fire environment by developing a New Zealand Fire Danger Rating System (NZFDRS) to support fire management decision making. Key components of the NZFDRS include a New Zealand Fire Behaviour Prediction (FBP) System comprising models that predict fire behaviour in different vegetation types, and models describing the effectiveness of various firefighting resources in relation to fire behaviour and other fire environment factors (e.g. vegetation and terrain). Increasing our knowledge of the role of fire in the sustainable management of New Zealand ecosystems is also a high priority, and the second major objective, research to quantify the effects of fire on tussock grasslands, provides a case study on the role of fire in ecosystem management so that appropriate management can be developed.

### *Outputs achieved*

A pilot study of fire danger communication, conducted via a University of Canterbury Social Science Research Centre summer studentship, has been completed. Interviews were conducted with fire managers from the Canterbury region to determine the messages being portrayed through fire danger signs and other methods. Results were presented to the Canterbury–West Coast Regional Rural Fire Committee, and a report on the findings is being edited prior to publication. Extension of the pilot study to other parts of the country is currently being planned.

An analysis of the effects of the Interdecadal Pacific Oscillation (IPO) was completed as part of the first stage of a broader project on the impact of climate variability on seasonal fire danger. The fire climatology database containing weather and fire danger records was also updated. The second stage of the analysis, investigating the effects of El Niño-Southern Oscillation (ENSO) events is presently underway.

The Fire Research team hosted the NZ Fire Service Commission in Christchurch on 21 and 22 February 2006, and presented an outline of research activities, the Ensis Bushfire Research Group and Bushfire Cooperative Research Centre involvement. Commission members also visited the Torlesse research burn site, and were given an overview of the fire behaviour research being conducted.

# Appendix 11

## AGRESEARCH INVERTEBRATE STUDY IN OTAGO

<table>
<tr><td colspan="4">Department of Conservation<br>*Te Papa Atawhai*</td><td colspan="3">***Interim Investigation Summary: 2003/04***</td></tr>
<tr><td rowspan="2">**Investigation Number**</td><td rowspan="2">**3667**</td><td rowspan="2">**Key Output**</td><td rowspan="2"></td><td>**Agreed Completion Date**</td><td colspan="2">31 Dec 2008</td></tr>
<tr><td>**Reporting Date**</td><td colspan="2">21 Jun 2005</td></tr>
<tr><td>**Title**</td><td colspan="6">Tussock grassland invertebrate community structure and function, and impact of habitat disturbance by fire</td></tr>
<tr><td>**Agency**</td><td colspan="3">**AgResearch**</td><td>**Investigation Leader**</td><td colspan="2">**Dr Barbara Barratt**</td></tr>
<tr><td>**Investigation Collaborators**</td><td colspan="6">Marcus Simons, Otago Conservancy: support by coordinating maintenance of field sites, fencing and weather stations, and any other local operational assistance as required<br>Greg Sherley, DOC Central Regional Office, Wellington: science review and liaison<br>Ian Payton, Landcare Research, Lincoln: overall Fire Ecology project leader<br>Kath Dickinson, Ecology Research Group, Otago University: research collaborator<br>Colin Ferguson, AgResearch Invermay<br>Nigel Bell, AgResearch Ruakura: research collaborator*<br>Upali Sarathchandra, AgResearch Ruakura: research collaborator*<br>Trevor Jackson, AgResearch Lincoln: research collaborator*<br>* researchers in FRST programme</td></tr>
</table>

### *Investigation overview*

Invertebrate biodiversity in tussock grasslands is poorly understood, although studies have indicated that the fauna is diverse with a high degree of endemism. DOC is responsible for the management of significant areas of native grassland and this area is increasing as a result of the Land Tenure Review process. In order to maintain conservation values of these areas, an improved understanding of the biodiversity and dynamics of grassland ecosystems is required. Fire is an important threat to dry eastern grasslands and a major disturbance mechanism, but it also has potential to be used as a management tool. The joint Fire Ecology project initiated in 1998 by DOC, Landcare Research and the Forest Research Institute (now Ensis) has laid the foundations for a comprehensive and unprecedented tussock grassland community ecology study.

Trial sites have been established at Deep Stream and Mt Benger in Otago, representing an eastern Otago lower altitude tussock grassland and a Central Otago higher altitude grassland, respectively. A major objective of the project is to provide DOC with information that will assist in the future management of natural grassland ecosystems. AgResearch will continue to contribute to knowledge of invertebrate biodiversity, and an understanding of the impacts of fire on the invertebrate fauna, and process of community recovery. In conjunction with FRST-funded work, the investigation includes studies of the composition, abundance, species diversity and trophic structure of the invertebrate fauna; short- to longer-term impacts of tussock burning on invertebrate communities; the comparative impact of managed burns in moist spring conditions compared with accidental fire in hot dry summer conditions; and characteristics of recovery of the fauna.

### *Results*

At both sites it is clear that total invertebrate densities vary considerably between years (Table A11.1), but that both the spring and summer burns were associated with significant reductions in invertebrate densities in 2001/02. In 2003, Thysanoptera numbers were so high that overall invertebrate numbers appear to have returned to or in some cases exceeded pre-burn levels. In fact many groups remained significantly adversely affected by the fires. In 2004, invertebrate densities in the control plots were quite similar to those of the previous 2 years. Densities in the spring and summer burnt plots were generally higher, especially in the tussock samples where total invertebrate densities were up to three times higher than in the control plots.

This could be attributed to Thysanoptera and Pseudococcidae densities, which remained relatively high, and a few other groups where population responses were positive. Of particular interest, Crickets (Gryllidae), which had been recorded only at very low densities at Deep Stream, appeared in burnt plot samples at densities of up to 69/m$^2$ in 2004. Many of the litter and organic detritus feeding groups remained at densities below those of the control plots. These included Amphipoda, Isopoda, Diplopoda, Symphyla and Protura.

TABLE A11.1. MEAN (± SEM) DENSITY (NUMBER/m$^2$) OF TOTAL INVERTEBRATES FROM 1993–2003 AT DEEP STREAM AND MT BENGER SITES (BOLD ITALICISED AREAS ARE POST-BURN).

| | CONTROL PLOTS | | SPRING BURN PLOTS | | SUMMER BURN PLOTS | |
|---|---|---|---|---|---|---|
| | INTER-TUSSOCK | TUSSOCK | INTER-TUSSOCK | TUSSOCK | INTER-TUSSOCK | TUSSOCK |
| **Deep Stream** | | | | | | |
| January 1999 | 7564 (1693) | 1866 (529) | 6135 (763) | 2291 (613) | 7748 (1634) | 936 (287) |
| January 2000 | 3683 (320) | 2115 (574) | 6617 (996) | 2081 (546) | 6286 (1418) | 1791 (336) |
| January 2001 | 3652 (393) | 2314 (98) | 7429 (2134) | 4216 (1771) | 5161 (1361) | 2135 (531) |
| March 2001 | 2345 (549) | 2562 (430) | – | – | ***320 (85)*** | ***495 (231)*** |
| January 2002 | 4098 (499) | 3224 (1340) | ***1161 (326)*** | ***1089 (191)*** | ***534 (27)*** | ***707 (151)*** |
| January 2003 | 4063 (1041) | 2781 (514) | ***2218 (346)*** | ***2181 (453)*** | ***5762 (738)*** | ***6592 (763)*** |
| January 2004 | 4533 (168) | 3608 (220) | ***6294 (463)*** | ***9841 (2229)*** | ***6181 (291)*** | ***10410 (140)*** |
| **Mt Benger** | | | | | | |
| January 1999 | 1064 (168) | 4325 (1187) | 1372 (405) | 3903 (709) | 1939 (486) | 4848 (2453) |
| January 2000 | 2801 (254) | 1713 (404) | 1981 (382) | 2055 (320) | 2452 (704) | 3040 (1317) |
| January 2001 | 1619 (94) | 2061 (307) | ***775 (402)*** | ***2022 (488)*** | – | – |
| January 2002 | 3329 (925) | 1584 (1042) | ***361 (140)*** | ***1226 (410)*** | 1974 (36) | 2794 (308) |
| January 2003 | 3085 (787) | 2397 (375) | ***3413 (452)*** | ***5533 (1194)*** | – | – |
| January 2004 | 2605 (549) | 3999 (534) | ***2321 (523)*** | ***3625 (600)*** | – | – |

At Mt Benger, data from the 2004 sampling show no significant differences in total invertebrate density between burnt and un-burnt treatments (Table A11.1). However, as for Deep Stream, this is masked by differences between taxonomic groups. Taxa that were significantly reduced in density immediately post-burn and that appear not to have recovered are Amphipoda, Opiliones, Pseudoscorpionida (low density in control plots but so far absent from burnt plots), Diplopoda, Blattidae, Formicidae, and some families of Coleoptera. Those that have responded positively post-burn, such as Aphidae, have returned to pre-burn densities, but the Chrysomelidae and particularly the Thysanoptera (which in 2003 increased dramatically in numbers in response to the fires) have remained high in 2004. These herbivorous insects have probably responded to the flush of new growth following the fire.

### *Conclusions*

The data are clearly demonstrating that the invertebrate density (excluding Collembola and mites) in tussock grassland at these two sites fluctuates naturally. At Deep Stream, inter-tussock and tussock densities averaged about $4500 \pm 607$ (SEM) and $2600 \pm 275$, respectively (control plots) over the 6 years of January measurements. At Mt Benger, inter-tussock and tussock densities were more similar, averaging about $2400 \pm 362$ and $2700 \pm 485$ (control plots) over the 6 years of January measurements. If microarthropods (Collembola and mites) are included, these figures increase by a factor of about 8–10 (Barratt, pers. comm. 2005). The sampling is now well into the period of measuring indirect impacts of burning rather than direct impacts of the fire on the particular groups. Hence the researchers assert that they are measuring effects on invertebrates that have been brought about by changes in litter availability, plant growth responses and plant species composition changes. Some very interesting community and population dynamics are starting to emerge, with some invertebrate groups responding very positively to the post-burn environment, and others still showing no sign of recovery to pre-burn densities.