

# Department of Conservation fire research needs analysis

## 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 Jaquiere, 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 (GMRD&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

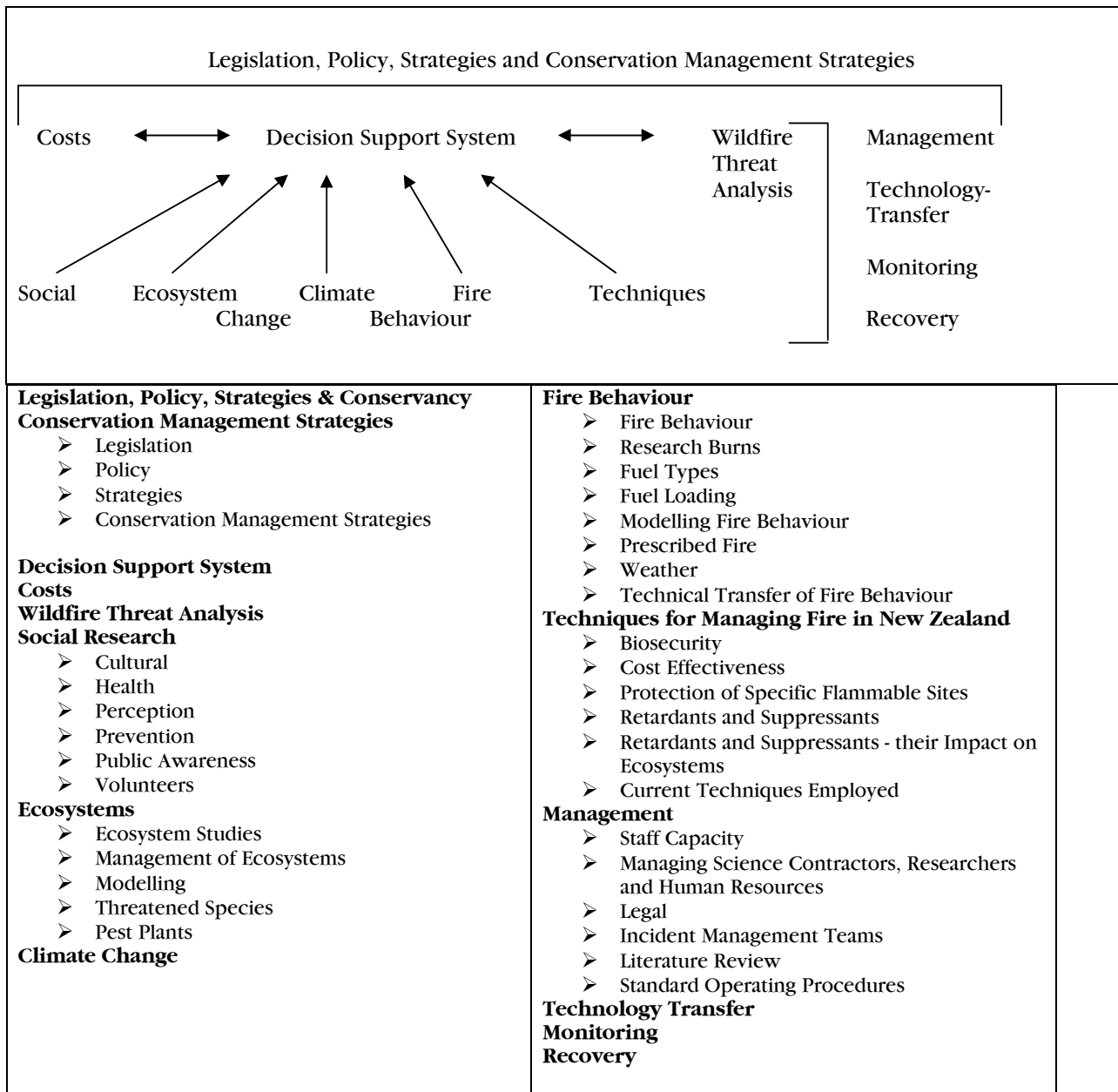


Figure 1. Model of fire management—the analysis tool underpinning this report. (To help make sense of the information gathered from the 80 people interviewed, the author identified the components of the framework that DOC calls 'Fire management'. Analysis led to the 13-part model shown. Information gathered 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<sup>1</sup>. 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

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<sup>1</sup> 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: <ul style="list-style-type: none"> <li>• 323 within the fire safety margin</li> <li>• 223 within the DOC State area</li> <li>• 75 on DOC land within Rural Fire District</li> </ul>
Area burnt	4388 ha, as follows: <ul style="list-style-type: none"> <li>• 914 within the fire safety margin</li> <li>• 3129 within the DOC State area</li> <li>• 345 on DOC land within the Rural Fire District</li> </ul>
Amount spent on fire suppression	NZ\$6,819,791 on fire suppression, as follows: <ul style="list-style-type: none"> <li>• \$1,256,337 within the fire safety margin</li> <li>• \$4,766,284 within the DOC State area</li> <li>• \$797,170 on DOC land within the Rural Fire District</li> </ul> <p>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.</p>
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<sup>2</sup> 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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<sup>2</sup> 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	<p>No clear policy on ecosystem management with regard to disturbance and long-term outcomes.</p> <p>No policy direction that would promote acceptance of fire research, especially on lands administered by DOC.</p> <p>National ecosystem models not completed.</p> <p>Strategic direction not set.</p> <p>Social acceptance work required.</p>
2. Decision support systems	<p>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.</p>
3. Costings	<p>Ongoing work is required to improve the cost-effectiveness of fire management.</p>
4. Wildfire threat analysis	<p>Model established; it needs to be applied nationally and analysis validated.</p>
5. Social	<p>Work begun on staff health.</p> <p>Public perception of DOC's fire management needs to be studied.</p> <p>Tools and techniques required.</p>
6. Ecosystems	<p>Considerable work started in some areas.</p> <p>Threatened ecosystems, especially those highly prone to fire, need to be studied.</p> <p>Studies begun on fire regimes, ecosystem disturbance, fire-plant-invertebrate relationships. Key actions are to complete current projects (e.g. Otago grasslands).</p>
7. Climate change	<p>Identify how fast it is changing and the impacts.</p>
8. Fire behaviour	<p>Complete and validate fuel loading, fuel mapping work.</p> <p>Improve and broaden fire behaviour models.</p>
9. Techniques	<p>Develop biosecurity management of fire-fighting techniques.</p>
10. Management	<p>Research burns (Mt Benger and Torlesse Range) have not been completed, nor has associated fire-plant-invertebrate work.</p>
11. Technical transfer	<p>Current information not being transferred to DOC staff, or the transfer is variable (e.g. information about ecosystems).</p>
12. Monitoring	<p>Not established; a national approach to post-fire monitoring of changes in ecosystems is required.</p>
13. Recovery	<p>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).</p>

- 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	<ol style="list-style-type: none"> <li>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.</li> <li>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).</li> </ol>
Structure and roles	<ol style="list-style-type: none"> <li>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). Key tasks are to: <ul style="list-style-type: none"> <li>• Ensure that there are links between fire researchers and other researchers to promote the benefits of fire management to decision makers</li> <li>• Ensure that there are links between researchers and between researchers and all levels of management in DOC</li> <li>• Coordinate research, and the technical transfer of the results and findings</li> <li>• Oversee the development and implementation of strategic planning</li> </ul> </li> </ol>
Tools	<ol style="list-style-type: none"> <li>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).</li> </ol>

*Continued on next page*



Table 3—continued

AREA OF OPPORTUNITY	COMMENTS	
Information gathering	<p>5. DOC should continue researching and improving fire fighting techniques and methods. In particular, it should:</p> <ul style="list-style-type: none"> <li>• Develop fire management plans for lands administered by DOC that are at risk of fire or have a history of fires</li> <li>• Prepare restoration plans to manage sites after fires have burnt through areas of significant conservation value, or when communities request these</li> <li>• Monitor recovery after fires in areas of conservation significance on land administered by DOC</li> </ul>	
	<p>6. DOC should complete a wildfire threat analysis in collaboration and research with all other Rural Fire Authorities.</p>	
	<p>7. DOC should undertake social research on community awareness, especially those communities adjoining the current research burns.</p>	
	<p>8. DOC should promote fire ecology research and advance research identified through the Rural Fire Research Programme and this document. This includes:</p> <ul style="list-style-type: none"> <li>• Supporting and assisting the completion of fuel accumulation and fuel type research that has begun</li> <li>• Completing and reporting on the current research burns</li> <li>• Further investigating prescribed burns for fuel management, especially on the Tenure Review process lands</li> <li>• Continuing and completing studies of fire-adapted and fire-prone ecosystems and species</li> <li>• Establishing ecosystem monitoring—including DOC research on various aspects of fire management (e.g. post-fire colonisation by pest plants and ecosystem restoration techniques)</li> <li>• Continuing and increasing research on the relationship between pest plants and ecosystem disturbance, especially fire</li> </ul>	
	<p>9. The transfer of technology and information associated with current projects to DOC managers and researchers needs to be increased.</p>	
	Collaboration	<p>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.</p>
		<p>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:</p> <ul style="list-style-type: none"> <li>• Contributing funding to the research programme</li> <li>• Providing governance on the direction of the research</li> <li>• Providing departmental resources during research-prescribed burning operations and other specific research work</li> <li>• Providing sites for research-prescribed burning operations</li> </ul>
		<p>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.</p>

### 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

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

YEAR	CUMULATIVE AREA (ha)
2005-2006	309000
2006-2007	394000
2007-2008	508000
2008-2009	600000

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.

Sitting within this context of fragmented ecosystems, constant change and public perceptions, are the recently released General Policies for National Parks<sup>3</sup> and the Conservation General Policy<sup>4</sup>. 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

<sup>3</sup> Section 4.7 Fire Management, in the General policy for national parks (NZCA 2005: 27-28).

<sup>4</sup> 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 Specific divisions within DOC are: <ul style="list-style-type: none"> <li>• Natural Heritage Management System (NHMS)</li> <li>• Research, Development &amp; Improvement (RD&amp;I)</li> <li>• Conservancies</li> <li>• Business Management Division (BMD)</li> <li>• People and Organisational Development (POD)</li> </ul>
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<sup>5</sup>:
  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.

<sup>5</sup> 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)

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Identify how DOC will undertake management of successional processes, and the types of sites on which this will occur	Underway and ongoing	A1	G
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- ii. What are the management outcomes on lands administered by DOC?

---

ACTION 2: DOC (NHMS)

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Identify the processes DOC will use to define management on lands it administers	Underway and ongoing	A1	G
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##### 1(b) Strategies

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

---

ACTION 3: DOC (NHMS)

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

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ACTION 4: DOC

---

Establish guidelines to determine under which circumstances fires should be left to burn	To be done	B2 S
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iii. What is the direction for DOC's fire management over the next 20 years?

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ACTION 5: DOC

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Prepare a strategy to identify DOC's fire directions for the next 20 years	To be done	A2 G
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iv. How does DOC maintain fire management as part of its culture?

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ACTION 6: DOC (POD, RD&I)

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Identify appropriate tools to encourage and support staff interest in fire management	To be done	B2 G
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v. What is the effect of landscape fire on social and ecological communities?

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ACTION 7: NRFA, DOC (RD&I), ENSIS

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Identify appropriate tools and techniques to better understand the effect of fire on social and ecological communities	Underway and ongoing	B2 S
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vi. What is the national approach to managing recovery activities (social and ecological) on DOC-administered lands after a fire event?

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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
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**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?

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ACTION 9: DOC (RD&I, CONSERVANCIES)

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Develop and enhance current tools and techniques to enable integrated fire management plans to be developed	To be done	B2 G
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#### 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?

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ACTION 10: DOC (RD&I, NHMS)

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Identify, test and apply the components of a decision support system to assist DOC's fire management capability	To be done	A1	S
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#### 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)

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Identify and analyse the costs of current and future fire control and management	Underway and ongoing	A1	G
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#### 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?

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ACTION 12\*: DOC (RD&I, CONSERVANCIES)

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Investigate and prepare a national wildfire threat analysis for DOC	To be done	B2 S
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#### 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?

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ACTION 13: DOC, ENSIS, NRFA

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Investigate the cultural concerns of key cultural communities in relation to fire management	To be done	B2 S
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##### 5(b) Health of firefighters

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

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ACTION 14: CRC (PROGRAMME D), NRFA, DOC (RD&I)

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Continue to investigate the health of those involved in fire fighting	Underway and ongoing	B2 S
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**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?

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ACTION 15: DOC, NRFA, ENSIS, UNIVERSITIES

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Study public perception of DOC's policies on fire management	To be done	B2 S
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- 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.)

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ACTION 16: DOC, ENSIS, NRFA UNIVERSITIES

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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 Bengier.	To be done	A2 S
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- iii. What causes individuals in some communities to deliberately start fires?

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ACTION 17: NRFA, UNIVERSITIES

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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
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**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?

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ACTION 18: CRC (PROGRAMME C), NRFA

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Support investigation into arson	Underway and ongoing	B2 S
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vii. How effective are fire prevention strategies and the methods and timing of their delivery (e.g. mid-summer or late summer)?

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ACTION 19: CRC (PROGRAMME C), NRFA, ENSIS

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Study the effectiveness of fire prevention strategies, methods and timing	Underway and ongoing	B2	S
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**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.

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ACTION 20: CRC (PROGRAMME D), NRFA

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Study the recruitment and retention of volunteers	Underway and ongoing	B1	S
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**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?

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ACTION 21: NRFA, DOC

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Investigate the effectiveness of incident management as used in New Zealand and inform fire managers of the findings	Ongoing	B2	S
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**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?

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ACTION 22: ENSIS, LCR

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Study the fire regimes in New Zealand	Underway and ongoing	B1	S
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- 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?

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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
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- 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.

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ACTION 24: DOC, LCR, AGRESEARCH, ENSIS

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Continue the current vegetation and invertebrate work	Underway and ongoing	A1	S
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ACTION 25: DOC, LCR, ENSIS

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Identify the community and ecosystem changes in fire-induced systems	Underway and ongoing	B1	S
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ACTION 26: DOC, LCR

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

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ACTION 27\*: DOC

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Review literature biennially on the use of fire to manage ecosystems as described in Allen et al. (1996)	To be done	A2	S
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- v. What rehabilitation techniques are required to enhance ecosystems and ecosystem processes after disturbance by fire?

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ACTION 28\*: DOC, LCR, AGRESEARCH

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Investigate post-fire ecosystem rehabilitation techniques	Underway and ongoing	A2	G
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**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)?

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ACTION 29: DOC, LCR, AGRESEARCH

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Investigate how indigenous species and ecosystems respond to fire for ecosystem management	Underway and ongoing	A2	G
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- ii. What ecosystems are most vulnerable to modification by fire?

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ACTION 30: DOC, LCR

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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
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**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

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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
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**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

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

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ACTION 33: DOC (RD&I)

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

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ACTION 34: DOC, LCR

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Model and map new or similar ecosystems and sites that are naturally or human induced	Underway and ongoing	B2	G
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**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

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Establish the relationship between fire disturbance and pest plant species, with a focus on threatened ecosystems	Underway and ongoing	A1	S
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- 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)?

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ACTION 36: DOC, ENSIS

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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
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#### 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

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#### 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

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### **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

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Undertake experimental burns and analyse the fire behaviour and ecosystem responses, especially the responses of pest plants	Underway and ongoing	A2	S
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### **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?

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ACTION 40: ENSIS, DOC, LCR

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Continue improving the available fuel type analysis and mapping	Underway and ongoing	A1	S
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### **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?

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ACTION 41: ENSIS, DOC, LCR

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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
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**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 Ensiss (Opperman 2005).

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

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ACTION 42\*: DOC, ENSIS, NRFA

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Study ignition sources, such as lightning strikes and human-induced sources	Underway and ongoing	B2	S
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**8(f) Modelling fire behaviour**

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

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ACTION 43\*: DOC, ENSIS

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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
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- 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).

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ACTION 44: DOC, ENSIS

---

Use models to identify the appropriate techniques for using fire as an ecosystem management tool	Underway and ongoing	B1	S
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**8(g) Prescribed fire**

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

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ACTION 45: DOC, ENSIS

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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
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**8(h) Weather**

- i. Can the fire weather indices be improved?

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ACTION 46: ENSIS

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Increase understanding and validation of the fire weather indices	Underway and ongoing	B1	S
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#### 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?

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ACTION 47\*: DOC (BIOSECURITY)

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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
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##### 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?

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ACTION 48\*: DOC, ENSIS, LCR

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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
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##### 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

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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
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**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

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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
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- 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?

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ACTION 51\*: DOC

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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
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**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?

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ACTION 52\*: ENSIS

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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
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#### 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?

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ACTION 53\*: DOC

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Investigate the current and planned staffing capacity for fire research, coordination, management and transfer	To be done	A2 G
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##### 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?

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ACTION 54\*: DOC, LCR, AGRESEARCH, ENSIS

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Continue the studies relating to the research burns (e.g. invertebrate and flora studies)	Underway and ongoing	A1 S
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##### 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?

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ACTION 55: DOC

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Investigate DOC's capacity to maintain staff with fire management and incident management experience over the next 20 years	To be done	A2 G
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ACTION 56: DOC

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Identify what motivates staff to become involved in fire management at all levels of the organisation	To be done	B2 S
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**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?

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ACTION 57\*: NRFA, ENSIS, CRC

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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
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**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?

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ACTION 58\*: DOC (RD&I)

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Integrate research findings into DOC's standard operating procedures	To be done	A2 G
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## 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?

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### ACTION 59\*: DOC (RD&I—INVENTORY AND MONITORING)

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Collect, store and manage fire-related data under DOC's Biodiversity, Inventory and Monitoring framework	To be done	A2	G
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## 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?

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### ACTION 60\*: DOC (RD&I), NRFA, ENSIS

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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
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### ACTION 61\*: DOC, LCR, ENSIS

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Continue, complete and publicise the results of the current grassland and shrubland research burns at Lake Taylor, Mt Bengier, Deep Stream and the Torlesse Range	Underway and ongoing	A1	S
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- ii. How can the public be informed about current and future fire risks?

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### ACTION 62\*: NRFA, DOC (RD&I), ENSIS

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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
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#### 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?

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ACTION 63\*: DOC (NHMS), LCR, ENSIS, NRFA

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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
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#### 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?

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ACTION 64: DOC, ENSIS, LCR

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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
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## 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 Action 40: Fuel types Action 41: Fuel loadings 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<sup>6</sup>. 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 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 Actions 23, 29, 30, 32 & 34: Ecosystem studies Actions 38, 40 & 41: Fire behaviour (fuel models) Action 49: Techniques for managing fires Action 62: Technology transfer 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'	Most relevant actions have been identified above, with the addition of:
Resolve the compromise between protecting biodiversity and the frequency and intensity of burns—that is high frequency, low intensity, and low frequency, high intensity	Action 16: Social research

<sup>6</sup> 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 activities

### 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 Bengier 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 Bengier; 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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