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An analysis of wildfire records in New Zealand: 1991-2007

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EXECUTIVE SUMMARY

An understanding of wildfire occurrence and causes in relation to fuels, weather and topography can enable fire managers to better quantify fire risk and target mitigation measures to reduce specific risks. Analysis of long-term fire records form the basis of this understanding of wildfire occurrence and severity, and this study has aimed to provide this information to the rural fire management sector. To our knowledge, this is the most detailed and comprehensive analysis of wildfire occurrence undertaken in New Zealand to date.

The objectives of this study were to:

- Undertake an analysis of long-term wildfire records in New Zealand at both the national and regional level to provide an indication of trends in fire occurrence, area burned and fire causes.
- Collate data on wildfires in New Zealand, and assess the suitability and quality of these records for further analysis.
- Analyse these data at both the regional and national level to determine the major factors contributing to the number and size of wildfires, as well as identifying any trends in these causes.
- Provide recommendations for future research.

This study was based on analyses of the National Rural Fire Authority's (NRFA) database of the annual return of fire records, based on records provided by the numerous Rural Fire Authorities across the country. Despite known issues with the quality, accuracy and coverage of some these records, this database represents the best available national records for analysis. This report summarises the results and findings from analyses of fire records at both the national and regional level, and provides a useful synopsis of wildfires in New Zealand from 1991 to 2007.

New Zealand experienced an average of 3,033 wildfires and 5,865 ha burned annually from 1991/92 to 2006/07. The total area burned over this period was 54% grass fuels, 40% scrub fuels and 6% forest fuels. The number of wildfires increased from around 1,000 (in the early 1990's) to over 4,000 fires (2006/07). The increase in wildfire occurrence observed nationally was mirrored in most regions. No clear trend over time was observed in the area burned. Unknown and miscellaneous causes accounted for almost half (46%) of the total number of fires. Other main causes of wildfires were land clearing (20%), vehicles (16%), and incendiary (6%). Area burned was dominated by land clearing (47%). Unknown (24%), miscellaneous (7%) and incendiary (6%) were other major causes contributing to the total area burned. Natural causes (lightning) made up 0.1% of wildfires and area burned. Otago accounted for 6% of wildfires and 42% of the total area burned nationally. The South Island accounted for 75% of the total area burned and 34% of the number of fires. Northland and the Eastern North Island accounted for 60% of the total area burned in the North Island.

It is hoped to extend this work in the future, particularly to include the effects of national and regional climate patterns on wildfire occurrence. It is also hoped that the recommendations from this study will lead to improvements in reporting and recording of wildfire information that will allow more meaningful and detailed analyses in the future, to provide more sound information and input into the development of wildfire reduction and readiness strategies.

Specific recommendations from this study are:

- Review the cause classes listed in the NRFA Annual Returns to obtain a more realistic assessment of the causes of wildfires in New Zealand, to ensure that as many causes of wildfires as possible are reported and that these causes are consistent from year to year.
- Improved training and operational procedures to reduce the proportion of fires and area burned being classed as miscellaneous and unknown. This would provide for more meaningful conclusions to be drawn from the NRFA Annual Returns in the future.
- In applying results from this study to management practices, it is important to consider both number of fires and area burned, since they both display different results and can require different mitigation strategies.
- Targeted approaches to fire prevention in regions showing high areas burned from particular causes could reduce the incidence and consequences of wildfires in those regions.
- Human causes in New Zealand are responsible for the overwhelming majority of fires, but weather and climate may have a greater influence on the severity of fires. Research into the effects of weather and climate on regional and national fire occurrence is required.
- Analysis of the NRFA Annual Returns by fire authority type was not conducted here, but since different types of fire authorities can in some areas be responsible for different vegetation types, this analysis may be useful. However, this may be more difficult because of the decrease in the number of territorial authorities, the disestablishment of some forestry-based Rural Fire Districts, and increases in the area of the Department of Conservation estate.
- The need for a consistent national approach to data collection at all levels is required. Standardised cause classes, consistency in reporting, and quality control would greatly increase our understanding of the causes, occurrence, and impact of wildfires in New Zealand.

The main body of this report summarises the results at the national level and compares regional findings. More detailed information on wildfire occurrence and severity for each region of the country is contained in the individual regional reports in Appendix C. These regional reports will provide fire managers with a clear picture of the fire problem, and trends in data, for specific regions.

TABLE OF CONTENTS

INTRODUCTION

An understanding of wildfire occurrence and causes in relation to fuels, weather and topography can enable fire managers to better quantify fire risk, and target mitigation measures to reduce specific risks. If long-term fire records of good quality data are available, the findings from analyses of these records can provide input into a range of fire management strategies and activities, such as prevention of fire occurrence, determining potential fire suppression tactics and strategies, pre-positioning of suppression resources in high-risk areas, developing targeted prevention programmes, and prioritisation for areas that require fuel treatments (Opperman 2005).

The objectives of this study were to:

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- Collate data on wildfires in New Zealand, and assess the suitability and quality of these records for further analysis.
- Analyse these data at both the national and regional level to determine the major factors contributing to the number and size of wildfires, as well as identifying any trends in these causes.
- Provide recommendations for future research.

Unfortunately there are known issues with the quality and availability of long-term wildfire records in New Zealand. Different Rural Fire Authorities (RFAs) have over the last few decades developed their own reporting and data collection systems that has led to inconsistencies in both the quality and accuracy of reporting and recording of wildfire data. At the national level, there have also been difficulties in collecting data of adequate quality and coverage from all Rural Fire Authorities on an annual basis (Opperman 2005).

The most reliable national reporting system for wildfires is based on the “Annual Fire Returns Statistics Form” that is submitted to the National Rural Fire Authority annually by RFAs across the country. Whilst some records may either be missing from the dataset (not reported to the NRFA) or inaccurate, this is the best available comprehensive dataset and therefore formed the basis of this study. Notwithstanding the data issues that are highlighted in this report, the analysis and findings still provide a very useful overview of the occurrence and severity of wildfires in New Zealand over much of the last two decades. It is hoped that the information presented and the findings are relevant to fire managers, and that the recommendations will contribute to improvements in wildfire reporting to allow more detailed analyses to be carried out in the future to provide further information and tools to assist rural fire management in New Zealand.

METHODS

The NRFA collects wildfire statistics annually using a standard Annual Fire Return Statistics form (Appendix A), hereafter referred to as the Annual Returns. This only refers to wildfires, and not the large number of prescribed/permitted burns carried out across the country annually. This form requires RFAs to complete fields for the number of fires, the total area burned, and the area burned for the three main fuel types (grass, scrub and forest) for each fire year. A fire year runs from 1 May to 30 April.

The data from the Annual Returns were provided in electronic form by the NRFA. These are stored as Microsoft Access database files. For this analysis these data were exported to Microsoft Excel. Some data were exported to the R statistical software package (RFC 2008) for further analysis as necessary.

Annual returns contain the following fields (see Figure 1):

- ID – Identification number for each record (not always present in the electronic records).
- F/S – The relevant fire year (sometimes incorrectly referred to as fire season).
- RFA – The relevant Rural Fire Authority.
- Category – The type of RFA, i.e. territorial authority (TA), Rural Fire District (RFD), Department of Conservation (DOC), Defence Force (NZDF).
- Region – Based on the location of the relevant NRFA Rural Fire Manager.
- Cause – Taken from a predefined list of causes.
- Number – Total number of fires for each cause.
- Grass – The total grass area burned in hectares for each cause.
- Scrub – The total scrub area burned in hectares for each cause.
- Forest – The total forest area burned in hectares for each cause.
- Number of sawmills – number of sawmills burnt for each cause (not consistently included in the records over the study period).

Data are not recorded individually by fire incident, but rather are grouped together by fire cause. The total area burned is not a field in the form, and was calculated by adding together the data for all fuel types.

F/S	RFA	CATEGORY	REGION	CAUSE	NUMBER	GRASS (Ha)	SCRUB (Ha)	FOREST (Ha)
02/03	Ashburton DC	TA	Christchurch	Industrial (sawmill, logging, etc)	1	0.1	0	0
02/03	Ashburton DC	TA	Christchurch	Land Clearing	69	54.3	4	3.6
02/03	Ashburton DC	TA	Christchurch	Tractors and Motor Vehicles	27	58.2	0.4	0
02/03	Ashley RFD	RFD	Christchurch	Industrial (sawmill, logging, etc)	2	45	25	0
02/03	Ashley RFD	RFD	Christchurch	Land Clearing	1	2	0	0
02/03	Ashley RFD	RFD	Christchurch	Miscellaneous	1	0	0	0
02/03	Auckland CC	TA	Auckland	Unknown	2	0	0	0
02/03	Auckland CC	TA	Auckland	Miscellaneous	5	0	0	0
02/03	Auckland CC	TA	Auckland	Smokers	3	2	0	0
02/03	Aupouri Karikari RFD	RFD	Auckland	Smokers	4	0.03	1.012	0
02/03	Aupouri Karikari RFD	RFD	Auckland	Tractors and Motor Vehicles	2	0.05	0	0

Figure 1. Example of National Rural Fire Authority Annual Return electronic record.

Fuel types used in the NRFA Annual Returns are only broadly classified. In the case of forests in particular, this includes both exotic plantations and native forests, as well as woodlots and other tree vegetation such as tree mixes in riverbeds, shelterbelts, hedges, etc. This can also include areas of scrub or wetlands that are dominated by trees.

Fire causes listed within the Annual Returns are not consistent from year to year and the current NRFA form lists the following causes:

- Road Traffic
- Tractors and motor vehicles
- Railways
- Hunters (camp or billy fires, etc.)
- Picnics
- Smokers
- Land clearing
- Incendiary
- Industrial (sawmill, logging, etc.)
- Chainsaws
- Miscellaneous
- Unknown

In an attempt to reduce the number of causes and provide consistency across all years, data were collated according to the following causes: arson, chainsaw, incendiary, industrial, land clearing, lightning, power lines, railways, recreational, smokers, structures, vehicles, miscellaneous and unknown (Table 1). Animal rescue, false alarm, haz/chem, landslip, nil return, pumping flooded properties and rescue were not included in the analysis as they quite clearly did not relate to wildfires. While lightning was recorded as a separate class in 1988/89, from 1989/90 until 1999/2000 it was included in the miscellaneous category (Craig 2002). For the purposes of this report all ‘Careless’ records were added to the miscellaneous class since it was not possible to differentiate between smokers or chainsaws within the ‘Careless-Smokers, Chainsaws, etc’ class. Analysis of individual causes by region was also undertaken, and the results of this analysis are contained separately in Appendix B.

Table 1. Summary of Fire Cause Classes used in this report.

Arson	Chainsaw	Incendiary	Industrial	Land clearing	Lightning	Power lines
Vehicle Arson		Army	Industrial/structures	Burnoffs		
		Fireworks	Super skid	Rubbish		
				Unpermitted burns		
Recreational	**Smokers**	**Structures**	**Vehicles**	**Miscellaneous**	**Unknown**	**Railways**
Hunters		Barns	Lawnmowers	Careless	Scrub fires	Tramways
Picnics		Hay Barns	Road Traffic	Careless - Smokers, Chainsaw etc.	Vegetation fires	
Camping/ Picnics		Houses	Tractors and Motor Vehicles	Children		
				Electrical faults		
				Other		

The composition of Rural Fire Authorities has also not been consistent over time (due to changes in territorial authorities and establishment of enlarged Rural Fire Districts) so, for the purposes of this study, RFAs were grouped according to their region as of the 2006/07 fire year (with the exception of authorities in the West Coast and Southland which retain their own regional status in this report) (Table 2). These regions are: Northland, Auckland, Waikato, Wanganui/Manawatu, Central North Island, Taranaki, Eastern North Island, Greater Wellington, Nelson/Marlborough, West Coast, Canterbury, Otago, and Southland. Individual regional analyses of fire numbers, area burned by cause and fuel type are contained in a separate regional appendix at the end of this report (Appendix C).

Table 2. Regional grouping of Rural Fire Authorities.

Northland	Auckland	Waikato	Wanganui/ Manawatu	Central North Island	Taranaki	Eastern North Island	Greater Wellington	Nelson/ Marlborough	West Coast	Canterbury	Otago	Southland
Aupouri Karikari RFD	Auckland CC	DOC Waikato	Chatham Islands CC	DOC Bay of Plenty	New Plymouth DC	Bay Forests RFD	Carterton DC	DOC Nelson/ Marlborough	Buller DC	Ashburton DC	Central Otago DC	DOC Southland
DOC Northland	DOC Auckland	Hamilton CC	DOC Wanganui	DOC Tongariro/ Taupo	South Taranaki DC	Cook CC	DOC Wellington	Golden Bay RFD	DOC West Coast	Ashley RFD	Clutha DC	Gore DC
Far North DC	Franklin DC	Hauraki DC	Horowhenua DC	Kaingaroa RFD	Stratford DC	DOC East Coast	Hutt CC	Golden Downs RFD	Grey DC	Banks Peninsula DC	DOC Otago	Invercargill CC
Hobson CC	Great Barrier Island CC	Matamata Piako RFD	Linton Army Camp RFD	Kawerau DC		Eastland RFD	Kapiti Coast DC	Kaikoura DC	West Coast RFD	Bottle Lake RFD	Dunedin CC	Invercargill Reserves RFD
Hokianga CC	Hunua RFD	Ohinemuri CC	Mako Mako RFD	Lake Taupo RFD		Gisborne DC	Masterton DC	Maitai Roding RFD	Westland DC	Burnham RFD	Dunedin RFD	Southern Plantations RFD
Kaipara DC	Manukau CC	Otorohanga DC	Manawatu DC	Mayor & Motiti Island RFD		Hastings DC	Porirua CC	Marlborough DC		Chaneys RFD	Queenstown Lakes DC	Southern RFD
Mangonui CC	North Shore CC	Piako CC	Ohakea RFD	Opotiki DC		Napier CC	South Wairarapa DC	Marlborough North RFD		Christchurch CC	Waipori RFD	
Pouto RFD	Papakura DC	Raglan CC	Palmerston North CC	Pumicelands RFD		Waikohu CC	Upper Hutt CC	Moutere Hills RFD		DOC Canterbury	Waitaki DC	
Whangarei DC	Rodney DC	South Waikato DC	Rangitikei DC	Rotorua DC		Waipu CC	Wairarapa RFD	Nelson CC		Hurunui DC		
Whangaroa CC	Waiheke CC	Te Rapa NZFD RFD	Raumai RFD	Tauhara RFD		Wairoa DC	Wellington CC	Rabbit Island RFD		Mackenzie RFD		
	Waitakere RFD	Thames Coromandel DC	Ruapehu DC	Taupo DC			Wellington RC RFD	Tasman DC		Selwyn DC		
	Waitemata CC	Thames Valley RFD	Tararua DC	Tauranga CC				Waimea RFD		South Canterbury RFD		
	Woodhill/ Riverhead RFD	Waikato DC	Taumaranui CC	Timberlands Turangi RFD				Woodbourne RFD		Tekapo Military Training Area RFD		
		Waipa DC	Waiouru RFD	Tokoroa RFD						Timberlands Aorangi RFD		
		Waipa CC	Wanganui DC	Waiarihi RFD						Waimakariri DC		
		Waitomo DC		Western Bay Moana RFD						Waimate CC		
				Western Bay Of Plenty DC						West Melton RFD		
				Whakatane DC								

Every attempt was made to include all usable data and electronic records were available for fire years 1988/89 to 2006/07. On closer inspection, however, the records that were provided for 1989/90 and 1990/91 only contained the returns from Canterbury. Attempts to locate the records for the rest of the country for these years were unsuccessful. As a result, only fire records from 1991/92 to 2006/07 were used in the subsequent analyses.

The New Zealand Defence Force return for 1995/96 had to be removed from the regional analysis because the records were not broken down into their respective regions or Rural Fire Districts. There was also one instance where area burned was assigned without any associated number of fires (Figure 2). An assumption was made that this corresponded to a single fire event (15 ha of scrub burned).

	F/S	RFA	CATEGORY	REGION	CAUSE	NUMBER	GRASS (Ha)	SCRUB (Ha)	FOREST (Ha)
	01/02	West Coast RFD	RFD	Christchurch	Incendiary	11	0	223	0
▶	01/02	West Coast RFD	RFD	Christchurch	Industrial (sawmi	0	0	15	0
	01/02	West Coast RFD	RFD	Christchurch	Miscellaneous	2	2	1	0

Figure 2. Highlighted record shows no fires recorded against an area of 15 ha of scrub burned.

With the potential for analyses to be impacted by large fire events, records with significant areas burned were identified, and an attempt was made to attribute them to large known historical fires. Primarily, this was done to ensure wherever possible the data matched those previously published, and to detect any errors in the original data entry. Only one record could not be verified (Figure 3), a railway fire of 2,500 ha for South Wairarapa DC in 2000/01 that did not correlate with previous records (totals were different). One (previous) copy of the NRFA Annual Returns database had this listed as 0.25 ha, and it was subsequently confirmed that this fire was 2,500 m^2 and had been incorrectly recorded as 2,500 hectares (J.Rasmussen, NRFA, pers.comm). This change was made in the data used here. Despite the greatest of care, inaccuracies and errors may be present within the dataset.

	ID1	F/S	RFA	CATEGORY	REGION	CAUSE	NUMBER	GRASS (Ha)	SCRUB (Ha)	FOREST (Ha)
	101	00/01	South Wairarapa DC	TA	Palmersto	Land Clearing	20	0	0	0
	98	00/01	South Wairarapa DC	TA	Palmersto	Tractors and Mot	3	0	0	0
	104	00/01	South Wairarapa DC	TA	Palmersto	False Alarms	6	0	0	0
▶	99	00/01	South Wairarapa DC	TA	Palmersto	Railways	1	0	2500	0
	100	00/01	South Wairarapa DC	TA	Palmersto	Picnics	10	1	58	0

Figure 3. Suspected recorded error in data entry in NFRA annual return 2000/01.

Data including number of fires and area burned were reclassified by cause (see Table 1), and summarized by fire year, region, cause and fuel type in both tabular and graphical format. This was then used to highlight trends in data. Data were not summarised by fire authority type.

A correlation analysis was also performed to compare trends in the number of fires for individual regions against the national trend. This was done to determine how much each region reflected the overall national trend. Since we were not postulating that each region depended on the national trend, a correlation rather than a strict regression analysis was conducted. Regression was however conducted for the national number of fires against time.

Both the regression analysis of variance and correlation trends used 0.05 as the standard alpha (or significance) level. A P-value or significance value of less than 0.05 indicates that there is a 95% (or greater) probability that the difference between the two things being tested is due to an actual difference than to chance alone (Quinn 2002).

In regression and correlation:

- A P-value of less than 0.05 indicates that the slope of the regression line (generated from the values given) significantly differs from zero; i.e. the value of y depends on the values of x;
- The R^2 value indicates how tightly the values of y cluster about the regression line and indicate the strength (or "goodness of fit") of the regression relationship, therefore an R^2-value of 1 indicates a good fit, whereas an R^2-value of 0 indicates that none of the values of y significantly cluster about the regression line and is a poor fit.
- In practice this means the following: a significant P-value (less than 0.05) with a high R^2-value indicates that there is a strong directional trend (positive or negative) in values of y over x and that this is mostly due to x; a significant P-value with a low R^2-value indicates that there is a strong directional trend in values of y over x but factors other than x may be influencing y; a non-significant P-value but high R^2-value indicates that y may not depend on x and another factor (another x) may be constraining y; and a non-significant P-value and a low R^2-value may indicate that there is no clear relationship between y and x.

The null hypotheses being tested were: (1) that no individual region's total number of fires correlated (positively or negatively) with the national trend; and (2) that at the national level, the number of fires remained constant over time. This was not conducted for area burned as there was no clear year-on-year directional trend in area burned (i.e. no significant positive or negative trend in the national area burned over time).

Data quality issues

It is important to reiterate that underlying data quality must be considered when interpreting these results. From the data sets it is clear that the area burned is not always being recorded accurately. In many cases, the number of fires were listed (up to as high as 125 fires) without any corresponding area burned listed. It is possible that in some cases a zero area burned is being recorded for small and fully contained fires, e.g. vehicle fires that burn little or no surrounding vegetation. However, it is impossible to estimate whether actual areas burned are unrecorded. Thus all results presented here in relation to area burned should be considered reported rather than actual area burned, and should be interpreted with caution.

In addition, the Annual Returns form has not always been submitted by all RFAs in a single fire year (NRFA unpublished data). Whether this is because there were no fires to report, or the return was not submitted, is unclear. Although not available for all years, the percentage of returns submitted by authorities was recorded in some instances at 85-95%, and it is highly likely that data from some fires are missing.

RESULTS – NATIONAL OVERVIEW

Number of fires

For the last sixteen years (from 1991/92 to 2006/07), New Zealand has seen an increase in the number of wildfires from around 1,200 to more than 4,000 per fire year (Figure 4). The increase in the number of fires over time was statistically significant (R^2 = 0.8106; F-value = 67.12; P-value <0.001). The number of fires peaked in 2004/05 at over 4,700 and appears to have declined in the last two years; however, more data are needed to confirm this declining trend. The lowest number of wildfires occurred in 1992/93, with around 1,000 fires.

The national average number of annual total wildfires reported annually for the full period was 3,033 (1991/92 to 2006/07)
The national average number of annual wildfires over four-year periods was:

- 1,566 (1991/92 to 1994/95),
- 2,714 (1995/96 to 1998/99),
- 3,563 (1999/2000 to 2002/03),
- 4,289 (2003/04 to 2006/07).

Interestingly, the number of fires over time may be levelling out, as illustrated by the polynomial trend line in Figure 4, with a marginally higher R^2 value of 0.85. The increases also appear to be cyclical, with peak years followed by two or three years of fewer fires then followed by another peak. However, another few

years of data are required to determine whether the number of fires are in fact levelling out or not.

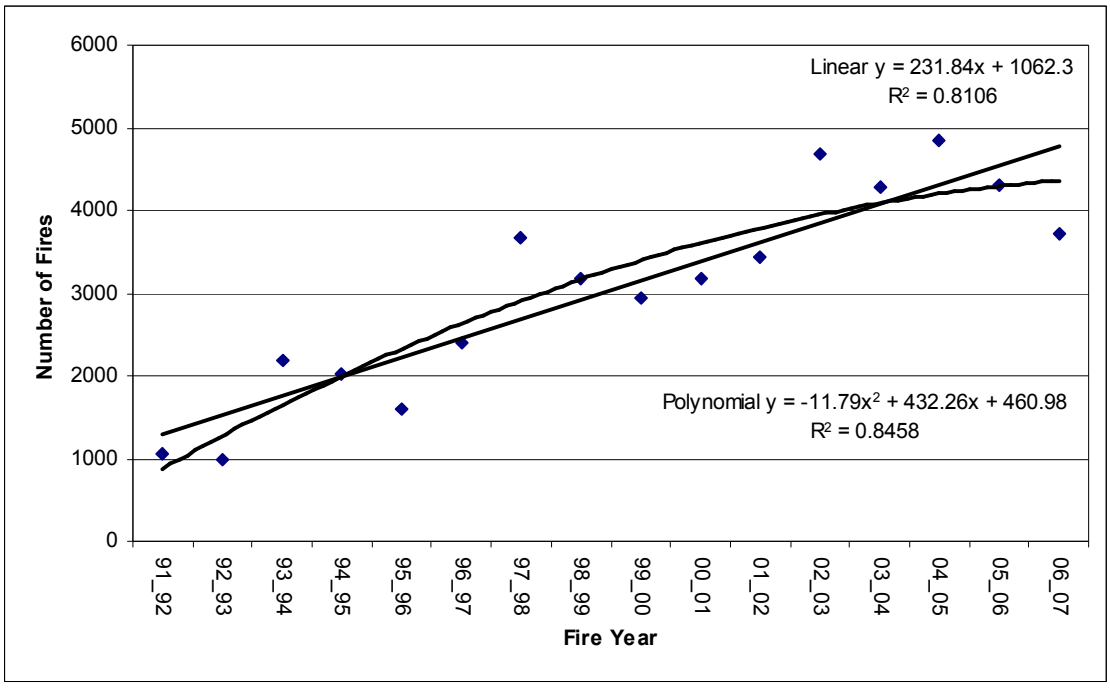

Figure 4. National number of wildfires from 1991/92 to 2006/07.

Number of fires by region

The occurrence of wildfires in New Zealand varies significantly between years and is not evenly distributed between all regions (Figure 5). However, proportionally, fire numbers for each region are more consistent from year to year (Table 3).

The North Island accounted two-thirds (66%) of the total number of wildfires from 1991/92 to 2006/07. Four regions (Waikato 10%, Central North Island 9%, Eastern North Island 14.1%, Canterbury 18%) accounted for just over half of the number of wildfires (Figure 6).

Some individual regions accounted for a greater number of fires than others, such as Canterbury with up to around 1,300 (30% of the annual total) in 2003/04. The Eastern North Island also had around 700 fires(20%) in 2001/02. Southland at most had only 270 fires (7%) for 2006/07 (Figure 5 and Table 3). Overall the proportion of the annual total number of wildfires accounted for by each region was relatively constant over the study period (Figure 5). More detailed discussion on the number of fires in individual regions is contained in Appendix C.

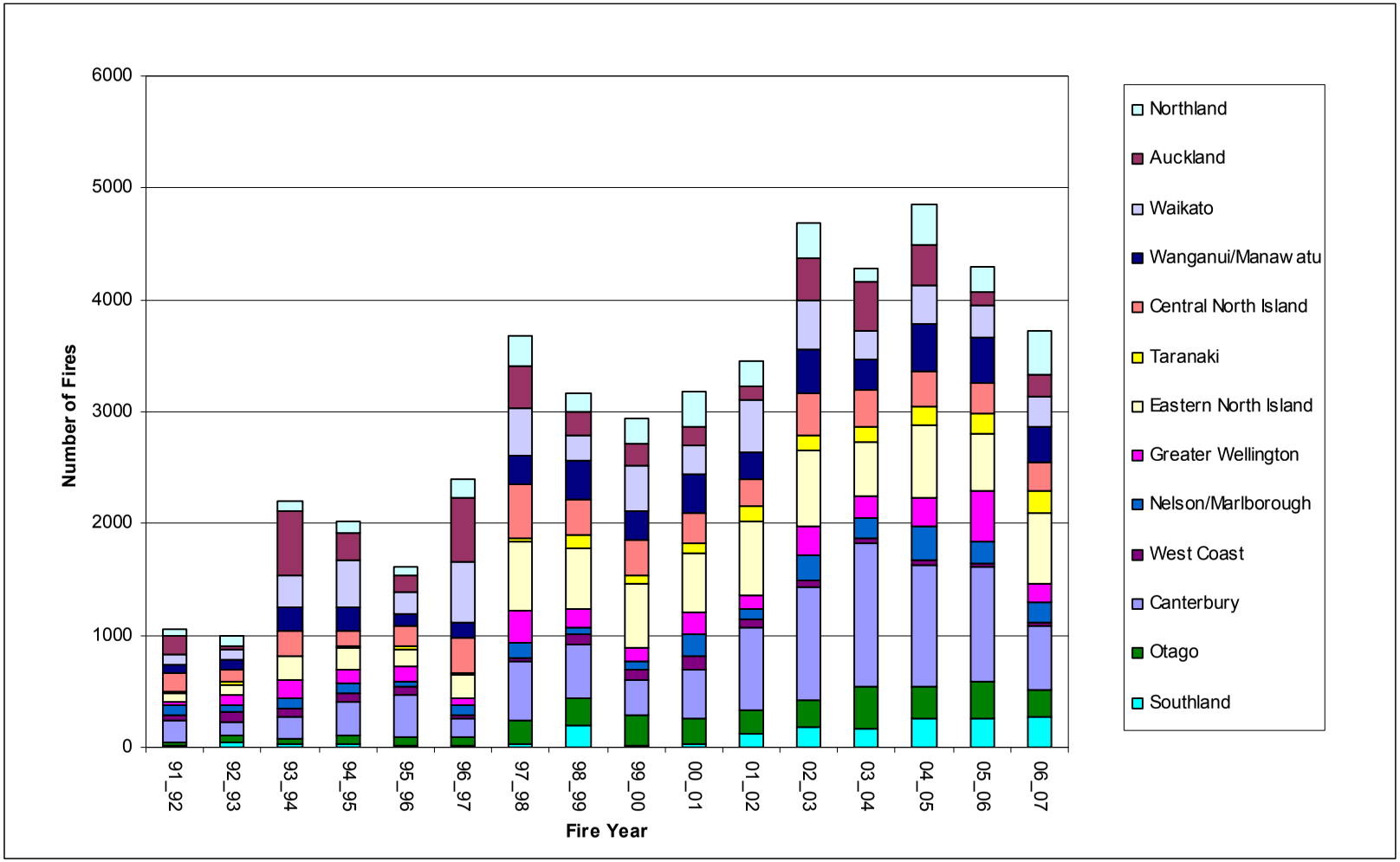

Figure 5. Number of wildfires for all regions from 1991/92 to 2006/07.

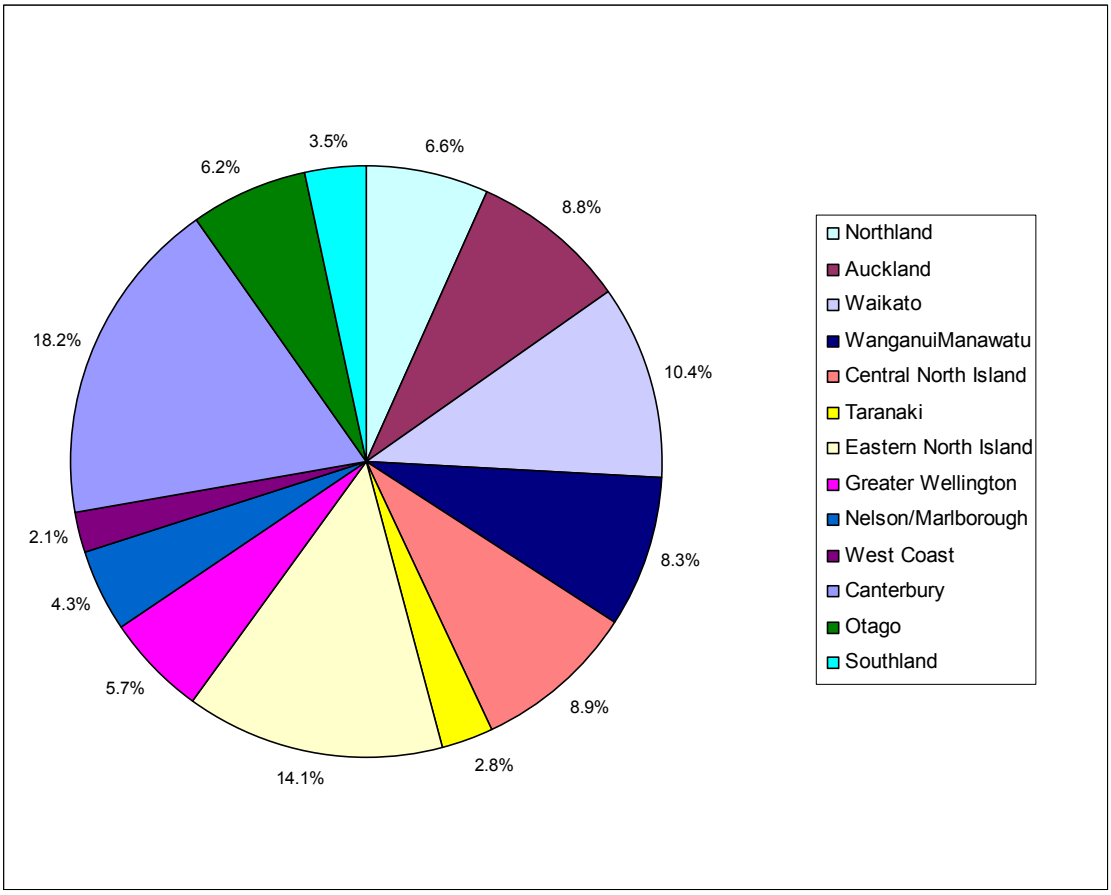

Figure 6. Proportion of total number of wildfires by region from 1991/92 to 2006/07.

Table 3. Annual number of wildfires recorded for all New Zealand regions from 1991/92 to 2006/07.

		Fire Year																
Region		91_92	92_93	93_94	94_95	95_96	96_97	97_98	98_99	99_00	00_01	01_02	02_03	03_04	04_05	05_06	06_07	Average**
Northland	#	62.0	83.0	86	109.0	69.0	179.0	259.0	166.0	213.0	317.0	217.0	320.0	121.0	358.0	238.0	385.0	197.1
	%*	5.9	8.4	3.9	5.4	4.3	7.4	7.1	5.2	7.3	10.0	6.3	6.8	2.8	7.4	5.5	10.3	6.5
Auckland	#	163.0	30.0	572.0	240.0	159.0	567.0	381.0	216.0	204.0	165.0	123.0	369.0	427.0	359.0	110.0	196.0	267.6
	%	15.5	3.0	26.0	11.9	9.9	23.6	10.4	6.8	7.0	5.2	3.6	7.9	10.0	7.4	2.6	5.3	9.7
Waikato	#	96.0	93.0	291.0	427.0	188.0	537.0	430.0	224.0	412.0	266.0	460.0	446.0	263.0	354.0	286.0	280.0	315.8
	%	9.1	9.4	13.2	21.1	11.7	22.3	11.7	7.1	14.0	8.4	13.4	9.5	6.1	7.3	6.6	7.5	11.2
Wanganui/Manawatu	#	72.0	86.0	215.0	204.0	117.0	137.0	244.0	347.0	248.0	348.0	252.0	382.0	265.0	412.0	410.0	314.0	253.3
	%	6.8	8.7	9.8	10.1	7.3	5.7	6.6	11.0	8.5	10.9	7.3	8.1	6.2	8.5	9.5	8.4	8.3
Central North Island	#	165.0	115.0	216	140.0	167.0	325.0	495.0	320.0	317.0	260.0	240.0	378.0	344.0	323.0	268.0	264.0	271.0
	%	15.6	11.6	9.8	6.9	10.4	13.5	13.5	10.1	10.8	8.2	7.0	8.1	8.0	6.7	6.2	7.1	9.6
Taranaki	#	17.0	26.0	2.0	8.0	31.0	12.0	30.0	111.0	79.0	94.0	129.0	146.0	131.0	169.0	183.0	183.0	84.4
	%	1.6	2.6	0.1	0.4	1.9	0.5	0.8	3.5	2.7	3.0	3.7	3.1	3.1	3.5	4.3	4.9	2.5
Eastern North Island	#	74.0	84.0	206.0	207.0	163.0	216.0	611.0	546.0	577.0	536.0	674.0	679.0	483.0	647.0	514.0	643.0	428.8
	%	7.0	8.5	9.4	10.2	10.1	9.0	16.6	17.2	19.7	16.8	19.6	14.5	11.3	13.3	11.9	17.3	13.3
Greater Wellington	#	30.0	96.0	180.0	115.0	123.0	60.0	294.0	166.0	109.0	189.0	112.0	244.0	190.0	251.0	458.0	157.0	173.4
	%	2.8	9.7	8.2	5.7	7.6	2.5	8.0	5.2	3.7	5.9	3.3	5.2	4.4	5.2	10.6	4.2	5.8
Nelson/Marlborough	#	86.0	58.0	79.0	84.0	55.0	92.0	124.0	67.0	74.0	201.0	95.0	225.0	180.0	299.0	191.0	192.0	131.4
	%	8.2	5.9	3.6	4.2	3.4	3.8	3.4	2.1	2.5	6.3	2.8	4.8	4.2	6.2	4.4	5.2	4.4
West Coast	#	54.0	86.0	80.0	82.0	73.0	22.0	32.0	82.0	102.0	115.0	74.0	64.0	50.0	44.0	28.0	27.0	63.4
	%	5.1	8.7	3.6	4.1	4.5	0.9	0.9	2.6	3.5	3.6	2.1	1.4	1.2	0.9	0.7	0.7	2.8
Canterbury	#	188	133	202	301	376	162	529	484	312	442	741	1015	1274	1089	1029	565	552.6
	%	17.8	13.5	9.2	14.9	23.3	6.7	14.4	15.3	10.6	13.9	21.5	21.6	29.8	22.4	23.9	15.2	17.1
Otago	#	33.0	53.0	33.0	81.0	80.0	86.0	220.0	237.0	268.0	216.0	210.0	241.0	382.0	285.0	327.0	248.0	187.5
	%	3.1	5.4	1.5	4.0	5.0	3.6	6.0	7.5	9.1	6.8	6.1	5.1	8.9	5.9	7.6	6.7	5.8
Southland	#	15.0	45.0	36.0	25.0	10.0	9.0	24.0	200.0	19.0	36.0	118.0	180.0	168.0	261.0	260.0	270.0	104.8
	%	1.4	4.6	1.6	1.2	0.6	0.4	0.7	6.3	0.6	1.1	3.4	3.8	3.9	5.4	6.0	7.3	3.0
Total	#	1055.0	988.0	2198.0	2023.0	1611.0	2404.0	3673.0	3166.0	2934.0	3185.0	3445.0	4689.0	4278.0	4851.0	4302.0	3724.0	3032.9

**Percentage values represent the actual number of fires for each region expressed as a proportion of the total number of fires for that year for all regions. **Overall averages were calculated by averaging values from each year, and may differ from proportional totals over the study period.*

A regression analysis was carried out for each region, and the trend line equations (Table 4, as well as the regional graphs of number of fires over time (in Appendix C) were fitted to the data for number of fires, with the general form:

$$Y = bX \pm a$$

where Y = number of fires,
b = the slope of the line,
X = fire year, and
a = intercept or the point where the equation line intercepts the y-axis.

Therefore, when considering the national number of fires see (Figure 4), the slope (b) increases on average at around 230 fires each year, from a starting point of around 1,050 fires in 1991/92.

Table 4. Trends in regional number of fires and correlation results compared with the national number of fires (Values in bold are statistically significant).

Trend line comparison for each region for Number of Fires			
Region	**Slope of regression line**	**Correlation Coefficient**	**Significance Value (region correlated if less than 0.05)***
Northland	y = 17.849x + 47.25	0.772	**0.001**
Auckland	y = -0.4882x + 273.53	0.241	0.368
Waikato	y = 8.2397x + 245.78	0.463	0.071
Wanganui/ Manawatu	y = 19.413x + 88.3	0.896	**<0.0001**
Central North Island	y = 10.054x + 185.58	0.722	**0.002**
Taranaki	y = 13.272x - 28.375	0.826	**<0.0001**
Eastern North Island	y = 39.953x + 89.15	0.889	**<0.0001**
Greater Wellington	y = 12.944x + 63.35	0.697	**0.003**
Nelson/ Marlborough	y = 11.832x + 30.8	0.812	**<0.0001**
West Coast	y = -2.025x + 80.65	-0.345	0.190
Canterbury	y = 62.871x + 18.225	0.876	**<0.0001**
Otago	y = 20.268x + 12.075	0.880	**<0.0001**
Southland	y = 17.606x - 44.9	0.748	**0.001**
National	**y = 237.16x + 1036.7**		

Correlation analyses were undertaken to compare regional trends in number of fires over time against the increase in fire numbers found nationally. The correlation between each region and the national total of number of fires is shown in Table 4. Regions that significantly correlate with the national trend (P-values less than 0.05) are highlighted in bold. The sign of the correlation coefficient shows the direction of the trend, and for each factor the closer to one (+1) the more positive the correlation, while the closer to minus one (-1) the more negative the correlation. If the correlation coefficient is close to one and is significant, then it can be said that there is a significant positive relationship between that region's trend and the national trend. If the correlation coefficient is close to zero then there is very little correlation between the regional and national trend.

Correlation tests show that all regions except Auckland, the West Coast and, to a lesser degree Waikato, strongly follow the national trend of increasing fires over time (Table 4). Auckland's annual wildfire occurrence has fluctuated from around 30 to almost 600 fires but the trend is generally flat (Figure 7).

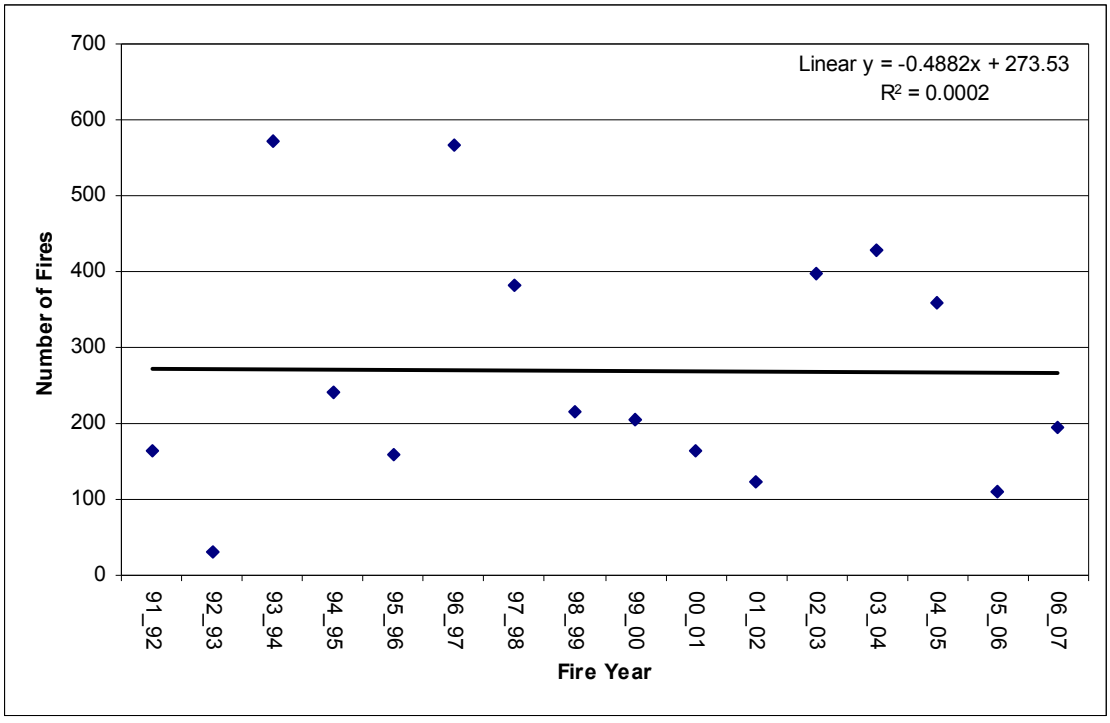

Figure 7. Numbers of wildfires for the Auckland region from 1991/92 to 2006/07.

The West Coast (Figure 8) also differs to the national trend in that the number of fires reported has declined over time. However, the West Coast's number of fires per year is relatively small (average for 1991/92 to 2006/07 is 63 fires per year) compared to most other regions.

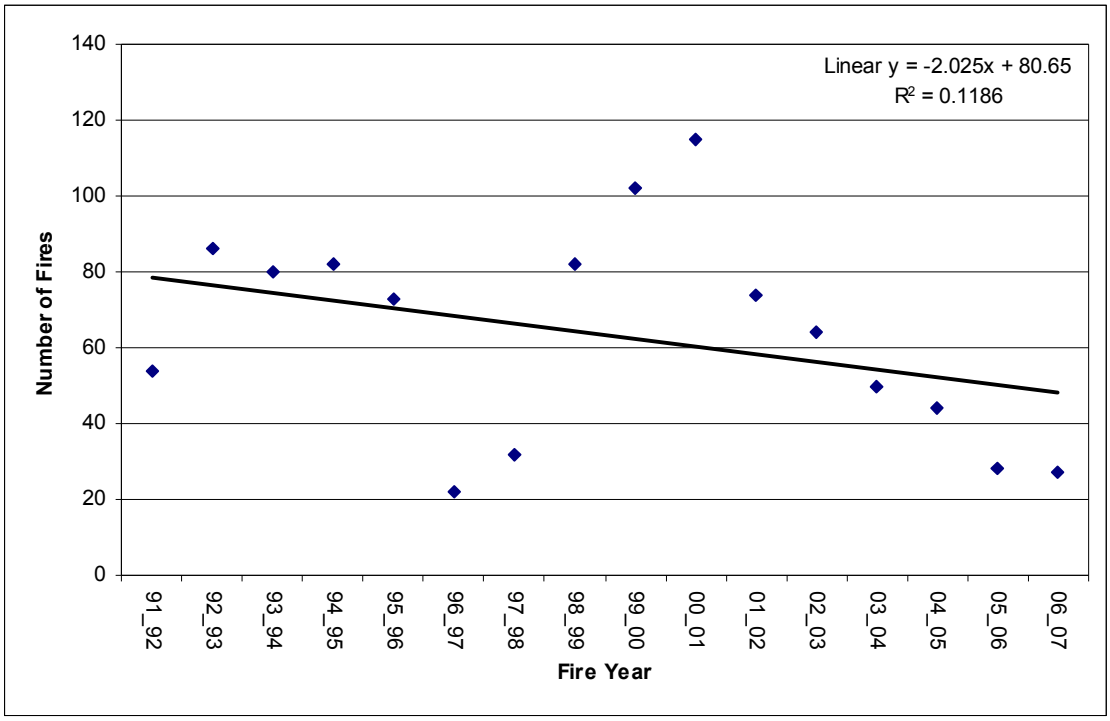

Figure 8. Annual number of wildfires for the West Coast from 1991/92 to 2006/07.

Number of fires by cause

Accurately determining fire cause can often be difficult and, particularly in the case of very small fires, may not be worth the resources and cost involved. However, there still seems to be an unacceptably high number of fires being attributed to the cause classes of miscellaneous and unknown (Figure 9). From 1991/92 to 2006/07, 47% of the total number of wildfires were assigned to "unspecified" causes, either classed as unknown (13.4% or 6,546 fires) or miscellaneous (33.1% or 16,162 fires).

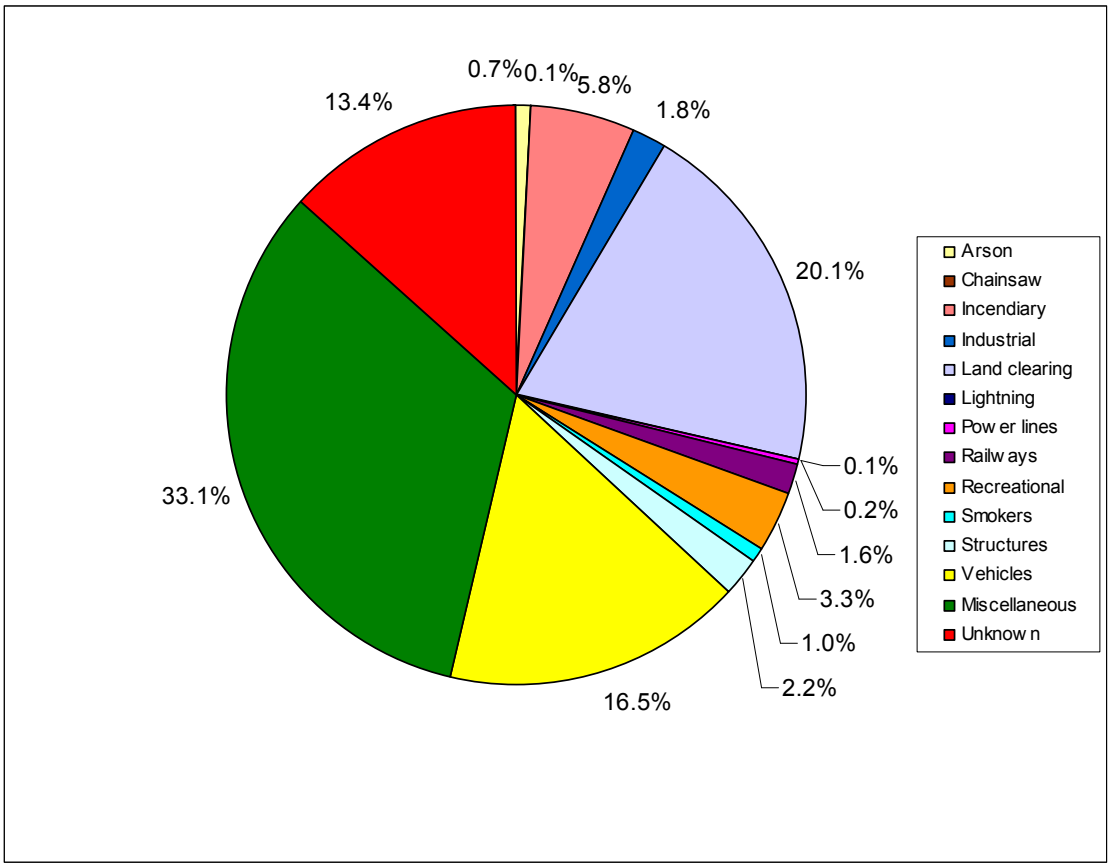

Figure 9. The total proportion of wildfires nationally by fire cause from 1991/92 to 2006/07.

Whilst the number of fires at the national level increased for most causes (Table 5), the proportion of fires for each cause remained roughly constant (Figure 10). One interesting trend is that over time the relative number of unknown fires appeared to decrease whilst the relative number of miscellaneous fires increased (the proportion of miscellaneous fires annually (over time) was significantly negatively correlated with the proportion of unknown fires: correlation coefficient = -0.873; P-value <0.0001). Unknown accounted for 15% of the national total number of fires in 1991/92, around 28% in 1993/94 and less than 10% in 2006/07 (Table 5). Over the same period of time, fires listed as miscellaneous made up around 27% of the total number of fires in 1991/92, 45% in 2003/04 and nearly 40% in 2006/07. After miscellaneous and unknown causes, land clearing (20%) and vehicles (17%) were the most significant fire causes nationally.

Key overall trends (Figure 9) were:

- Land clearing fires varied considerably in number, from just 275 fires in 1992/93 (27.7%) to 965 fires (20.3%) in 2004/05. This illustrates how the proportion represented is important. The number of fires appeared to show a significant increase, but in actual fact the proportion of the national total this represented decreased.

- The number of vehicle fires varied more than most other causes, from just 78 fires (8%) in 1992/93 to 935 fires (around 20%) in 2004/05. The average number of vehicle fires for all years was around 504 fires.
- Incendiary fires varied from 50 fires (5%) in 1992/93 to 403 fires (12.1%) in 2000/01 and averaged around 6%.
- The proportion of fires from recreational causes had a downward trend from about 7% (84 fires) in 1991/92 to around 2% (73 fires) in 2006/07.
- The number of fires occurring annually from arson, chainsaw, industrial, lightning, structures, power lines and railways were usually fewer in comparison to those from other causes.
- The number of lightning-caused fires increased significantly, possibly due to better technology in reporting; the number of arson and incendiary fires increased over time; fires from chainsaws and smokers decreased over time and recreational and structure fires increased (Table 5).
- The number of fires classed as being caused by smokers remained relatively small, at less than 50 fires per year for most years. The largest number of reported smoker fires was 101 in 1997/98.
- More detail on fire causes across each region are contained in Appendix B.
- More detail on causes for individual regions contained in Appendix C.

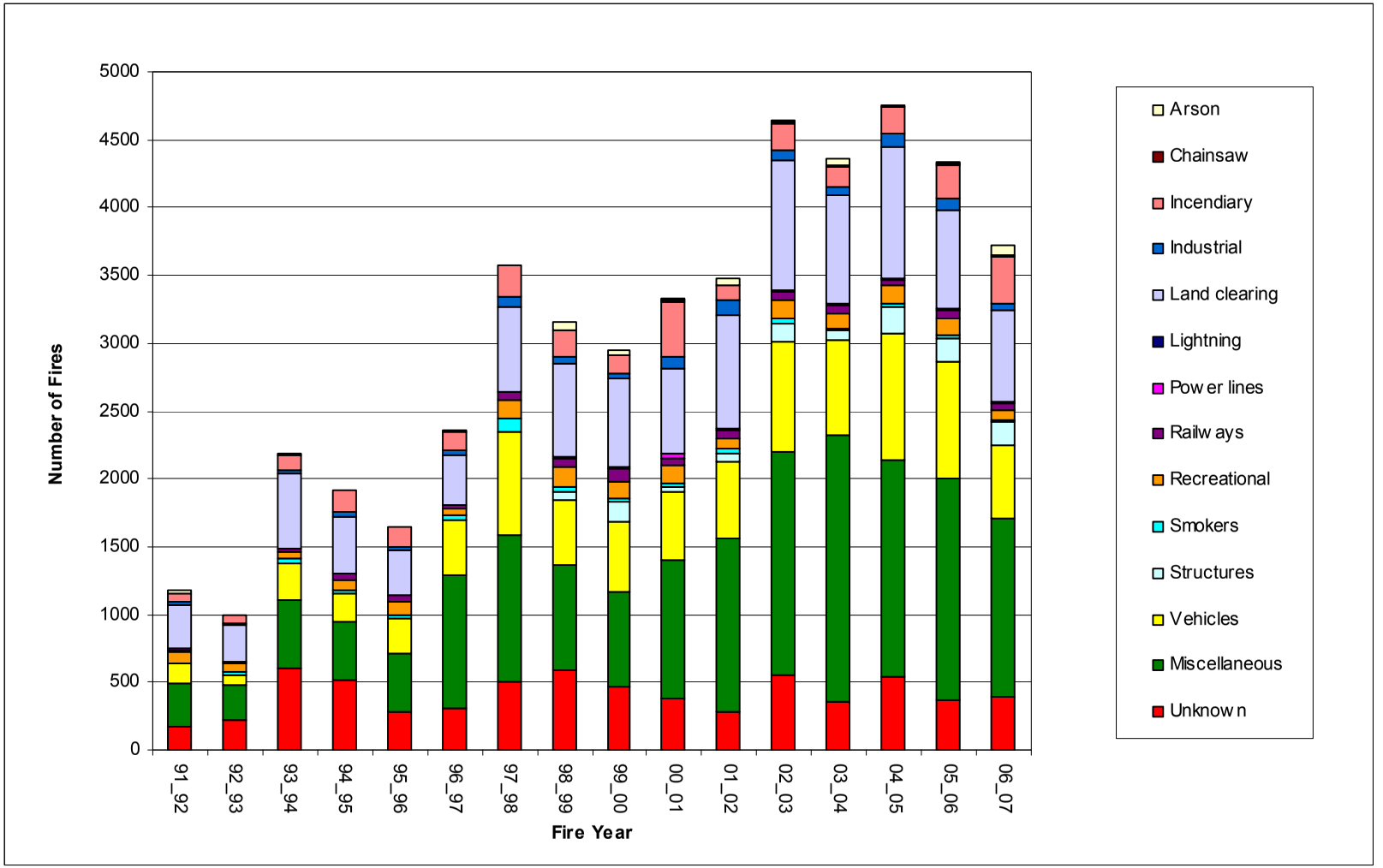

Figure 10. Number of fires nationally for all fire cause classes from 1991/92 to 2006/07.

Table 5. National Number of Fires for all Cause classes from 1991/92 to 2006/07.

		Fire Year																
Cause		91_92	92_93	93_94	94_95	95_96	96_97	97_98	98_99	99_00	00_01	01_02	02_03	03_04	04_05	05_06	06_07	Average**
Arson	#	24	0	0	0	0	0	0	58	35	15	42	21	56	8	19	82	22.5
	%*	2.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	1.2	0.5	1.2	0.5	1.3	0.2	0.4	2.2	0.7
Chainsaw	#	4	2	11	4	3	8	1	1	1	7	3	2	7	3	5	2	4
	%	0.3	0.2	0.5	0.2	0.2	0.3	0.0	0.0	0.0	0.2	0.1	0.0	0.2	0.1	0.1	0.1	0.1
Incendiary	#	67	50	103	162	143	139	242	192	140	403	117	199	149	195	249	351	181.3
	%	5.7	5.0	4.7	8.4	8.7	5.9	6.8	6.1	4.8	12.1	3.4	4.3	3.4	4.1	5.7	9.4	6.2
Industrial	#	19	18	30.5	31	28	40	72	60	36	87	107	74	61	104	84	43	55.9
	%	1.6	1.8	1.4	1.6	1.7	1.7	2.0	1.9	1.2	2.6	3.1	1.6	1.4	2.2	1.9	1.2	1.8
Land clearing	#	321	275	545	418	334	361	622	687	642	629	835	961	801	965	731	674	612.6
	%	27.1	27.7	25.0	21.8	20.3	15.3	17.4	21.8	21.8	18.9	24.0	20.7	18.4	20.3	16.9	18.1	21.0
Lightning	#	2	0	0	0	0	0	0	0	9	7	2	0	5	2	6	1	2.1
	%	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.1	0.0	0.1	0.0	0.1	0.0	0.1
Power lines	#	5	0	0	0	0	0	0	7	9	26	6	9	9	9	3	13	6.0
	%	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.8	0.2	0.2	0.2	0.2	0.1	0.3	0.2
Railways	#	14	12	31	50	39	29	59	64	98	58	67	61	58	39	64	47	49.4
	%	1.2	1.2	1.4	2.6	2.4	1.2	1.6	2.0	3.3	1.7	1.9	1.3	1.3	0.8	1.5	1.3	1.7
Recreational	#	84	55	50	70	104	49	140	149	126	134	74	141	107	133	112	77	100.3
	%	7.1	5.5	2.3	3.6	6.3	2.1	3.9	4.7	4.3	4.0	2.1	3.0	2.5	2.8	2.6	2.1	3.7
Smokers	#	8	22	36	32	25	31	101	28	23	27	41	33	13	30	31	12	30.8
	%	0.7	2.2	1.6	1.7	1.5	1.3	2.8	0.9	0.8	0.8	1.2	0.7	0.3	0.6	0.7	0.3	1.1
Structures	#	0	0	0	0	0	0	0	70	141	35	57	139	74	196	174	170	66.0
	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	4.8	1.1	1.6	3.0	1.7	4.1	4.0	4.6	1.7
Vehicles	#	142	78	267.5	200	253	411	757	475	526	495	569	809	706	935	853	549	501.6
	%	12.0	7.9	12.3	10.4	15.4	17.4	21.1	15.1	17.8	14.9	16.4	17.4	16.2	19.7	19.7	14.7	15.5
Miscellaneous	#	316	254	502	439	433	978	1078	775	694	1025	1275	1648	1964	1597	1634	389	409.1
	%	26.7	25.6	23.0	22.9	26.3	41.5	30.1	24.6	23.5	30.8	36.7	35.5	45.0	33.6	37.7	10.4	15.1
Unknown	#	178	225	606	513	284	310	509	589	467	381	280	550	353	539	373	1315	995.4
	%	15.0	22.7	27.8	26.7	17.3	13.2	14.2	18.7	15.8	11.4	8.1	11.8	8.1	11.3	8.6	35.3	31.2
Total	#	1184	991	2182	1919	1646	2356	3581	3155	2947	3329	3475	4647	4363	4755	4338	3725	3037.1

**Percentage values represent the actual number of fires for each cause expressed as a proportion of the total number of fires for that year for all causes. **Overall averages were calculated by averaging values from each year and may differ from proportional totals over the study period.*

Area burned

At the national level, the total area burned displayed no distinct directional trend, either for total area burned (Figure 11) or for area by fuel type (Figure 12). The total area burned fluctuated from 1,813 ha in 1991/92 to a high of 17,698 ha (in part due to the Alexandra fires) in 1998/99. Linear regression analysis on the total area burned over time (Figure 11) was not statistically significant (R^2 = 0.002; F-value = 0.02; P-value = 0.880).

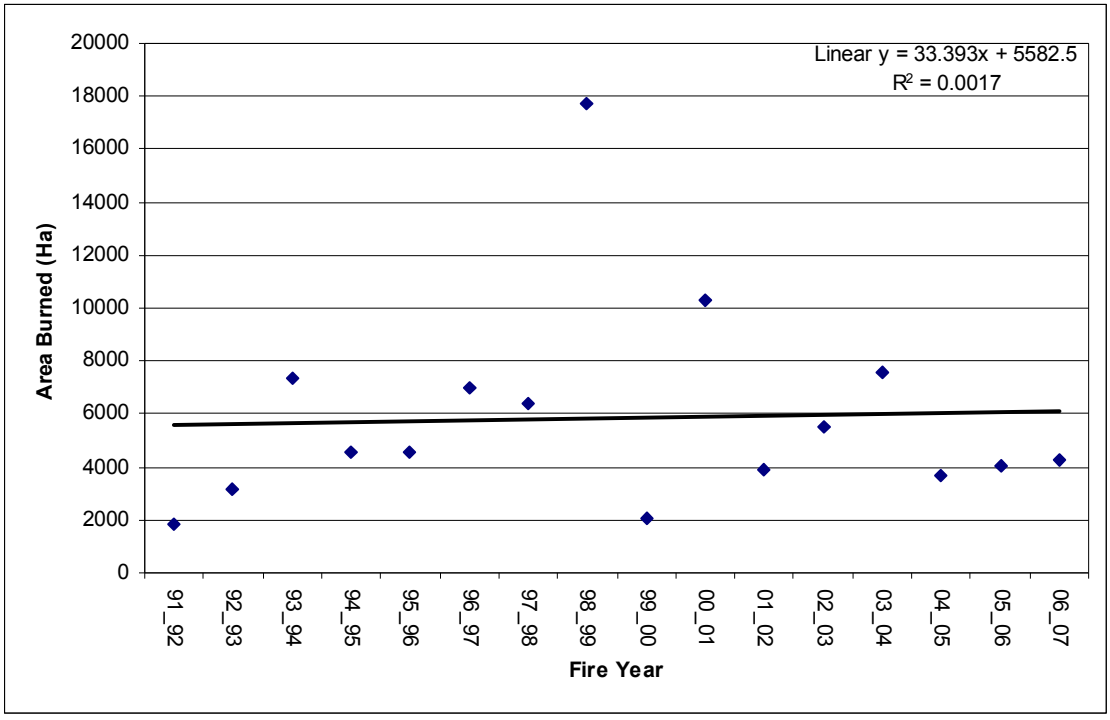

Figure 11. Total area burned for all fuel types from 1991/92 to 2006/07.

The national average annual total area burned for the full period was 5,865 ha (1991/92 to 2006/07).
The national average annual total area burned for four-year periods was:

- 4,221 ha (1991/92 to 1994/95),
- 8,898 ha (1995/96 to 1998/99),
- 5,455 ha (1999/2000 to 2002/03),
- 4,885 ha (2003/04 to 2006/07).

The annual total area burned was greatly influenced by large individual fire events or particularly large total areas burned in a single region, such as the 2000/01 when the Marlborough fires (Wither Hills, Ward and others) burned over 6,500 ha. Annual total area burned is also likely to be driven by weather and

climate, and an analysis of trends in area burned (and fire numbers) with weather and/or fire danger ratings was beyond the scope of this analysis.

Area Burned by fuel type

Over the study period the proportion of total area burned was not uniform between fuel types. Grass fuels made up the majority of the total area burned, followed by scrub fuel and a small proportion was attributed to the forest fuel type.

Key points were (Figures 12 and 13, and Table 6):

- Total grass area burned over the study period (1991/92 to 2006/07) was 50,403 ha (54% of the total area burned); average total grass area burned was 3,150 ha per year.
- The total grass area burned was lowest in 2005/06 with just 573 ha burned (14% of annual total area burned), and highest in 1998/99 with nearly 12,000 (66%) ha burned (due to large wildfires near Alexandra in Otago).
- Total scrub area burned was 37,287ha (40%); average total scrub area burned was 2,330 ha per year.
- The total scrub area burned varied annually from just 851ha (47%) in 1991/92 to 5764 ha (33%) in 1998/99. Scrub area burned was 31% in 2004/05 and as much as 78% in 2005/06 of the total national area burned.
- Total forest area burned was 6,170 ha (6%); average total forest area burned was 386 ha per year.
- Forest area burned was lowest in 1991/92 with just 119 ha (3%) and highest in 1997/98 where 1,399 ha (22%) burned. Proportionally, forest area burned has made up less than 10% for most years.

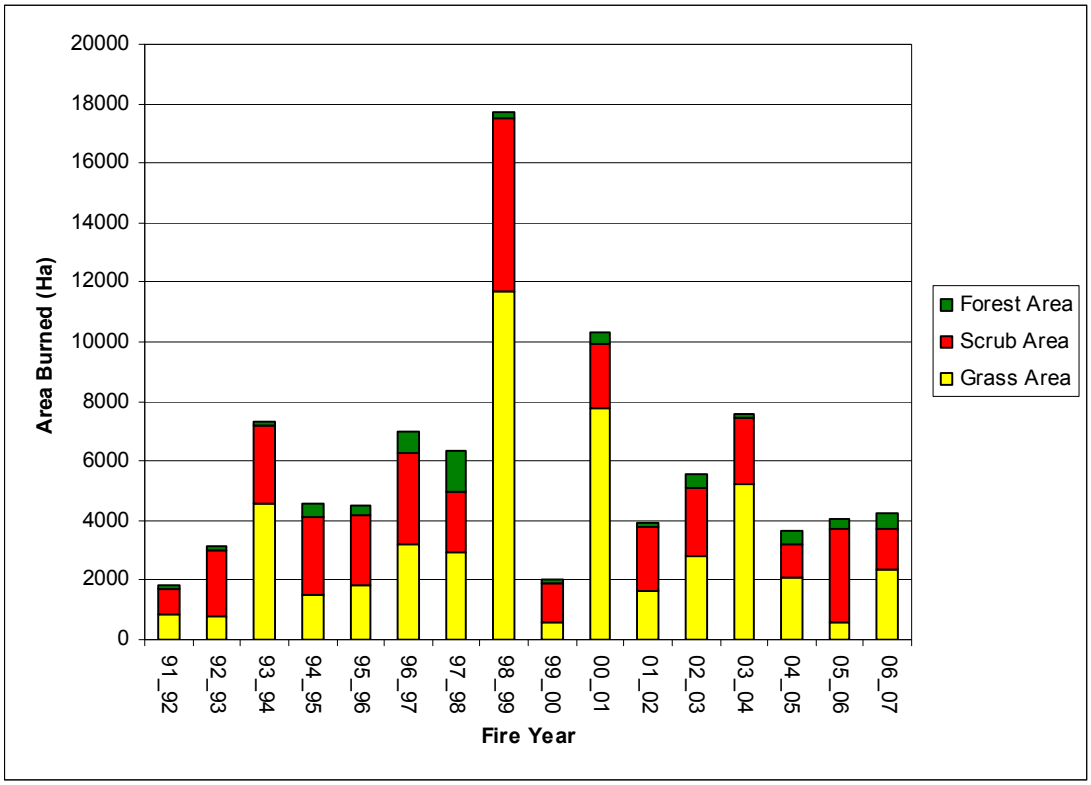

Figure 12. Area burned nationally by fuel types from 1991/92 to 2006/07.

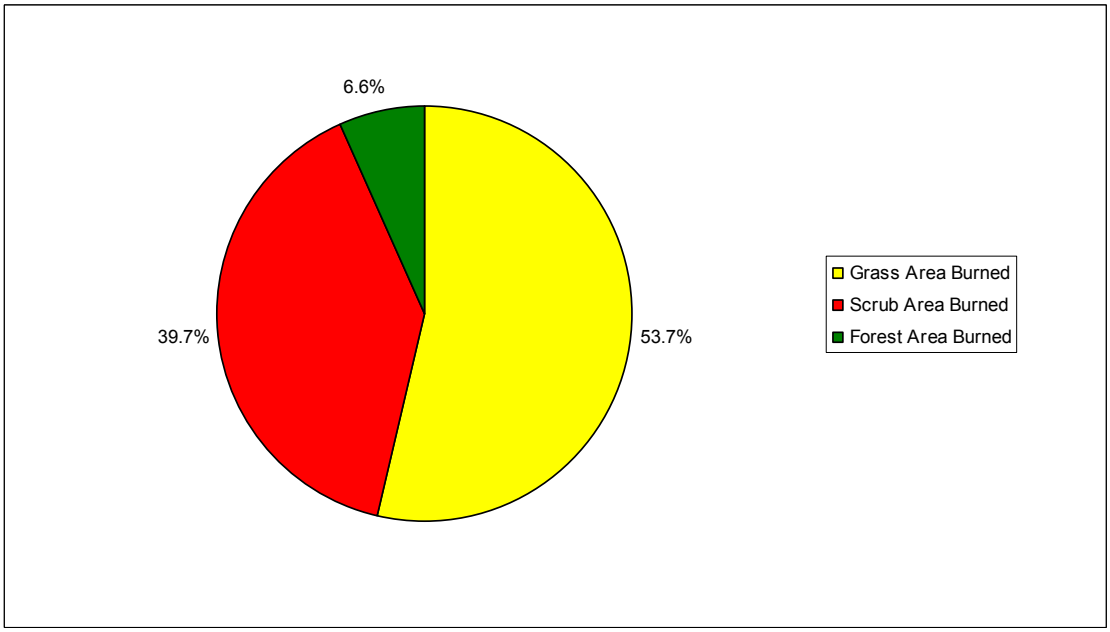

Figure 13. Proportion of total area burned by fuel type for all New Zealand regions from 1991/92 to 2006/07.

Table 6. Area burned by fuel type nationally (all New Zealand regions) from 1991/91 to 2006/07.

		Fire Year																
Fuel Type		91_92	92_93	93_94	94_95	95_96	96_97	97_98	98_99	99_00	00_01	01_02	02_03	03_04	04_05	05_06	06_07	Average**
Grass	ha	817.8	784.6	4543.5	1524.4	1828.0	3183.8	2949.0	11725.1	563.6	7802.1	1631.1	2841.9	5230.8	2084.0	573.0	2320.7	3150.2
	%*	45.1	25.1	61.8	33.2	40.3	45.5	46.3	66.2	27.4	75.5	41.5	51.4	68.8	57.0	14.2	54.6	47.1
Scrub	ha	851.0	2192.3	2629.0	2603.3	2354.3	3066.8	2019.7	5763.8	1349.5	2100.3	2178.5	2249.5	2225.1	1145.3	3166.7	1392.3	2330.5
	%	46.9	70.1	35.8	56.7	52.0	43.8	31.7	32.6	65.7	20.3	55.5	40.7	29.3	31.3	78.4	32.8	45.2
Forest	ha	144.1	149.0	177.2	466.0	348.2	746.6	1398.7	209.4	141.4	427.2	118.9	441.6	142.7	424.9	299.4	534.9	385.6
	%	7.9	4.8	2.4	10.1	7.7	10.7	22.0	1.2	6.9	4.1	3.0	8.0	1.9	11.6	7.4	12.6	7.6
Total	ha	1812.9	3125.9	7349.7	4563.7	4530.4	6997.2	6367.4	17698.3	2054.5	10329.6	3928.5	5532.9	7598.6	3654.2	4039.2	4247.8	5866.3

** Percentage values in rows calculated from yearly totals. **Overall average percentages were calculated as an average of the values for all individual years and may differ from proportion of the total over the study period.*

Area burned by region and fuel type

The total area burned for all regions varied considerably from 1991/92 to 2006/07 (Figure 15 and Table 7).

Key points (Figures 14 and 15, and Table 7) and comparison with results for number of fires (Figure 6):

- Otago accounted for around 42% of the reported total area burned from 1991/92 to 2006/07; but only 6% of the number of fires (see Figure 6).
- Otago and Canterbury together accounted for half the area burned.
- The South Island regions accounted for 75% of the total area burned but only 34% of the number of fires.
- Nelson/Marlborough accounted for 12% of the total area burned but only 6% of the total number of fires.
- Eastern North Island accounted for around 8% of the total area burned but 14% of total the number of fires.
- 15% of the total area burned occurred in Northland and the Eastern North Island, and these two regions accounted for most of the North Island total area burned (60%).
- Otago in 1998/99 had just over 14,500 ha burned (83% of the total national area burned for that year) (see Figure 15). That one year of Otago returns was more than any other year's national combined total area burned.
- Otago had the highest average total area burned at 2,400ha, while Taranaki had the lowest average area burned of just 30 ha per year.
- Otago had the highest average annual grass, scrub and total area burned (Table 8).
- Nelson/Marlborough had the highest annual average forest area burned (Table 8).

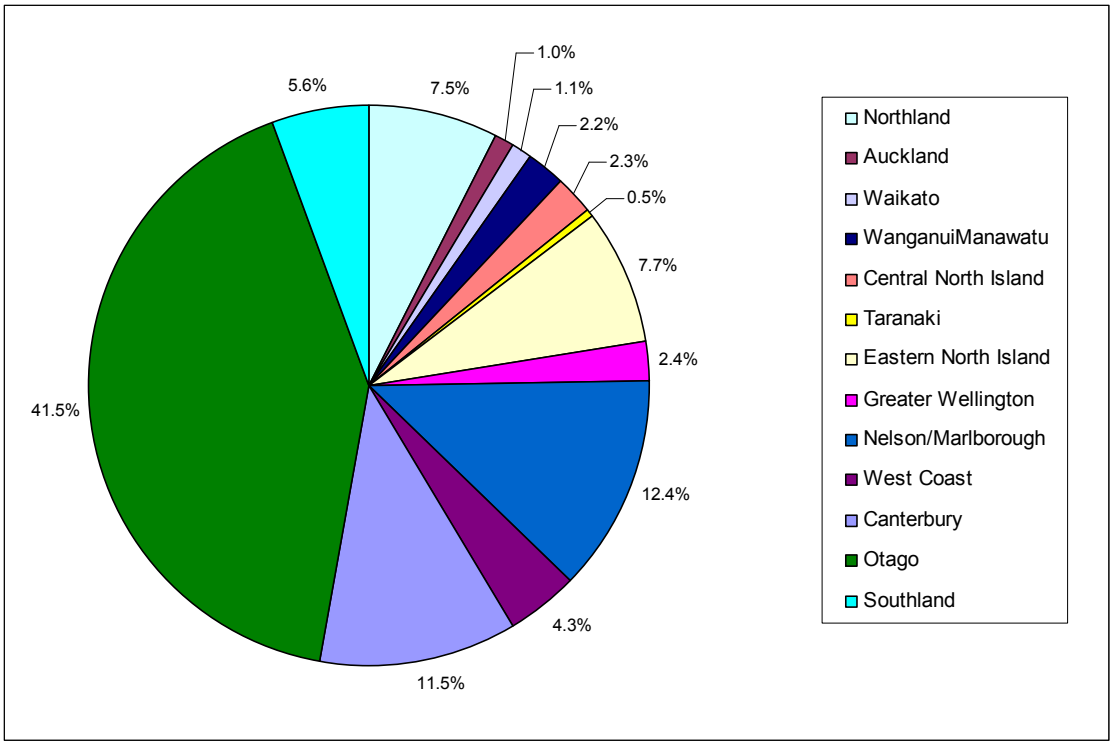

Figure 14. Proportion of the total area burned by region nationally from 1991/92 to 2006/07.

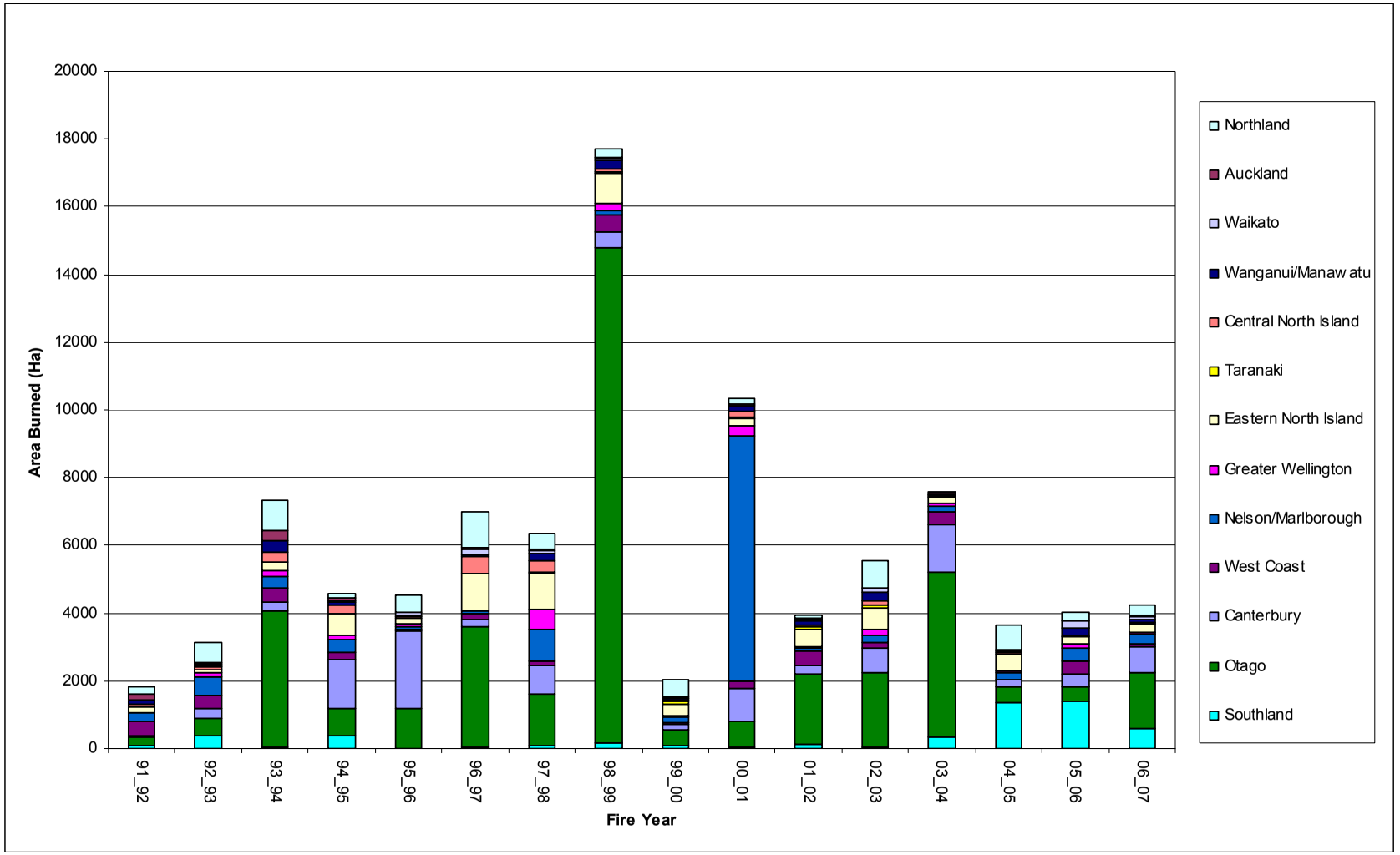

Figure 15. Total area burned for all New Zealand regions from 1991/92 to 2006/07.

Table 7. Regional breakdown of national total area burned from 1991/92 to 2006/07.

Region		Year																
		91_92	92_93	93_94	94_95	95_96	96_97	97_98	98_99	99_00	00_01	01_02	02_03	03_04	04_05	05_06	06_07	Average**
Northland	ha	204.5	595.2	902.8	161.0	492.1	1072.3	473.6	235.0	513.8	147.7	77.2	777.2	41.1	744.9	270.6	323.1	439.5
	%*	11.3	19.0	12.3	3.5	10.9	15.3	7.4	1.3	25.0	1.4	2.0	14.0	0.5	20.4	6.7	7.6	9.9
Auckland	ha	167.3	21.1	283.0	79.8	13.5	42.9	35.2	58.7	39.0	14.9	27.5	26.2	53.4	15.7	16.9	17.6	57.0
	%	9.2	0.7	3.9	1.7	0.3	0.6	0.6	0.3	1.9	0.1	0.7	0.5	0.7	0.4	0.4	0.4	1.4
Waikato	ha	15.3	54.7	22.0	26.0	101.3	149.7	92.5	29.5	29.7	20.3	40.2	112.0	13.2	31.8	177.6	111.2	64.2
	%	0.8	1.7	0.3	0.6	2.2	2.1	1.5	0.2	1.4	0.2	1.0	2.0	0.2	0.9	4.4	2.6	1.4
Wanganui/ Manawatu	ha	103.3	56.6	351.5	71.0	38.3	68.0	210.7	253.8	33.8	188.2	120.5	246.4	33.0	17.0	230.0	72.6	130.9
	%	5.7	1.8	4.8	1.5	0.8	1.0	3.3	1.4	1.6	1.8	3.1	4.5	0.4	0.5	5.7	1.7	2.5
Central North Island	ha	83.3	49.8	262.3	285.0	20.4	499.0	333.5	94.8	35.1	161.6	68.4	135.6	46.5	30.0	41.1	31.7	136.1
	%	4.6	1.6	3.6	6.2	0.4	7.1	5.2	0.5	1.7	1.6	1.7	2.5	0.6	0.8	1.0	0.7	2.5
Taranaki	ha	1.1	11.7	0.0	8.0	2.0	8.5	40.5	56.0	96.5	41.5	93.8	68.7	10.4	14.4	6.0	21.2	30.0
	%	0.1	0.4	0.0	0.2	0.0	0.1	0.6	0.3	4.7	0.4	2.4	1.2	0.1	0.4	0.1	0.5	0.7
Eastern North Island	ha	173.1	76.6	252.7	599.3	163.3	1068.7	1081.6	867.1	335.9	211.9	509.0	663.9	159.0	514.7	207.2	252.5	446.0
	%	9.5	2.5	3.4	13.0	3.6	15.3	17.0	4.9	16.3	2.1	13.0	12.0	2.1	14.1	5.1	5.9	8.7
Greater Wellington	ha	12.4	131.9	202.0	127.5	110.2	22.1	591.4	216.1	45.3	298.4	17.8	160.1	64.9	29.2	115.4	42.6	136.7
	%	0.7	4.2	2.7	2.8	2.4	0.3	9.3	1.2	2.2	2.9	0.5	2.9	0.9	0.8	2.9	1.0	2.4
Nelson/Marlborough	ha	230.3	542.0	340.4	417.0	92.7	100.7	925.1	105.0	168.9	7232.0	103.8	203.3	198.6	214.4	396.9	281.3	722.0
	%	12.7	17.3	4.6	9.1	2.0	1.4	14.5	0.6	8.2	70.2	2.6	3.7	2.6	5.9	9.8	6.6	10.8
West Coast	ha	446.0	407.8	421.4	183.0	6.0	151.6	129.0	530.0	50.0	203.0	402.0	181.0	372.0	17.0	394.0	88.0	248.9
	%	24.6	13.0	5.7	4.0	0.1	2.2	2.0	3.0	2.4	2.0	10.2	3.3	4.9	0.5	9.8	2.1	5.7
Canterbury	ha	57.4	297.8	248.9	1440.1	2320.8	196.9	836.4	452.1	170.0	962.3	269.4	728.6	1374.9	203.1	363.0	769.0	668.2
	%	3.2	9.5	3.4	31.3	51.2	2.8	13.1	2.6	8.3	9.3	6.9	13.2	18.1	5.6	9.0	18.1	12.8
Otago	ha	219.7	482.6	4012.0	824.0	1167.1	3570.5	1550.7	14636.5	432.5	797.8	2062.2	2186.5	4891.7	450.7	425.9	1639.2	2459.3
	%	12.1	15.4	54.6	17.9	25.8	51.0	24.4	82.7	21.1	7.7	52.5	39.5	64.4	12.3	10.5	38.6	33.2
Southland	ha	99.2	398.3	50.6	372.0	3.1	46.5	67.3	163.8	104.1	25.8	136.9	43.4	340.0	1371.5	1394.6	598.0	325.9
	%	5.5	12.7	0.7	4.0	0.1	0.7	1.1	0.9	5.1	0.3	3.5	0.8	4.5	37.5	34.5	14.1	8.1
Total	ha	1812.9	3125.9	7349.7	4593.7	4530.4	6997.2	6367.4	17698.3	2054.5	10329.6	3928.5	5532.9	7598.6	3654.2	4039.2	4247.8	5864.8

**Percentage values represent the actual area burned for each region expressed as a proportion of the total area burned for that year for all regions. **Overall averages were calculated by averaging values from each year and may differ from proportional totals over the study period.*

Grass area burned

Total grass area burned over the study period (1991/92 to 2006/07) was 50,403 ha (54% of the total area burned); average total grass area burned was 3,150 ha per year (Figure 13 and Table 8). Otago dominated the total grass area burned with around 28,300 ha (56%) burned from 1991/92 to 2006/07 (Figure 16). Otago also had the largest average grass area burned for all regions at 1,781 ha per year (Table 8). As with the total area burned, the South Island accounted for much of the grass area burned, about 44,300 ha (or 88% of the total grass area burned). Nelson/Marlborough (15%) and Canterbury (11%) were the other dominant South Island regions for grass fires. Eastern North Island was the only North Island region to feature prominently (5%).

Table 8. Average Annual Area Burned by Fuel Types and Region from 1991/92 to 2006/07.

	Fuel Type			
Region	Grass Area (ha)	Scrub Area (ha)	Forest Area (ha)	Total Area (ha)
Northland	53.4	339.5	46.6	439.5
Auckland	20.4	35.1	1.5	57.0
Waikato	22.5	39.3	2.4	64.2
WanganuiManawatu	48.8	70.4	11.7	130.9
Central North Island	20.8	86.2	29.1	136.1
Taranaki	5.5	16.1	8.4	30.0
Eastern North Island	171.4	198.5	76.2	446.0
Greater Wellington	27.2	90.4	20.7	136.7
Nelson/Marlborough	491.2	147.6	83.2	722.0
West Coast	32.9	205.9	10.1	248.9
Canterbury	342.6	285.6	40.0	668.2
Otago	1781.0	631.1	47.3	2459.3
Southland	132.5	184.8	8.6	325.9
All	3150.2	2330.5	385.6	5824.9

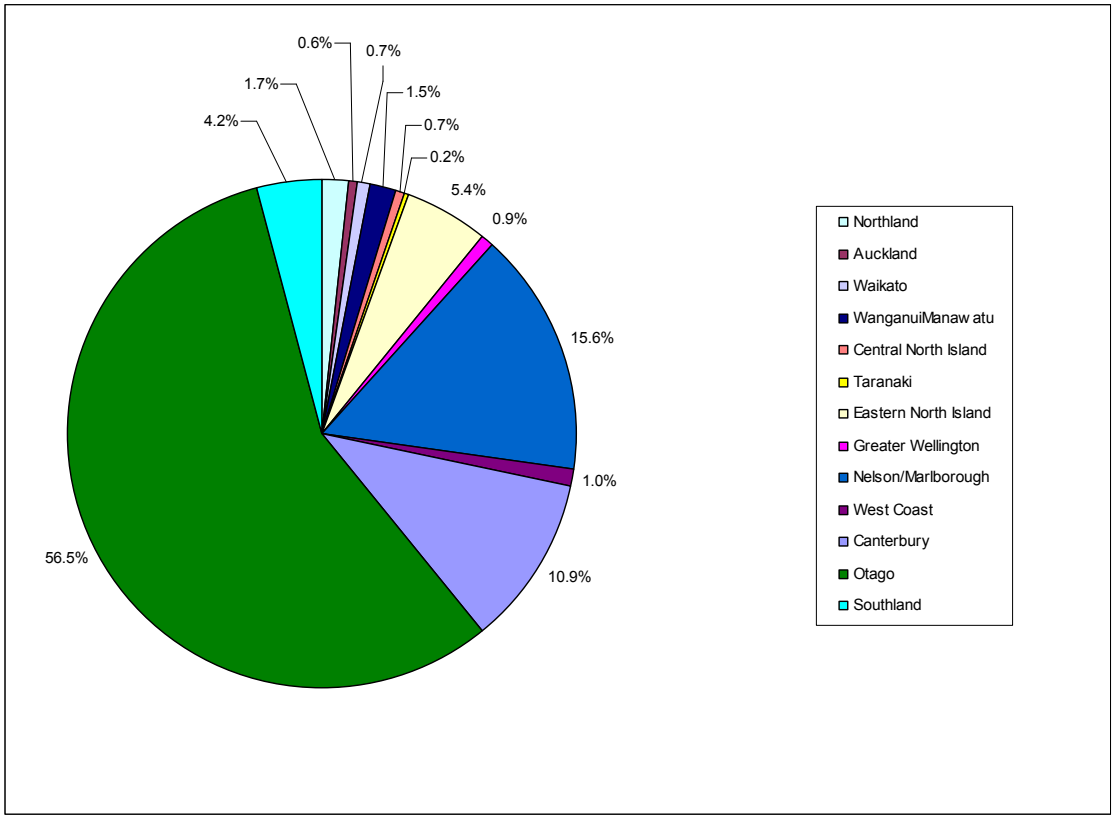

Figure 16. Proportion of total grass area burned by region from 1991/92 to 2006/07.

Due to the variability in grass area burned from year to year and between regions, no clear trends were evident (Figure 17). It is important to note that large fire years again contributed significantly to the total; for example the Blenheim fires (in Nelson/Marlborough) with over 6,500 ha of grass burned (in just two major fires) in 2000/01, and the Alexandra fires (in Otago) in 1998/99 with 9,600 ha burned (Figure 17). In comparison to the Otago and Nelson/Marlborough fires, grass fire losses in other regions were comparatively small (Figure 17, and Tables 8 and 9).

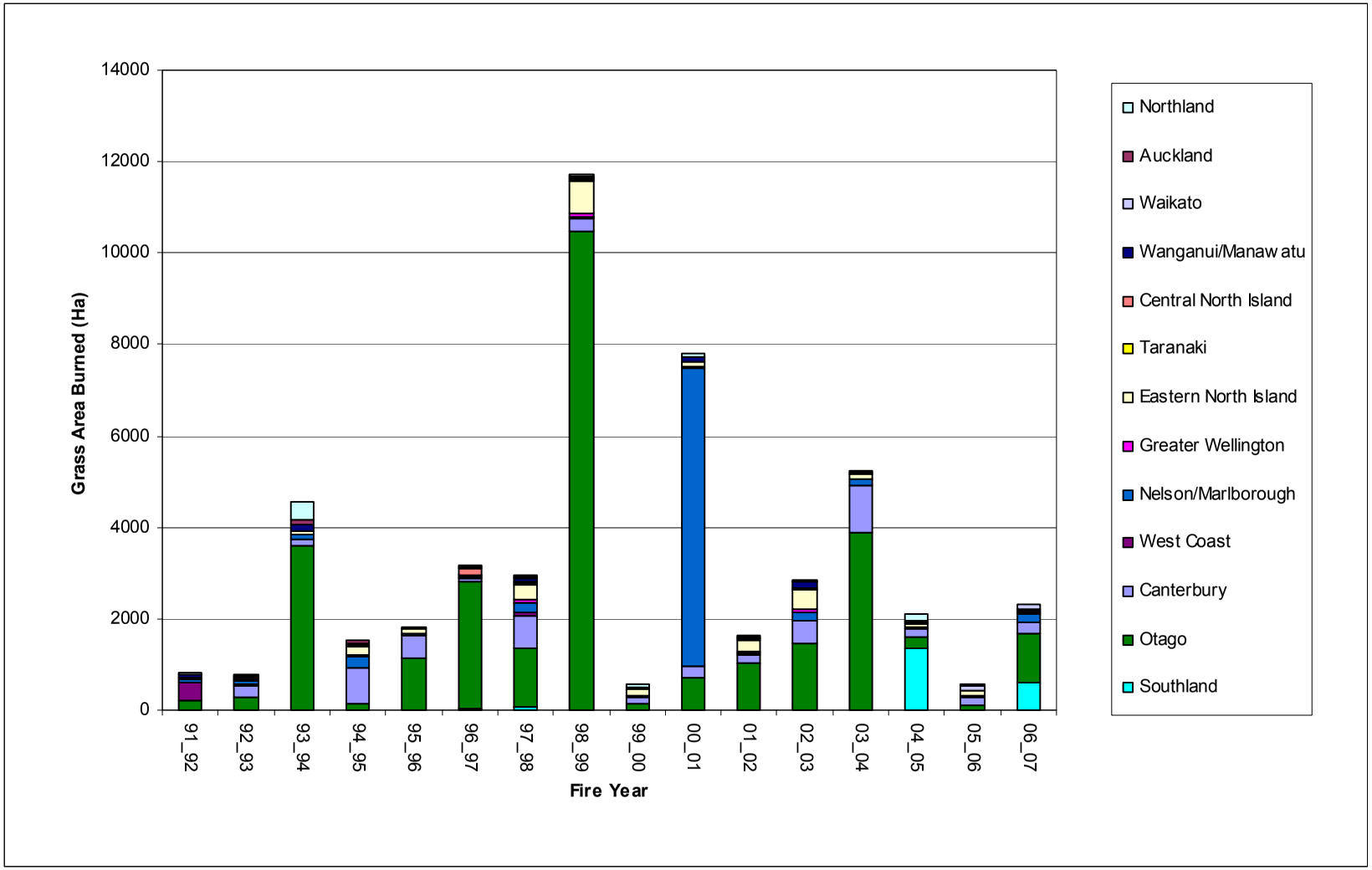

Figure 17. Total grass area burned for all New Zealand regions from 1991/92 to 2006/07.

Table 9. Annual total grass area burned by region from 1991/92 to 2006/07.

		Fire Year																
Region		91_92	92_93	93_94	94_95	95_96	96_97	97_98	98_99	99_00	00_01	01_02	02_03	03_04	04_05	05_06	06_07	Average**
Northland	ha	18.5	17.4	376.3	9.0	5.1	18.6	13.1	54.1	50.6	61.1	23.6	16.7	12.8	130.3	34.9	11.8	53.4
	%*	2.3	2.2	8.3	0.6	0.3	0.6	0.4	0.5	9.0	0.8	1.4	0.6	0.2	6.3	6.1	0.5	2.5
Auckland	ha	12.0	10.0	105.6	67.0	5.0	11.7	14.4	15.0	17.8	8.5	13.3	7.5	23.3	7.3	5.7	2.3	20.4
	%	1.5	1.3	2.3	4.4	0.3	0.4	0.5	0.1	3.2	0.1	0.8	0.3	0.4	0.4	1.0	0.1	1.1
Waikato	ha	5.4	5.2	9.5	1.0	2.3	34.9	32.7	4.4	14.3	4.8	33.6	9.3	0.7	21.2	95.0	85.4	22.5
	%	0.7	0.7	0.2	0.1	0.1	1.1	1.1	0.0	2.5	0.1	2.1	0.3	0.0	1.0	16.6	3.7	1.9
Wanganui/Manawatu	ha	53.8	23.6	137.3	39.0	12.8	29.0	75.6	37.5	5.6	87.5	33.6	150.1	22.2	6.3	13.0	2.3	48.8
	%	6.6	3.0	3.0	2.6	0.7	0.9	2.6	0.3	1.0	1.1	2.1	5.3	0.4	0.3	2.3	5.3	2.2
Central North Island	ha	4.6	11.9	7.8	33.0	11.8	116.9	27.0	23.8	8.5	14.3	8.9	23.2	10.3	16.1	8.3	7.1	20.8
	%	0.6	1.5	0.2	2.2	0.6	3.7	0.9	0.2	1.5	0.2	0.5	0.8	0.2	0.8	1.4	0.3	1.0
Taranaki	ha	0.1	1.6	0.0	0.0	0.1	5.5	29.5	14.5	5.0	2.0	2.4	1.2	4.9	5.2	1.5	15.0	5.5
	%	0.0	0.2	0.0	0.0	0.0	0.2	1.0	0.1	0.9	0.0	0.1	0.0	0.1	0.2	0.3	0.6	0.2
Eastern North Island	ha	48.3	26.5	50.5	166.8	114.0	57.6	323.1	698.5	136.9	124.3	249.5	421.0	107.3	96.8	85.0	36.7	171.4
	%	5.9	3.4	1.1	10.9	6.2	1.8	11.0	6.0	24.3	1.6	15.3	14.8	2.1	4.6	14.8	1.6	7.8
Greater Wellington	ha	7.1	36.7	12.5	37.5	5.7	4.0	72.5	83.7	19.2	26.3	1.8	84.3	4.4	8.2	25.5	5.3	27.2
	%	0.9	4.7	0.3	2.5	0.3	0.1	2.5	0.7	3.4	0.3	0.1	3.0	0.1	0.4	4.5	0.2	1.5
Nelson/Marlborough	ha	58.7	76.8	95.0	239.0	46.6	35.7	226.2	19.4	9.1	6520.2	32.6	154.0	137.1	25.5	9.6	174.3	491.2
	%	7.2	9.8	2.1	15.7	2.5	1.1	7.7	0.2	1.6	83.6	2.0	5.4	2.6	1.2	1.7	7.5	9.5
West Coast	ha	66.0	311.2	420.8	13.0	6.0	151.6	66.0	448.0	47.0	199.0	364.0	180.0	370.0	15.0	394.0	0.0	32.9
	%	7.8	14.2	16.0	0.9	0.3	4.9	3.3	7.8	3.5	4.3	16.7	8.0	16.6	1.3	12.4	0.0	3.4
Canterbury	ha	31.1	244.7	145.4	778.1	469.5	60.5	718.1	278.8	153.7	239.3	172.8	531.3	1028.5	176.0	191.3	262.3	342.6
	%	3.8	31.2	3.2	51.0	25.7	1.9	24.4	2.4	27.3	3.1	10.6	18.7	19.7	8.4	33.4	11.3	17.2
Otago	ha	196.3	280.6	3603.1	141.0	1155.2	2764.5	1291.9	10466.7	141.9	707.5	1041.0	1432.7	3872.1	231.7	100.2	1070.1	1781.0
	%	24.0	35.8	79.3	9.2	63.2	86.8	43.8	89.3	25.2	9.1	63.8	50.4	74.0	11.1	17.5	46.1	45.5
Southland	ha	4.0	12.5	0.0	0.0	0.0	45.1	63.1	11.9	1.1	3.5	5.1	10.7	5.3	1359.5	3.0	596.0	132.5
	%	0.5	1.6	0.0	0.0	0.0	1.4	2.1	0.1	0.2	0.0	0.3	0.4	0.1	65.2	0.5	25.7	6.1
Total	ha	817.8	784.6	4543.5	1524.4	1828.0	3183.8	2949.0	11725.1	563.6	7802.1	1631.1	2841.9	5230.8	2084.0	573.0	2320.7	3150.2

**Percentage values represent the actual area burned for each region expressed as a proportion of the total area burned for that year for all regions. **Overall averages were calculated by averaging values from each year and may differ from proportional totals over the study period.*

Scrub area burned

Total scrub area burned for the study period was 37,287 ha (40% of the total area burned), and the average annual area burned was 2,330 ha (Figure 13 and Table 8). In contrast to total grass area burned, Otago was less significant in terms of the total reported scrub area burned, but was still the dominant region (Figure 18), with 27% (compared to 55.3% for grass). Other significant areas were Northland with 15% of the total scrub area burned and Canterbury with 12%, the West Coast with 9% and Southland with 8%. The South Island accounted for around 60% of the total scrub area burned, with a third of the remaining 40% recorded in Northland. The Eastern North Island was the only other North Island region to feature prominently (9%).

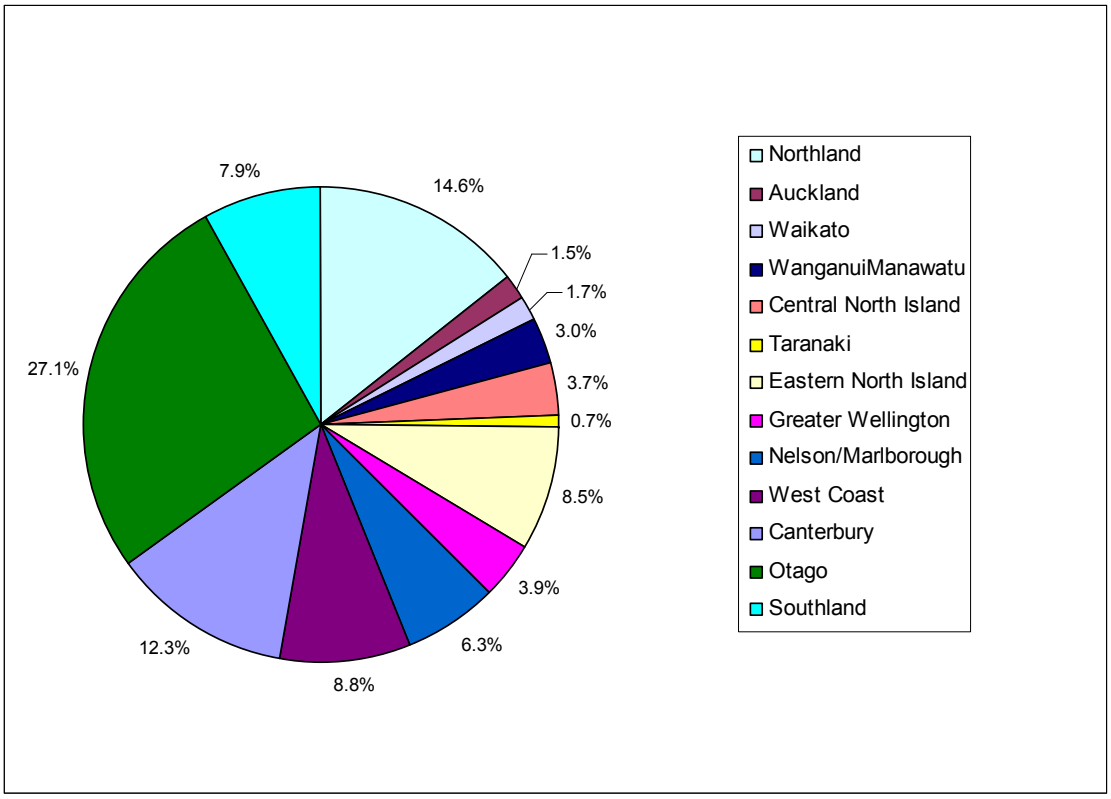

Figure 18. Proportion of total scrub area burned by region from 1991/92 to 2006/07.

With the exception of 1998/99 (again as a result of the Alexandra fires in Otago), total scrub area burned annually appeared to be more consistent (less variable) than area burned for other fuel types, especially grass. On average around 2,000-2,500 ha were burned annually, although this did range between 1,000 ha and 3,000 ha.

Other key regional findings for scrub area burned were (Figures 18 and 19, and Table 10):

- Northland had an average total scrub area burned of 339 ha across all years, with a large area of scrub burned in 1996/97 of 1032 ha (34%). Northland's greatest proportion of the national scrub area burned occurred in 2004/05, with over half (52% or 597 ha).
- Auckland's total scrub area burned has decreased over time. Comparatively larger areas of scrub were reported burned in the early 1990's (155 ha (18%) in 1991/92 and 177 ha (7%) in 1993/94). In all other years less than 50 ha were reported burned, and outside of those years the proportion of scrub burned was not more than 1.5% of the national total in any year. However, scrub area burned was higher on average than other the fuel types for the region.
- The Eastern North Island had an average total scrub area burned of around 200 ha across all years. Two fire years had much higher total scrub area burned: 1996/97 with 552 ha (18% of the annual total), and 1997/87 with over 600 ha (30%).
- Wanganui/Manawatu, Central North Island, Taranaki, Waikato and Greater Wellington had comparatively small total scrub areas burned.
- Nelson/Marlborough averaged 148 ha per year burned.
- On the West Coast the average total scrub area burned for all years was 206 ha (around 8% of the total scrub area burned for all years).
- Canterbury returned the second highest (South Island) and the third highest (national) total scrub area burned for all the years combined (accounting for 13%), with an average of 286 ha per year.
- Canterbury's total scrub area burned peaked at 1531 ha (65%) in 1995/96. No clear trend was present, although in five of the sixteen fire years studied Canterbury had a total scrub area burned in excess of 200 ha.
- Otago had the highest average total scrub area burned (631 ha). The Otago total scrub area burned of 4128 ha (72%) in 1998/99 (Alexandra fires, plus other numerous scrub fires around the region) was higher than the total area burned for all regions combined for any other year.
- For the sixteen years studied, Southland had an average total scrub area burned of 185 ha. Southland's largest total scrub area burned occurred in 2005/06 with 1,384 ha (or 44% of that year's total national scrub area burned) due to the Awarua wetland fire in Oct 2005.

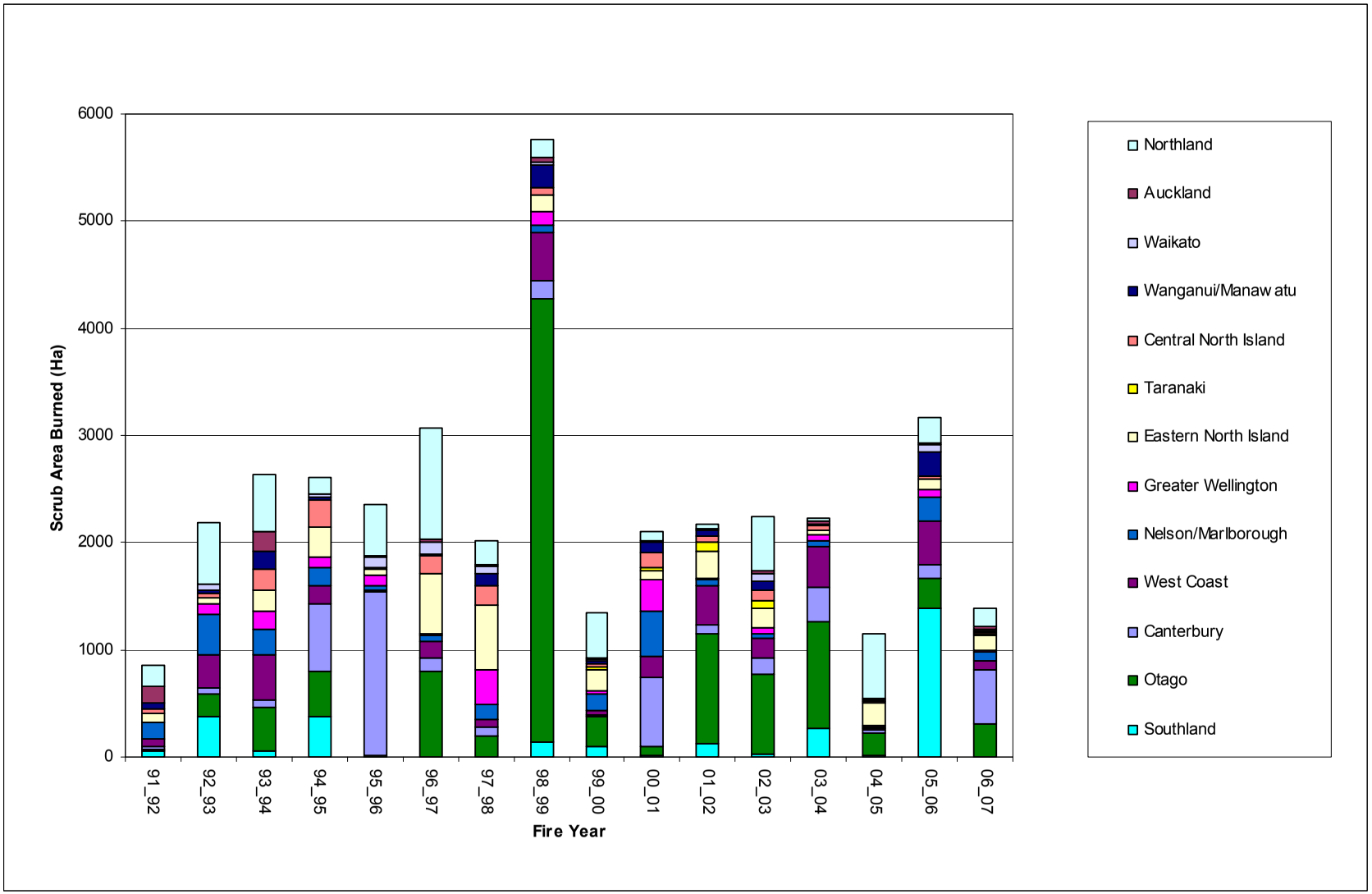

Figure 19. Total scrub area burned for all New Zealand regions from 1991/92 to 2006/07.

Table 10. Annual total scrub area burned by region from 1991/92 to 2006/07.

		Year																
Region		91_92	92_93	93_94	94_95	95_96	96_97	97_98	98_99	99_00	00_01	01_02	02_03	03_04	04_05	05_06	06_07	Average
Northland	ha	186.0	574.9	526.0	145.0	477.7	1031.7	225.5	165.6	420.7	80.6	47.5	518.6	23.2	596.5	233.2	179.4	339.5
	%	21.9	26.2	20.0	5.6	20.3	33.6	11.2	2.9	31.2	1.8	2.2	23.1	1.0	52.1	7.4	12.9	17.2
Auckland	ha	155.4	9.1	176.9	10.8	8.5	25.9	17.5	43.7	20.5	4.9	10.8	18.8	25.6	7.9	10.9	15.3	35.1
	%	18.3	0.4	6.7	0.4	0.4	0.8	0.9	0.8	1.5	0.2	0.5	0.8	1.2	0.7	0.3	1.1	2.2
Waikato	ha	9.8	49.0	12.5	25.0	99.0	114.3	59.9	25.1	14.8	12.5	6.6	70.6	12.2	10.5	81.6	25.8	39.3
	%	1.2	2.2	0.5	1.0	4.2	3.7	3.0	0.4	1.1	0.6	0.3	3.1	0.5	0.9	2.6	1.8	1.7
Wanganui/Manawatu	ha	47.5	31.5	158.3	29.0	12.0	20.1	114.7	210.8	23.1	98.7	50.5	84.6	6.3	9.6	214.9	14.1	70.4
	%	5.6	1.4	6.0	1.1	0.5	0.7	5.7	3.7	1.7	4.7	2.3	3.8	0.3	0.8	6.8	1.0	2.9
Central North Island	ha	43.4	36.6	204.2	246.0	8.5	165.6	187.4	71.0	26.4	134.3	58.2	105.9	34.5	12.9	30.4	14.4	86.2
	%	5.1	1.7	7.8	9.4	0.4	5.4	9.3	1.2	2.0	6.4	2.7	4.7	1.6	1.1	1.0	1.0	3.8
Taranaki	ha	1.0	10.0	0.0	8.0	0.5	3.0	5.0	6.0	31.5	35.5	80.3	65.5	0.5	7.2	0.7	3.1	16.1
	%	0.1	0.5	0.0	0.3	0.0	0.1	0.2	0.1	2.3	1.7	3.7	2.9	0.0	0.6	0.0	0.2	0.8
Eastern North Island	ha	81.0	49.5	187.6	281.5	49.3	552.2	600.2	154.6	198.5	84.6	253.0	176.4	50.2	204.4	105.2	147.2	198.5
	%	9.5	2.3	7.1	10.8	2.1	18.0	29.7	2.7	14.7	4.0	11.6	7.8	2.3	17.8	3.3	10.6	9.7
Greater Wellington	ha	5.3	94.2	169.5	85.0	101.5	17.1	312.4	127.5	21.2	290.5	12.0	62.7	56.3	10.8	63.4	17.3	90.4
	%	0.6	4.3	6.4	3.3	4.3	0.6	15.5	2.2	1.6	13.8	0.5	2.8	2.5	0.9	2.0	1.2	3.9
Nelson/Marlborough	ha	157.6	387.9	238.4	178.0	45.7	62.7	143.9	69.5	159.8	419.3	58.7	45.2	58.0	22.7	231.4	83.3	147.6
	%	18.5	17.7	9.1	6.8	1.9	2.0	7.1	1.2	11.8	20.0	2.7	2.0	2.6	2.0	7.3	6.0	7.4
West Coast	ha	66.0	311.2	420.8	170.0	6.0	151.6	66.0	448.0	47.0	199.0	364.0	180.0	370.0	15.0	394.0	86.0	205.9
	%	7.8	14.2	16.0	6.5	0.3	4.9	3.3	7.8	3.5	9.5	16.7	8.0	16.6	1.3	12.4	6.2	8.4
Canterbury	ha	24.0	52.7	77.8	624.0	1530.9	117.2	94.3	172.5	7.6	640.5	88.6	149.9	324.5	25.4	139.2	500.6	285.6
	%	2.8	2.4	3.0	24.0	65.0	3.8	4.7	3.0	0.6	30.5	4.1	6.7	14.6	2.2	4.4	36.0	13.0
Otago	ha	18.8	200.5	406.4	429.0	11.9	805.5	188.8	4128.8	278.4	83.2	1016.7	739.2	994.4	211.5	277.8	305.9	631.1
	%	2.2	9.1	15.5	16.5	0.5	26.3	9.3	71.6	20.6	4.0	46.7	32.9	44.7	18.5	8.8	22.0	21.8
Southland	ha	55.2	385.3	50.6	372.0	3.0	0.0	4.2	140.7	100.0	16.8	131.8	32.2	269.5	11.0	1384.0	0.0	184.8
	%	6.5	17.6	1.9	14.3	0.1	0.0	0.2	2.4	7.4	0.8	6.0	1.4	12.1	1.0	43.7	0.0	7.2
Total	ha	851.0	2192.3	2629.0	2603.3	2354.3	3066.8	2019.7	5763.8	1349.5	2100.3	2178.5	2249.5	2225.1	1145.3	3166.7	1703.7	2330.5

**Percentage values represent the actual area burned for each region expressed as a proportion of the total area burned for that year for all regions. **Overall averages were calculated by averaging values from each year and may differ from proportional totals over the study period.*

Forest area burned

The total reported forest area burned nationally from 1991/92 to 2006/07 was around 5,900 ha, or 6% of the total reported area burned (see Figure 13). The average annual total forest area burned for the study period was 370 ha.

The trends in total forest area burned at the regional level were distinct from the other two main fuel types. Regions that contributed a high relative percentage of the total grass or scrub area burned generally featured less with respect to total forest area burned (Figure 20).

Other key findings were (Figures 20, 21 and Table 11):

- Nelson/Marlborough accounted for 1330 ha or 22% of the total forest area burned for all years, with an average of 83 ha burned annually.
- The Eastern North Island was a close second with a total of 1219 ha of forest burned (20% of the total national forest area burned for all years), and averaged 76 ha burned per year.
- Canterbury had 639 ha reported burned over the study period (10%), and had an average annual total forest area burned of around 40 ha.
- Northland reported 12% of the total forest area burned around 746 ha, averaging 47 ha burned annually.
- Otago accounted for 12% (756 ha) of the total forest area burned, with an annual average of 47 ha.
- The Central North Island reported 465 ha (8%) of forest burned over the study period, averaging 29 ha burned per year.
- The largest total forest area burned was in 1997/98, due in part to large fires in Nelson/Marlborough, Northland, and Greater Wellington.

The total forest area burned figures were highly variable, and these again appeared to be influenced by large fire events or severe fire years (as was the case for grass).

Large fire events or years (of greater than 100 ha of forest) occurred in (Figure 21):

- Northland in 1997/98, 2002/03, and 2006/07,
- Central North Island in 1996/97 and 1997/98 (Welcome Bay and others),
- Eastern North Island in 1994/95, 1996/97, 1997/98 and 2004/05,
- Greater Wellington in 1997/98,
- Nelson/Marlborough in 1997/98, 2000/01 (Blenheim fires) 2004/05 and 2005/06,
- Canterbury in 1995/96,
- Otago in 1994/95, 1997/98, and 2006/07.

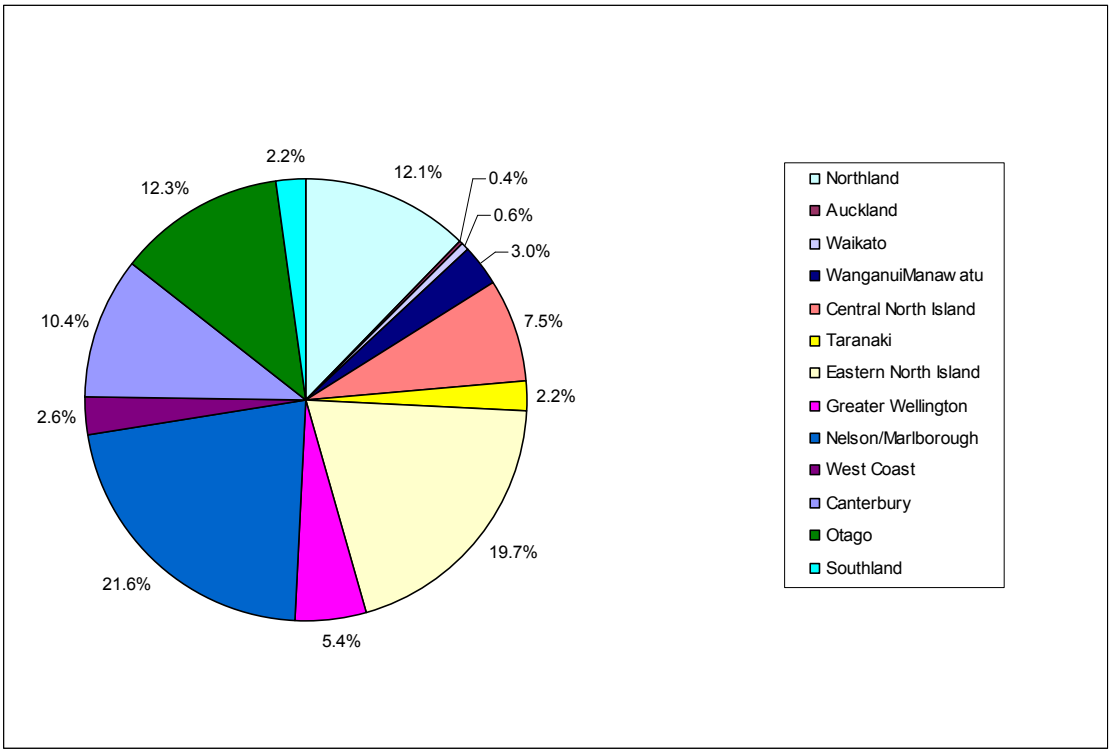

Figure 20. Proportion of total forest area burned by region from 1991/92 to 2006/07.

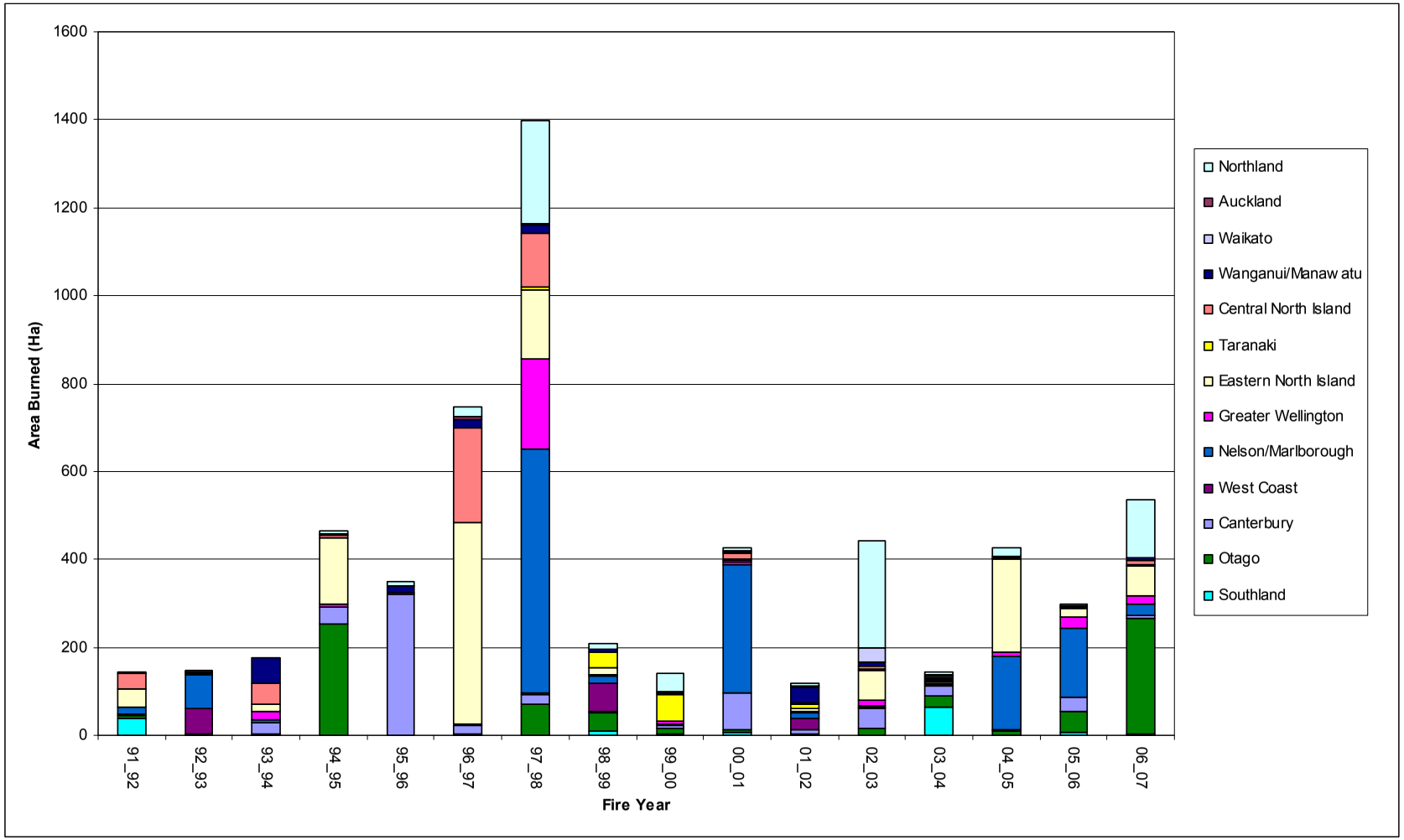

Figure 21. Total forest area burned by region from 1991/92 to 2006/07.

Table 11. Annual total forest area burned by region from 1991/92 to 2006/07.

		Year																
Region		91_92	92_93	93_94	94_95	95_96	96_97	97_98	98_99	99_00	00_01	01_02	02_03	03_04	04_05	05_06	06_07	Average**
Northland	ha*	0.0	3.0	0.5	7.0	9.3	22.0	235.0	15.3	42.5	6.0	6.1	241.9	5.1	18.0	2.5	131.9	46.6
	%	0.0	2.0	0.3	1.5	2.7	2.9	16.8	7.3	30.1	1.4	5.2	54.8	3.6	4.2	0.8	24.9	9.9
Auckland	ha	0.0	2.0	0.5	2.0	0.0	5.3	3.3	0.0	0.7	1.5	3.4	0.0	4.5	0.5	0.3	0.0	1.5
	%	0.0	1.3	0.3	0.4	0.0	0.7	0.2	0.0	0.5	0.4	2.8	0.0	3.2	0.1	0.1	0.0	0.6
Waikato	ha	0.1	0.5	0.0	0.0	0.0	0.5	0.0	0.0	0.6	3.1	0.0	32.1	0.4	0.1	1.0	0.0	2.4
	%	0.1	0.3	0.0	0.0	0.0	0.1	0.0	0.0	0.4	0.7	0.0	7.3	0.3	0.0	0.3	0.0	0.6
Wanganui/Manawatu	ha	2.0	1.5	56.0	3.0	13.5	19.0	20.5	5.5	5.1	2.0	36.4	11.8	4.5	1.0	2.0	4.0	11.7
	%	1.4	1.0	31.6	0.6	3.9	2.5	1.5	2.6	3.6	0.5	30.6	2.7	3.2	0.2	0.7	0.7	5.5
Central North Island	ha	35.4	1.2	50.3	6.0	0.1	216.6	119.1	0.0	0.2	13.0	1.3	6.5	1.6	1.0	2.4	10.2	29.1
	%	24.6	0.8	28.4	1.3	0.0	29.0	8.5	0.0	0.1	3.0	1.1	1.5	1.1	0.2	0.8	1.9	6.4
Taranaki	ha	0.0	0.1	0.0	0.0	1.4	0.0	6.0	35.5	60.0	4.0	11.1	2.0	5.0	2.0	3.8	3.1	8.4
	%	0.0	0.0	0.0	0.0	0.4	0.0	0.4	17.0	42.4	0.9	9.3	0.5	3.5	0.5	1.3	0.6	4.8
Eastern North Island	ha	43.8	0.6	14.7	151.0	0.0	458.9	158.3	14.0	0.5	3.0	6.5	66.5	1.5	213.5	17.0	68.7	76.2
	%	30.4	0.4	8.3	32.4	0.0	61.5	11.3	6.7	0.4	0.7	5.5	15.1	1.1	50.3	5.7	12.8	15.1
Greater Wellington	ha	0.0	1.0	20.0	5.0	3.0	1.0	206.5	5.0	4.9	6.1	4.0	13.0	4.2	10.3	26.5	20.0	20.7
	%	0.0	0.7	11.3	1.1	0.9	0.1	14.8	2.4	3.5	1.4	3.4	2.9	2.9	2.4	8.9	3.7	3.8
Nelson/Marlborough	ha	14.0	77.3	7.0	0.0	0.4	2.3	555.0	16.1	0.0	292.4	12.6	4.2	3.5	166.2	156.0	23.7	83.2
	%	9.7	51.9	4.0	0.0	0.1	0.3	39.7	7.7	0.0	68.4	10.6	0.9	2.5	39.1	52.1	4.4	18.2
West Coast	ha	2.0	59.5	0.0	0.0	0.0	0.0	1.0	65.0	3.0	1.0	25.0	1.0	0.0	2.0	0.0	2.0	10.1
	%	1.4	39.9	0.0	0.0	0.0	0.0	0.1	31.0	2.1	0.2	21.0	0.2	0.0	0.5	0.0	0.4	6.1
Canterbury	ha	2.2	0.3	25.7	38.0	320.3	19.1	24.0	0.8	8.7	82.5	8.0	47.4	22.0	1.8	32.4	6.1	40.0
	%	1.5	0.2	14.5	8.2	92.0	2.6	1.7	0.4	6.2	19.3	6.7	10.7	15.4	0.4	10.8	1.1	12.0
Otago	ha	4.6	1.5	2.5	254.0	0.0	0.5	70.0	41.0	12.2	7.1	4.5	14.6	25.1	7.5	47.9	263.1	47.3
	%	3.2	1.0	1.4	54.5	0.0	0.1	5.0	19.6	8.6	1.7	3.8	3.3	17.6	1.8	16.0	49.2	11.7
Southland	ha	40.0	0.5	0.0	0.0	0.1	1.4	0.0	11.2	3.0	5.5	0.0	0.5	65.2	1.0	7.6	2.0	8.6
	%	27.8	0.3	0.0	0.0	0.0	0.2	0.0	5.3	2.1	1.3	0.0	0.1	45.7	0.2	2.5	0.4	5.4
Total	ha	144.1	149.0	177.2	466.0	348.2	746.6	1398.7	209.4	141.4	427.2	118.9	441.6	142.7	424.9	299.4	528.7	385.6

Percentage values represent the actual area burned for each region expressed as a proportion of the total area burned for that year for all regions. Overall averages were calculated by averaging values from each year and may differ from proportional totals over the study period.*

Area burned by cause

When the national area burned figures were broken down into fire cause classes, key results were (Figures 22, 23 and Table 12):

- Land clearing was the dominant cause of wildfires, at around 47% (or 44,070 ha) of the total across all years.
- Land clearing also represented the highest annual average area burned at 2,754 ha annually (50% of the total annual average).
- The area burned from fires of unknown cause represented a quarter (24%) of the total area burned nationally for all years (22,621 ha), and the annual average was 1,414 ha.
- 1998/99 and 2000/01 were significant years for area burned by unknown causes (Figure 23), with nearly 7,000 ha in 1998/99 (Fruitlands fires near Alexandra) and around 6,700 ha in 2000/01 (Wither Hills fire near Blenheim).
- Miscellaneous causes represented 6,885 ha or 7% of the total.
- Unknown and miscellaneous causes combined represented 31.4% of the total area burned.
- Total area burned caused by incendiary fires made up 6%, and vehicles made up 5% for 1991/92 to 2006/07.
- No clear directional trends were found at the national level for causes in relation to total area burned.
- The significant increase in the number of vegetation fires attributed to structure fires shown in Table 5 was not reflected for area burned (Table 12); vegetation fires from structures may not have resulted in significant areas burned, or were under-reported with regards to area burned.
- Arson accounted for relatively little total area burned nationally in any year, and while an increase in the number of incendiary fires was readily apparent (Table 5), no such corresponding increase was found in the area burned by incendiary-caused fires (Table 12).

These results contrasted in many cases with the data on total number of fires by cause (Figure 9). Nearly half of all fire numbers were classed as unknown or miscellaneous, whereas one third of the total area burned was accounted for by the same causes. It also appeared that 20% of all fires from land clearing accounted for 48% of all area burned. Escaped land clearing fires are more likely to result in large areas burned and to require rural fire suppression and therefore are more likely to have their area burned recorded. Land clearing fires also often result from known permitted burns where the cause is obvious. Incendiary causes accounted for 6% of the number of fires (Figure 9) and 6% of the area burned over the period (Figure 22); while vehicles made up 17% (Figure 9) of the number of fires, they only accounted for 6% of the area burned (Figure 22).

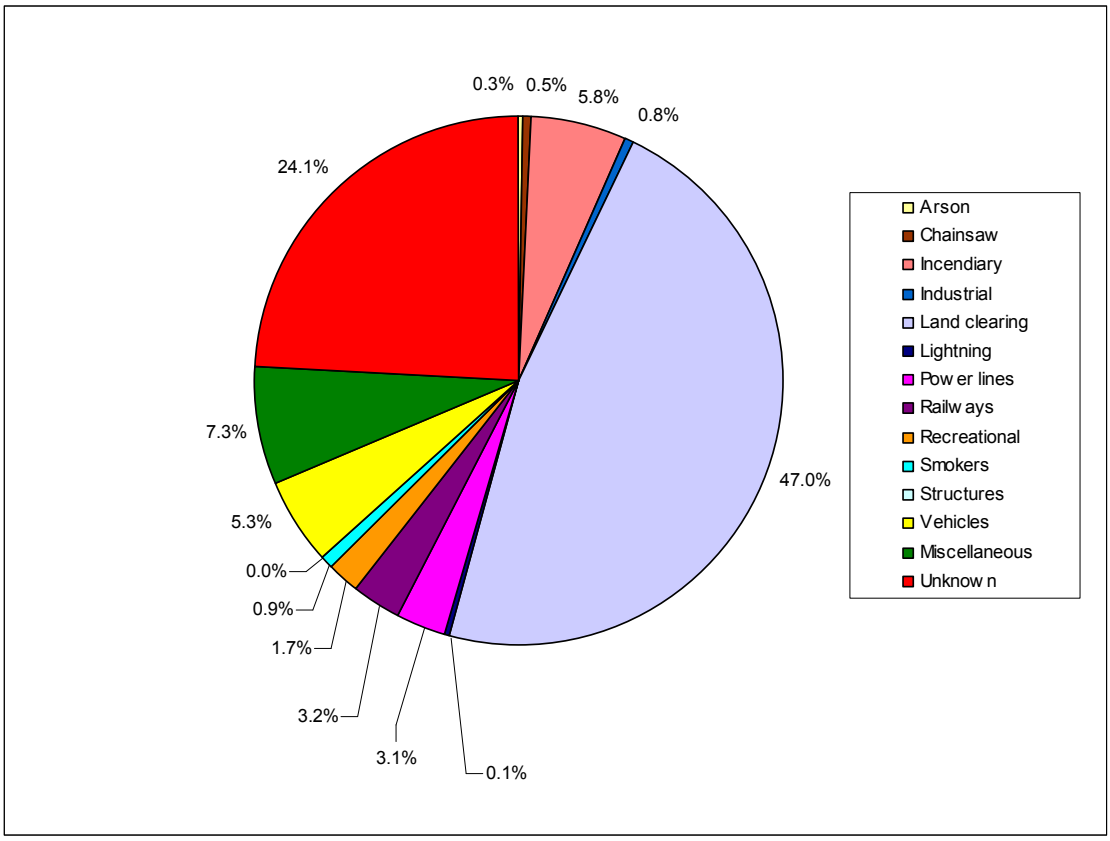

Figure 22. Proportion of total area burned by cause nationally from 1991/92 to 2006/07.

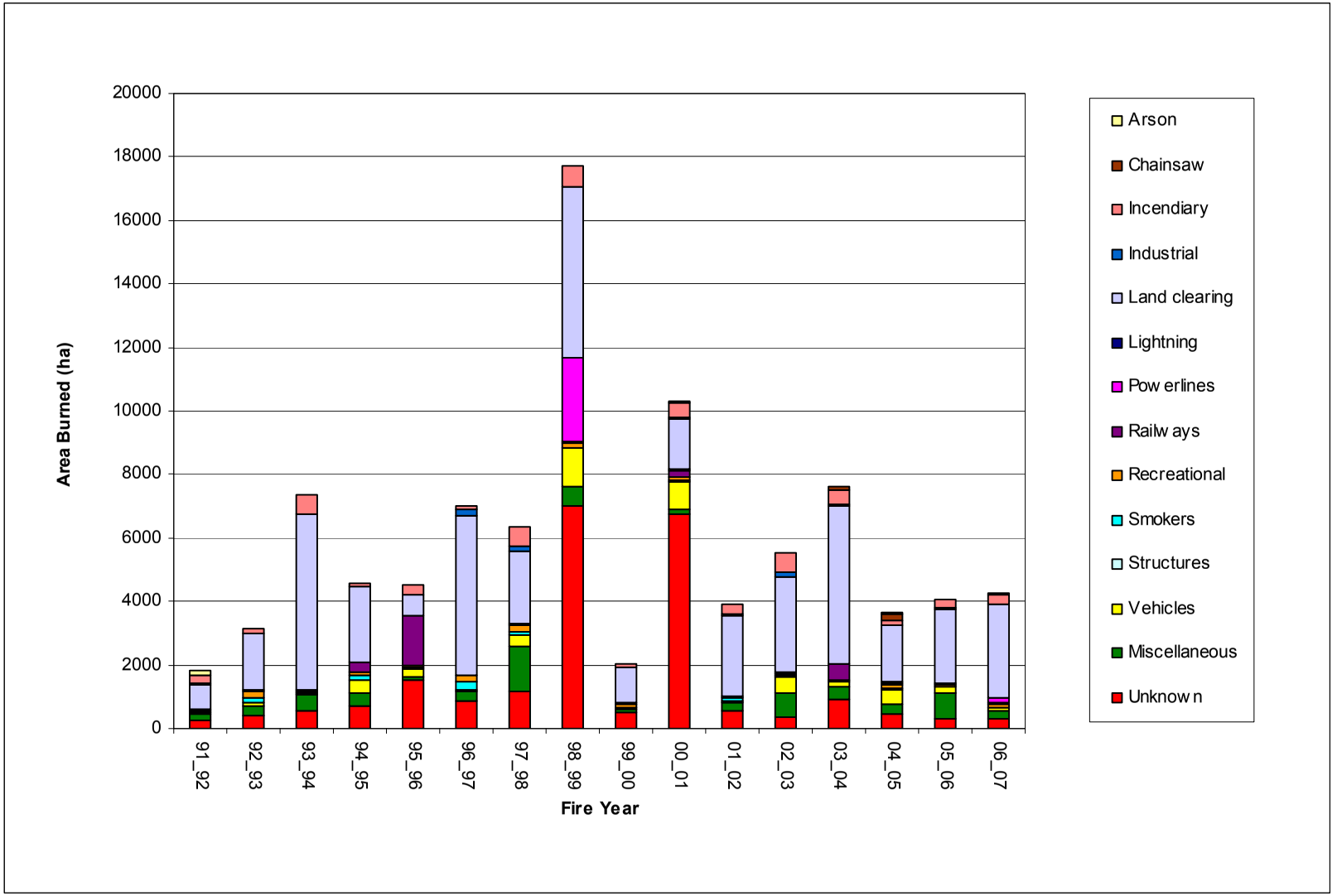

Figure 23. Total area burned by cause nationally from 1991/92 to 2006/07.

Table 12. Annual total area burned nationally by causes from 1991/92 to 2006/07.

		Fire Year																
Cause		91_92	92_93	93_94	94_95	95_96	96_97	97_98	98_99	99_00	00_01	01_02	02_03	03_04	04_05	05_06	06_07	Average
Arson	ha	135.5	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.5	0.0	6.3	9.0	3.5	46.0	2.1	46.1	15.7
	%*	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	1.3	0.1	1.1	0.6
Chainsaw	ha	10.0	0.0	3.6	2.0	10.2	12.0	1.0	0.0	0.0	99.3	0.8	0.7	84.2	204.0	0.0	2.3	26.9
	%	0.6	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	1.0	0.0	0.0	1.1	5.6	0.0	0.1	0.5
Incendiary	ha	270.1	152.4	588.1	106.9	318.2	87.0	619.5	638.0	148.3	453.2	320.5	619.2	465.3	160.7	234.1	270.4	340.7
	%	14.9	4.9	8.0	2.3	7.0	1.2	9.7	3.6	7.2	4.4	8.2	11.2	6.1	4.4	5.8	6.4	6.6
Industrial	ha	43.5	3.0	10.5	4.0	4.7	204.1	163.9	16.9	0.1	17.7	33.6	141.4	30.3	4.1	28.4	6.7	44.6
	%	2.4	0.1	0.1	0.1	0.1	2.9	2.6	0.1	0.0	0.2	0.9	2.6	0.4	0.1	0.7	0.2	0.8
Land clearing	ha	757.1	1769.6	5529.5	2421.6	645.8	5005.0	2286.3	5374.1	1103.7	1584.7	2542.7	2995.5	4966.5	1770.0	2335.1	2983.2	2754.4
	%	41.8	56.6	75.2	52.7	14.3	71.5	35.9	30.4	53.7	15.3	64.7	54.1	65.4	48.5	57.8	70.2	50.5
Lightning	ha	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	16.2	0.5	0.0	4.8	65.9	0.4	0.1	5.7
	%	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.1	1.8	0.0	0.0	0.1
Power lines	ha	20.8	0.0	0.0	0.0	0.0	0.0	0.0	2631.1	5.0	49.4	1.0	43.3	35.0	7.3	5.0	136.5	183.4
	%	1.1	0.0	0.0	0.0	0.0	0.0	0.0	14.9	0.2	0.5	0.0	0.8	0.5	0.2	0.1	3.2	1.3
Railways	ha	12.5	8.4	43.6	302.0	1594.8	36.8	59.1	56.7	57.1	166.9	15.7	42.5	475.5	20.0	87.7	28.6	188.0
	%	0.7	0.3	0.6	6.6	35.2	0.5	0.9	0.3	2.8	1.6	0.4	0.8	6.3	0.5	2.2	0.7	3.8
Recreational	ha	47.8	238.2	40.5	103.8	33.7	181.3	186.1	127.7	72.1	141.2	67.9	53.5	57.7	116.9	28.6	95.3	99.5
	%	2.6	7.6	0.6	2.3	0.7	2.6	2.9	0.7	3.5	1.4	1.7	1.0	0.8	3.2	0.7	2.2	2.2
Smokers	ha	6.3	137.1	11.1	120.3	26.0	276.5	83.9	8.9	23.5	18.3	62.6	12.3	6.6	4.5	12.4	2.5	50.8
	%	0.3	4.4	0.2	2.6	0.6	4.0	1.3	0.1	1.1	0.2	1.6	0.2	0.1	0.1	0.3	0.1	1.1
Structures	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.5	25.0	0.0	0.0	1.6
	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0
Vehicles	ha	49.2	116.7	46.1	428.0	249.0	45.3	398.8	1248.7	55.7	876.6	70.4	480.4	147.2	453.5	181.3	123.8	310.7
	%	2.7	3.7	0.6	9.3	5.5	0.6	6.3	7.1	2.7	8.5	1.8	8.7	1.9	12.4	4.5	2.9	5.0
Miscellaneous	ha	213.1	273.3	532.6	396.7	104.4	291.6	1410.1	610.5	76.5	157.3	232.3	801.6	385.4	325.9	815.6	258.5	430.3
	%	11.8	8.7	7.2	8.6	2.3	4.2	22.1	3.4	3.7	1.5	5.9	14.5	5.1	8.9	20.2	6.1	8.4
Unknown	ha	245.6	427.3	544.1	708.5	1543.6	857.5	1158.7	6982.9	509.8	6748.7	574.4	333.7	936.0	449.1	308.6	293.3	1413.9
	%	13.5	13.7	7.4	15.4	34.1	12.3	18.2	39.5	24.8	65.3	14.6	6.0	12.3	12.3	7.6	6.9	19.0
Total	ha	1812.9	3125.9	7349.7	4593.7	4530.4	6997.2	6367.4	17698.3	2054.5	10329.6	3928.5	5532.9	7598.6	3652.7	4039.2	4247.3	5866.2

**Percentage values represent the actual area burned for each cause expressed as a proportion of the total area burned for that year for all causes. **Overall averages were calculated by averaging values from each year and may differ from proportional totals over the study period.*

Grass area burned by cause

Due to the dominance of the grassland fuels in the total area burned statistics (54%), the results for national grass area burned by cause (Figure 24) mirrored those for all fuel types combined. The national total grass area burned from 1991/92 to 2006/07 was 50,402 ha.

Key findings (Figure 24, 25 and Table 13) were:

- Over 26,700 ha (53%) of the total grass area burned was due to land clearing fires; and the average annual total grass area burned from land clearing was 1,670 ha (60%).
- Over 14,000 ha (28%) of total grass area burned was due to unknown causes, with the average annual total at 885 ha (19%).
- Over 1,700 ha (3.5%) of total grass area burned was assigned to miscellaneous causes, and the annual average was around 100 ha.
- Unknown and miscellaneous causes combined made up 32% of the total grass area burned, and on average 24% annually.
- Just under 2,600 ha (5%) of total grass area burned was reported from vehicle fires; average per year was 160 ha.
- Power lines (4%), railways (2%), and incendiary (2%) were the only other significant causes of fires in grassland fuels.
- Interestingly, smokers were not identified as a major cause of grass fires despite concerns of discarded cigarettes starting fires along roadsides.
- For most years the total annual grass area burned ranged between 1,000 ha and 3,000 ha; larger areas were burned in 1993/94, 1998/99, 2000/01 and 2003/04 (Figure 25).
- The predominance of land clearing was obvious (Figure 25), however power lines (in 1998/99, Springvale near Alexandra) and unknown (in 1998/99 Fruitlands, Alexandra and 2000/01 Wither Hills, Blenheim) causes were also important cause classes due to the contribution of individual fire events.

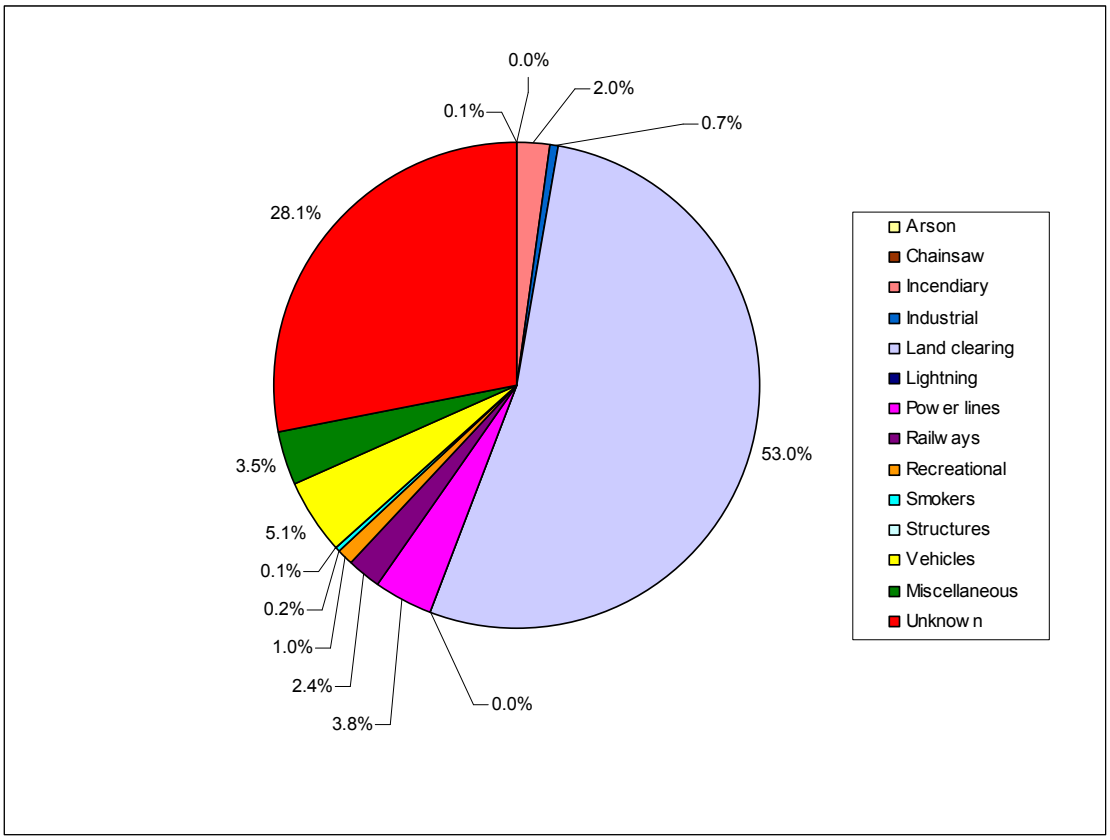

Figure 24. Proportion of total grass area burned by fire cause from 1991/92 to 2006/07.

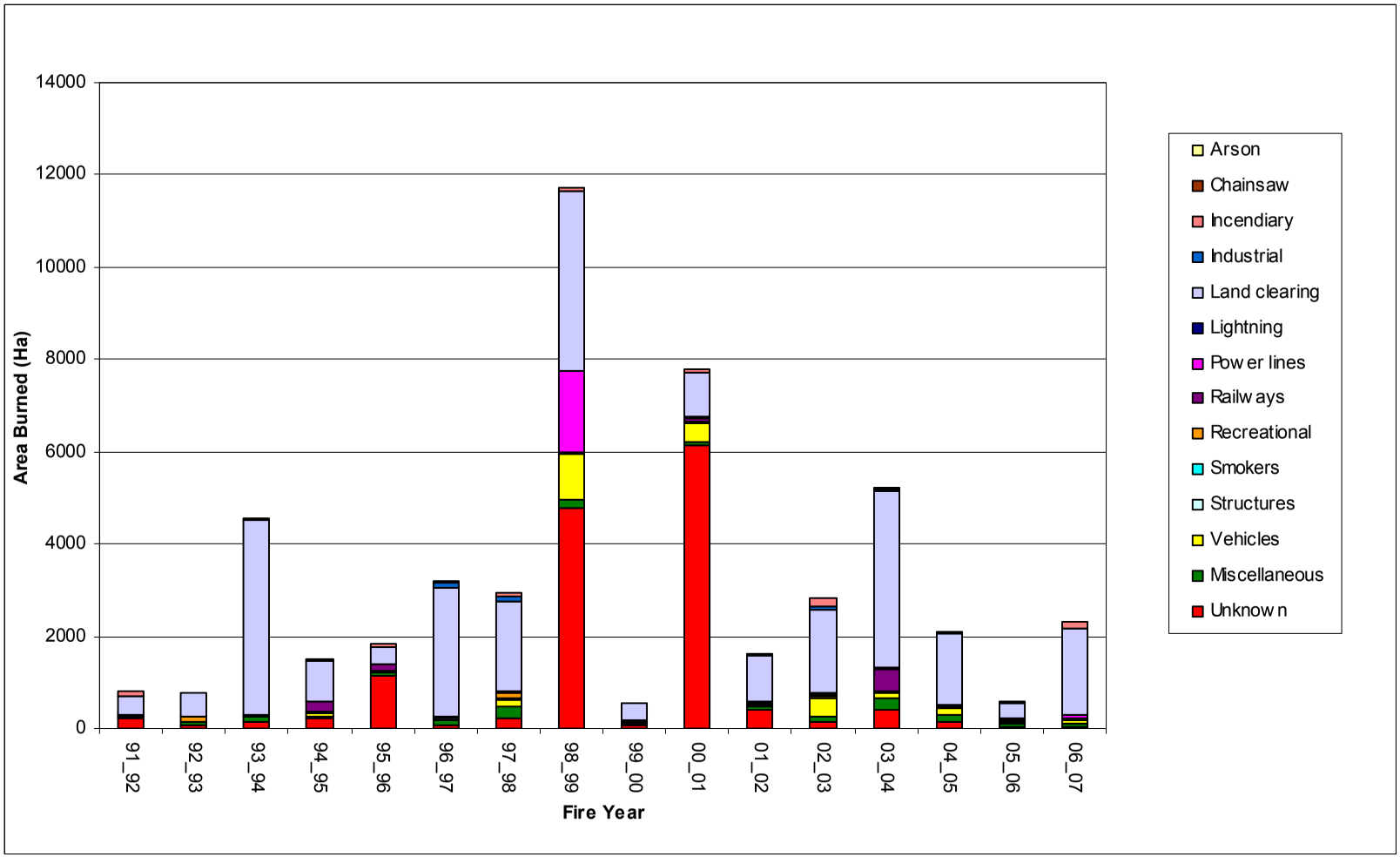

Figure 25. Total grass area burned nationally by fire cause classes from 1991/92 to 2006/07.

Table 13. Annual grass area burned by fire cause from 1991/92 to 2006/07.

		Fire Year																
Cause		91_92	92_93	93_94	94_95	95_96	96_97	97_98	98_99	99_00	00_01	01_02	02_03	03_04	04_05	05_06	06_07	Average**
Arson	ha	21.2	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.1	1.1	1.0	12.0	0.0	2.1	2.4
	%*	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.1	0.2
Chainsaw	ha	0.0	0.0	0.5	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.5	0.0	0.0	0.1	1.0
	%	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
Incendiary	ha	82.7	6.0	18.1	46.1	49.0	37.5	74.9	62.3	16.8	83.5	49.8	212.0	50.0	26.5	33.3	149.6	62.4
	%	10.1	0.8	0.4	3.0	2.7	1.2	2.5	0.5	3.0	1.1	3.1	7.5	1.0	1.3	5.8	6.4	3.1
Industrial	ha	3.0	0.0	2.5	0.0	2.5	100.5	131.9	10.4	0.0	8.7	0.1	65.6	10.2	3.1	4.6	1.7	21.5
	%	0.4	0.0	0.1	0.0	0.1	3.2	4.5	0.1	0.0	0.1	0.0	2.3	0.2	0.1	0.8	0.1	0.7
Land clearing	ha	405.4	526.2	4221.1	887.0	382.4	2793.8	1933.4	3890.8	353.8	960.4	1008.5	1804.8	3842.4	1526.3	309.6	1877.2	1670.2
	%	49.6	67.1	92.9	58.2	20.9	87.8	65.6	33.2	62.8	12.3	61.8	63.5	73.5	73.3	54.0	80.9	59.8
Lightning	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.0	0.0	0.0	0.0	0.0	0.4	0.1	0.1
	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Power lines	ha	4.3	0.0	0.0	0.0	0.0	0.0	0.0	1760.5	0.5	15.2	1.0	40.3	30.0	2.3	1.0	55.5	119.4
	%	0.5	0.0	0.0	0.0	0.0	0.0	0.0	15.0	0.1	0.2	0.1	1.4	0.6	0.1	0.2	2.4	1.3
Railways	ha	9.5	8.3	7.2	227.0	156.8	33.8	41.1	39.1	20.0	64.6	9.2	33.3	468.4	13.3	49.6	26.3	75.5
	%	1.2	1.1	0.2	14.9	8.6	1.1	1.4	0.3	3.6	0.8	0.6	1.2	9.0	0.6	8.7	1.1	3.4
Recreational	ha	15.2	98.5	3.1	48.8	26.3	15.3	111.8	15.6	9.4	36.0	7.0	20.3	31.7	15.7	22.2	29.9	31.7
	%	1.9	12.6	0.1	3.2	1.4	0.5	3.8	0.1	1.7	0.5	0.4	0.7	0.6	0.8	3.9	1.3	2.1
Smokers	ha	0.2	2.6	4.7	3.0	0.6	1.7	36.6	5.4	0.8	10.2	34.8	4.5	1.6	1.0	7.3	0.7	7.2
	%	0.0	0.3	0.1	0.2	0.0	0.1	1.2	0.0	0.1	0.1	2.1	0.2	0.0	0.0	1.3	0.0	0.4
Structures	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	25.0	0.0	0.0	1.6
	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.1
Vehicles	ha	29.2	8.0	28.0	50.0	9.1	35.4	143.3	979.0	43.0	418.3	49.8	388.8	118.2	154.7	42.1	71.3	160.5
	%	3.6	1.0	0.6	3.3	0.5	1.1	4.9	8.3	7.6	5.4	3.1	13.7	2.3	7.4	7.3	3.1	4.6
Miscellaneous	ha	35.3	65.1	125.2	57.6	62.4	96.1	238.2	172.2	45.1	74.3	74.8	133.9	279.2	165.7	83.2	76.9	111.6
	%	4.3	8.3	2.8	3.8	3.4	3.0	8.1	1.5	8.0	1.0	4.6	4.7	5.3	8.0	14.5	3.3	5.3
Unknown	ha	211.9	70.0	133.0	205.0	1133.9	69.6	237.9	4788.9	73.1	6129.9	396.1	137.2	387.6	137.0	19.8	29.2	885.0
	%	25.9	8.9	2.9	13.4	62.0	2.2	8.1	40.8	13.0	78.6	24.3	4.8	7.4	6.6	3.5	1.3	19.0
Total	ha	817.8	784.6	4543.5	1524.4	1828.0	3183.8	2949.0	11725.1	563.6	7802.1	1631.1	2841.9	5230.8	2082.5	573.0	2320.5	3150.1

**Percentage values represent the actual area burned for each cause expressed as a proportion of the total area burned for that year for all causes. **Overall averages were calculated by averaging values from each year and may differ from proportional totals over the study period.*

Scrub area burned by cause

As in the case of the grass area burned, land clearing accounted for the greatest proportion (42%) the total scrub area burned (Figure 26). Of all the fuel types, scrub area burned generally showed the least variation over time. With the exception of 1998/99, the total scrub area burned reported nationally ranged from just under 1,000 ha per year to just over 3,000 ha per year. In 1998/99, more than twice the highest previous scrub area burned from miscellaneous causes was recorded, mostly from fires in Otago (Figure 27). Nine of the sixteen years had total scrub area burned between 2,000 and 3,000 ha (Figure 27 and Table 14).

Key findings of causes of national total scrub area burned from 1991/92 to 2006/07 were (Figures 26, 27 and Table 14):

- Land clearing accounted for 14,953 ha (around 42%) of total scrub area burned, and an average annual area burned of 988 ha (43% on average annually).
- Scrub area burned from unknown causes represented 7,340 ha (around 21%), with an annual average of 446 ha (18%).
- Miscellaneous causes represented 3,533 ha (around 10%), and annual average of 231 ha (11%).
- Combined miscellaneous and unknown accounted for on average around 30% of all scrub fires.
- Vehicles, railways and incendiary were (again) other significant causes of scrub fires.
- Total scrub area burned from incendiary fires was 3,555 ha (around 10% of the total scrub area burned), and the annual average total scrub area burned from incendiary was 227 ha (annual average was 11%).
- Power lines and recreational (both 3%) were also important causes in scrub fires.

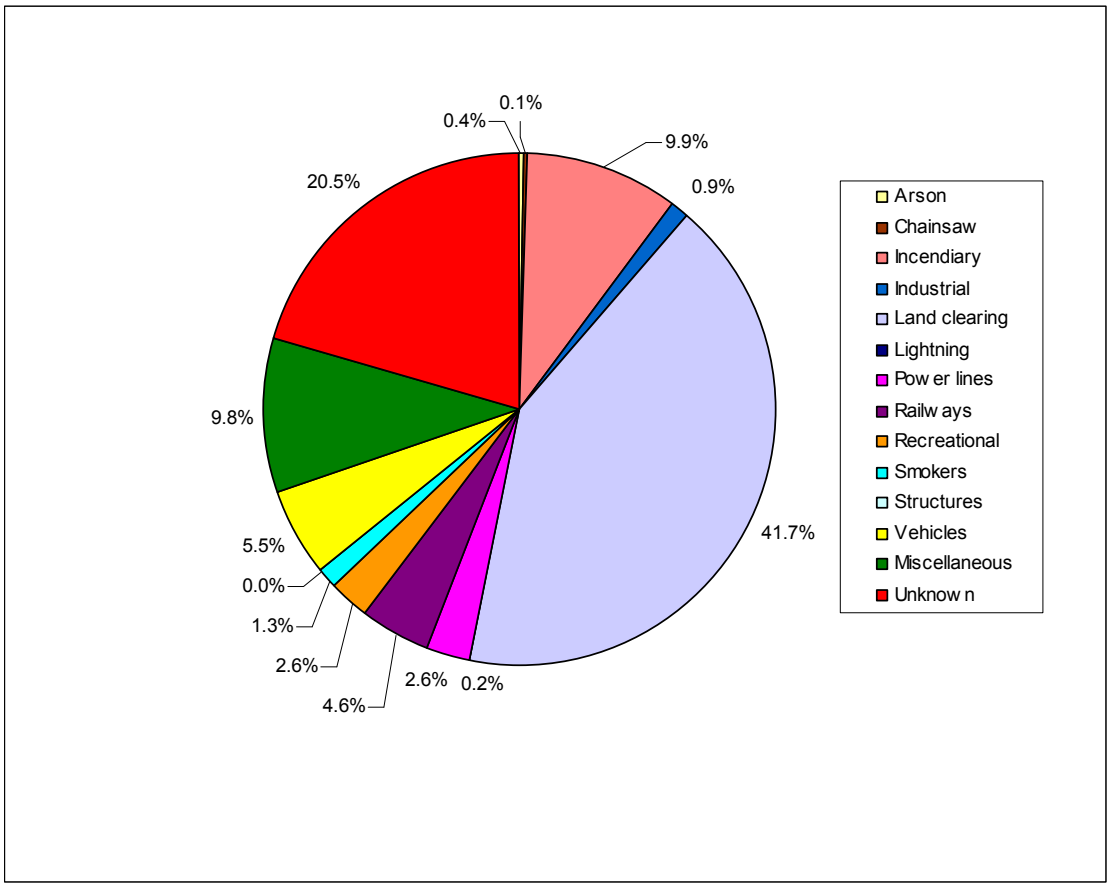

Figure 26. Proportion of total scrub area burned nationally by cause from 1991/92 to 2006/07.

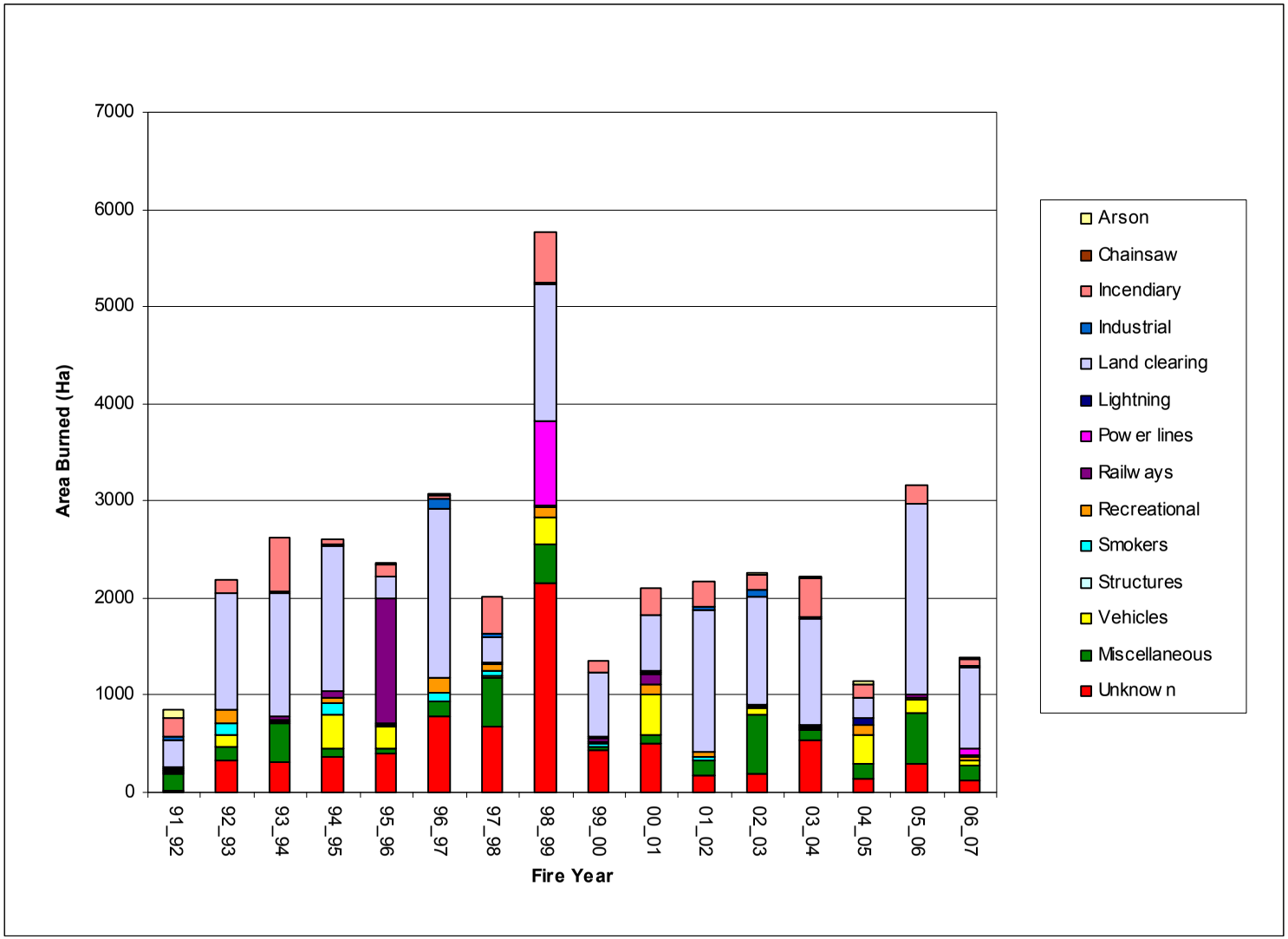

Figure 27. Total scrub area burned nationally by cause from 1991/92 to 2006/07.

Table 14. Annual scrub area burned nationally by cause from 1991/92 to 2006/07.

		Fire Year																
Cause		91_92	92_93	93_94	94_95	95_96	96_97	97_98	98_99	99_00	00_01	01_02	02_03	03_04	04_05	05_06	06_07	Average**
Arson	ha	85.3	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.5	0.0	5.6	7.0	2.5	34.0	0.0	18.0	9.7
	%*	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.1	3.0	0.0	1.3	0.9
Chainsaw	ha	10.0	0.0	0.9	0.0	5.2	2.0	1.0	0.0	0.0	0.3	0.5	0.0	18.0	0.0	0.0	0.0	2.4
	%	1.2	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.1
Incendiary	ha	186.4	143.4	566.5	58.6	120.1	38.9	387.6	519.9	123.0	268.1	268.1	156.5	391.8	133.5	193.1	73.3	226.8
	%	21.9	6.5	21.5	2.2	5.1	1.3	19.2	9.0	9.1	12.8	12.3	7.0	17.6	11.7	6.1	5.3	10.5
Industrial	ha	36.2	1.5	8.0	4.0	2.0	102.0	31.9	6.0	0.0	8.0	23.4	75.1	17.7	0.3	4.1	5.0	20.3
	%	4.3	0.1	0.3	0.2	0.1	3.3	1.6	0.1	0.0	0.4	1.1	3.3	0.8	0.0	0.1	0.4	1.0
Land clearing	ha	280.7	1191.3	1266.1	1491.6	231.5	1737.2	260.4	1416.9	659.3	580.3	1456.5	1114.0	1093.3	214.2	1959.9	849.2	987.7
	%	33.0	54.3	48.2	57.3	9.8	56.6	12.9	24.6	48.9	27.6	66.9	49.5	49.1	18.7	61.9	61.1	42.5
Lightning	ha	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	15.2	0.5	0.0	4.1	65.9	0.0	0.0	5.5
	%	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.2	5.8	0.0	0.0	0.4
Power Lines	ha	16.0	0.0	0.0	0.0	0.0	0.0	0.0	870.1	4.5	15.0	0.0	3.0	5.0	5.0	4.0	71.0	62.1
	%	1.9	0.0	0.0	0.0	0.0	0.0	0.0	15.1	0.3	0.7	0.0	0.1	0.2	0.4	0.1	5.1	1.5
Railways	ha	3.0	0.1	32.4	75.0	1288.0	3.0	18.0	17.7	37.1	98.3	6.5	9.1	7.1	6.2	38.1	2.2	102.6
	%	0.4	0.0	1.2	2.9	54.7	0.1	0.9	0.3	2.7	4.7	0.3	0.4	0.3	0.5	1.2	0.2	4.4
Recreational	ha	30.6	137.2	22.4	53.0	7.4	165.5	72.6	100.1	27.6	103.1	57.0	18.6	18.9	99.7	6.4	45.3	60.3
	%	3.6	6.3	0.9	2.0	0.3	5.4	3.6	1.7	2.0	4.9	2.6	0.8	0.8	8.7	0.2	3.3	2.9
Smokers	ha	6.0	134.2	5.9	117.3	21.3	72.7	47.0	2.5	21.5	7.6	26.9	3.8	2.0	2.5	5.1	1.8	29.9
	%	0.7	6.1	0.2	4.5	0.9	2.4	2.3	0.0	1.6	0.4	1.2	0.2	0.1	0.2	0.2	0.1	1.3
Structures	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vehicles	ha	5.0	107.3	17.1	360.0	234.6	5.2	21.5	268.8	11.9	413.6	10.0	63.3	28.7	286.7	137.6	45.1	126.0
	%	0.6	4.9	0.7	13.8	10.0	0.2	1.1	4.7	0.9	19.7	0.5	2.8	1.3	25.0	4.3	3.2	5.8
Miscellaneous	ha	172.8	141.1	390.4	70.9	39.7	160.9	496.8	408.8	29.8	78.4	149.6	604.7	104.4	153.2	531.6	160.0	230.8
	%	20.3	6.4	14.8	2.7	1.7	5.2	24.6	7.1	2.2	3.7	6.9	26.9	4.7	13.4	16.8	11.5	10.6
Unknown	ha	17.6	336.1	319.4	373.0	404.5	779.4	682.8	2151.3	433.8	512.3	174.0	194.4	531.1	144.3	286.8	119.3	466.2
	%	2.1	15.3	12.1	14.3	17.2	25.4	33.8	37.3	32.1	24.4	8.0	8.6	23.9	12.6	9.1	8.6	17.8
Total	ha	851.0	2192.3	2629.0	2603.3	2354.3	3066.8	2019.7	5763.8	1349.5	2100.2	2178.5	2249.5	2225.1	1145.3	3166.7	1390.2	2330.3

**Percentage values represent the actual area burned for each cause expressed as a proportion of the total area burned for that year for all causes. **Overall averages were calculated by averaging values from each year and may differ from proportional totals over the study period.*

Forest Area Burned by Cause

There were few consistent year-on-year cause trends evident for total forest area burned. It is possible that many single events, or years that have one cause dominant, were more influential than any underlying relationships. 1997/98 was an exceptional year for forest losses, with nearly 1,400 ha burned primarily as a result of fires caused by unknown (as well as miscellaneous, vehicle and incendiary) causes.

Key points from the total forest area burned by cause from 1991/92 to 2006/07 were (Figures 28 and 29 and Table 15):

- Land clearing accounted for 1,545 ha (25% of the national total), with an annual average of 97 ha, either as a result of escapes from forestry burnoffs or land clearing activities on lands adjacent to (or outside of) forest areas.
- Miscellaneous causes were attributed to 1,414 ha (23% of the total), with an annual average of 88 ha.
- Unknown causes also accounted for around 1,000 ha (16%) of the total forest area burned, with an annual average around 62 ha.
- Combined 'unspecified' causes of forest area burned were around 2,400 ha (around 40%) for miscellaneous and unknown, with an annual average of 150 ha.
- Incendiary causes accounted for over 800 ha (13%) of the total forest area burned, with an annual average of 52 ha.
- In relation to the other fuel types, chainsaws were a more important cause in terms of forest area burned (6%); nearly half (48%) of the total forest area burned for 2004/05 was from chainsaw-caused fires.
- In comparison, industrial fires caused by forestry activities (harvesting etc) were not significant. This may have been due to fires from forestry vehicles, smoking, and chainsaws being recorded separately, or due to improved mitigation of these fire causes in forests.
- Other less significant causes of forest area burned were: vehicles (6%); smokers (4%); and railways (3%).
- Finally, although often perceived to be significant causes of forest fires, recreational use of forests accounted for just 2%, arson accounted 1%, and power lines less than 1% of the total forest area burned.

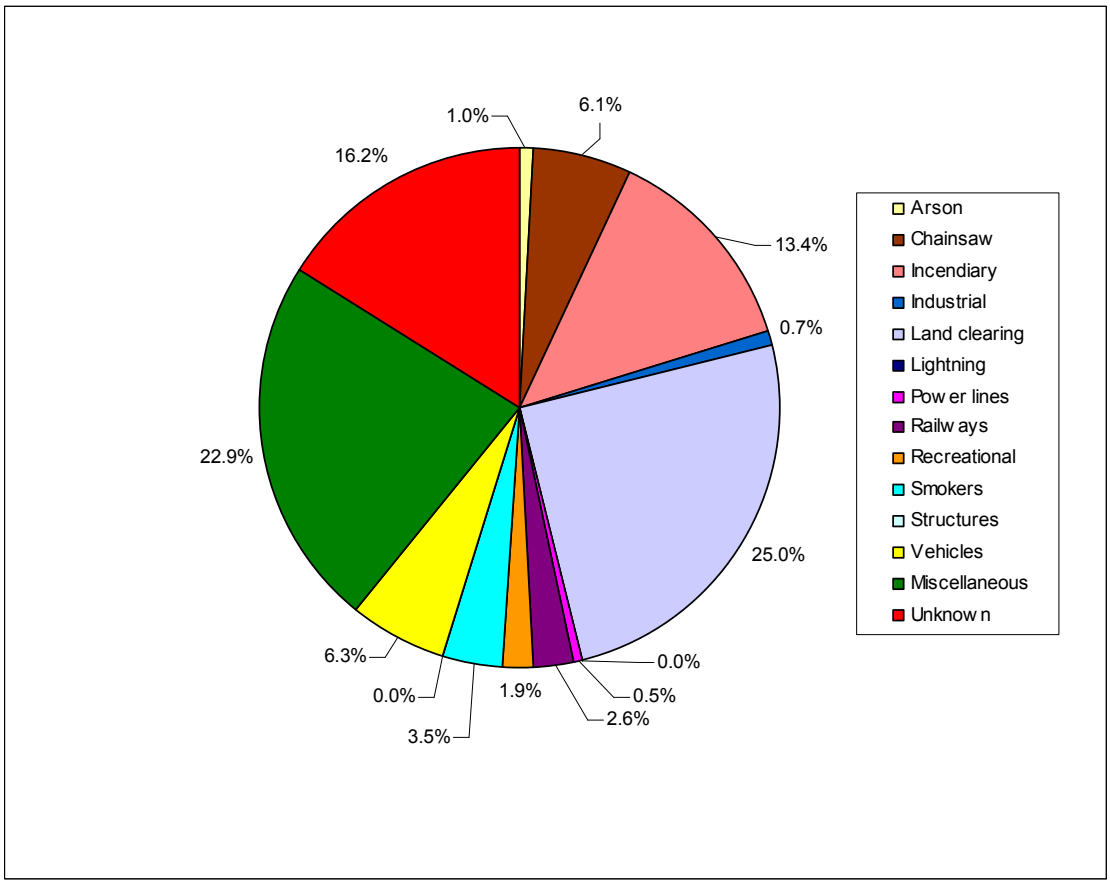

Figure 28. Proportion of total forest area burned nationally by fire cause classes from 1991/92 to 2006/07.

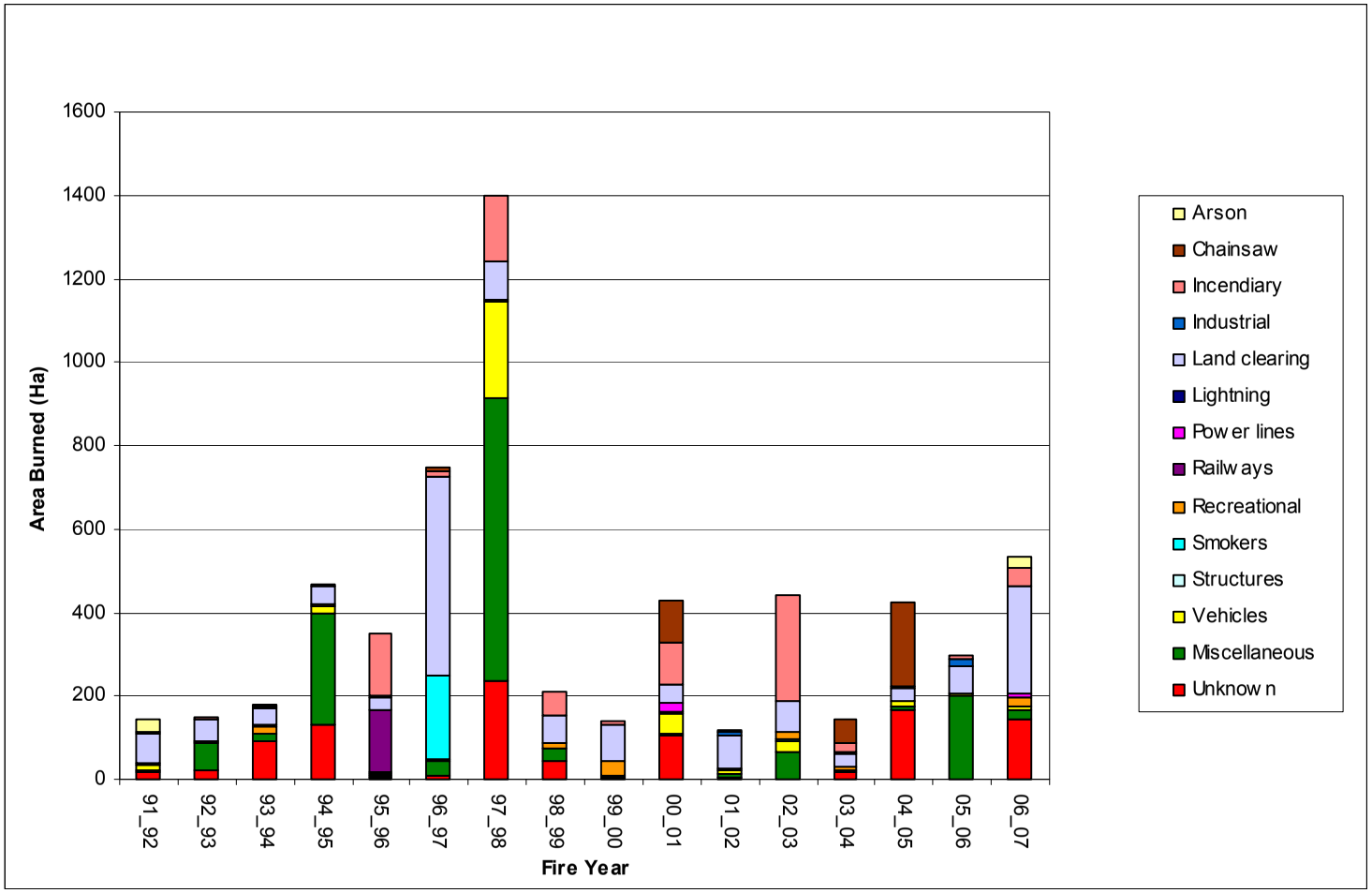

Figure 29. Annual total forest area burned nationally by fire cause classes from 1991/92 to 2006/07.

Table 15. Annual forest area burned nationally by fire cause classes from 1991/92 to 2006/07.

		Fire Year																
Cause		91_92	92_93	93_94	94_95	95_96	96_97	97_98	98_99	99_00	00_01	01_02	02_03	03_04	04_05	05_06	06_07	Average**
Arson	ha*	29.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.6	0.9	0.0	0.0	2.1	26.0	3.7
	%	20.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.5	0.2	0.0	0.0	0.7	4.8	1.6
Chainsaw	ha	0.0	0.0	2.2	2.0	0.0	10.0	0.0	0.0	0.0	99.0	0.3	0.7	55.7	204.0	0.0	0.0	23.4
	%	0.0	0.0	1.2	0.4	0.0	1.3	0.0	0.0	0.0	23.2	0.2	0.1	39.0	48.0	0.0	0.0	7.1
Incendiary	ha	1.1	3.0	3.5	2.3	149.1	10.6	157.0	55.7	8.5	101.6	2.6	250.7	23.5	0.7	7.6	47.5	51.6
	%	0.8	2.0	2.0	0.5	42.8	1.4	11.2	26.6	6.0	23.8	2.1	56.8	16.5	0.2	2.6	8.8	12.8
Industrial	ha	4.3	1.5	0.0	0.0	0.2	1.6	0.1	0.5	0.1	1.0	10.1	0.6	2.4	0.8	19.7	0.0	2.7
	%	3.0	1.0	0.0	0.0	0.1	0.2	0.0	0.2	0.1	0.2	8.5	0.1	1.7	0.2	6.6	0.0	1.4
Land clearing	ha	71.1	52.1	42.2	43.0	31.9	474.0	92.5	66.4	90.6	44.0	77.7	76.7	30.8	29.6	65.7	256.8	96.6
	%	49.3	35.0	23.8	9.2	9.2	63.5	6.6	31.7	64.1	10.3	65.3	17.4	21.6	7.0	21.9	47.3	30.2
Lightning	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.1
	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.1
Power Lines	ha	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	19.2	0.0	0.0	0.0	0.0	0.0	10.0	1.9
	%	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	4.5	0.0	0.0	0.0	0.0	0.0	1.8	0.4
Railways	ha	0.0	0.0	4.0	0.0	150.0	0.0	0.0	0.0	0.0	4.0	0.0	0.1	0.0	0.5	0.0	0.0	9.9
	%	0.0	0.0	2.3	0.0	43.1	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.1	0.0	0.0	2.9
Recreational	ha	2.0	2.5	15.0	2.0	0.0	0.5	1.7	12.0	35.1	2.1	4.0	14.6	7.1	1.5	0.0	20.1	7.5
	%	1.4	1.7	8.5	0.4	0.0	0.1	0.1	5.7	24.8	0.5	3.4	3.3	5.0	0.4	0.0	3.7	3.7
Smokers	ha	0.1	0.3	0.5	0.0	4.1	202.1	0.3	1.0	1.2	0.5	1.0	4.0	3.0	1.0	0.0	0.0	13.7
	%	0.1	0.2	0.3	0.0	1.2	27.1	0.0	0.5	0.9	0.1	0.8	0.9	2.1	0.2	0.0	0.0	2.1
Structures	ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vehicles	ha	15.0	1.3	1.0	18.0	5.3	4.7	234.0	1.0	0.8	44.7	10.6	28.3	0.3	12.1	1.6	8.0	24.2
	%	10.4	0.9	0.6	3.9	1.5	0.6	16.7	0.5	0.6	10.5	8.9	6.4	0.2	2.8	0.5	1.5	4.2
Miscellaneous	ha	4.9	67.1	17.0	268.3	2.3	34.6	675.1	29.5	1.7	4.6	7.9	62.9	1.8	7.0	200.8	29.1	88.4
	%	3.4	45.0	9.6	57.6	0.7	4.6	48.3	14.1	1.2	1.1	6.6	14.3	1.3	1.6	67.0	5.4	17.6
Unknown	ha	16.1	21.2	91.8	130.5	5.2	8.5	238.0	42.7	2.9	106.5	4.3	2.1	17.4	167.8	2.0	144.8	62.6
	%	11.2	14.3	51.8	28.0	1.5	1.1	17.0	20.4	2.0	24.9	3.6	0.5	12.2	39.5	0.7	26.7	16.0
Total	ha	144.1	149.0	177.2	466.0	348.2	746.6	1398.7	209.4	141.4	427.2	118.9	441.6	142.7	424.9	299.4	542.4	386.1

**Percentage values represent the actual area burned for each cause expressed as a proportion of the total area burned for that year for all causes. **Overall averages were calculated by averaging values from each year and may differ from proportional totals over the study period.*

DISCUSSION AND CONCLUSIONS

Key findings

New Zealand experienced an average of 3,033 wildfires and 5,865 ha burned annually from 1991/92 to 2006/07. The total area burned over this period comprised of 54% grass fuels, 40% scrub fuels and 6% forest fuels. The number of wildfires increased from around 1,000 (in the early 1990's) to over 4,000 fires (2006/07). The increase in wildfire occurrence observed nationally was mirrored in most regions. Unknown and miscellaneous causes accounted for almost half (46%) of the total number of fires. Other main causes of wildfires were land clearing (20%), vehicles (16%), and incendiary (6%). No clear trend over time was observed in the area burned. Area burned was dominated by land clearing (47%). Unknown (24%), miscellaneous (7%) and incendiary (6%) were other major causes contributing to the total area burned. Natural causes (lightning) made up 0.1% of wildfires and area burned. Otago accounted for 6% of wildfires and 42% of the total area burned nationally. The South Island accounted for 75% of the total area burned and 34% of the number of fires. Northland and the Eastern North Island accounted for 60% of the total area burned in the North Island.

Cause classes

There was considerable variation in fire causes within and between years in the Annual Returns database. An example was one RFA's return for the year which listed a number of causes that did not appear to be related to wildfires: pumping flooded properties, aircraft, rescue, animal rescue, and landslip. Whilst some of these causes may in fact be related to wildfires, it is difficult to tell. It is possible that some (or all) these classes originated from the NZ Fire Service Fire Station Management System (SMS), and were incorrectly assigned as wildfires or vegetation fires. Over time the high number of fires previously attributed to railways caused by steam trains have been replaced by vehicle fires, including the current trend of "torching" stolen cars.

The lack of consistency in assigning cause classes between years made meaningful long-term analysis difficult. There are a number of possible approaches that can be taken to collect more reliable data on fire cause. The first would be a diffuse system where no cause categories are stipulated, and where rural fire officers describe the fire cause as what they deemed appropriate and correct. The data would then later be grouped according to the needs of the analyst. This approach might yield data on new emerging causes of fires. Obviously a disadvantage to this approach would be that contradictory, confusing, and erroneous fire causes might be used which would reduce the overall data usefulness. The time and effort to later group causes could also be significant. The second approach would be a system based on clearly-defined categories. However, these categories might become restrictive in their interpretive use, and this approach may result in fires being tallied in a cause class that may not accurately describe the actual

cause. A good example of this is the presence of 'Careless – Smokers, Chainsaws etc' as a single class in many returns. In the same years, other RFAs appeared to record smoker and chainsaw fires separately. Another approach worth considering might be to have well-defined classes listed, with the option to record a fire as "other" and then specify the cause. This might enable better interpretation of new and emerging causes, within a clearly-defined cause framework. This system might also allow for better integration of the information from individual authorities that may capture more diverse causes of wildfires. Another option could be to not allow fires to be assigned to miscellaneous or unknown cause classes. This would have the advantage of forcing the user to determine cause, but the disadvantage could be that fires are assigned incorrectly (if the cause really is unknown).

Opperman (2005) suggested that a hierarchical cause category system designed for vegetation fires is needed, preferably with separate fire cause fields for the ignition mechanism and responsible party. It was suggested that the categories used by the US wildfire agencies could be used as a basis for developing an appropriate New Zealand equivalent and that such a system would *'allow data to be collapsed into (a) few recognizable categories for regional or national summaries, but also allows area managers to know exactly how to target local fire prevention and mitigation activities.'*

Number of Fires

The primary reasons for the four-fold increase in the number of fires over the 16-year period are likely to be due to better reporting of wildfires by the public through the use of the 111 system, and better reporting by RFAs to the National Rural Fire Authority. It is impossible to tell what part of the increase was due to an actual increase in the number of fires, but this is likely to be significantly less than the increase due to improved reporting.

In addition to the increase in number of fires from better reporting of wildfires, the apparent cyclical nature of the increase (peaking and falling over the period but showing a general increasing trend) suggests that other factors may be influencing fire occurrence. The most obvious of these are climatic. Fire severity varies from year to year in different parts of the country as a result of normal climatic variability, ENSO (El Niño Southern Oscillation), and long-term climate patterns (Pearce 2003, 2007). An investigation of climatic influences in fire occurrence and severity was beyond the scope of this study.

Most regions followed the positive increasing trend seen in the national number of fires. Auckland, the West Coast and Waikato differed to the national trend. The annual number of fires in Auckland (over the study period) was highly variable and did not show any trend, and the number and proportion attributed to different causes varied. In contrast, the West Coast's annual number of fires decreased overall. In most years, the bulk of fires were attributed to unknown and miscellaneous causes. Waikato's annual number of fires increased slightly over time but was highly variable, mostly driven by

changes in the number of fires in the miscellaneous, unknown, and vehicle cause classes.

The proportion of the total number of fires (nationally) attributed to unknown causes decreased (possibly due to improved training in, and investigation of, fire causes), whilst the proportion assigned to miscellaneous causes increased. These two trends may be unrelated, or it could be possible that fires are being assigned to miscellaneous causes in place of assigning fires to unknown causes.

Area Burned

The trend of increasing numbers of fires over time was for the most part not mirrored in the area burned. Nationally there seemed to be no clear year-on-year trend in area burned. The total area burned varied considerably, both within regions and nationally. It could be that the data reflected the true total area burned, and that regardless of the number of fires by cause per year, roughly the same area burned. However, this is extremely unlikely, since it became clear whilst compiling the data for this analysis that frequently the number of fires was recorded with no corresponding area burned for any fuel type. The largest example was one region that had over 500 fires attributed to miscellaneous causes in a single year, but with a total of only 20 ha recorded burned. It may be that some RFAs only record large areas burned, or that area burned is being recorded only when the cause of a fire is clear.

Large fire events often had a major influence on the results in relation to area burned. For example, in Nelson/Marlborough in 2000/01 over 6,000 ha of (mostly) grass burned and was attributed to unknown causes. In all other fire years the total area burned for Nelson/Marlborough did not exceed 1,000 ha, therefore the area burned for this fire year made up a large proportion of the average total area burned. The Fruitlands fire near Alexandra in 1998/99, which burned 5,600 ha of mostly grasslands, was also attributed to an unknown cause. These incidents dramatically inflated the significance of unknown as a cause in these regions. Similarly, the Springvale fire near Alexandra in 1998/99 burned a further 2,600 ha of grasslands but, in this case, was attributed to power lines (being brought down in strong winds). This single fire event also inflates the importance of power lines as a contributor to area burned, both nationally and for the Otago region.

Forest area burned differed from other fuel types. While significant proportions of the grass and scrub area burned occurred in Otago, forest area burned varied greatly across regions. Nelson/Marlborough and the Eastern North Island accounted for around 40% of the total forest area burned. This was probably due to a combination of more severe fire climates and larger areas of commercial forest being located in these regions. The total forest area burned differed in that chainsaws and incendiary causes accounted for a greater proportion of the area burned in forest than in other fuel types. A greater proportion of area burned in forests was also attributed to industrial (i.e. forestry operations) compared to grass and scrub. In addition, vehicle causes

accounted for less forest area burned than grass or scrub area burned. At the regional level, the total annual forest area burned was relatively low, and was mostly influenced by single fire events in most regions. Moreover, the national total forest area burned made up only a small proportion of the total area burned for all fuel types combined.

Number of fires and area burned

When considering options for mitigating wildfire risk it is important to consider both the area burned and the number of fires. For example, Otago accounted for around 40% of the total area burned but only 6% of the total number of fires; Canterbury accounted for 18% of the total number of fires and 12% of the total area burned; and Auckland accounted for 9% of the total number of fires but just 1% of the area burned. A large number of small “nuisance fires” (e.g. vehicle torching) over time can potentially cost as much in time and resources as larger fires. Reducing both the number of fires and area burned is important. This study did not include any discussion of suppression costs (and damages) since these were not included in the Annual Returns, and was beyond the scope of this study. Analysis of suppression costs using other sources such as RFFF claims could be conducted (e.g. Bayley 2006).

Land clearing was the most dominant known cause for the total number of fires (20%), total area burned (47%), total grass area burned (53%), total scrub area burned (42%), and total forest area burned (25%). However, large proportions (more than 20% of both area burned and number of fires) were attributed to unknown and miscellaneous causes, meaning that other more important causes were not captured, or that the true extent of the importance of other known causes were underestimated. Unknown causes accounted for 13% of the total number of fires, 24% of the total area burned, 28% of the total grass area burned, 21% of the total scrub area burned, and 16% of the total forest area burned. Miscellaneous causes accounted for 33% of the total number of fires, 7% of the total area burned, 3.5% of the total grass area burned, 10% of the total scrub area burned, and 23% of the total forest area burned. The combined ‘unspecified’ (unknown and miscellaneous) causes represented 46% of the total number of fires, 31% of the total area burned, 31% of the total grass area burned, 31% of the total scrub area burned, and around 40% of the total forest area burned.

Lightning accounted for only 0.1% of the total number of fires (34 fires) and 0.1% of the total area burned (91 ha) over the entire study period (1991-2007). This indicates that the overwhelming majority of fires in New Zealand are human-caused and can therefore arguably be largely mitigated.

It is apparent that there needs to be investigation into the relationships between weather and/or fire danger and fire occurrence. The number of fires and area burned were highly variable, but are likely to be influenced by factors such as weather and fire season severity (Harrington et al. 1983, Flannigan and Harrington 1988). With better quality data, it may also be possible to look at fire occurrence and severity in relation to future climate change (Flannigan 2005). It may also be possible to utilise relationships identified between

present climate or fire danger and area burned or number of fires to investigate fire activity under future climate change (Flannigan et al. 2005, Pearce et al. 2005).

RECOMMENDATIONS AND FUTURE WORK

- Review the cause classes listed in the NRFA Annual Returns to obtain a more realistic assessment of the causes of wildfires in New Zealand, to ensure that as many causes of wildfires as possible are reported and that these causes are consistent from year to year.
- Improved training and operational procedures to reduce the proportion of fires and area burned being classed as miscellaneous and unknown. This would provide for more meaningful conclusions to be drawn from the NRFA Annual Returns in the future.
- In applying results from this study to management practices, it is important to consider both number of fires and area burned, since they both display different results and can require different mitigation strategies.
- Targeted approaches to fire prevention in regions showing high areas burned from particular causes could reduce the incidence and consequences of wildfires in those regions.
- Human causes in New Zealand are responsible for the overwhelming majority of fires, but weather and climate may have a greater influence on the severity of fires. Research into the effects of weather and climate on regional and national fire occurrence is required.
- Analysis of the NRFA Annual Returns by fire authority type was not conducted here, but since different types of fire authorities can in some areas be responsible for different vegetation types, this analysis may be useful. However, this may be more difficult because of the decrease in the number of territorial authorities, the disestablishment of many forestry-based RFDs, and increases in the area of the DOC estate.
- The need for a consistent national approach to data collection at all levels is required. Standardised cause classes, consistency in reporting, and quality control would greatly increase our understanding of the causes, occurrence, and impact of wildfires in New Zealand.

ACKNOWLEGMENTS

Thanks are extended to the National Rural Fire Authority for supplying the Annual Returns of Fires database for this study. Special thanks to Rob Goldring, Manager Rural Fire (NRFA) and Veronica Clifford, Bushfire Research Officer (Scion) for reviewing the draft of this report.

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APPENDICES

Appendix A - Copy of National Rural Fire Authority Annual Fire Return Statistics Form (1 May 2006 to 30 April 2007)

ANNUAL FIRE RETURN STATISTICS

FOR THE PERIOD:	1 May 2006 to 30 April 2007

Name of Fire Authority:	
Principal Rural Fire Officer:	
Deputy Principal Rural Fire Officer:	

Cause of Fire	**No. of Fires**	**Area of Ground Cover Burnt**			
		Grass (Ha)	**Scrub (Ha)**	**Forest (Ha)**	**Total (Ha)**
Road Traffic					
Tractors and motor vehicles					
Railways					
Hunters (camp or billy fires, etc.)					
Picnics					
Smokers					
Land Clearing					
Incendiary					
Industrial (sawmill, logging, etc.)					
Chainsaws					
Miscellaneous					
Unknown					
Total					

Signature (for Fire Authority) **Date**

Appendix B - Regional distribution of average number of fires by cause from 1991/92 to 2006/07

Figure 1.1. Regional Distribution of Average Number of Fires **Arson** Caused from 1991/92 to 2006/07

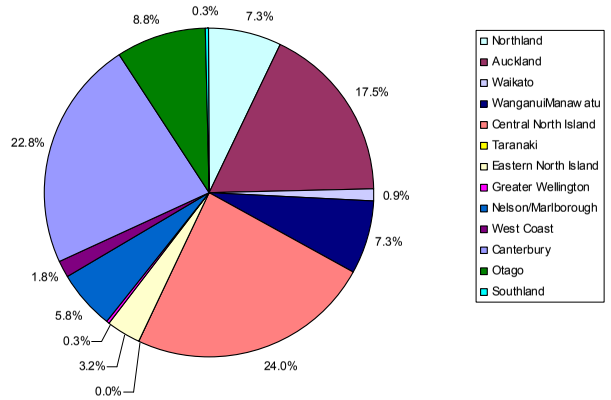


Figure 1.2. Regional Distribution of Average Number of Fires **Chainsaw** Caused from 1991/92 to 2006/07

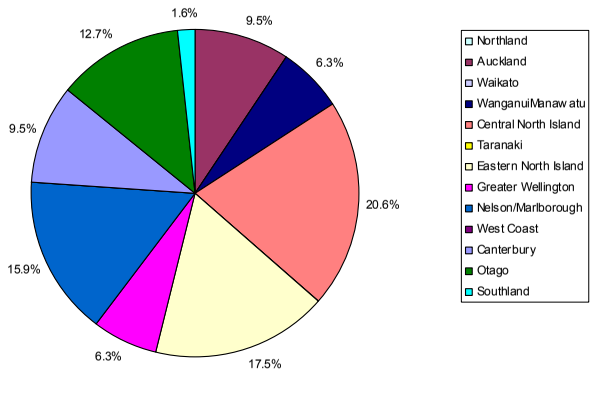


Figure 1.3. Regional Distribution of Average Number of Fires **Incendiary** Caused from 1991/92 to 2006/07

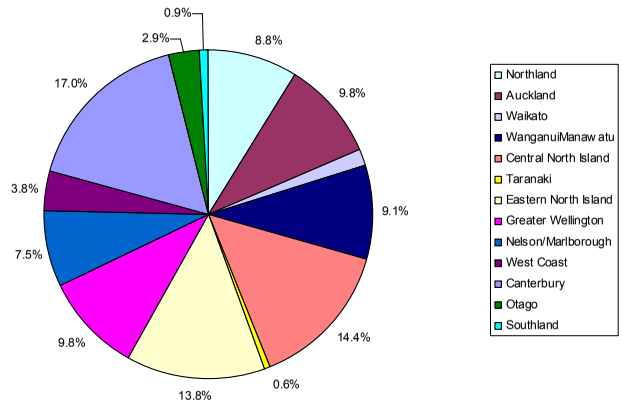


Figure 1.4. Regional Distribution of Average Number of Fires **Industrial** Caused from 1991/92 to 2006/07

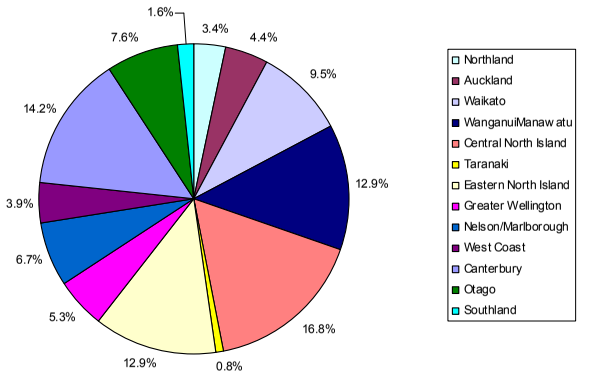


Figure 1.5. Regional Distribution of Average Number of Fires **Land clearing** Caused from 1991/92 to 2006/07

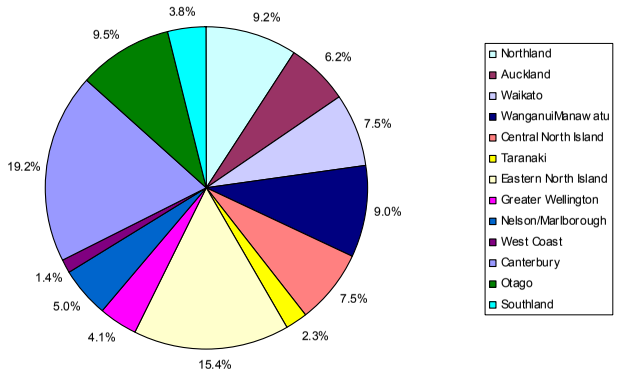


Figure 1.6. Regional Distribution of Average Number of Fires **Lightning** Caused from 1991/92 to 2006/07

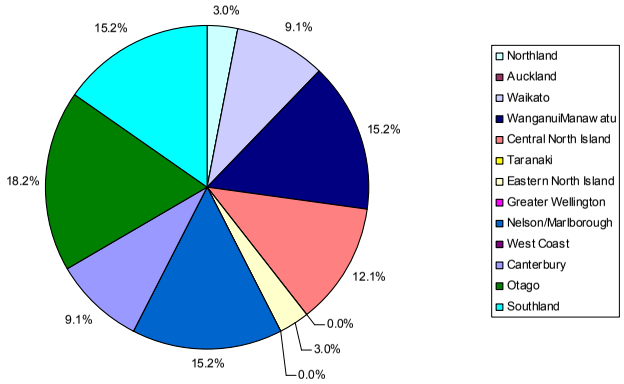


Figure 1.7. Regional Distribution of Average Number of Fires **Powerlines** Caused from 1991/92 to 2006/07

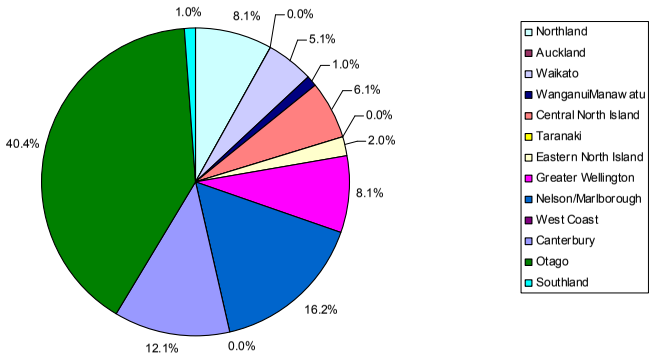


Figure 1.8. Regional Distribution of Average Number of Fires **Railways** Caused from 1991/92 to 2006/07

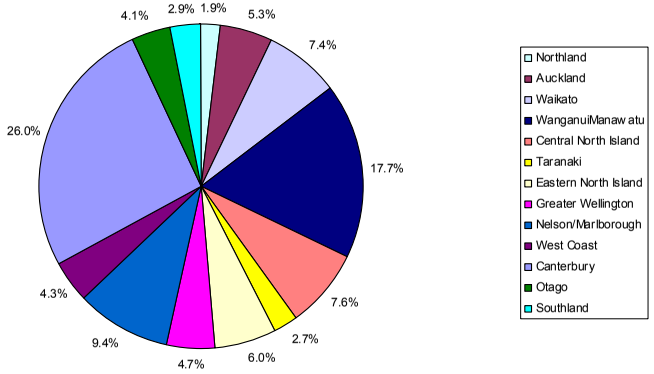


Figure 1.9. Regional Distribution of Average Number of Fires **Recreational** Caused from 1991/92 to 2006/07

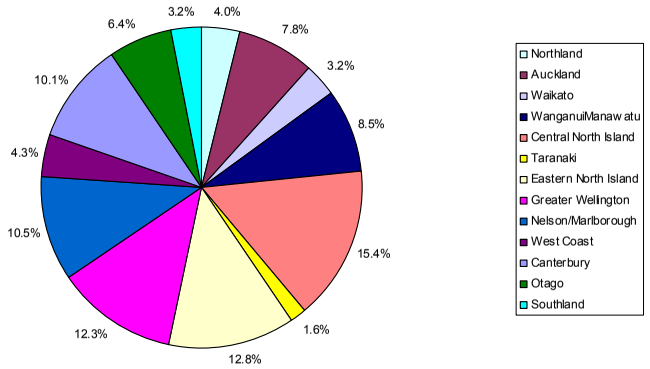


Figure 1.10. Regional Distribution of Average Number of Fires **Smoker** Caused from 1991/92 to 2006/07

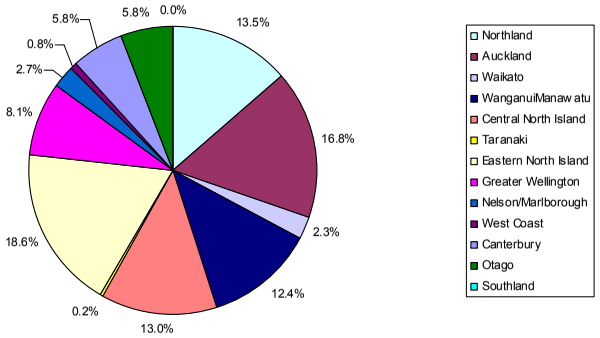


Figure 1.11. Regional Distribution of Average Number of Fires **Structures** Caused from 1991/92 to 2006/07

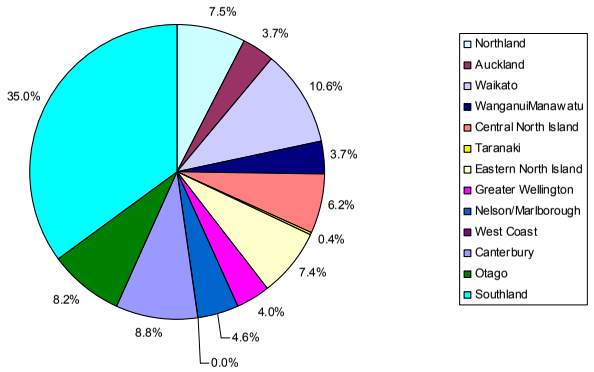


Figure 1.12. Regional Distribution of Average Number of Fires **Vehicle** Caused from 1991/92 to 2006/07

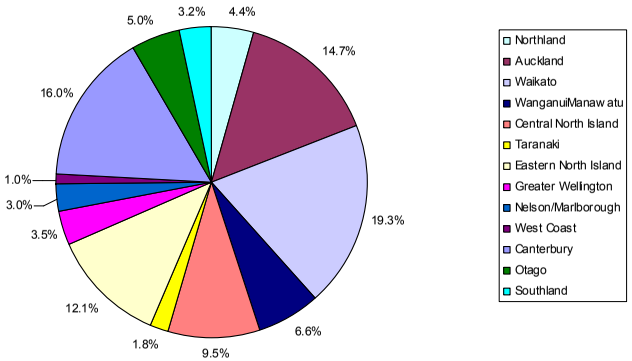


Figure 1.13. Regional Distribution of Average Number of Fires **Miscellaneous** Caused from 1991/92 to 2006/07

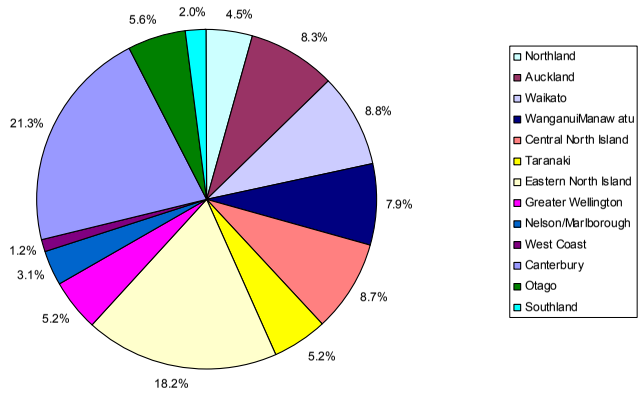
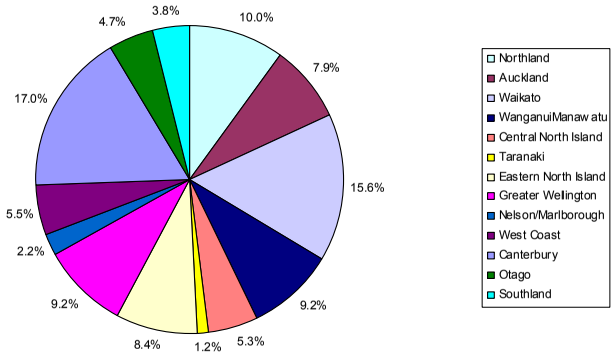


Figure 1.14 Regional Distribution of Average Number of Fires **Unknown** Cause Classed from 1991/92 to 2006/07



Appendix C - Regional reports

C1. Northland Region Fire Returns Report

C2. Auckland Region Fire Returns Report

C3. Waikato Region Fire Returns Report

C4. Wanganui/Manawatu Region Fire Returns Report

C5. Central North Island Region Fire Returns Report

C6. Taranaki Region Fire Returns Report

C7. Eastern North Island Region Fire Returns Report

C8. Greater Wellington Region Fire Returns Report

C9. Nelson/Marlborough Region Fire Returns Report

C10. West Coast Region Fire Returns Report

C11. Canterbury Region Fire Returns Report

C12. Otago Region Fire Returns Report

C13. Southland Region Fire Returns Report

Appendix C1 Northland Region Fire Returns 1991/92 to 2006/07

Number of fires (Figure N1):

- From 1991/92 to 2006/07, Northland had on average 200 wildfires per year or around 7% of the total national number of fires.
- Northland has experienced between 62 (6% of the national) fires in 1991/92 and 385 fires (10% of the national) in 2006/07.
- The total number of fires for Northland over the study period significantly increased over time. (Linear regression: R^2 = 0.63; F-value = 23.85; P-value = <0.001). The trend in Northland's total number of fires over time was also significantly correlated with the overall national trend (correlation coefficient = 0.77; P-value = <0.001).

Area burned (Figure N2):

- The average per year total area burned for Northland was 440 ha (around 8% of the national).
- Total area burned varied considerably from just 41 ha (0.5% of national) in 2003/04 to around 1,070 ha (15% of national) in 1996/97.
- The total area burned for Northland shows no statistically significant clear directional trend over time (Regression R^2 = 0.04; F-value = 0.59; P-value = 0.45). However average total area burned over time shows a decrease, although not significant and highly variable.

Number of fires by cause (Figure N3 and N4):

- On average around 28% (average 55 fires annually) of the Northland fires were attributed to land clearing.
- Around 23% were classed as miscellaneous (average of 45 fires annually) and 21% to unknown (average of 41 fires annually); combined these 'unspecified' cause fires were 44%.
- Around 11% of fires, on average, were attributed to vehicles.
- Fires from miscellaneous, unknown and vehicle causes feature almost every year, whereas incendiary and structure fires feature highly only in some years (incendiary in 2000/01 and 2006/07, structures in 2002/03).

Area burned by fuel type (Figures N5 and N6):

- Around 77% of Northland's total area burned over the study period was scrub. Northland average per year scrub area burned was around 340 ha (15% of national).
- Around 12% of Northland's total area burned was grass; average per year grass area burned was around 53 ha (2% of national).
- Around 8% of Northland's total area burned was forest; average per year forest area burned was 47 ha (12% of national).
- A large area of scrub was burned in 1996/97 of 1,070 ha (34% of national). Northland's greatest proportion of the national scrub area burned occurred in 2004/05 with over half (52%) or 597 ha.
- In terms of number of fires 1997/98, 2000/01, 2002/03 and 2004/05 were significant fire years. However, fire year with greatest number of fires

(2006/07) is not reflected in area burned. Greatest losses were recorded in 1996/97, followed by 1993/94 and 2004/05.

Area burned by cause (Figures N7 and N8):

- Land clearing accounted for 25% of the total reported area burned (average annually 110 ha) and vehicle fires accounted for around 11% of the total area burned (average annually 48 ha). Most of the area burned from vehicle fires occurred in three fire years (1995/96, 1997/98 and 2004/05).
- The total area burned classed as unknown was around 31% (average annually 135 ha); miscellaneous around 13% (average annually 56 ha); combined 45% of total area burned was unknown or miscellaneous.
- In contrast, incendiary fires make up 8% of the number of fires but 16% of the total area burned.

Area burned by cause and fuel type (Figures N9, N10, N11, N12, N13, and N14):

Area burned by cause for the three main fuel types varies considerably for Northland and emphasizes the importance of individual years on particular cause classes.

- Land clearing accounted for on average 40% of the total grass area burned (annual average 21 ha). Large grassland areas were burned through land clearing of around 180 ha in 1993/94.
- Unknown classed fires on average made up around 35% of the total grass area burned (per year average of around 19 ha).
- Total average scrub area burned for Northland from miscellaneous and unknown causes made up around the same percentage as total grass area burned.
- Incendiary, however, on average accounted for 15% of the total annual scrub area burned. No clear year-on-year trends for other causes were obvious.
- Most of the Northland scrub area burned was classed as miscellaneous in 2002/03, while most was due to land clearing in 1992/93, and most as incendiary in 1993/94.
- Average Northland forest area burned shows no consistent cause trends. It was dominated by a large relative area burned in 1997/98 (over 200 ha) classed as vehicles; over 200 ha was burned in 2002/03 in the Aupouri fire; and over 100ha was classed as unknown in 2006/07.

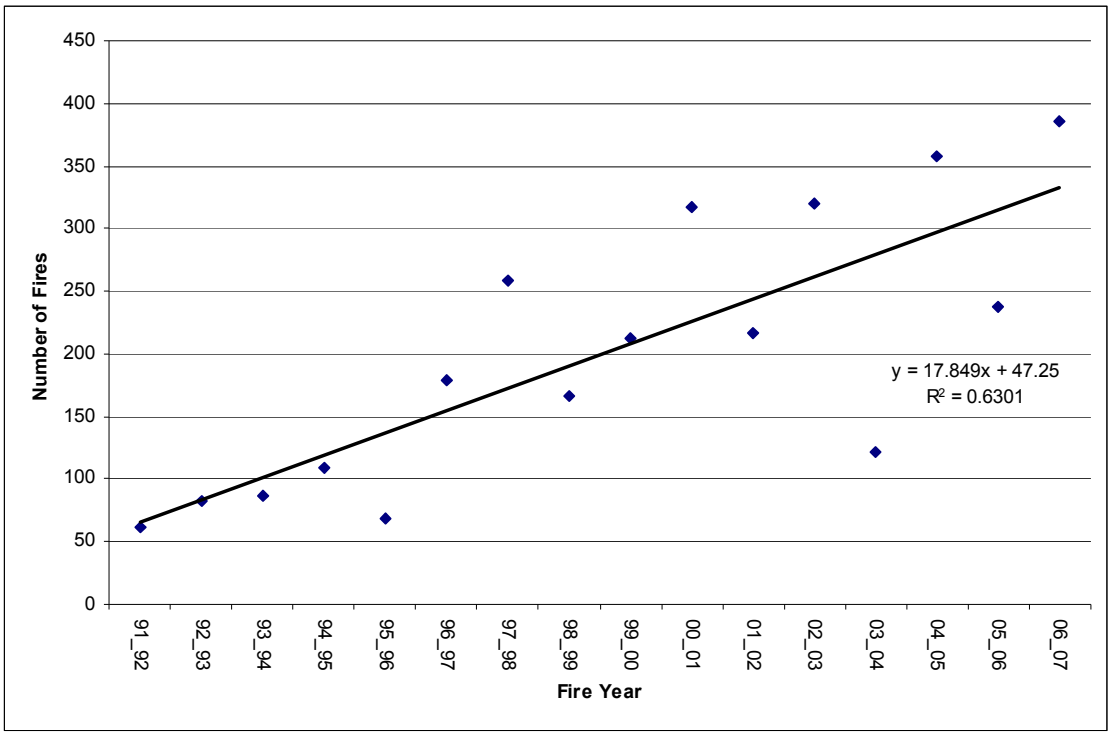


Figure N1. Northland total number of fires from 1991/92 to 2006/07.

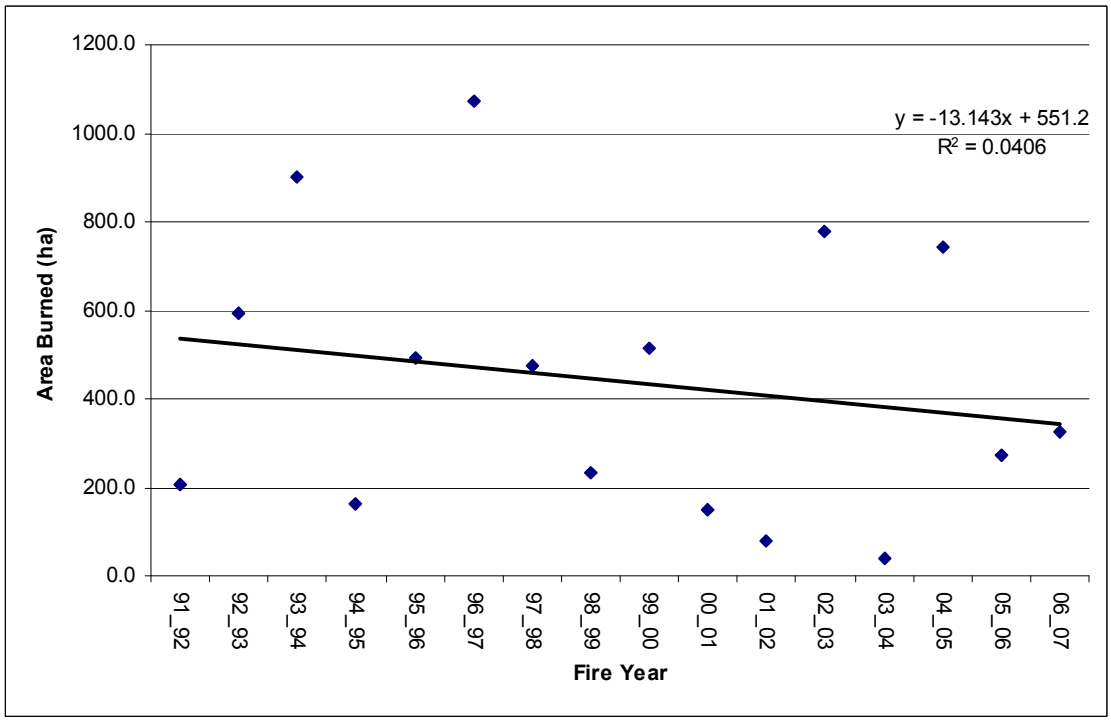


Figure N2. Northland total area burned from 1991/92 to 2006/07.

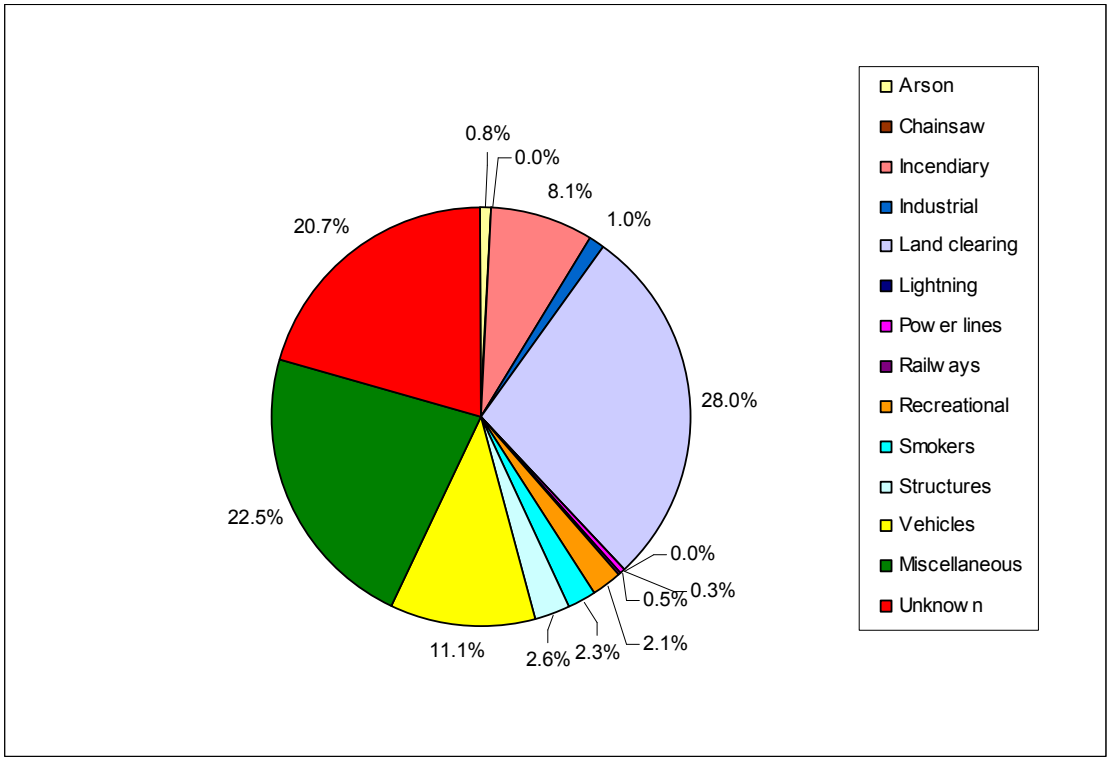


Figure N3. Northland average annual total number of fires by cause from 1991/92 to 2006/07.

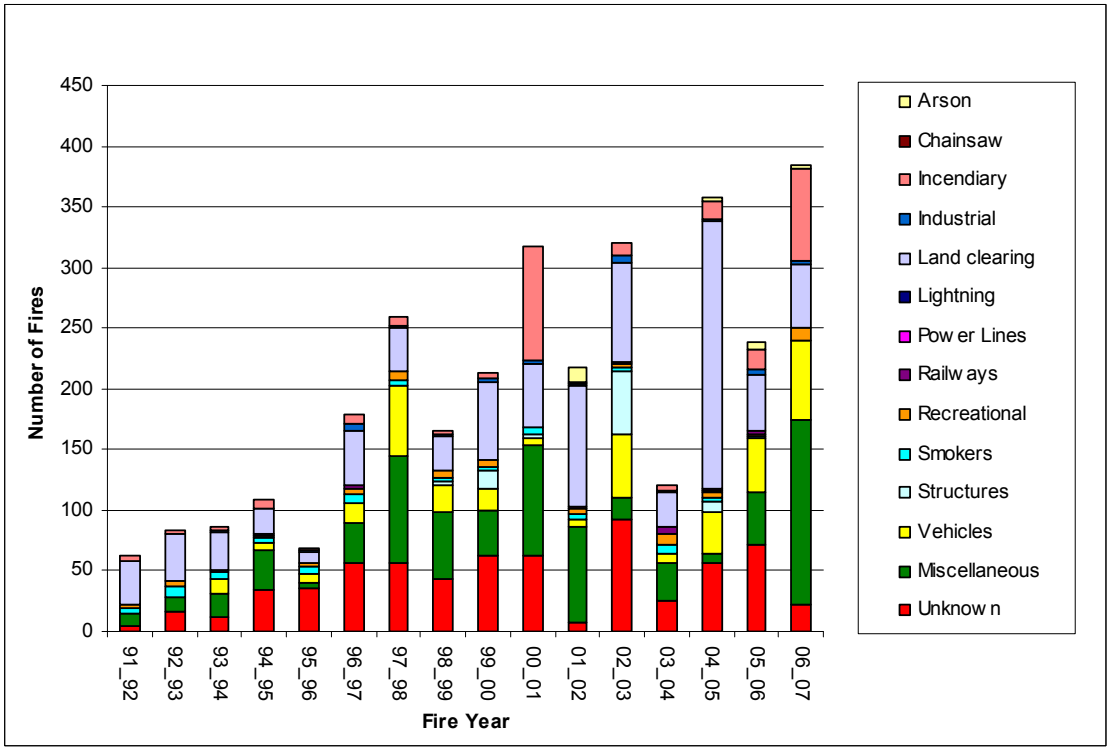


Figure N4. Northland number of fires by cause from 1991/92 to 2006/07.

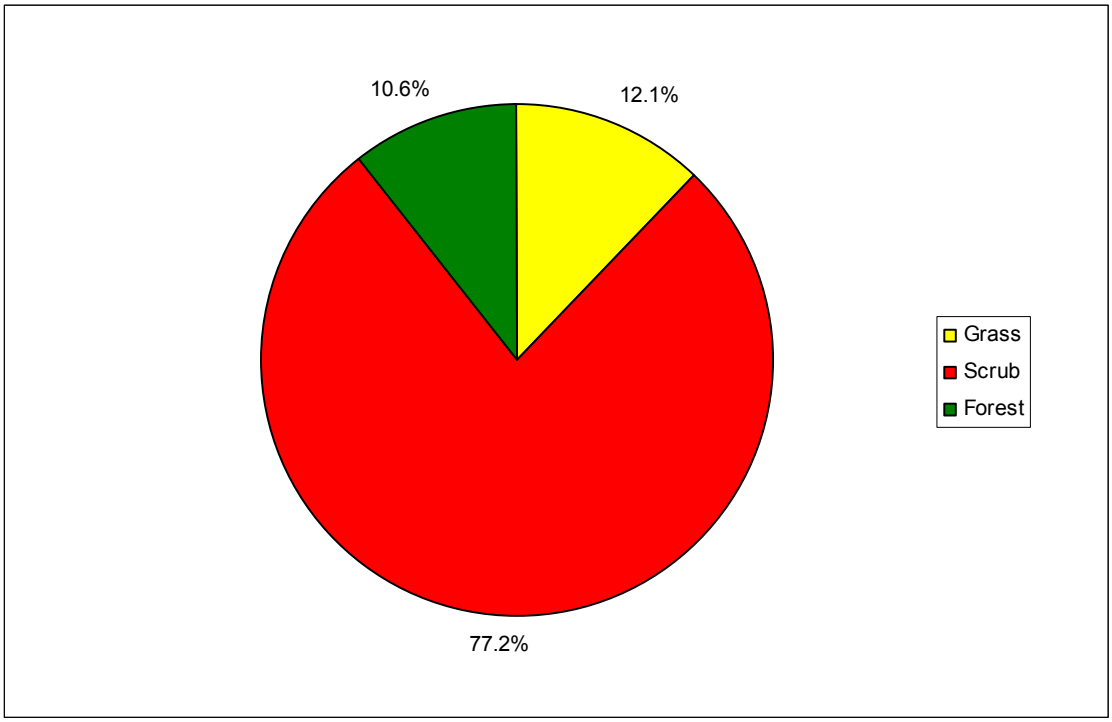


Figure N5. Northland total area burned by fuel type from 1991/92 to 2006/07.

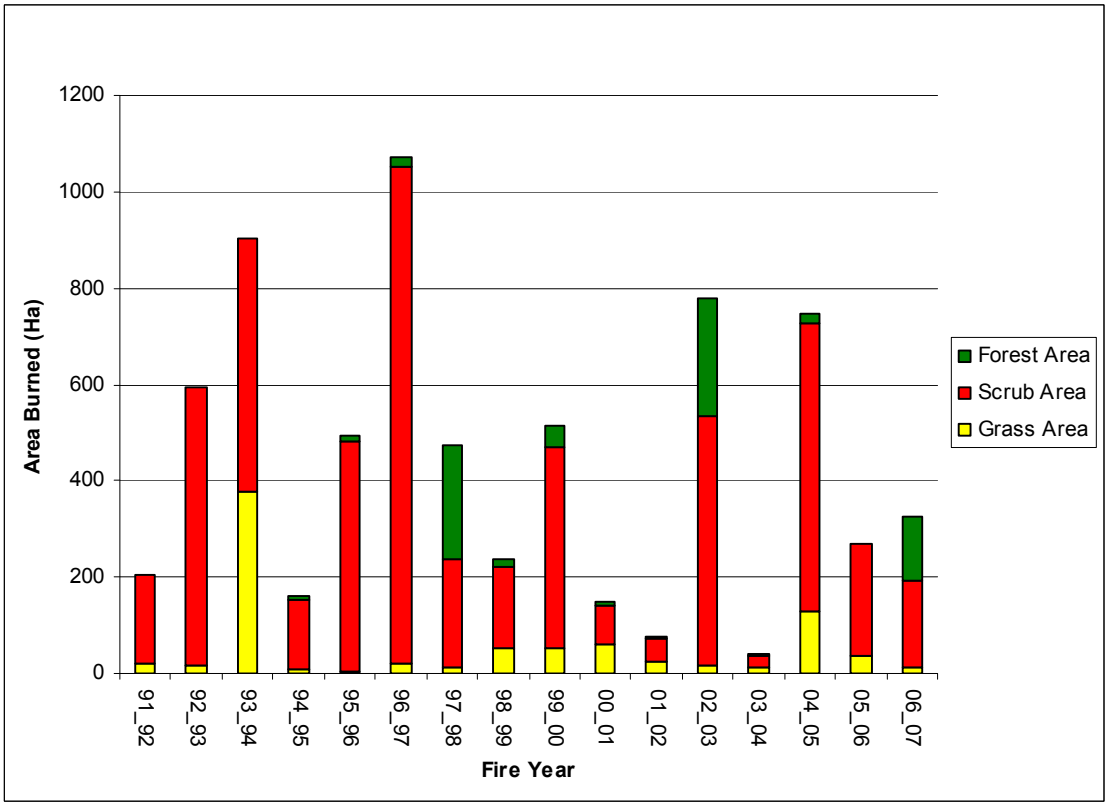


Figure N6. Northland total annual area burned by fuel type from 1991/92 to 2006/07.

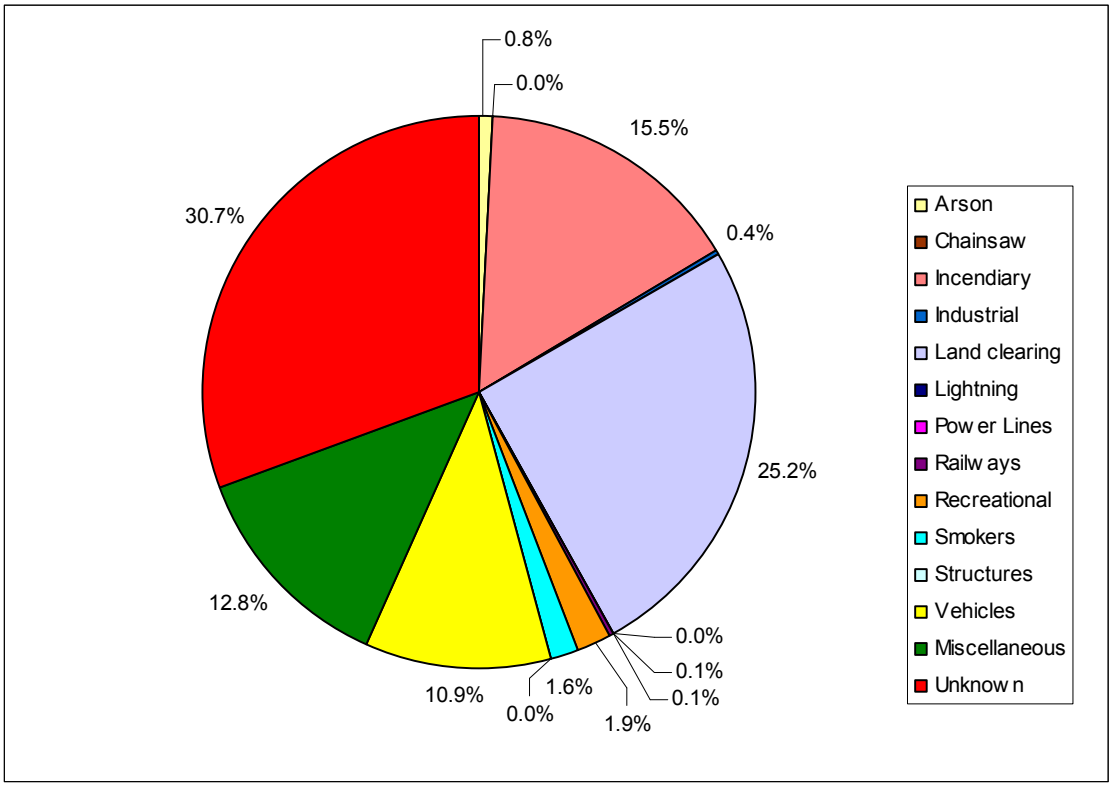


Figure N7. Northland total area burned by cause from 1991/92 to 2006/07.

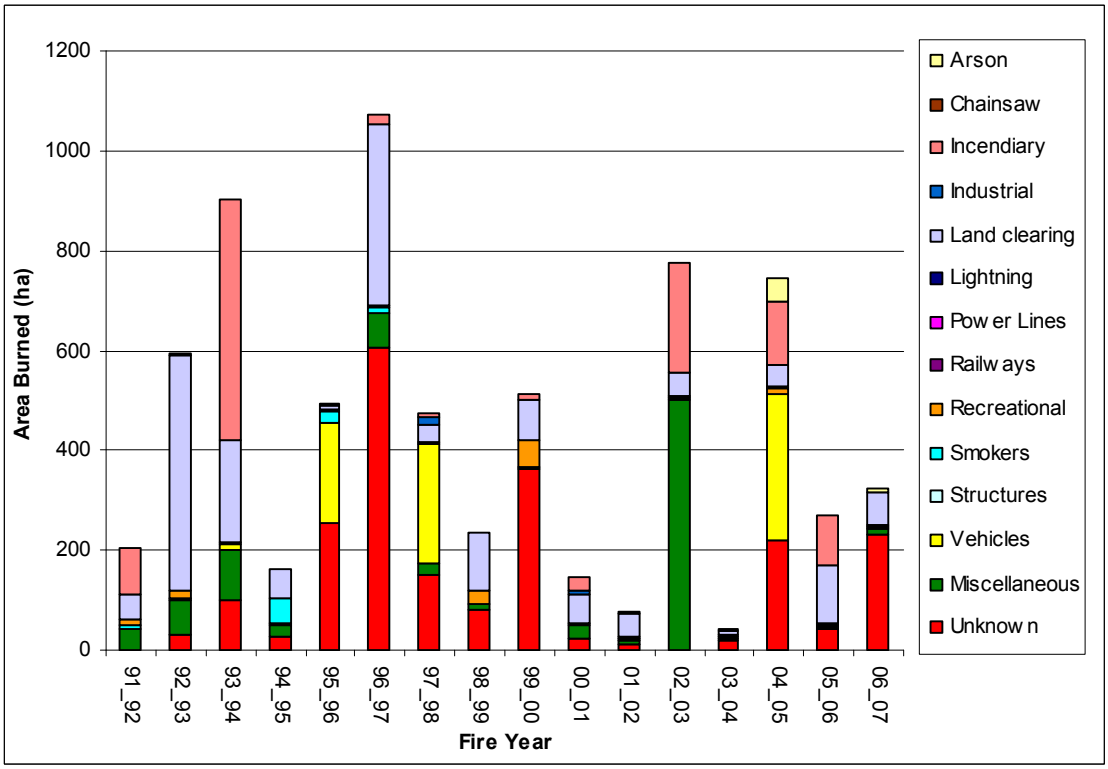


Figure N8. Northland total annual area burned by cause from 1991/92 to 2006/07.

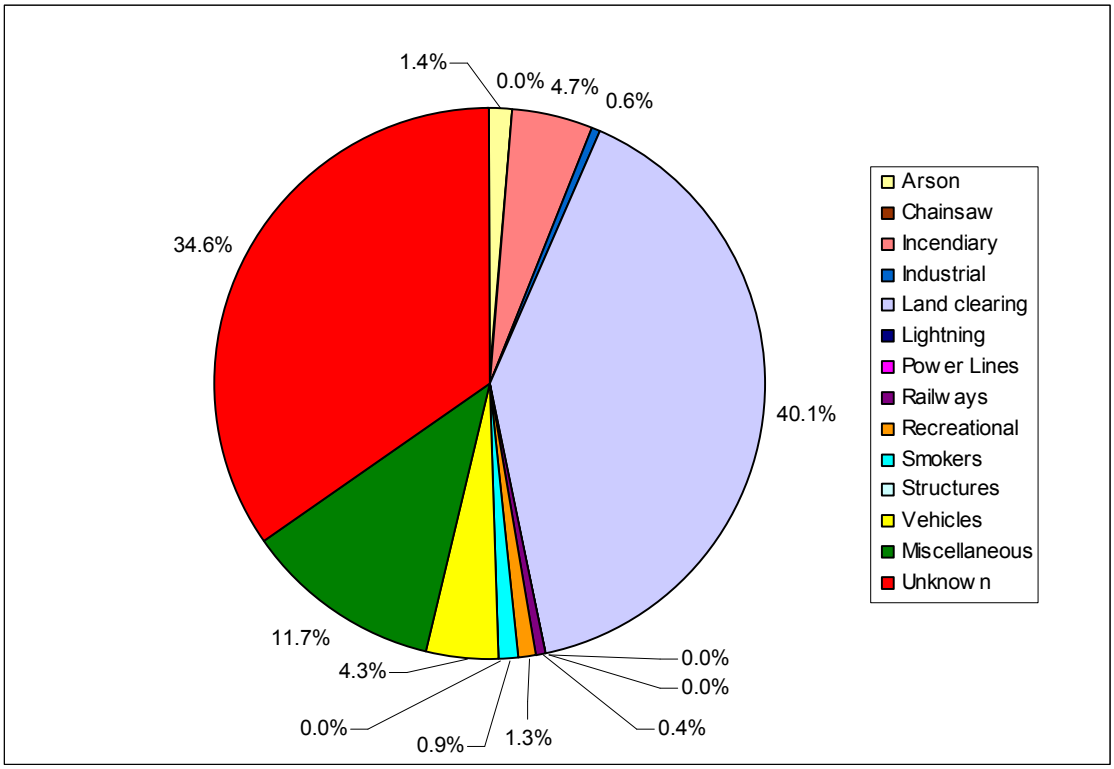


Figure N9. Northland average total annual grass area burned by cause from 1991/92 to 2006/07.

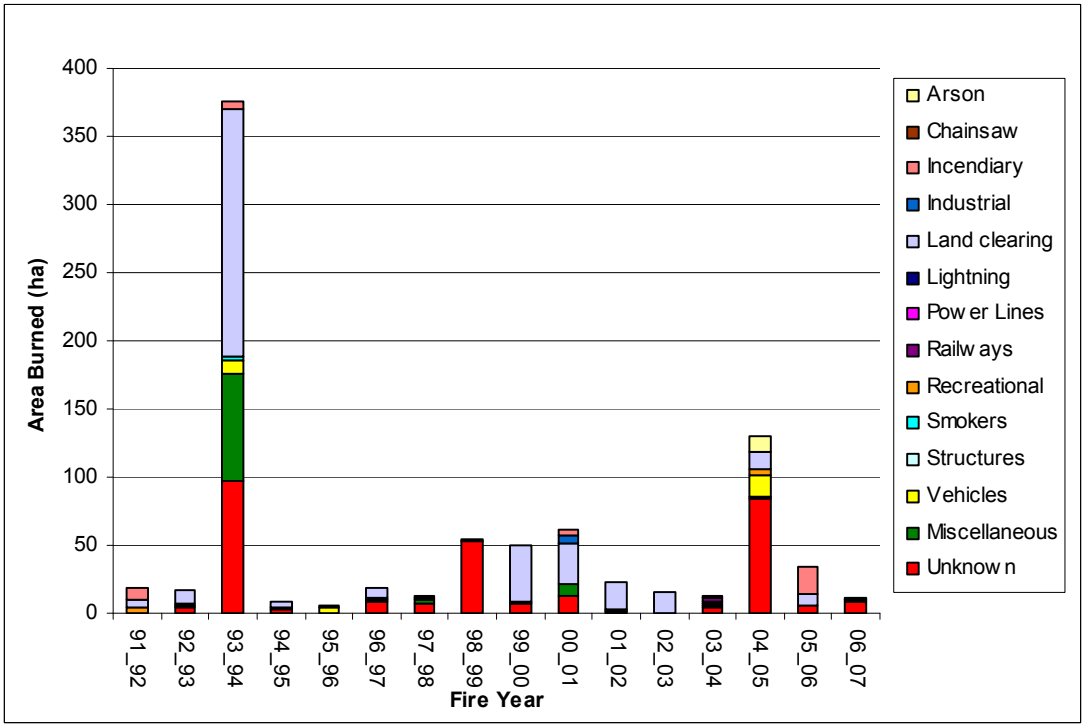


Figure N10. Northland total annual grass area burned by cause from 1991/92 to 2006/07.

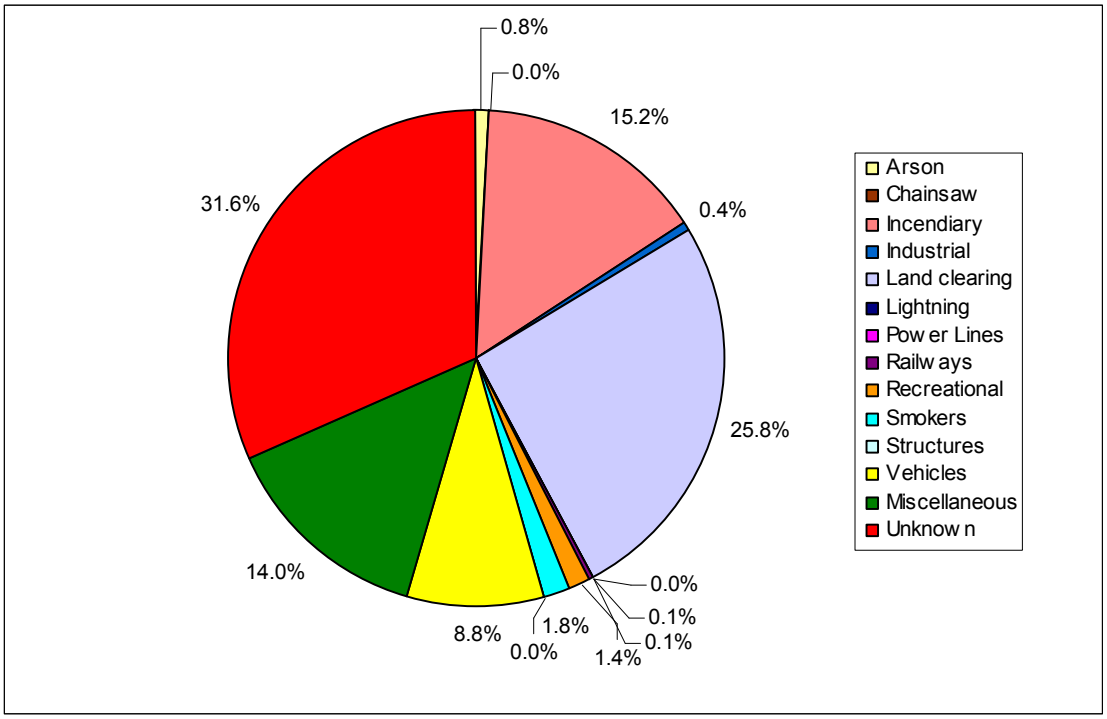


Figure N11. Northland average total scrub area burned by cause from 1991/92 to 2006/07.

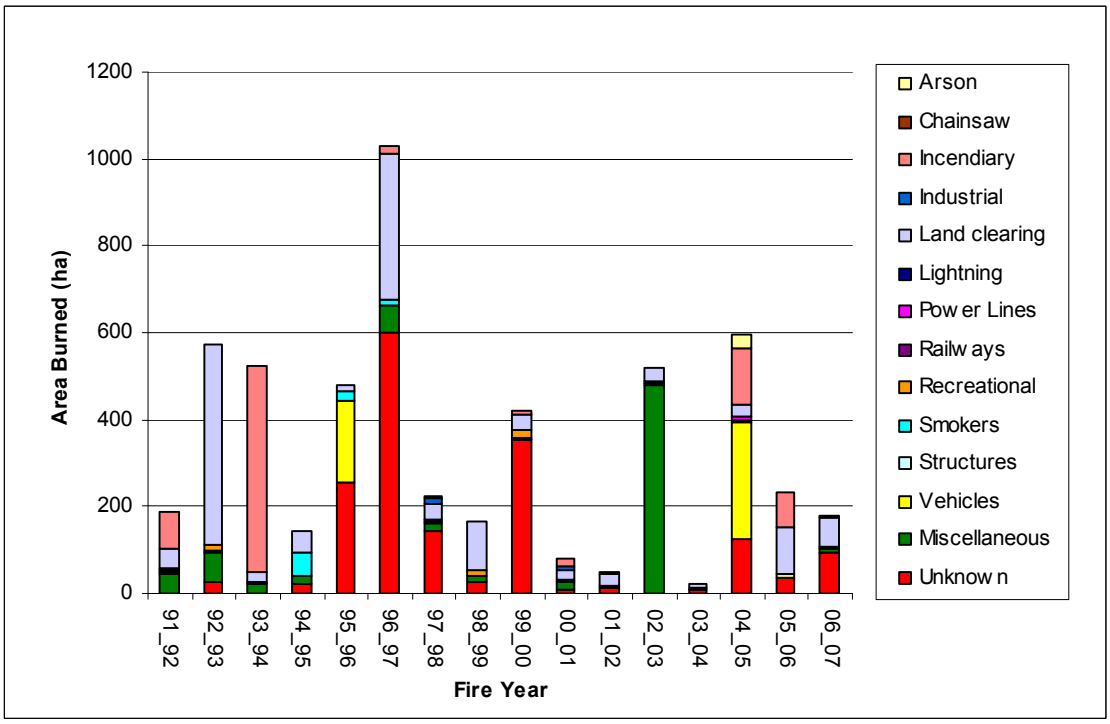


Figure N12. Northland total annual scrub area burned by cause from 1991/92 to 2006/07.

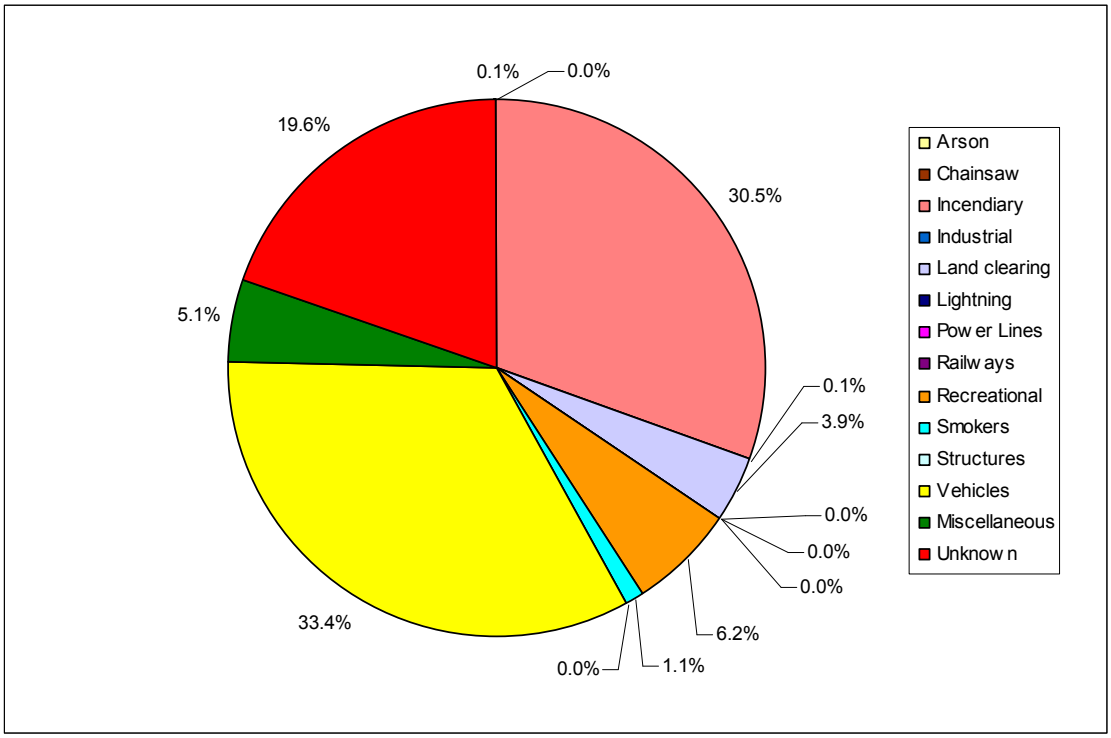


Figure N13. Northland average total forest area burned by cause from 1991/92 to 2006/07.

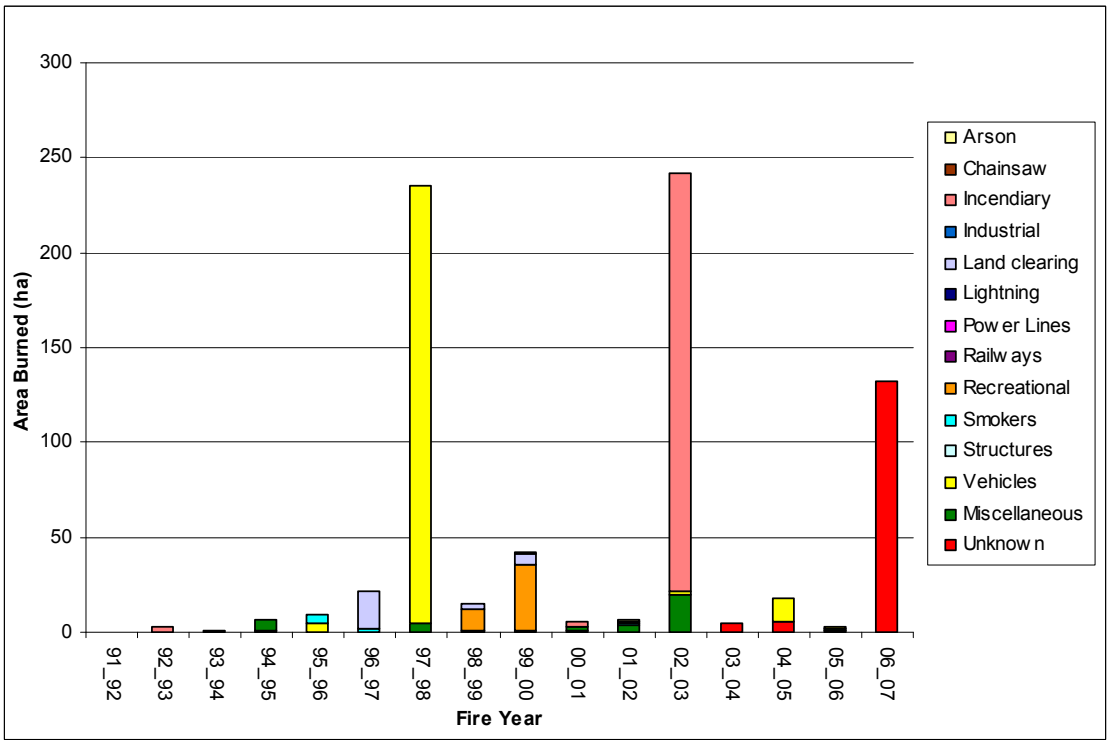


Figure N14. Northland annual total forest area burned by cause from 1991/92 to 2006/07.

Appendix C2 Auckland Region Fire Returns 1991/92 to 2006/07

Number of Fires (Figure A1):

- From 1991/92 to 2006/07, Auckland had on average about 270 fires annually or around 9% of the total national number of fires.
- Auckland varied from 30 (3% of the national) fires in 1992/93 to 572 (26% of the national) in 1993/94.
- The total number of fires for Auckland varied greatly (R^2= 0.0002) but did not display a clear statistically significant directional trend (linear regression: F-value = 0.01; P-value = 0.93). In addition, Auckland total number of fires does not significantly correlate with the national increasing trend (Same slope as above; correlation coefficient = 0.241; P-value =0.368).

Area Burned (Figure A2):

- The average annual total area burned for Auckland was 57 ha (around 1% of the national).
- Total annual area burned over time varied considerably from around 14 ha (0.3% of national) in 1995/96 to around 280 ha (4% of national) in 1993/94 (Figure A2).
- The total area burned for Auckland showed a statistically significant decreasing trend over time (linear regression: R^2 = 0.29; F-value = 5.89; P-value = 0.03).

Number of Fires by Cause (Figures A3 and A4):

- On average around 27% (average 74 annually) of the Auckland fires were attributed to vehicles.
- Around 31% (average 82 annually) were classed as miscellaneous; 12% unknown (average of 33 fires annually); combined these 'unspecified' cause fires were 45%.
- Around 14% of fires (average of 37 fires annually) were classed as land clearing.
- Around 7% (average of just 19 annually) of Auckland's fires were attributed to incendiary.
- Fires from unknown, miscellaneous and vehicle causes made up the bulk of the reported total number of fires for most years studied for Auckland.

Area Burned by Fuel type (Figures A5 and A6):

- Around 62% of Auckland's total area burned over the study period was scrub. Average annual total scrub area burned was around 35 ha (2% of national).
- Around 30% of Auckland's total area burned was classed as grass; average annual grass area burned was 21 ha (1% of national).
- Around 3% of Auckland's total area burned was forest; average annual forest area burned was 2 ha (1% of national).
- Compared with other regions Auckland's area burned is relatively small, total area burned from 1991/92 to 2006/07 never exceeded 300 ha. The largest annual area burned occurred in 1993/94 and 2002/03.

Area Burned by Cause (Figures A7 and A8):

- Incendiary accounted for around 16% of the Auckland total area burned (annual average of just 9 ha).
- Land clearing accounted for around 39% of the Auckland total area burned (annual average of 22 ha).
- The total area burned classed as miscellaneous was around 25% (annual average of 14 ha); area burned classed as unknown made up around 11% (annual average of just 6 ha).

Area Burned by Cause and Fuel type (Figures A9, A10, A11, A12, A13, and A14):

- Land clearing accounted for just under 50% of the average grass area burned (annual average 10 ha).
- Unknown and miscellaneous each accounted for around 17% (annual average just 3 ha) of grass area burned.
- The largest grass area burned for a single cause was 90 ha attributed to land clearing in 1993/94. Compared to other regions, Auckland's total annual grass area burned is low (less than 200 ha).
- Land clearing accounted for around 34% of average scrub area burned from 1991/92 to 2006/07 (average annual just 12 ha).
- Incendiary accounted for about 20% of the average scrub area burned (annual average of 8 ha).
- Miscellaneous accounted for 29% (annual average 10 ha); unknown accounted for around 8% of the average total scrub area burned 1991/92 to 2006/07 (annual average just 3 ha).
- The largest total scrub areas burned for single causes occurred in 1991/92 (miscellaneous 100 ha), 1993/94 (land clearing 74 ha incendiary 68 ha).
- The annual forest area burned was less than 10 ha. Very little meaningful conclusions with relation to cause can be draw from an area burned so low.

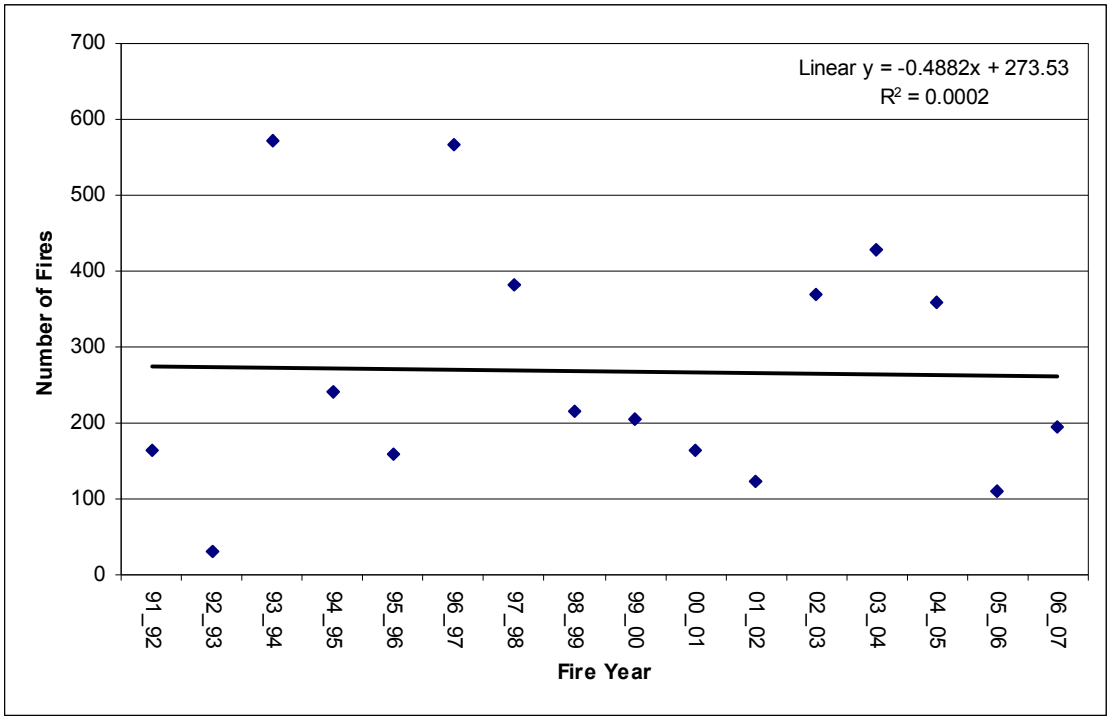


Figure A1. Auckland total annual number of fires from 1991/92 to 2006/07.

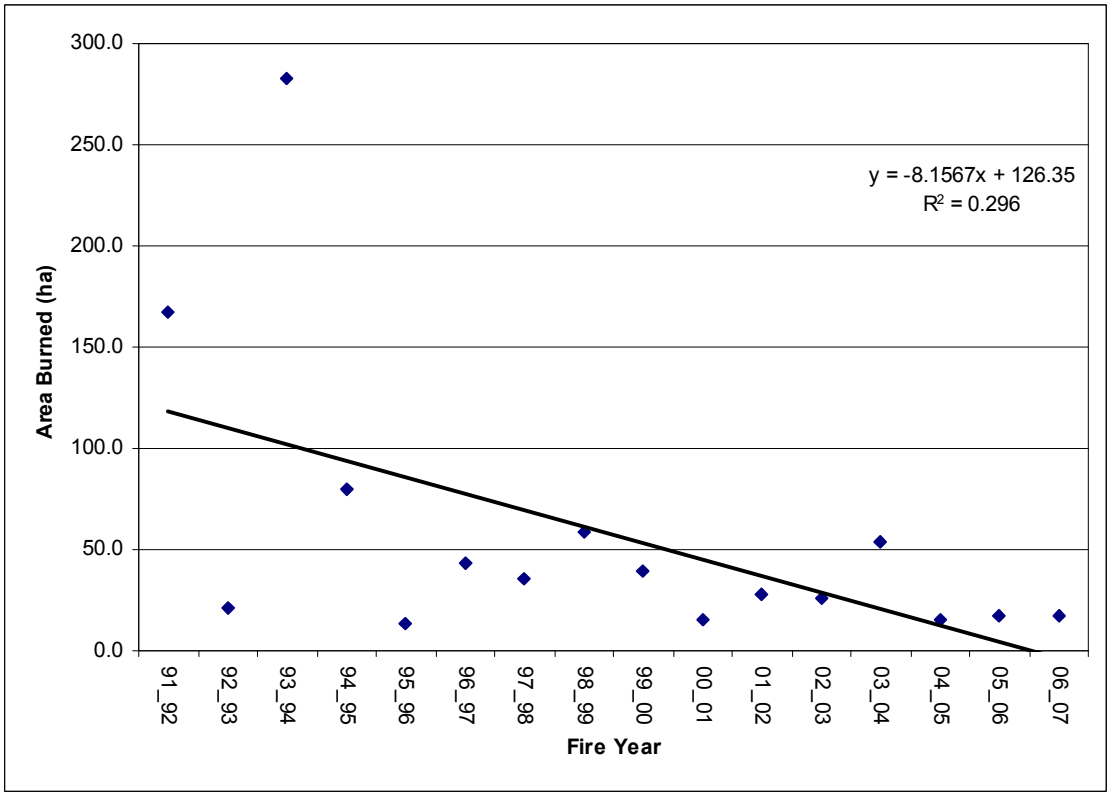


Figure A2. Auckland total annual area burned from 1991/92 to 2006/07.

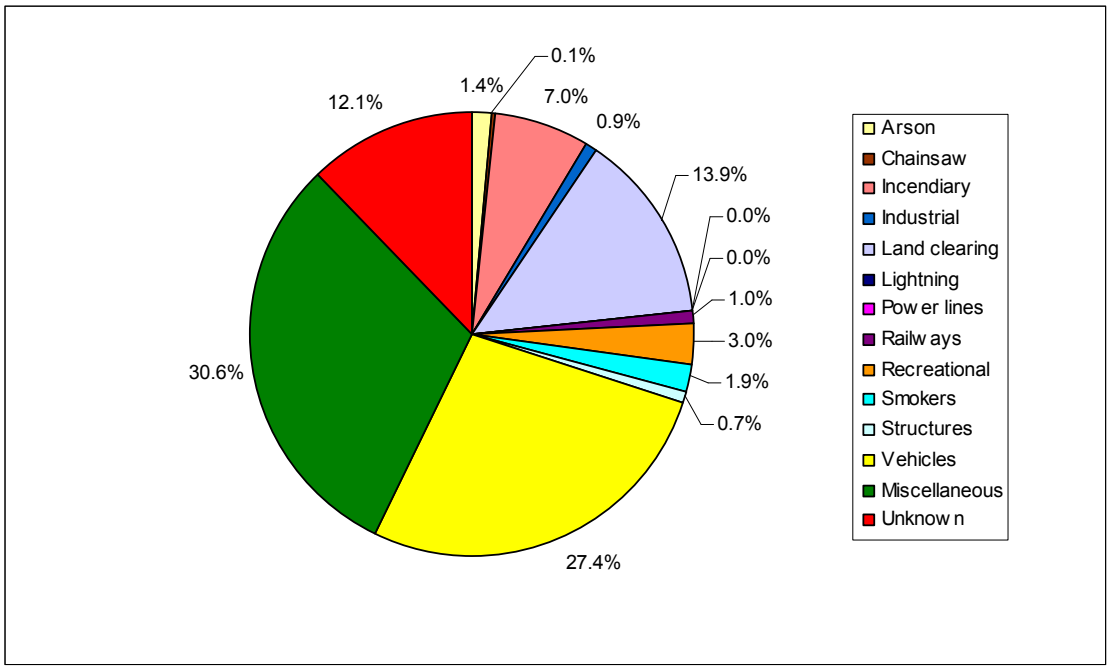


Figure A3. Auckland total number of fires by cause from 1991/92 to 2006/07.

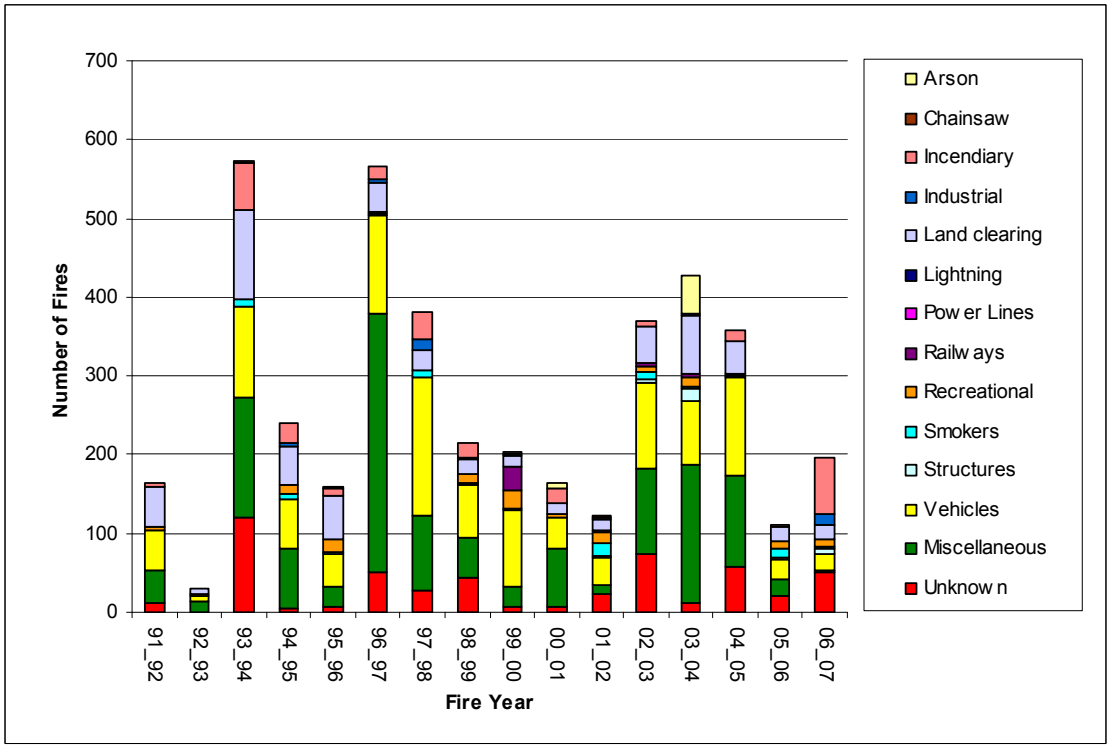


Figure A4. Auckland total number of fires by cause from 1991/92 to 2006/07.

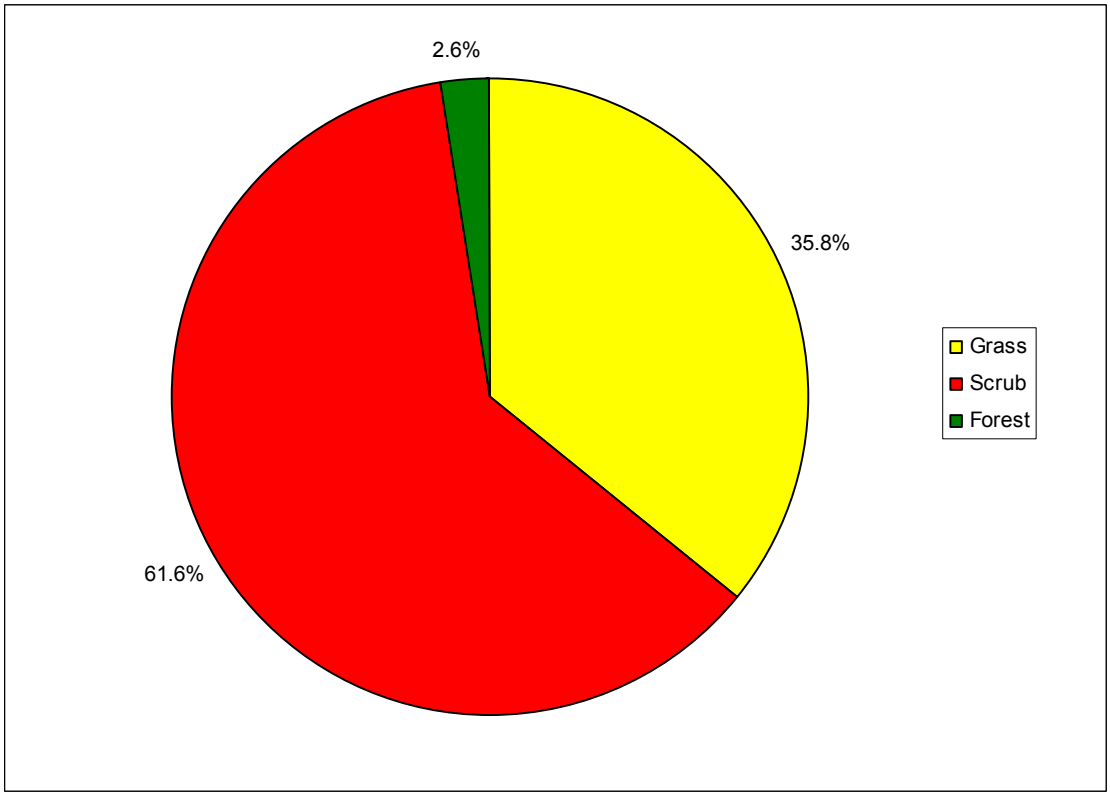


Figure A5. Auckland total area burned by fuel type from 1991/92 to 2006/07.

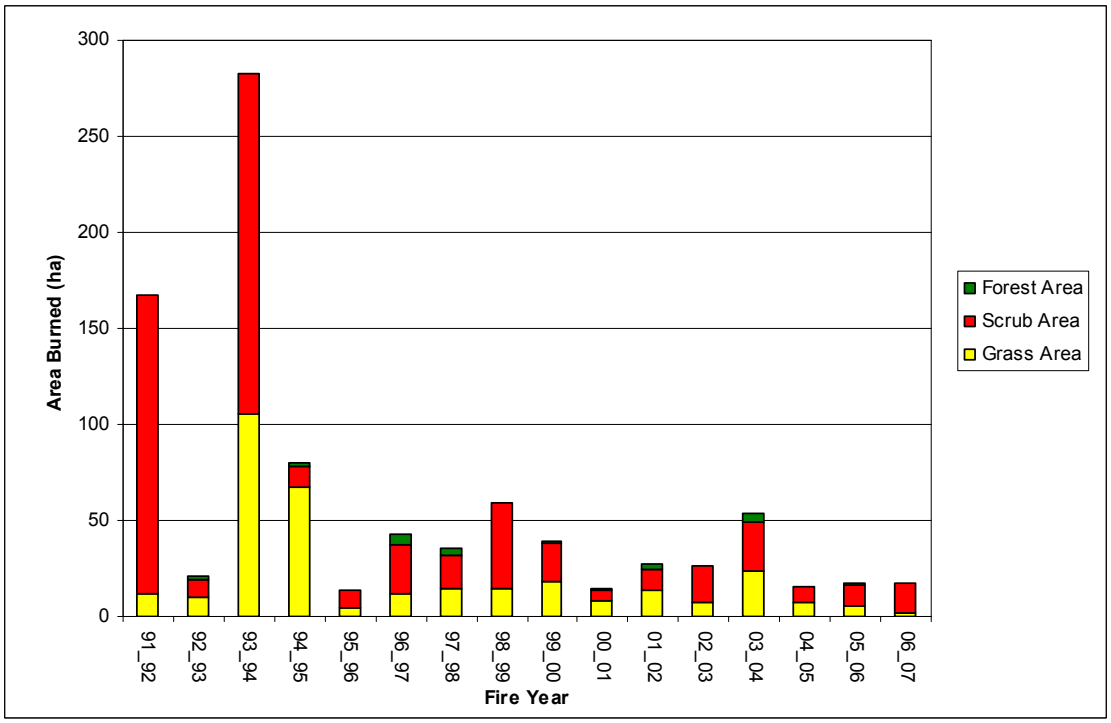


Figure A6. Auckland total area burned by fuel type from 1991/92 to 2006/07.

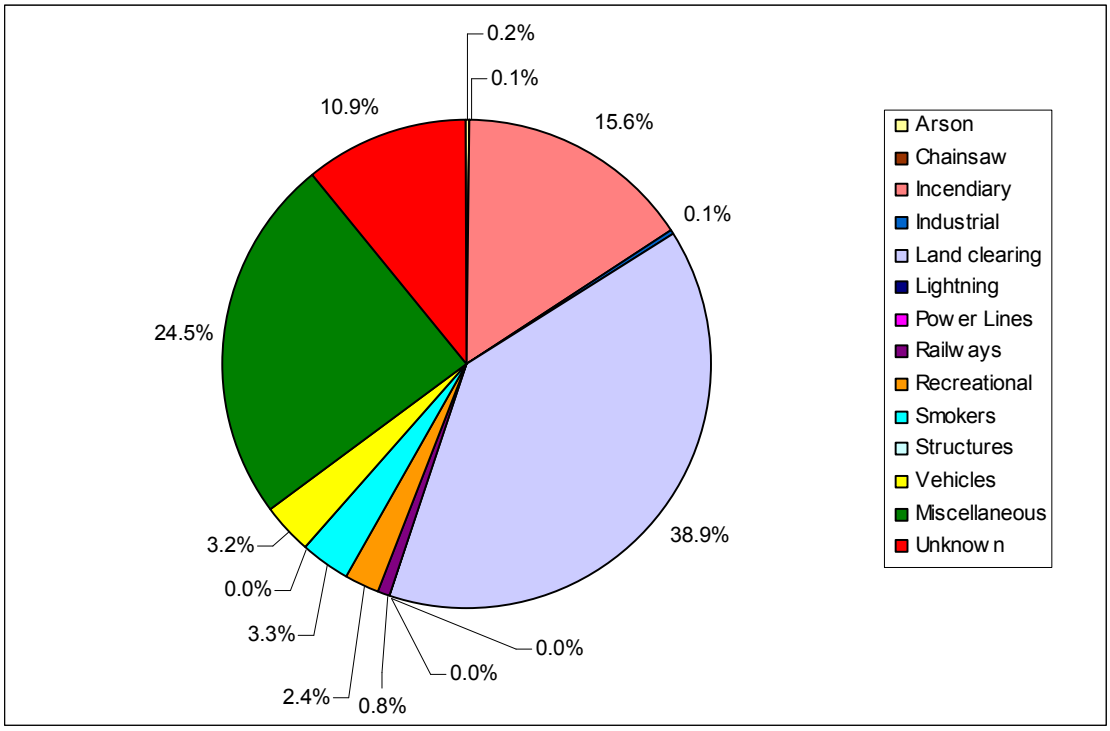


Figure A7. Auckland total area burned by cause from 1991/92 to 2006/07.

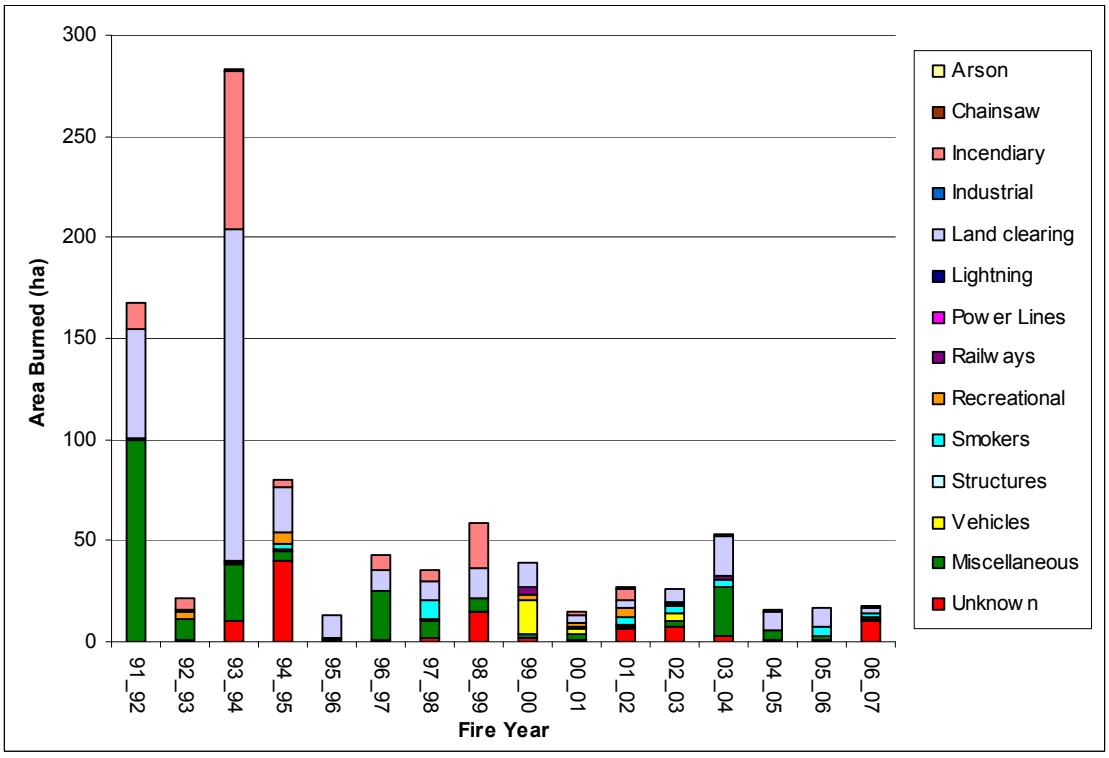


Figure A8 .Auckland total area burned by cause 1991/92 to 2006/07.

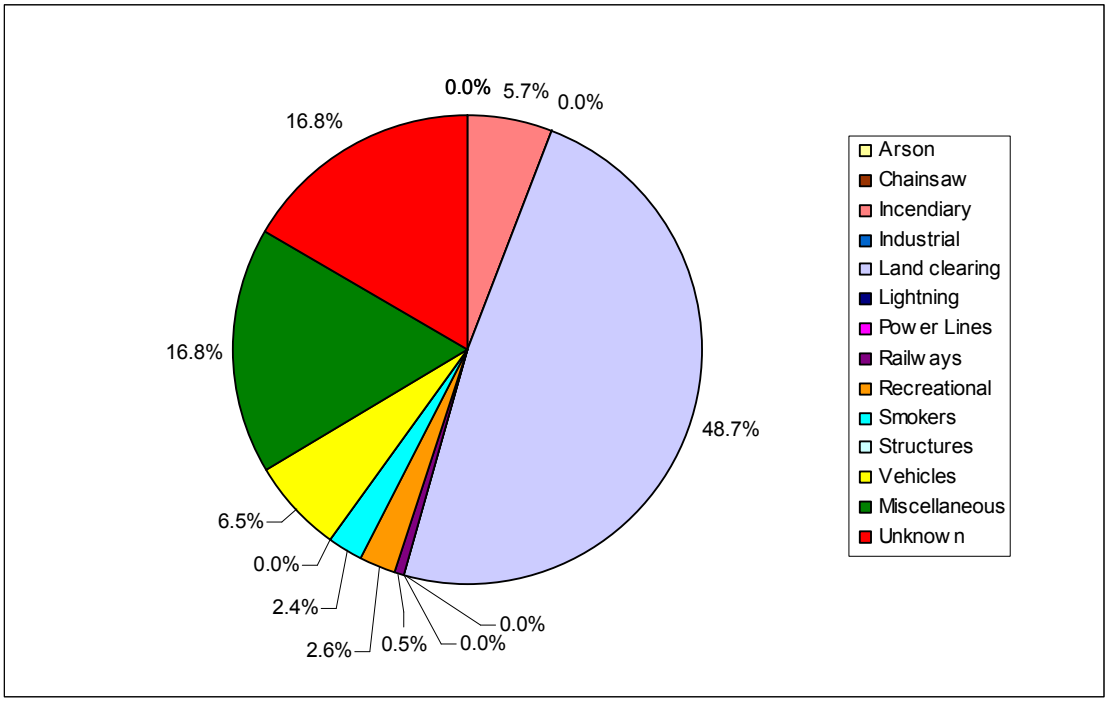


Figure A9. Auckland average total grass area burned by cause from 1991/92 to 2006/07.

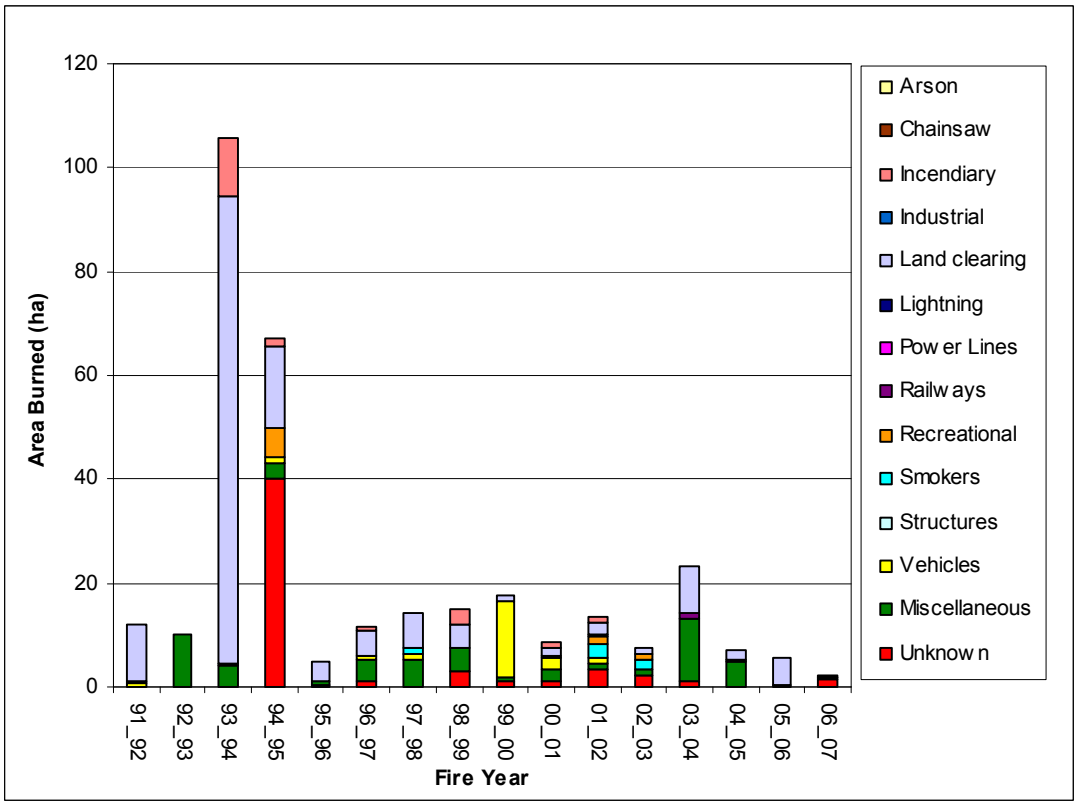


Figure A10. Auckland total grass area burned by cause from 1991/92 to 2006/07.

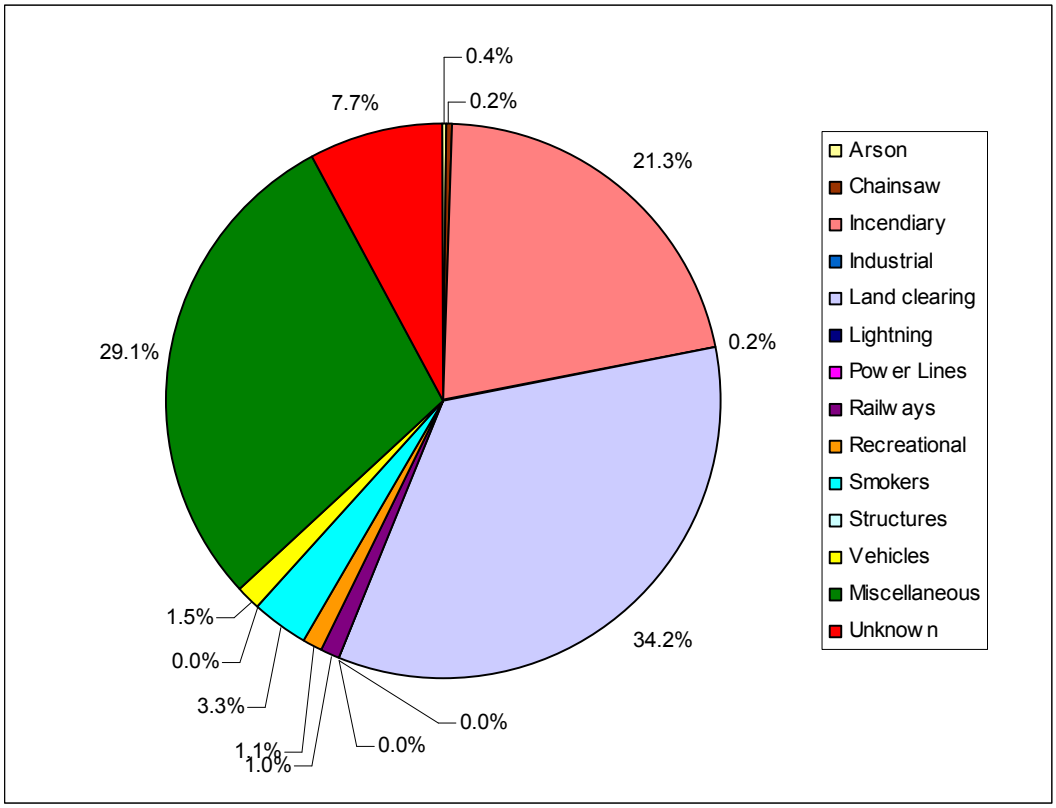


Figure A11. Auckland average total scrub area burned by cause from 1991/92 to 2006/07.

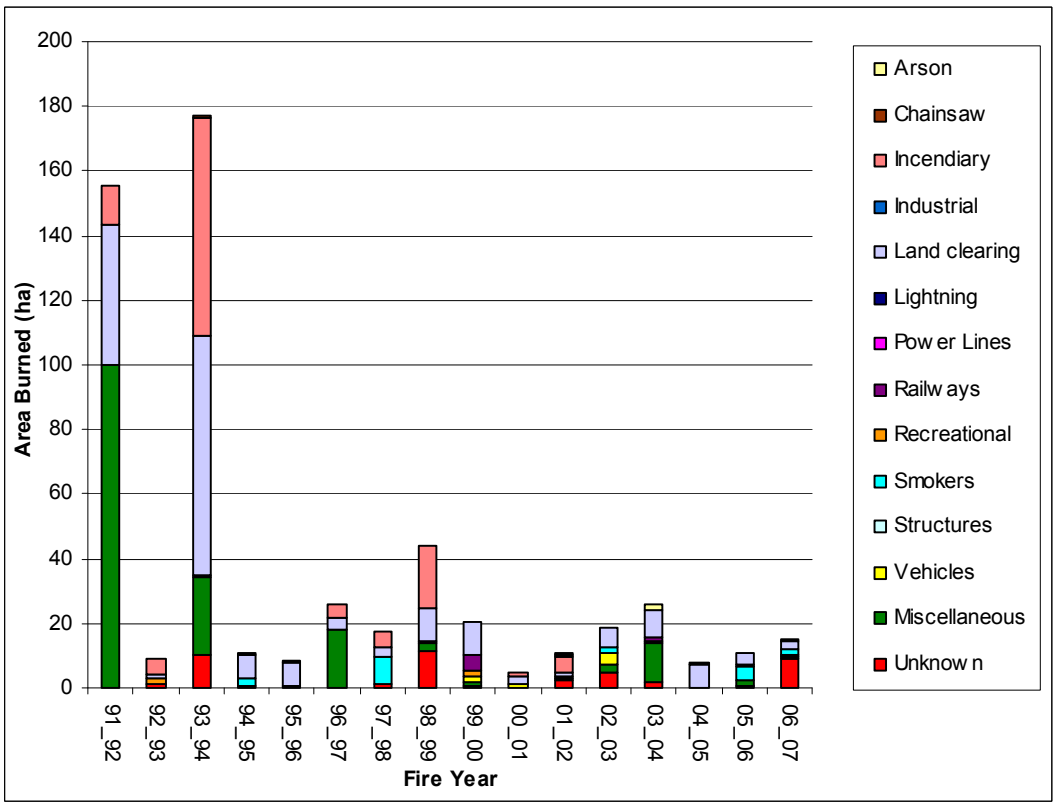


Figure A12. Auckland total scrub area burned by cause from 1991/92 to 2006/07.

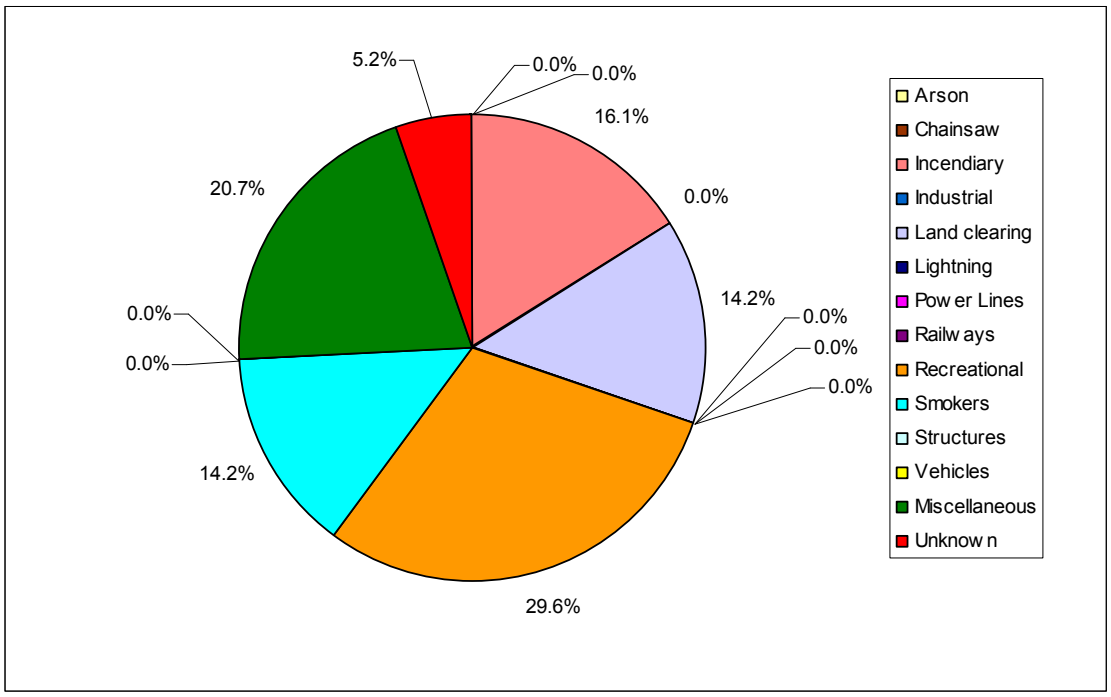


Figure A13. Auckland average total forest area burned by cause from 1991/92 to 2006/07.

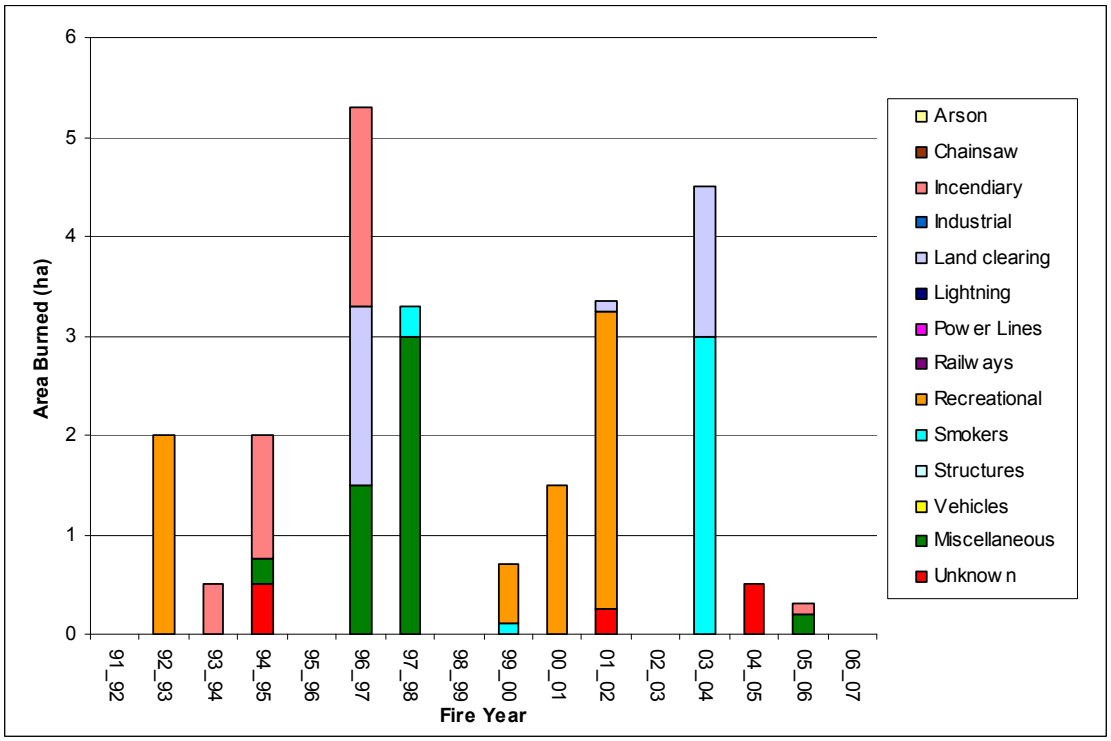


Figure A14. Auckland total forest area burned by cause from 1991/92 to 2006/07.

Appendix C3 Waikato Region Fire Returns 1991/92 to 2006/07

Number of Fires (Figure W1):

- From 1991/92 to 2006/07 Waikato had on average 316 wildfires annually or around 10% of the total national annual number of fires.
- The number of wildfires in Waikato varied between 93 fires (9% of national) in 1992/93 and 537 fires (22% of national) in 1994/95.
- The total number of fires for Waikato did not significantly increase or decrease over time (Linear regression: $R^2 = 0.091$; F-value = 1.4; P-value = 0.256). Waikato's number of fires did not significantly correlate with the increasing trend over time seen nationally as a whole (correlation coefficient = 0.463; P-value = 0.071).

Area Burned (Figure W2):

- The average annual total area burned for Waikato (1991/92 to 2006/07) was 64 ha (around 1% of the national).
- Total area burned varied from just 13 ha (0.2% of national) in 2003/04 to 178 ha (4% of national) in 2005/06.
- The total area burned for Waikato shows no statistically significant trend (linear regression: $R^2 = 0.0979$; F-value = 1.52; P-value = 0.238).

Number of Fires by Cause (Figures W3 and W4):

- On average 31% (average annually of 96 fires) of the Waikato were attributed to vehicles.
- Land clearing made up, on average, 14% (45 on average annually) of the number of fires.
- Around 28% of fires on average were attributed to miscellaneous causes (average annually of 87 fires); around 20% of fires were listed in the unknown (annual average around 65 fires); combined 'non-specified' (unknown and miscellaneous) Waikato fires were 48%.
- Considerable variation is seen over time in the number of fires attributed to miscellaneous and unknown

Area Burned by Fuel Type (Figures W5 and W6):

- Over 60% of the total area burned for Waikato, was scrub; Waikato had an average total annual scrub area burned of 39 ha (2% of national).
- Around 25% of the total area burned for Waikato was grassland; average annual total grass area burned for Waikato was 23 ha (about 2% of national).
- Of the total area burned for Waikato, 4% was forest; average annual total forest area burned for Waikato was 2 ha (0.6% of national).
- Most of the forest area burned for the study period (around 30 ha) occurred in 2002/03.

Area Burned by Cause (Figures W7 and W8):

- While land clearing made up, on average, only 14% of the number of fires, land clearing accounted for 41% of the average total area burned.
- Around 20% (12 ha) of the average annual total area burned was attributed to unknown causes; 17% (11 ha) of the average annual total area burned was attributed to miscellaneous; combined unspecified average annual total area burned was 37%.
- However, the annual total area burned for Waikato was small compared to other regions. The largest total area burned was just under 180ha in 2005/06.

Area Burned by Cause and Fuel Type (Figures W9 and W10):

- Around 55% of the average annual total grass area burned was attributed to land clearing (annual average of 12 ha).
- The large proportion of average grass area burned was due to two relatively large grass area burned due to land clearing in 2005/06 and 2006/07.
- Miscellaneous accounted for around 13% of the average annual grass area burned (annual average of around 3 ha); unknown was 14% (annual average of 3 ha); combined unspecified 26%.
- Vehicle fires accounted for another 13% (annual average of 3 ha) of the average annual total grass area burned 1991/92 to 2006/07.
- On average 30% (annual actual average 12ha) of Waikato scrub area burned was attributed to land clearing.
- Around 25% of the average annual total scrub area burned was due to unknown causes (annual actual average was around 9 ha); 20% was attributed to miscellaneous causes (actual average 8 ha); combined 'non-specified' 45%.
- Unlike many other regions, recreational causes accounted for 13% (actual per year average 5ha) of the average annual total scrub area burned.
- The causes of the annual total scrub area burned in Waikato varied considerably from year to year, and trends in individual causes were difficult to assess.
- The average total forest area burned by cause illustrates the importance individual years, 92% of the average annual total forest area burned was attributed to land clearing (actual just 2ha).

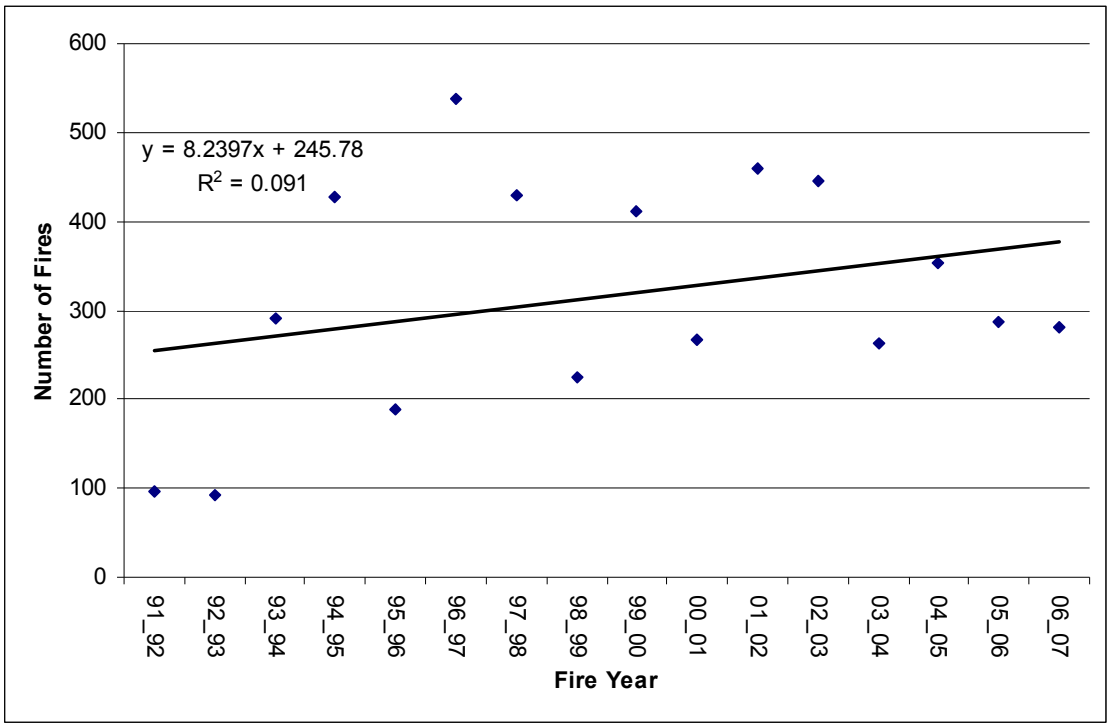


Figure W1. Waikato total number of fires from 1991/92 to 2006/07.

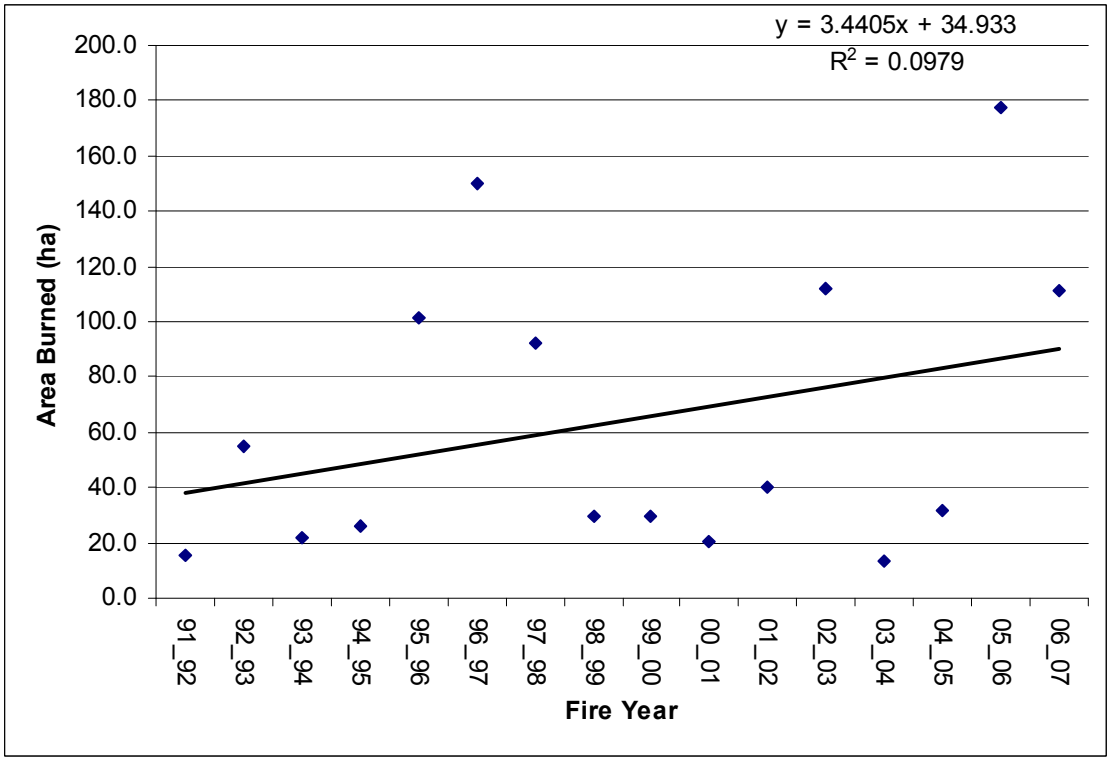


Figure W2. Waikato total area burned from 1991/92 to 2006/07.

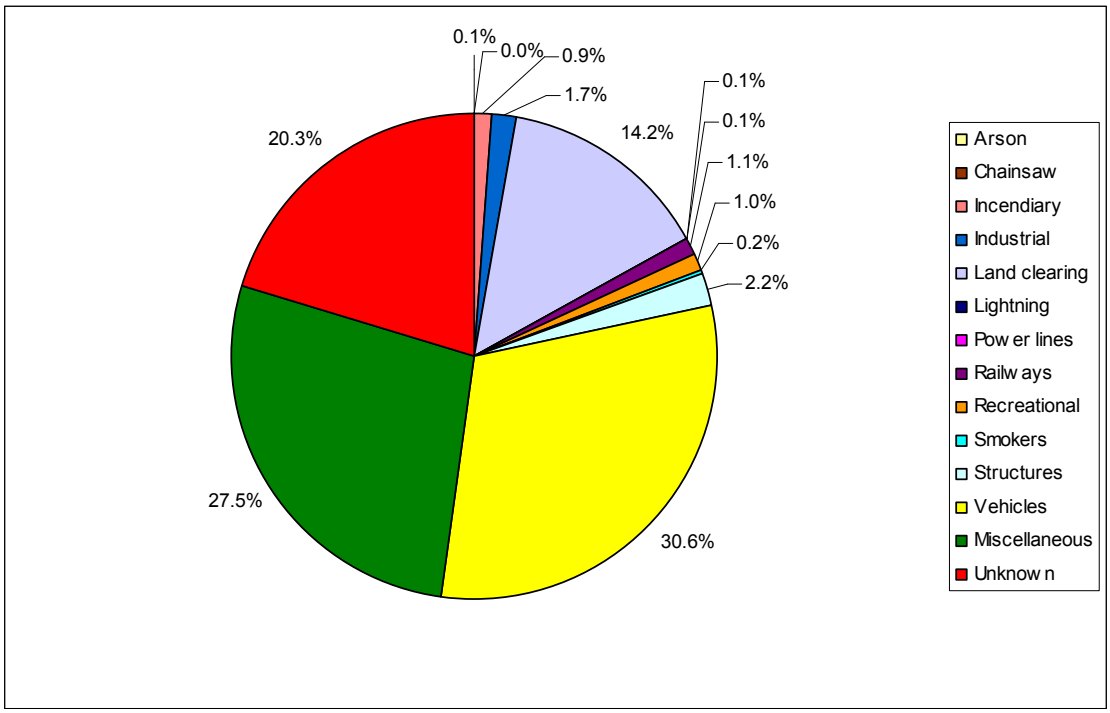


Figure W3. Waikato annual average total number of fires by cause from 1991/92 to 2006/07.

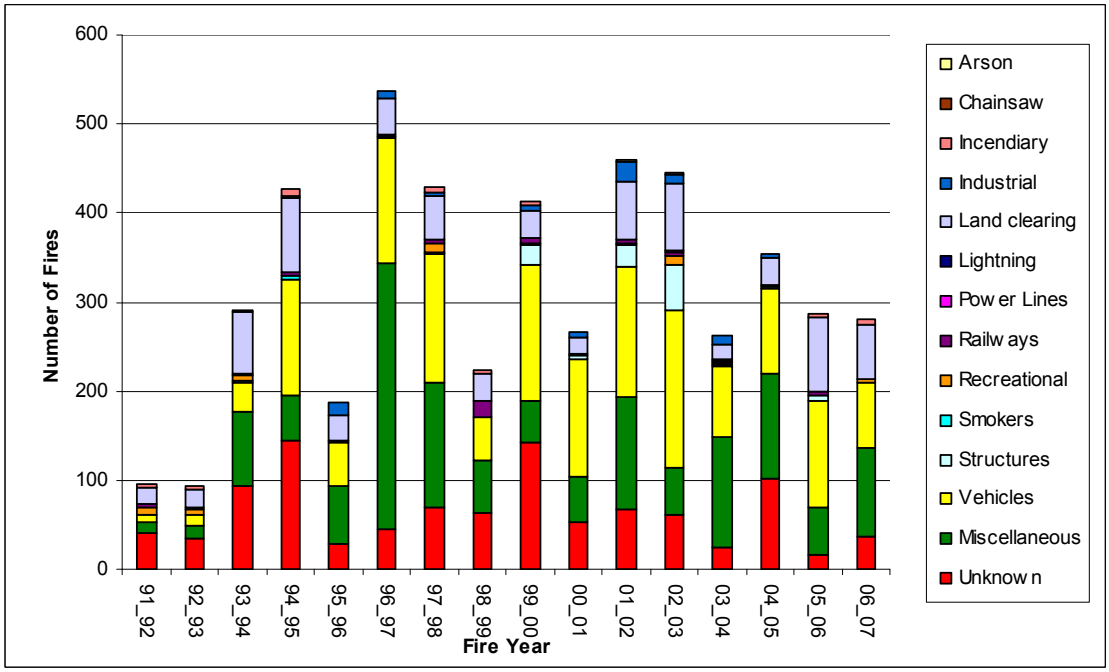


Figure W4. Waikato total number of fires by cause from 1991/92 to 2006/07.

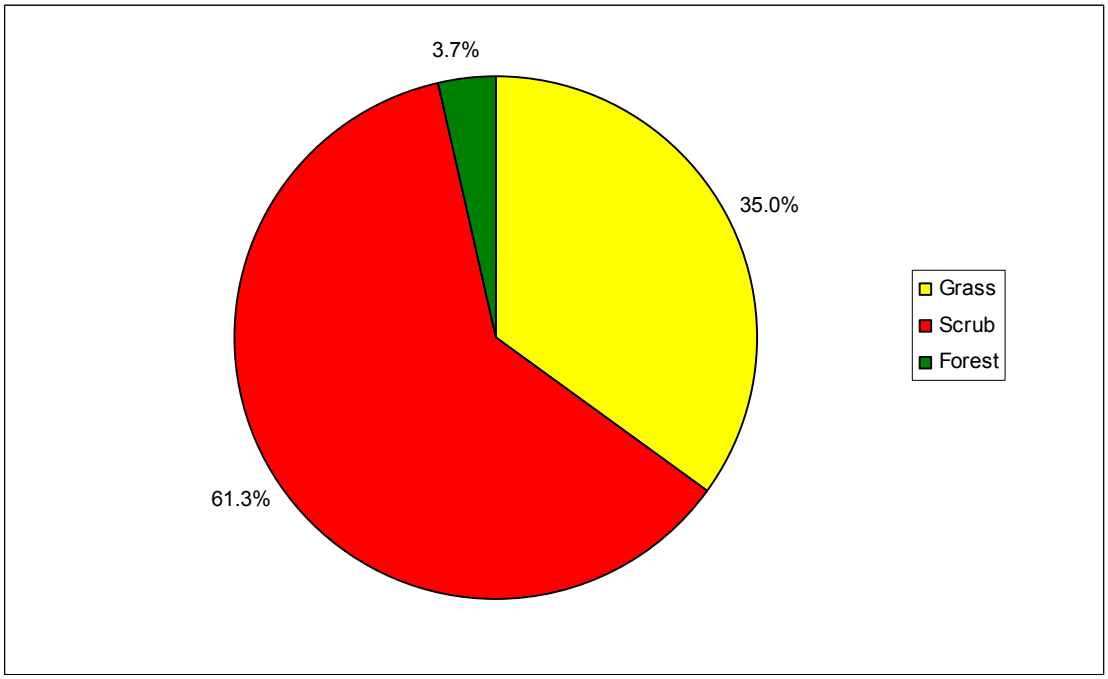


Figure W5. Waikato total area burned by fuel type from 1991/92 to 2006/07.

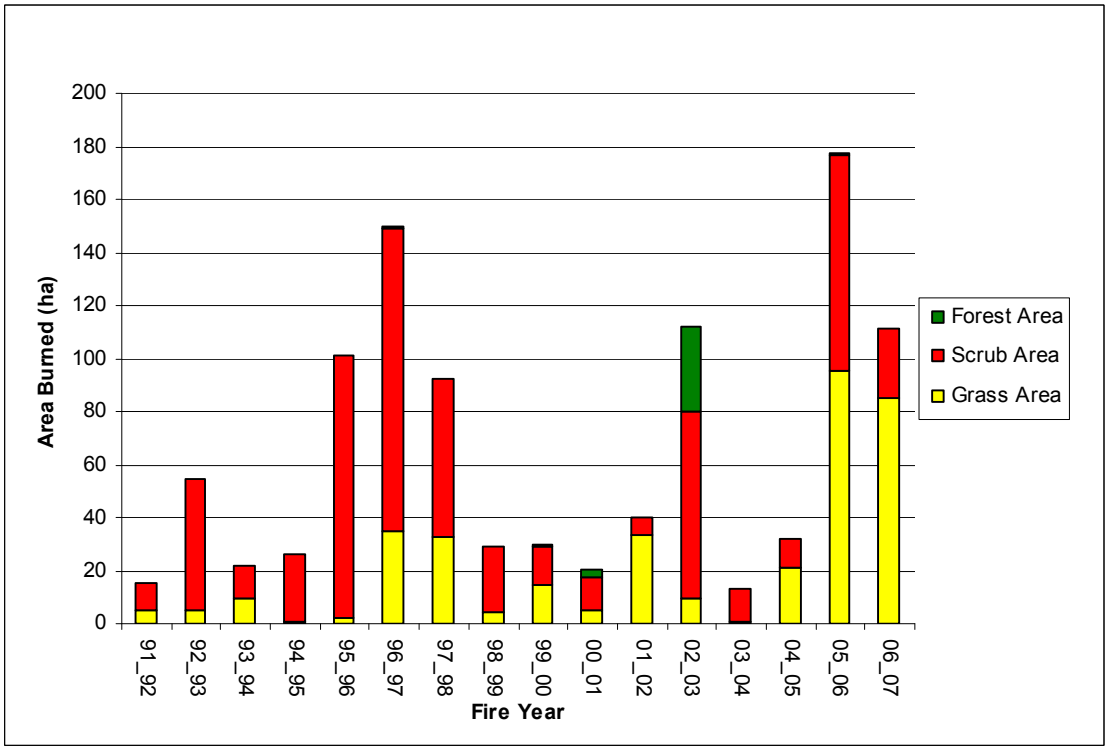


Figure W6. Waikato total area burned by fuel type from 1991/92 to 2006/07.

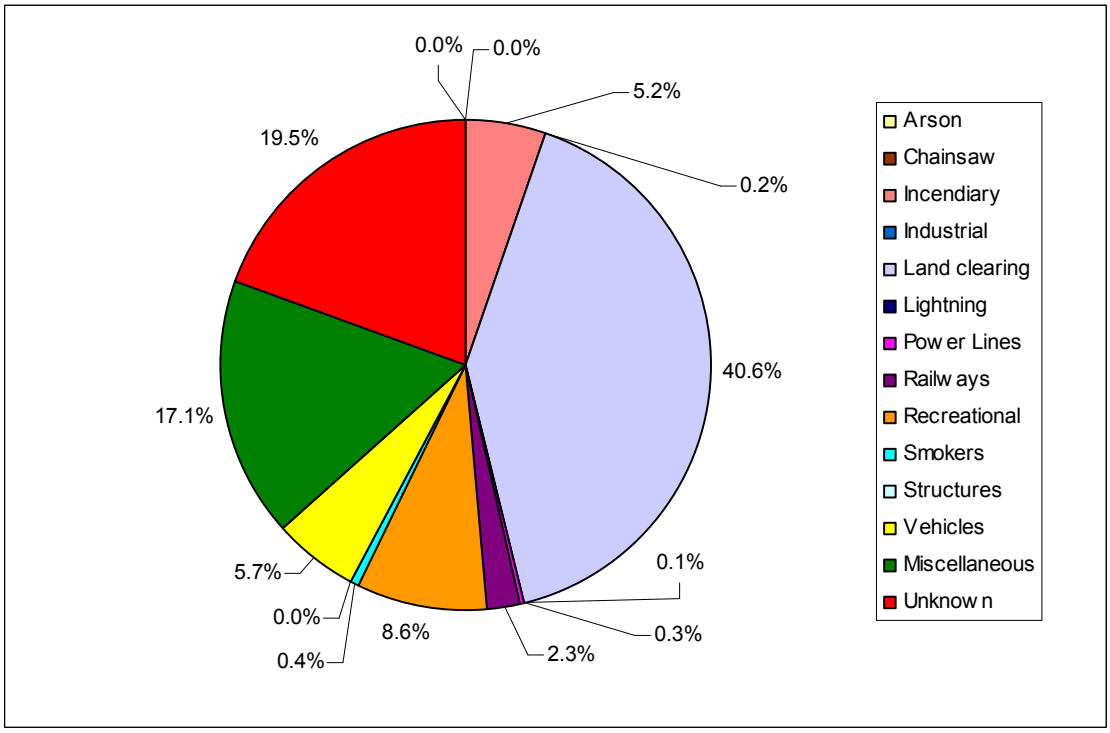


Figure W7. Waikato average annual total area burned by cause from 1991/92 to 2006/07.

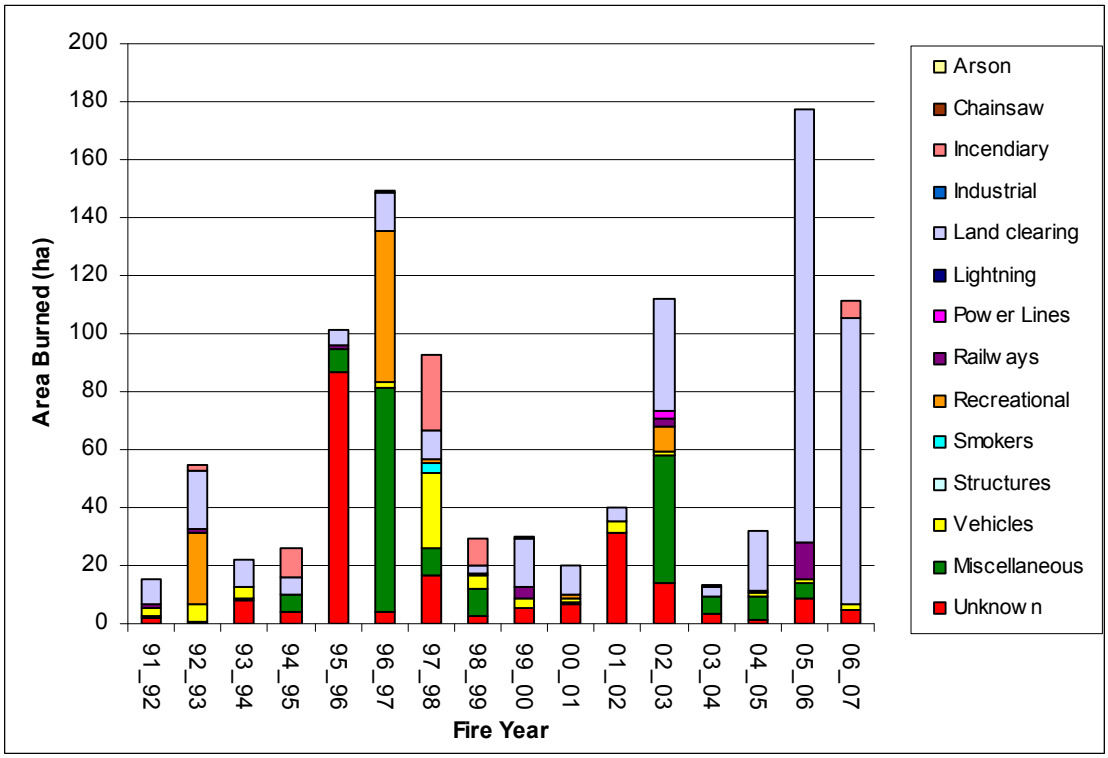


Figure W8. Waikato total area burned by cause from 1991/92 to 2006/07.

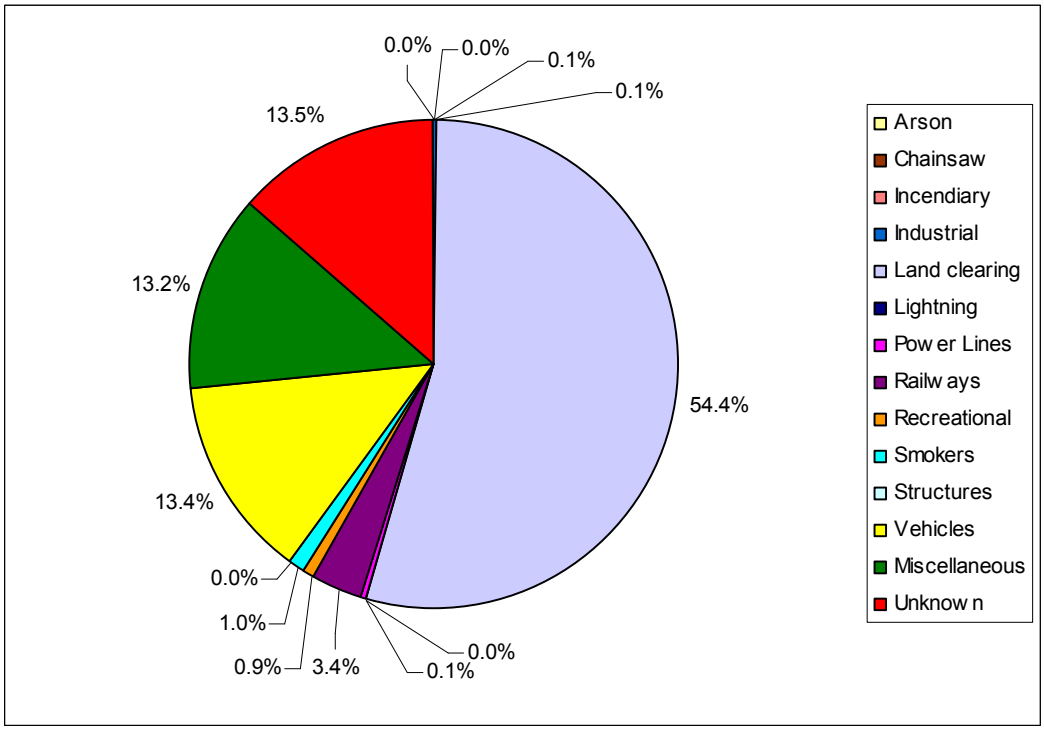


Figure W9. Waikato average annual grass area burned by cause from 1991/92 to 2006/07.

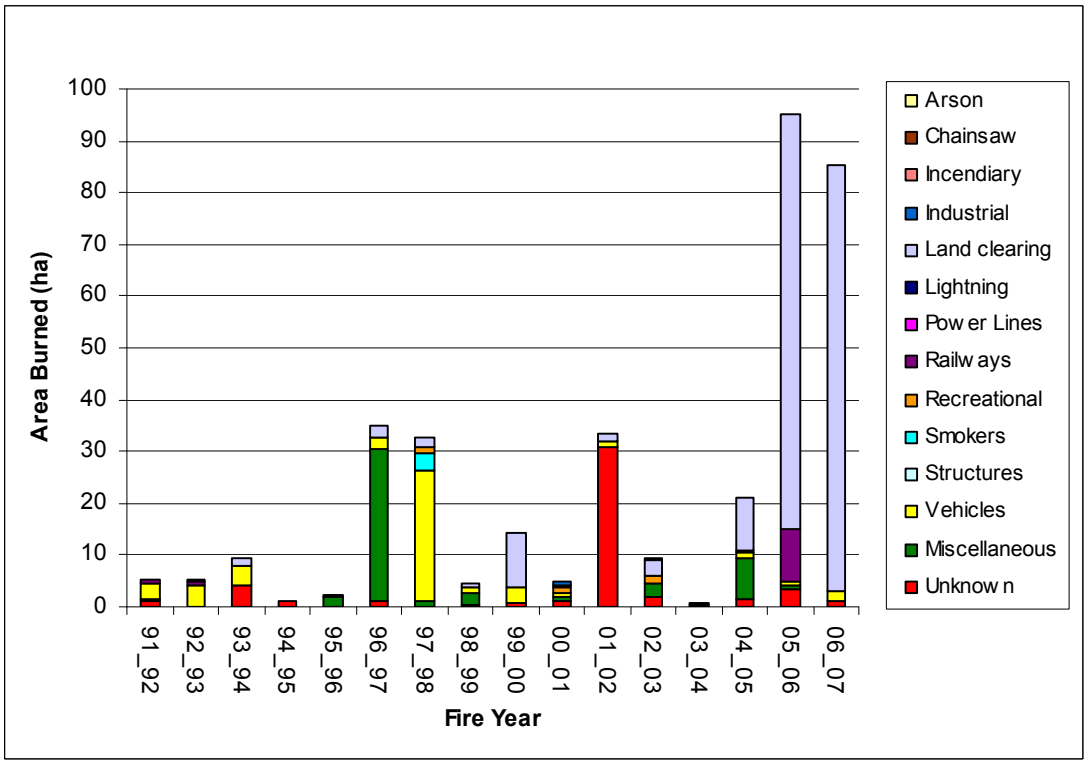


Figure W10. Waikato total grass area burned by cause from 1991/92 to 2006/07.

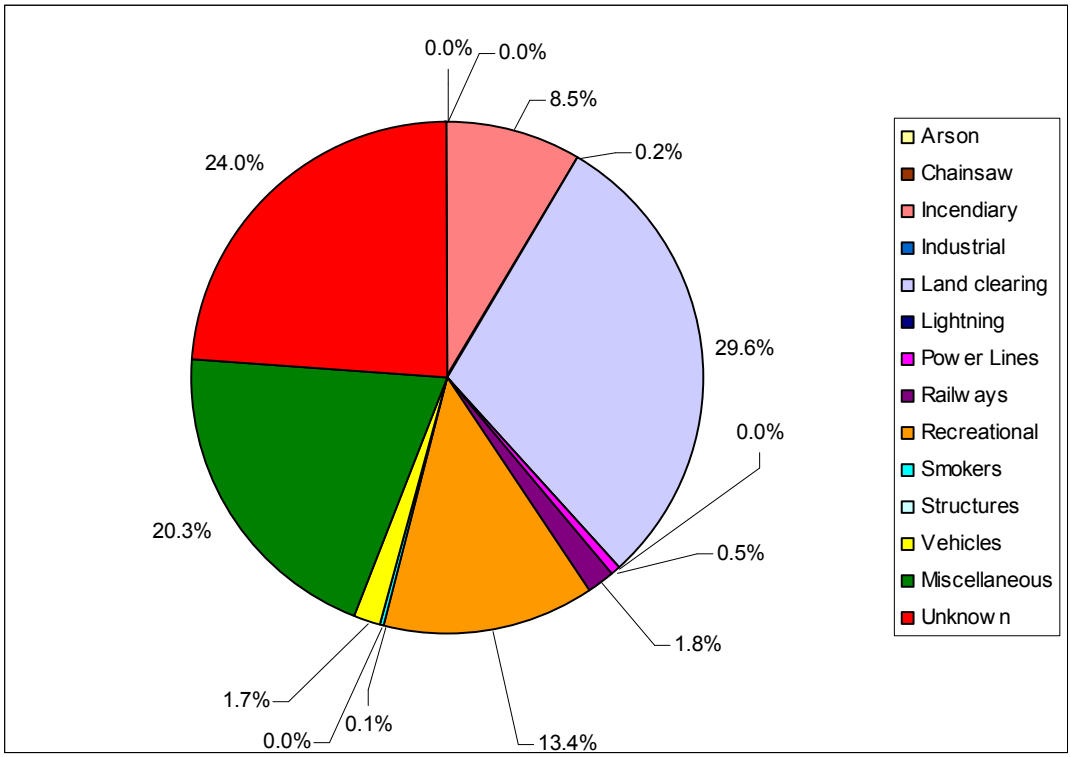


Figure W11. Waikato average annual total scrub area burned by cause from 1991/92 to 2006/07.

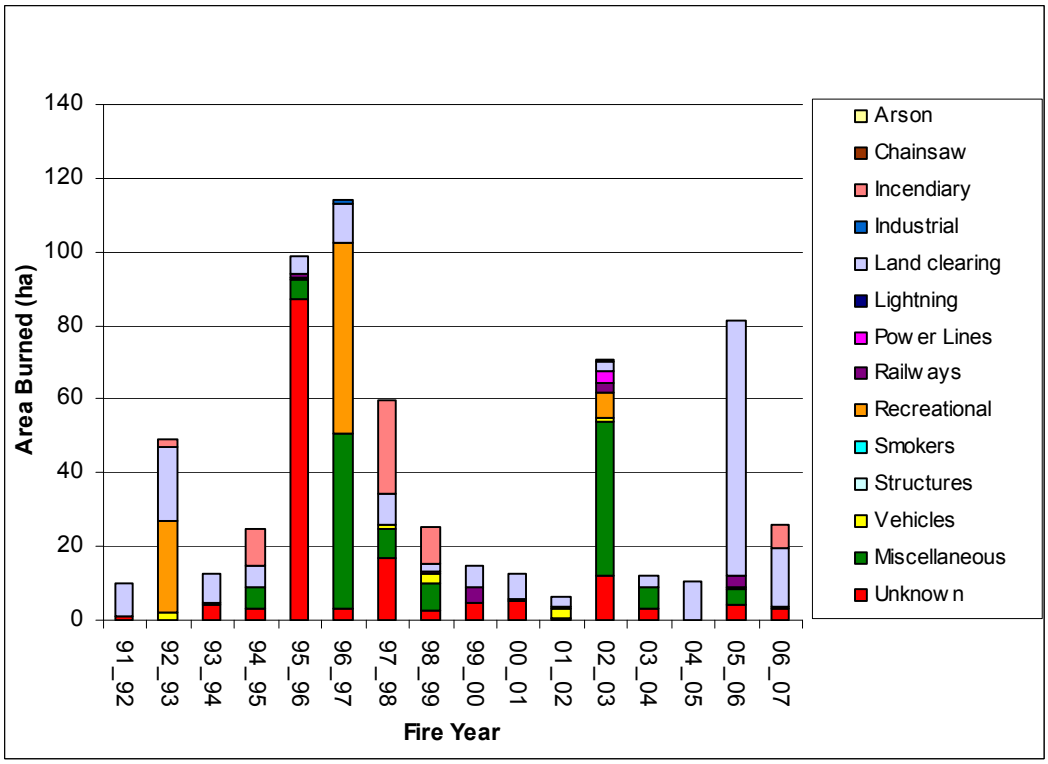


Figure W12. Waikato total scrub area burned by cause from 1991/92 to 2006/07.

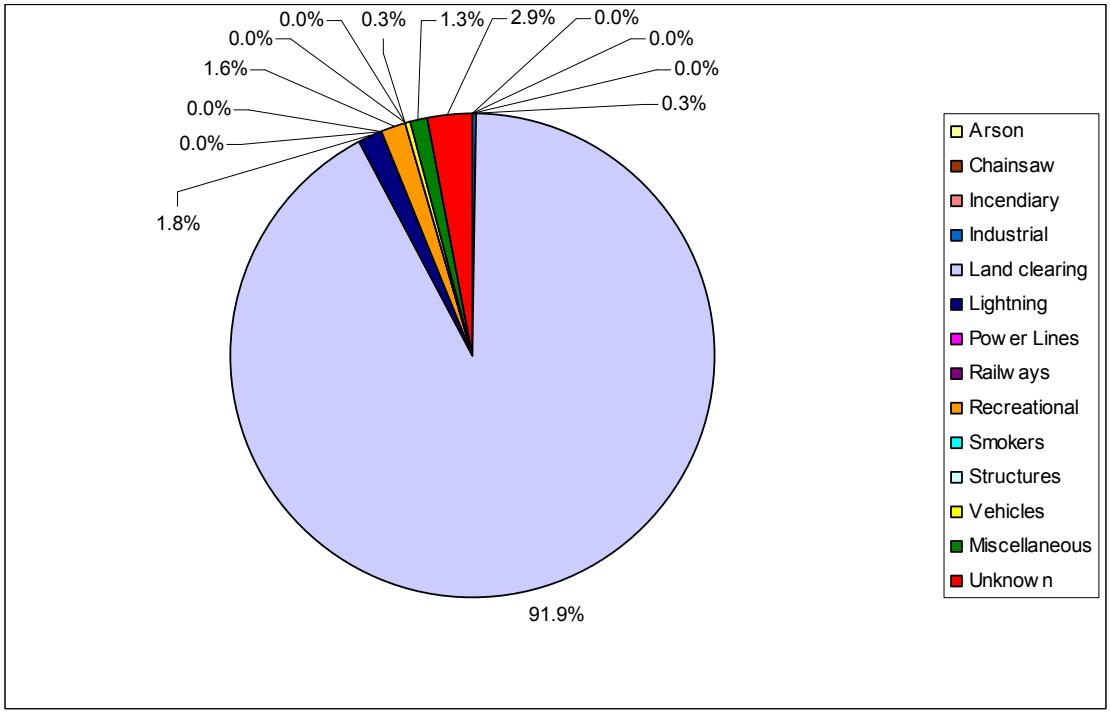


Figure W13. Waikato average total forest area burned by cause from 1991/92 to 2006/07.

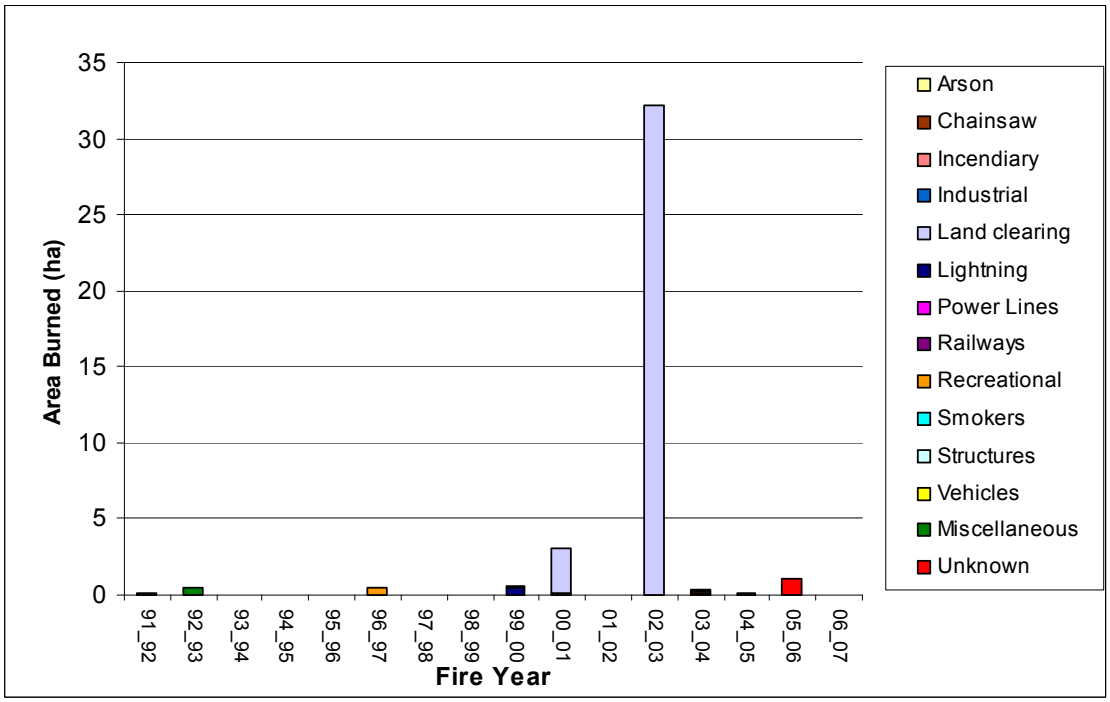


Figure W14. Waikato total forest area burned by cause from 1991/92 to 2006/07.

Appendix C4 Wanganui/Manawatu Regional Fire Returns 1991/92 to 2006/07

Number of Fires (Figure WM1):

- From 1991/92 to 2006/07 Wanganui/Manawatu annually averaged 253 fires, or about 8% of the national.
- Wanganui/Manawatu's total annual number of fires varied from just 86 fires (9% of national for that year) in 1992/93 to 412 (9% of national for that year) in 2004/05, proportionally similar for both years.
- The total number of fires for Wanganui/Manawatu shows a clear increase over time (Regression: $R^2 = 0.69$; F-value = 31.6; P-value = <0.001). This increasing trend was consistent (correlated positively) with the overall national trend (correlation coefficient = 0.896; P-value = <0.001).

Area Burned (Figure WM2):

- The average annual total area burned for Wanganui/Manawatu was 62 hectares, or around 1.5-2% of the national.
- The total annual area burned from 1991/92 to 2006/07 varied from just 17 ha (0.5% of that year's national total area burned) in 2004/05 to 351 ha (around 5% of the national).
- The total area burned varied considerably and showed no clear statistically significant positive or negative trend over time (regression: $R^2 = 0.003$; F-value = 0.04; P-value = 0.84).
-

Number of Fires by Cause (Figures WM3 and WM4):

- High proportions of the average annual total number of fires were attributed to miscellaneous and unknown causes.
- Around 31% of the average annual total number of fires were classed as miscellaneous (average annual 78 fires); around 15% (average annually of 38 fires) were attributed to unknown causes; and the combined unspecified proportion of average total number of fires was 46%.
- Around 21% of the average total number of fires was attributed to land clearing (annual average of 54 fires).
- Around 13% of the average total number of fires were attributed to vehicles (annual average of 33 fires).
- The increase in the total annual number of fires over time appears to be due to miscellaneous, vehicles, and land clearing causes.

Area Burned by Fuel Type (Figures WM5 and WM6):

- Around 54% of the total area burned for Wanganui/Manawatu (1991/92 to 2006/07) was attributed to the scrub fuel type; average annual total scrub area burned was 70 ha (around 3% of the national for scrub).
- Around 37% of the total area burned was classed as grass; average annual total grass area burned was about 49 ha or 2.2% of the national for grass.

- The remaining 9% of the total area burned was forest; annual average total forest area burned was just 12 ha, or about 6% of the national average annual forest area burned.
- No clear year-on-year trend for total area burned by fuel type was observed.

Area Burned by Cause (Figures WM7 and WM8):

- While unknown and miscellaneous causes dominate the average total annual number of fires, land clearing made up around 40% of the average total annual area burned (annual average of 52 ha).
- Around 18% of the average total annual area burned was attributed to miscellaneous causes (annual average of around 24 ha); about 13% to unknown causes (annual average of about 17 ha); combined 'unspecified' average total area burned was 31%.
- About 17% of the average total annual area burned was due to incendiary causes.
- From 1991/92 to 2006/07 few (if any) clear positive or negative trends are evident over time for individual causes solely with respect to total annual area burned. The annual total area burned for each year is often greatly influenced by a single cause class: land clearing in 1993/94, incendiary in 1997/98 and 2002/03, miscellaneous in 1998/99.

Area Burned by Cause and Fuel type (Figures WM9, WM10, WM11, WM12, WM13 and WM14):

- Land clearing dominated the average annual total grass area burned with 39% (annual average of 19 ha).
- About 10% of the average annual total grass area burned was attributed to miscellaneous causes (annual average around 5 ha); about 9% of the average annual total grass area burned was classed as unknown (annual average 4 ha).
- Incendiary causes accounted for 27% of the average annual total grass area burned (annual average around 13 ha). This is in part due to large grass fires from incendiary causes in 2002/03 (over 100 ha), 2000/01 (about 35 ha) and, 1991/92 (33 ha).
- Land clearing features highly in almost all years for total annual grass area burned, with the largest year 1993/94 with around 120 ha burned.
- More than half of the total scrub area burned was due to land clearing (42% or annual average of 29 ha).
- Around 25% of the average annual scrub area burned was due to miscellaneous causes (annual average 17ha); 12% (or on average annually around 10ha) was attributed to unknown causes; a combined 'unspecified' average annual total scrub area burned of just under 40%.
- Around 12% of the average annual total scrub area burned was attributed to incendiary fires.
- The annual total scrub area burned varied considerably over time with over 150 ha burned in 1993/94 (mostly attributed to land clearing and

miscellaneous), over 200 ha in 1998/99 again mostly due to miscellaneous and land clearing, and over 200 ha in 2005/06 mostly due to unknown and land clearing.

- 38% of the average annual total forest area burned was attributed to land clearing (actual annual average of just 5 ha).
- Around 28% of the average annual total forest area burned was attributed to unknown causes (average annual of around 3 ha); miscellaneous accounted for 14% or 2 ha; combined 'unspecified' average annual total forest area burned of 42%.

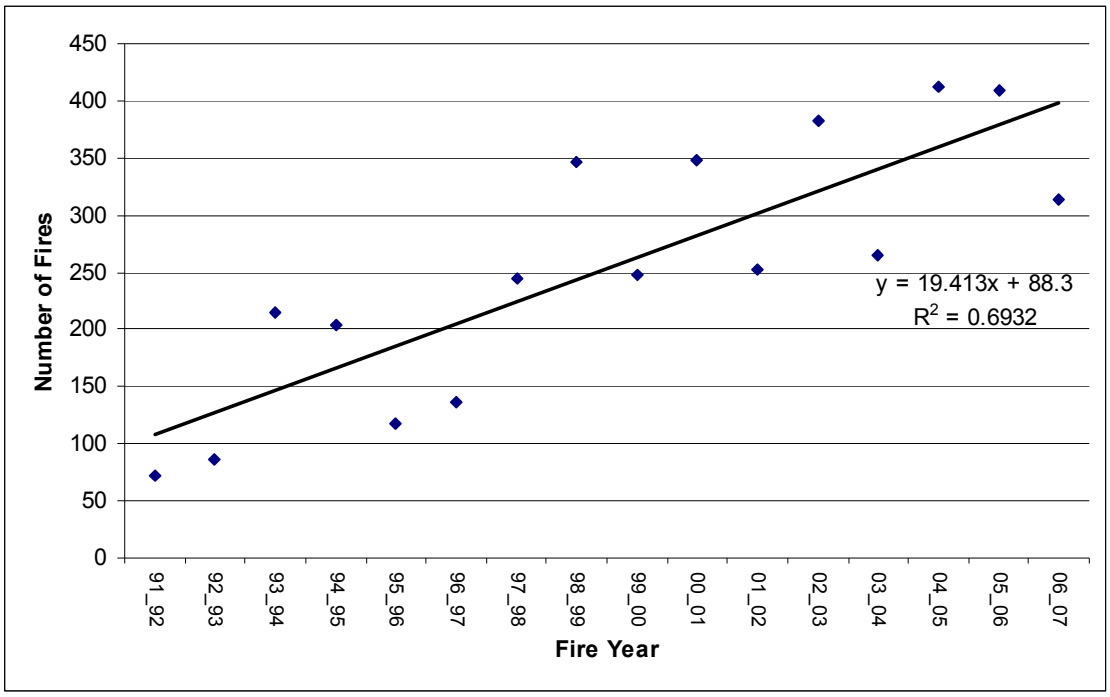


Figure WM1. Wanganui/Manawatu Total annual number of fires from 1991/92 to 2006/07.

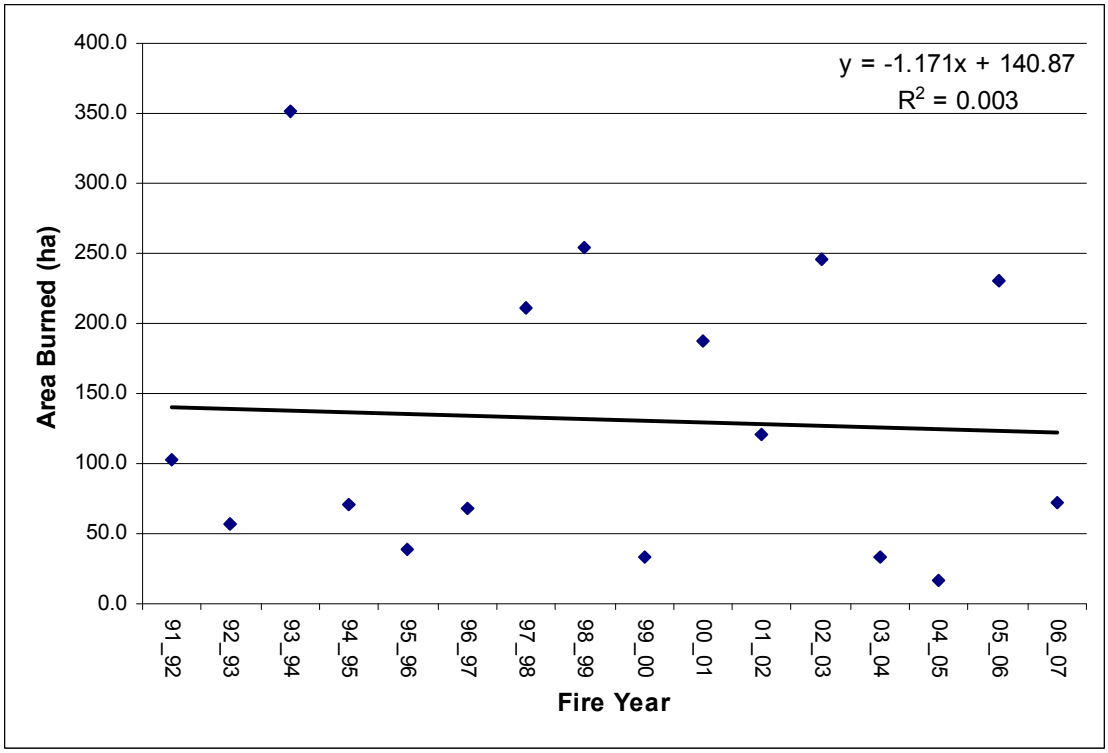


Figure WM2. Wanganui/Manawatu total annual area burned from 1991/92 to 2006/07.

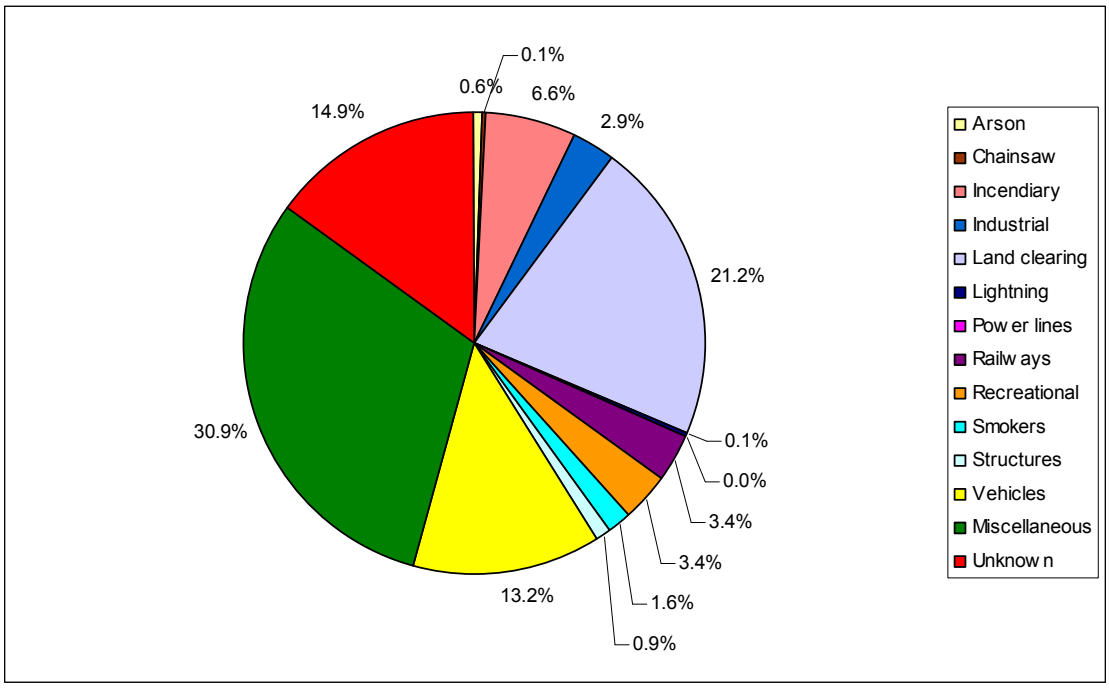


Figure WM3. Wanganui/Manawatu average total number of fires by cause from 1991/92 to 2006/07.

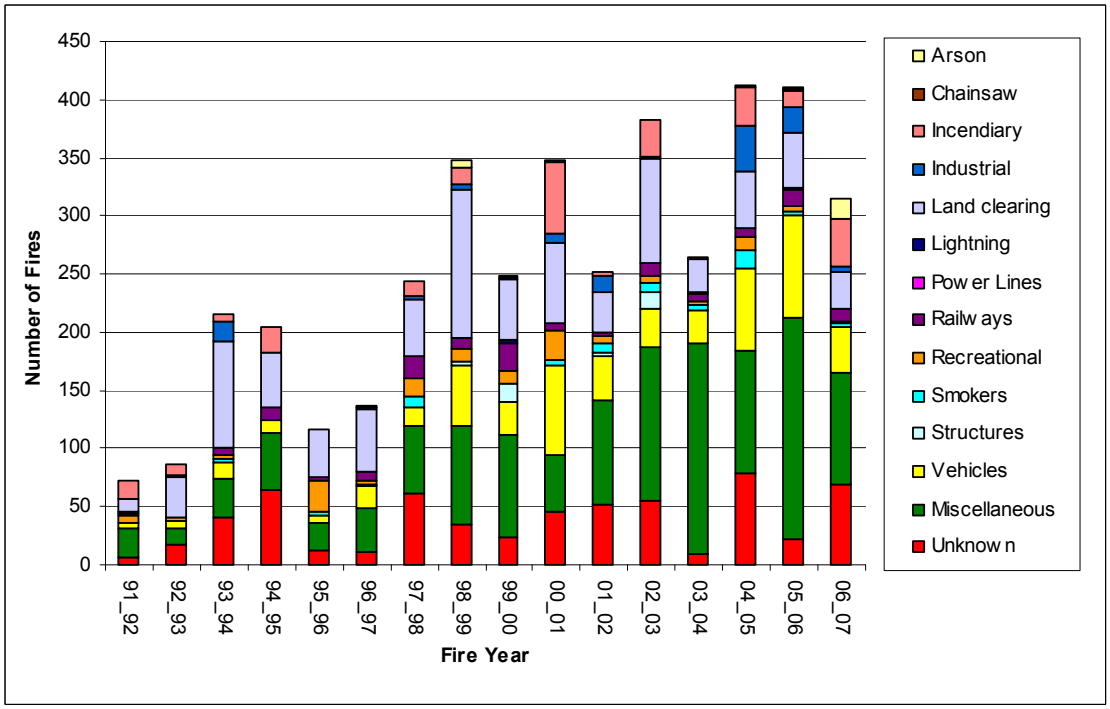


Figure WM4. Wanganui/Manawatu total annual number of fires by cause from 1991/92 to 2006/07.

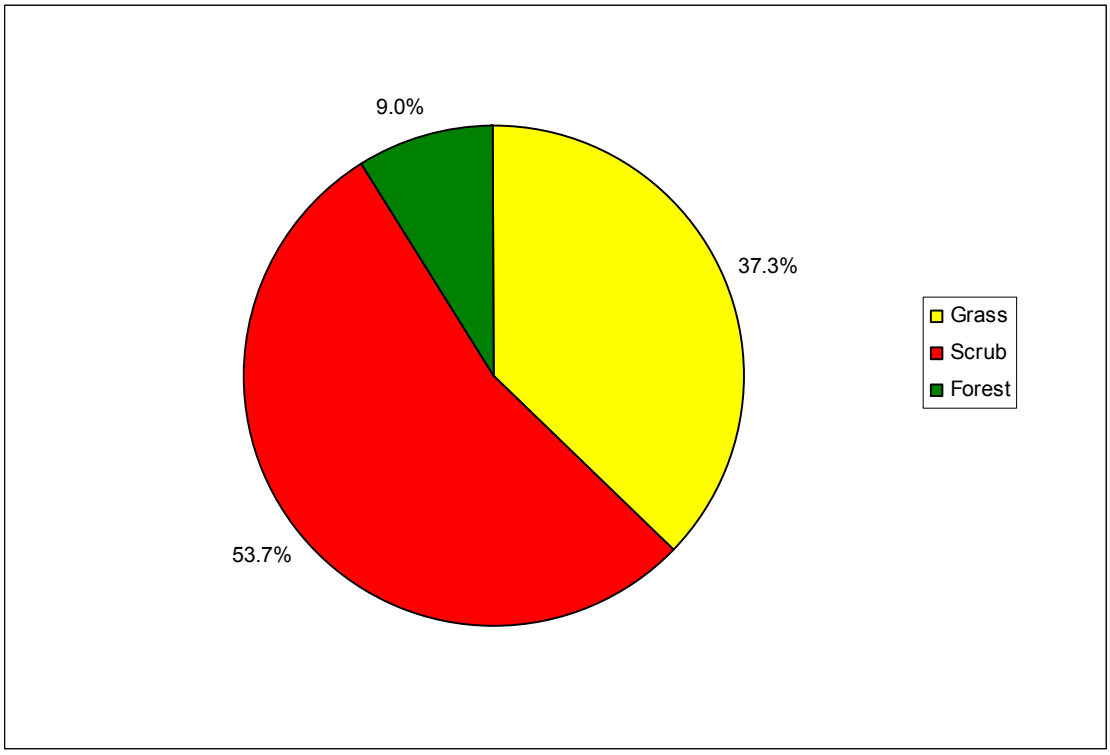


Figure WM5. Wanganui/Manawatu total area burned by fuel type from 1991/92 to 2006/07.

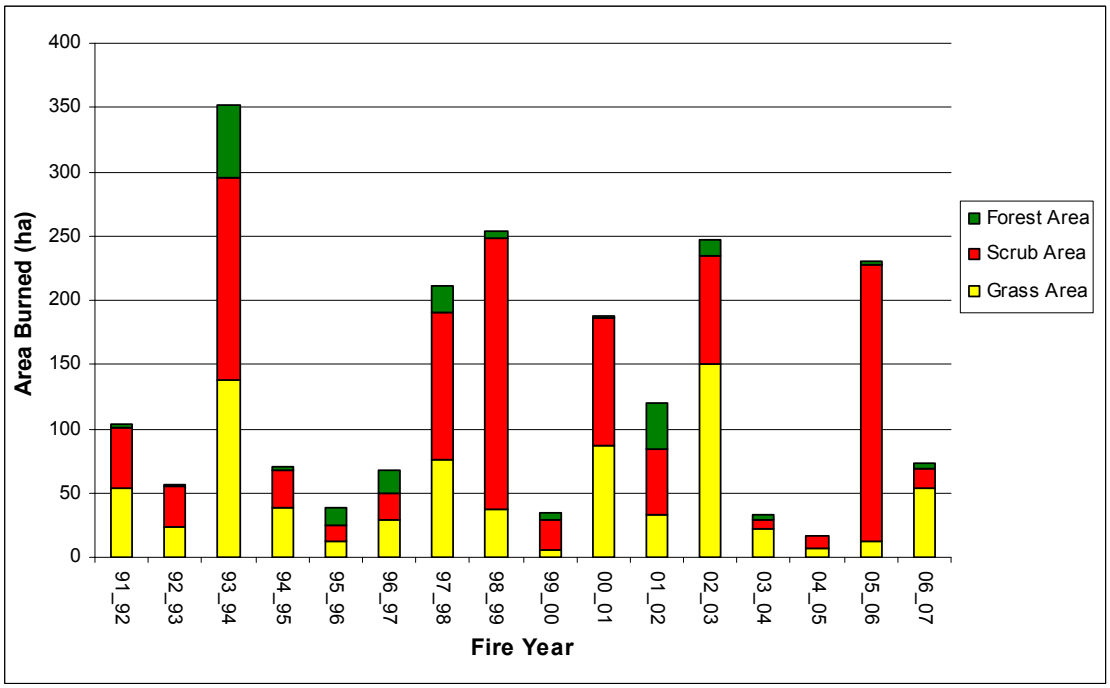


Figure WM6 .Wanganui/Manawatu total annual area burned by fuel type from 1991/92 to 2006/07.

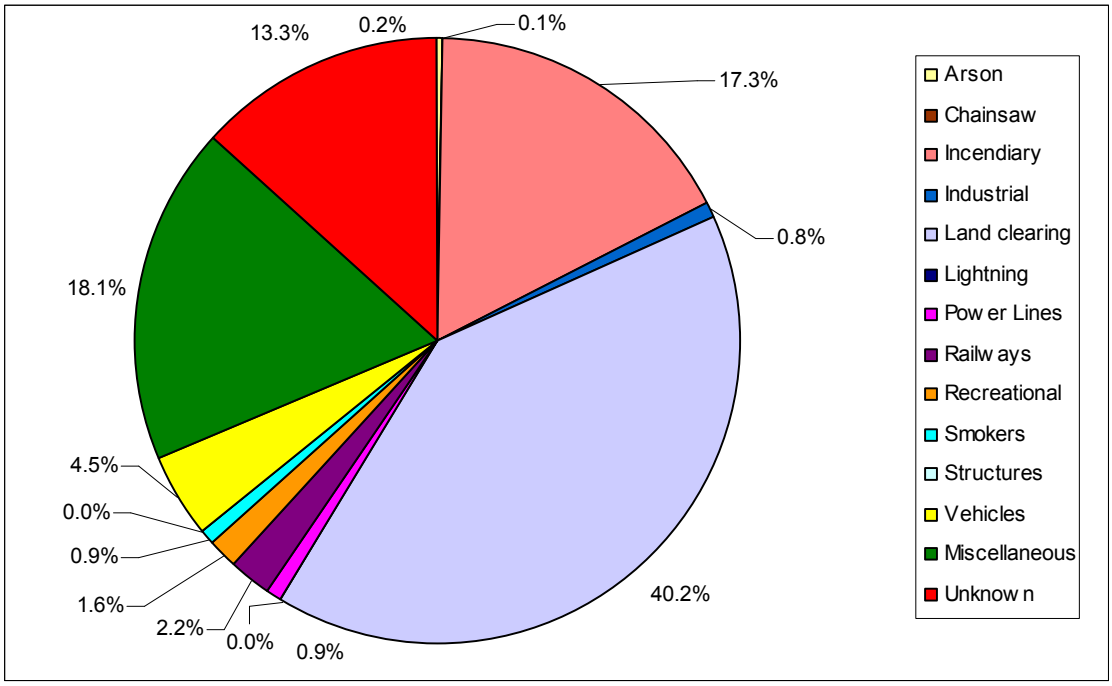


Figure WM7. Wanganui/Manawatu average total area burned by cause from 1991/92 to 2006/07.

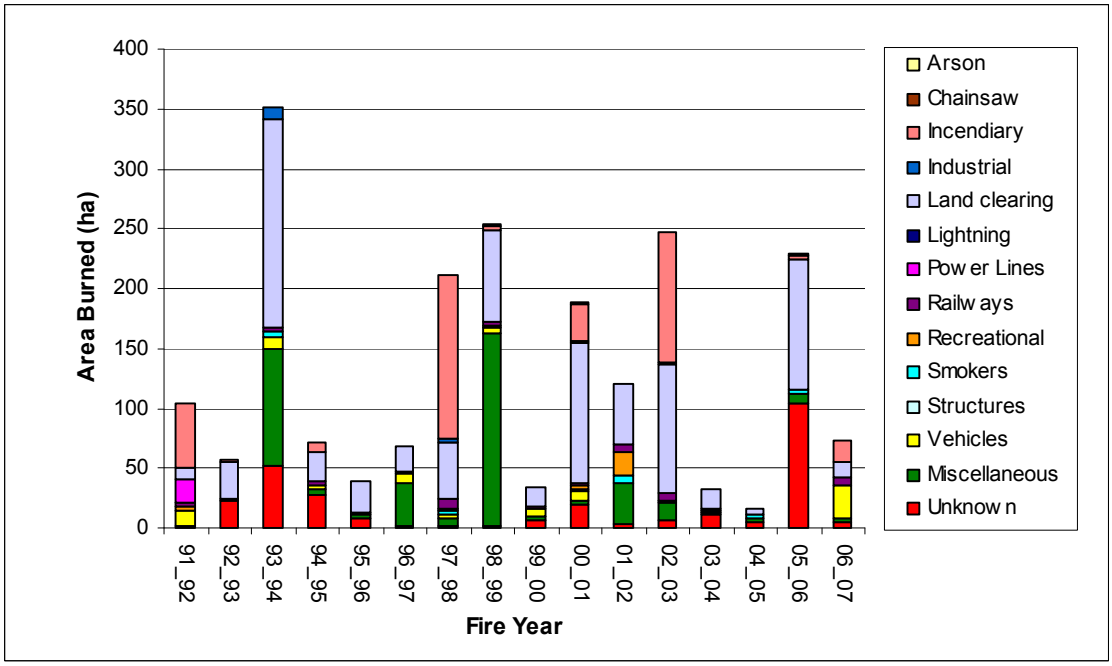


Figure WM8. Wanganui/Manawatu total annual area burned by cause from 1991/92 to 2006/07.

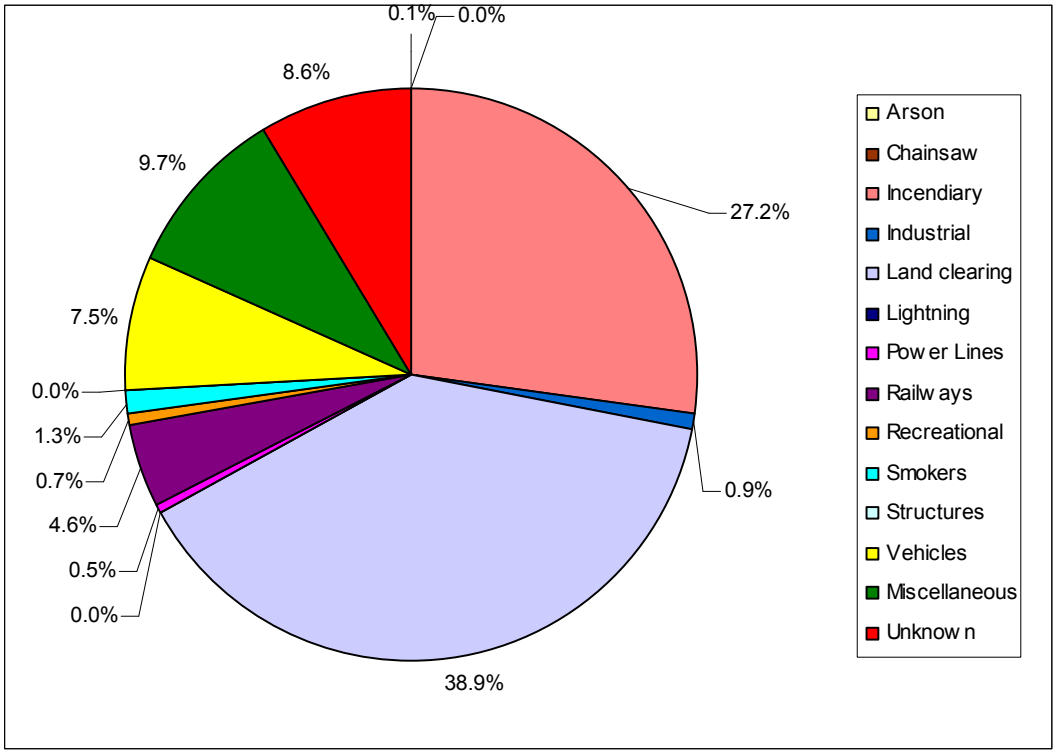


Figure WM9. Wanganui/Manawatu average total grass area burned by cause from 1991/92 to 2006/07.

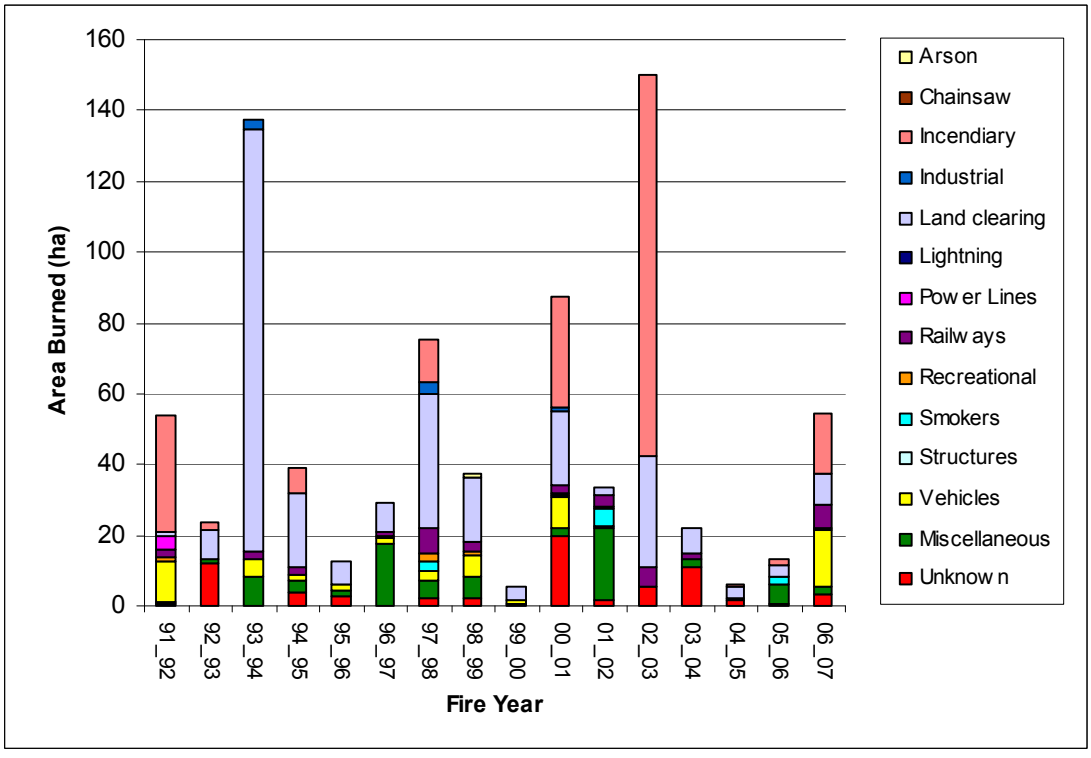


Figure WM10. Wanganui/Manawatu total annual grass area burned by cause from 1991/92 to 2006/07.

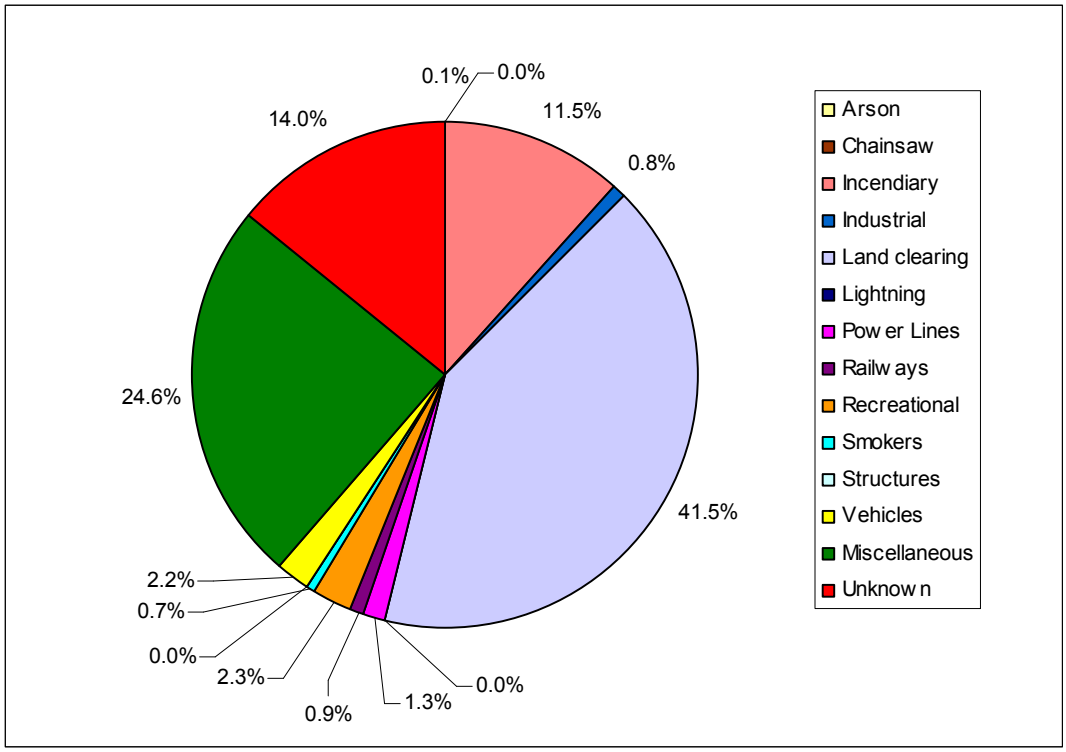


Figure WM11. Wanganui/Manawatu average total scrub area burned by cause from 1991/92 to 2006/07.

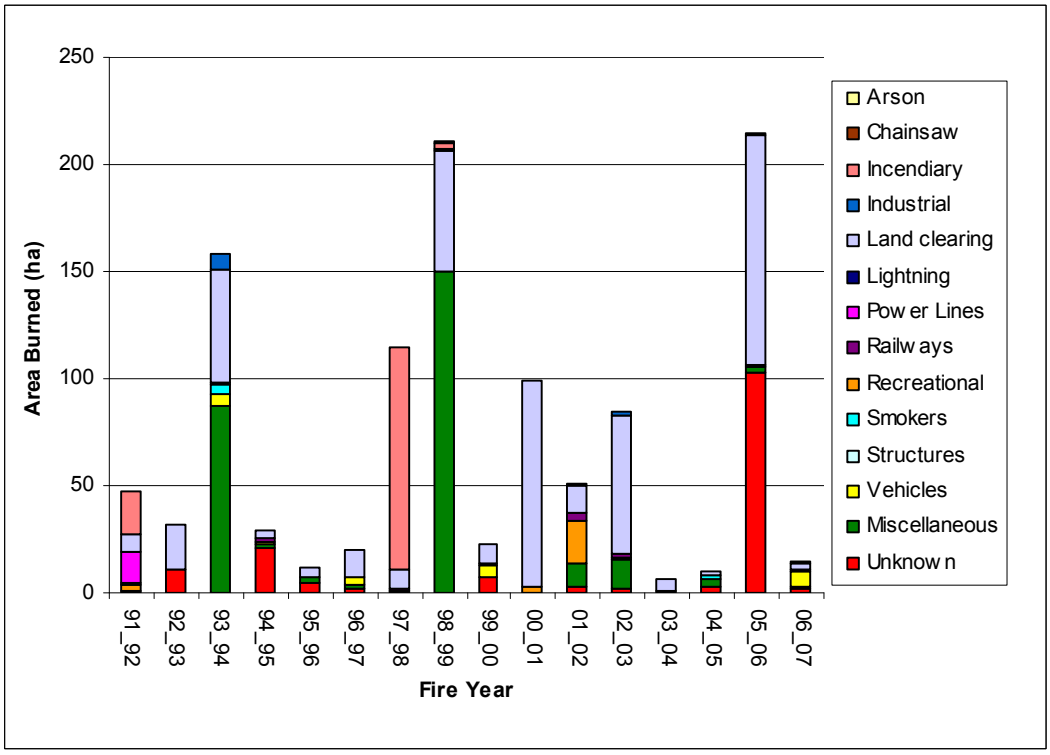


Figure WM12. Wanganui/Manawatu total annual scrub area burned by cause from 1991/92 to 2006/07.

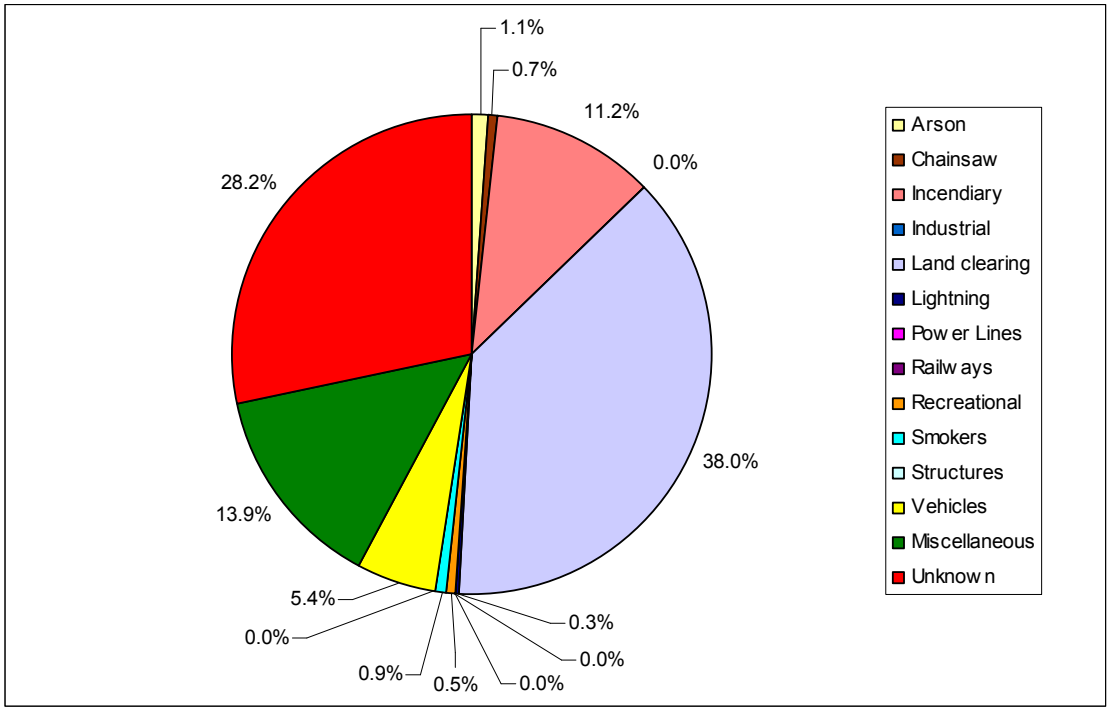


Figure WM13. Wanganui/Manawatu average annual total forest area burned by cause from 1991/92 to 2006/07.

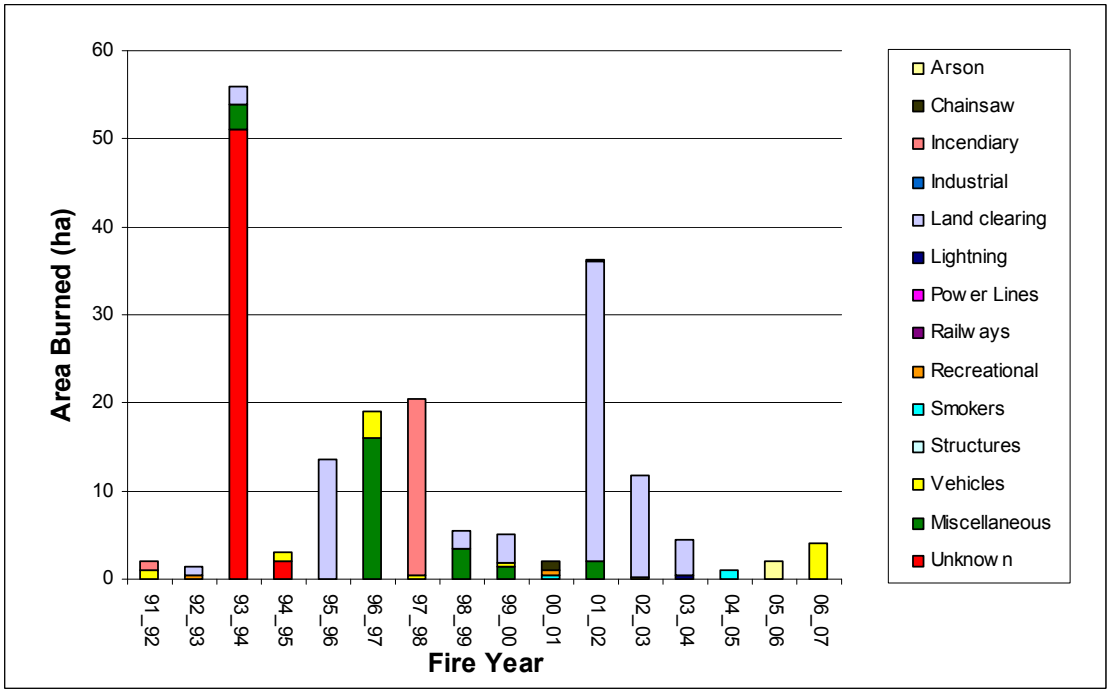


Figure WM14. Wanganui/Manawatu total annual forest area burned by cause from 1991/92 to 2006/07.

Appendix C5 Central North Island Region Fire Returns 1991/92 to 2006/07

Number of Fires (Figure CE1):

- From 1991/92 to 2006/07 the Central North Island had on average around 270 fires (10% of the national total number of fires) annually.
- The total number of fires in Central North Island varied from 115 fires in 1992/93 (12% of that years national) to 495 fires in 1997/98 (14% of that years national).
- The total number of fires for Central North Island varied marginally (R^2 = 0.237) but increased significantly over time (regression: F-value = 6.31; P-value = 0.025).
- The total number of fires over time correlated well with the increasing national trend (correlation coefficient = 0.722 P-value = 0.002).

Area Burned (Figure CE2):

- The average annual total area burned was 136 ha (or 3% of the national).
- The total area burned varied greatly in the 1990s, but has since become less variable (linear regression R^2 = 0.144); annual total area burned varied from 20 ha in 1995/96 (or 0.4% of that year's national) to 499 ha (or 7% of national) in 1996/97.
- The total annual area burned decreased over time but was not statistically significant (regression: R^2 = 0.144; F-value = 2.35; P-value = 0.15).

Number of Fires by Cause (Figures CE3 and CE4):

- Miscellaneous fires accounted for about 31% (the actual annual average was 86 fires) of the average total number of fires in Central North Island; unknown accounted for 8% (or on average annually 22 fires); combined 'unspecified' about 40%.
- Land clearing (actual annual average of 45 fires) and vehicle fires (actual annual average of 47 fires) each made up approximately 17% of the average annual total number of fires.
- About 10% (or annually on average 26 fires) of the average annual total number of fires were attributed to incendiary causes.

Area Burned by Fuel type (Figures CE5 and CE6):

- Around 15% of the total area burned in the Central North Island was grass; average annual grass area burned was 21ha (or about 1% of the national average grass area burned).
- About 63% of the total area burned was scrub; average annual total scrub area burned was 86ha or 3.8% of the national scrub area burned.
- The remaining 21% was classed as forest (annual average total forest area burned was 29ha or around 6% of the national average). In comparison to other regions, the Central North Island has a relatively high proportion of its total area burned classed as forest.
- Over 200ha of forest area was recorded burned in 1996/07, and over 100ha of forest area was burned in 1997/98.

Area Burned by Cause (Figures CE7 and CE8):

- Whilst fires from miscellaneous causes fires made up 32% of the average total annual number of fires in the Central North Island (Figure CE3), miscellaneous causes (actual average of 27 ha) accounted for 20% of the average total reported area burned. Area burned attributed to unknown causes made up around 9% or 13 ha. Total combined 'unspecific' annual average area burned was around 28%.
- In contrast to most other regions where it barely featured, 16% (actual annual average around 22 ha) of the average total area burned was attributed to smokers.
- Land clearing (actual average around 19 ha) and incendiary (actual average about 18 ha) made up around 14% of the average annual total area burned.
- Industrial causes accounted for about 10% of the average annual total area burned (actual average about 13 ha).
- Average total area burned was greatly influenced by different causes in different fire years. For example, 1996/97 saw over 200 ha burned from both smokers and industrial cause classes.

Area Burned by Cause by Fuel type (Figures CE9, CE10, CE11, CE12, CE13 and CE14):

- Around a third (30%) of the average total grass area burned was due to industrial causes.
- About 20% (actual figure just 4 ha) of the average annual total grass area burned was due to miscellaneous causes, land clearing accounted for 16% of the average annual total grass area burned (actual average was 3 ha).
- About 20% of the average annual total scrub area burned was attributed miscellaneous causes (or on average about 17 ha); unknown accounted for about 11% (or 9 ha); combined about 30% of average annual scrub area burned was in the 'unspecified' classes.
- Incendiary made up about 14% (12 ha) of the average annual total scrub area burned, while land clearing accounted for 17% (or 15 ha).
- Few clear trends were evident for individual causes over time in the total annual scrub area burned.
- 43% of the average annual total forest area burned was attributed to smokers (per year average 12 ha). This was due to around 200 ha of forest recorded burned in 1996/97.
- About 17% of the average annual total forest area burned was attributed to incendiary causes (actual annual average about 5 ha), but again this was mostly due to around 70 ha of forest being burned in 1997/98.

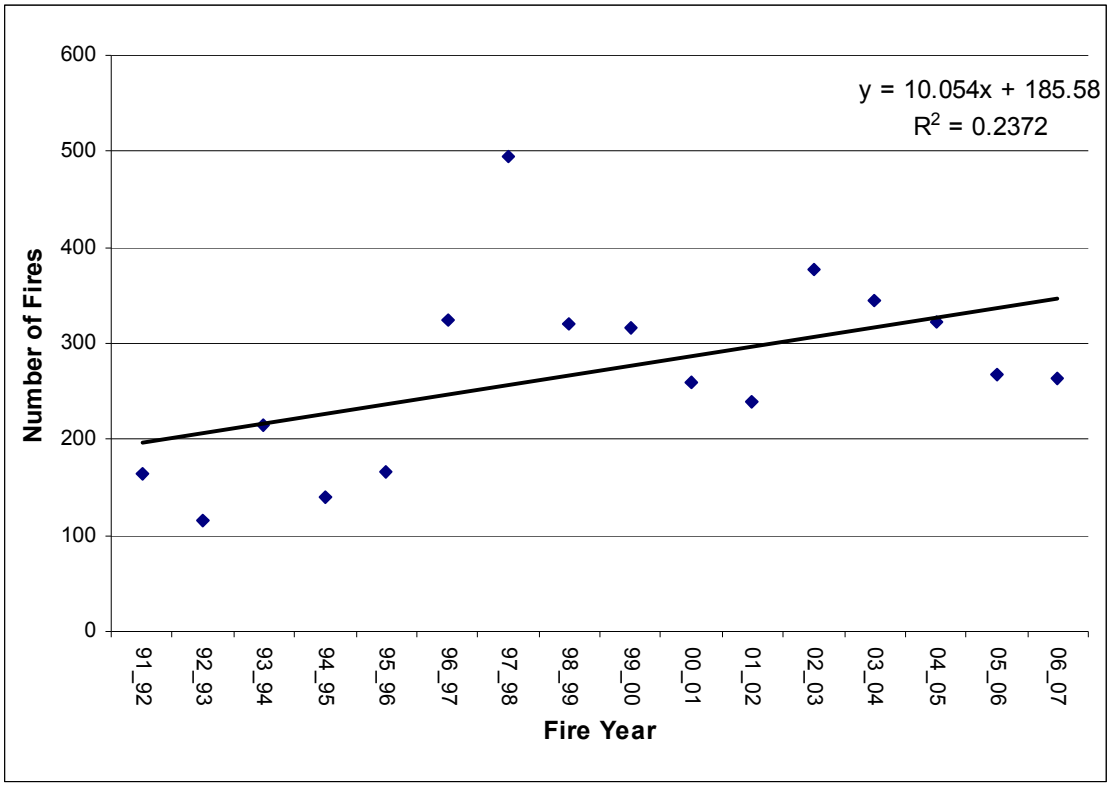


Figure CE1. Central North Island total annual number of fires from 1991/92 to 2006/07.

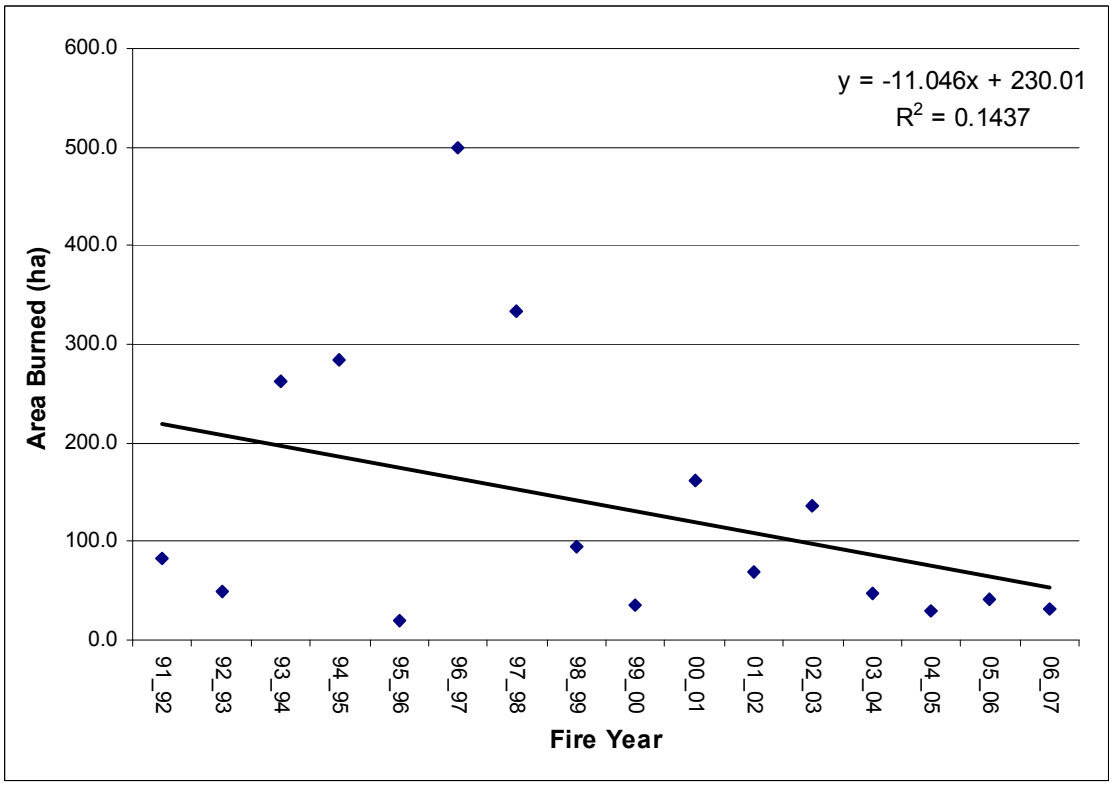


Figure CE2. Central North Island total annual area burned from 1991/92 to 2006/07.

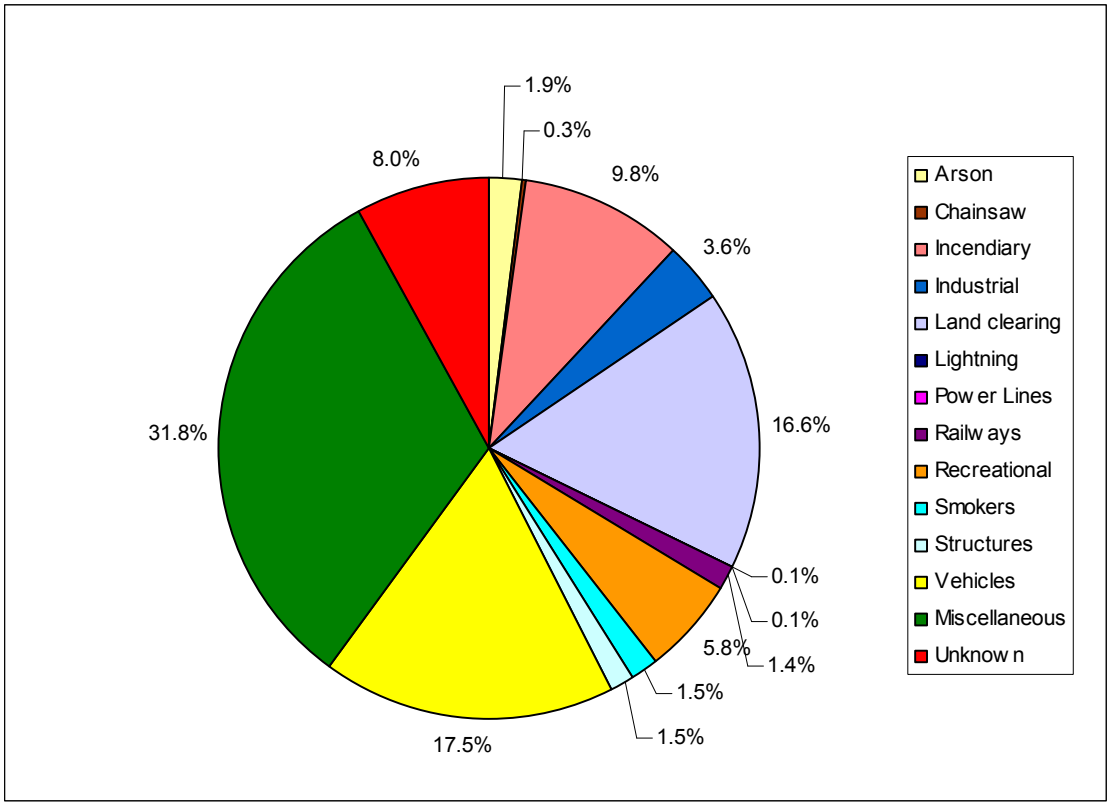


Figure CE3. Central North Island total number of fires by cause from 1991/92 to 2006/07.

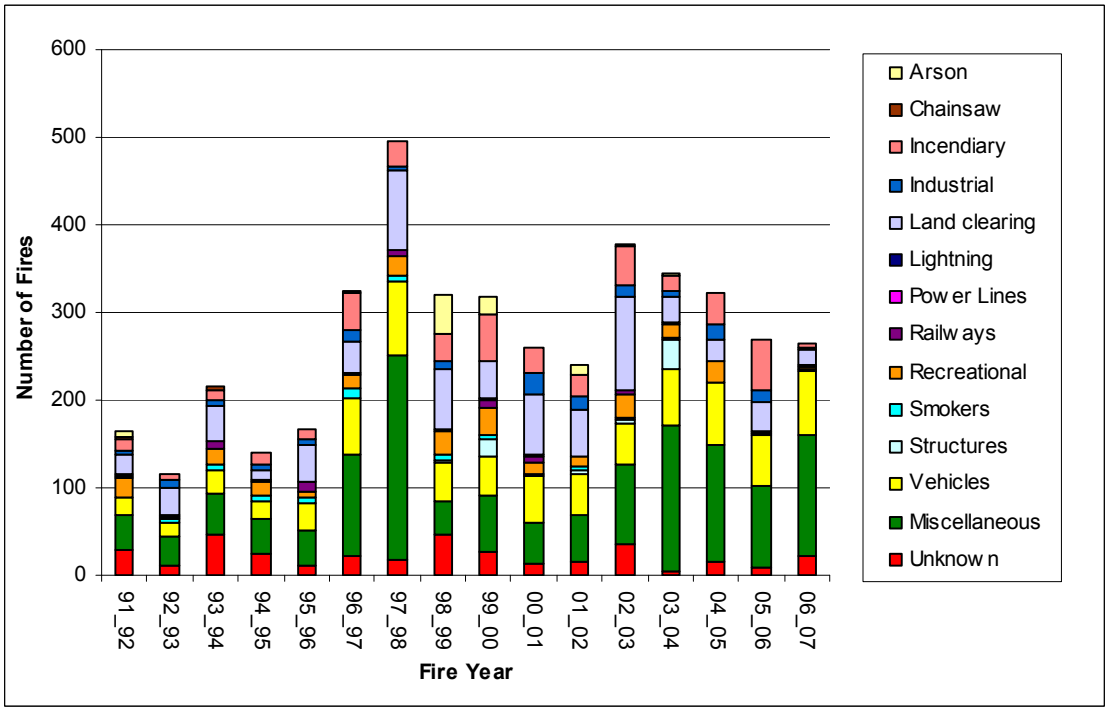


Figure CE4. Central North Island total number of fires by cause from 1991/92 to 2006/07.

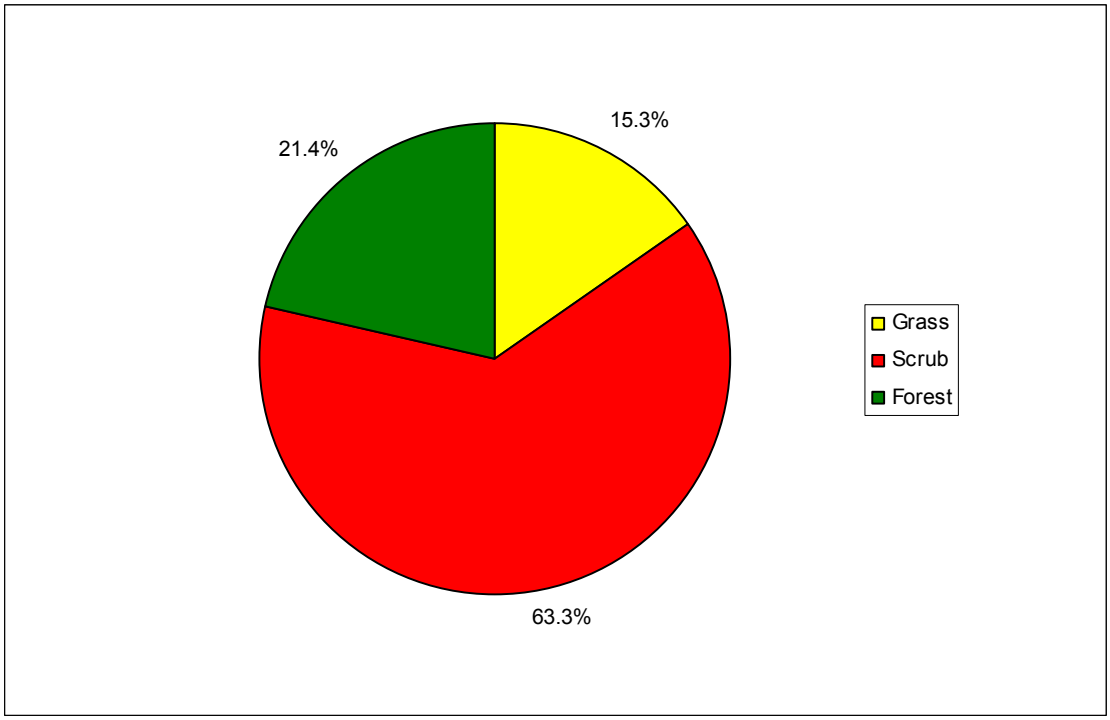


Figure CE5. Central North Island total area burned by fuel type from 1991/92 to 2006/07.

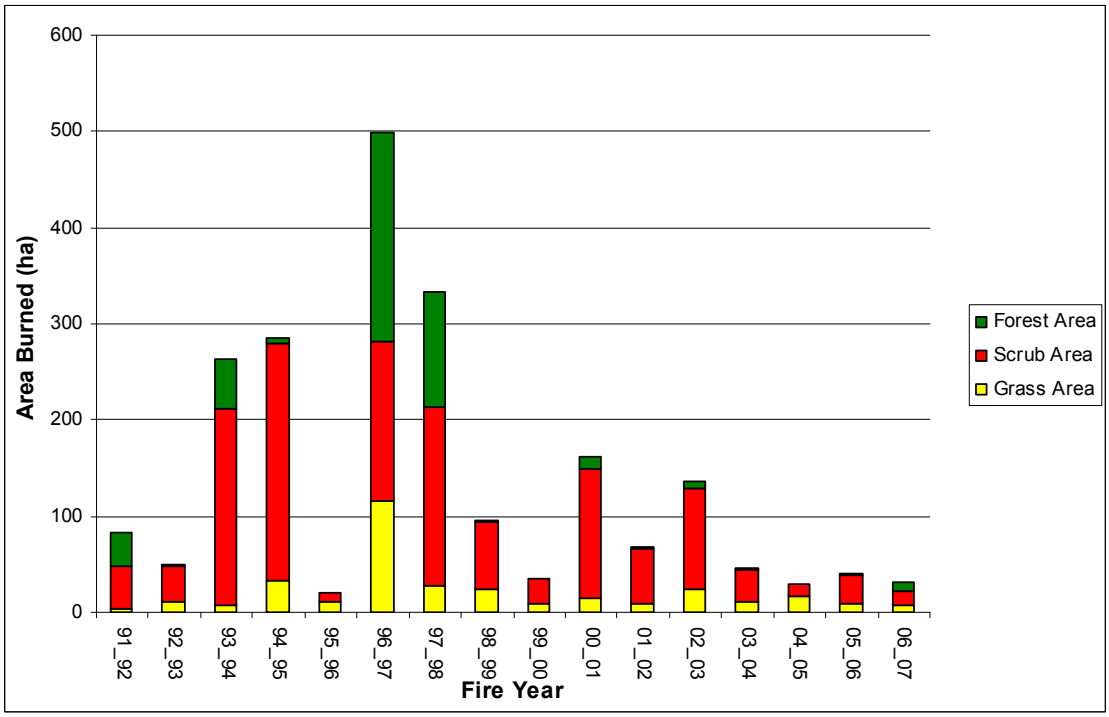


Figure CE6. Central North Island total area burned by fuel type from 1991/92 to 2006/07.

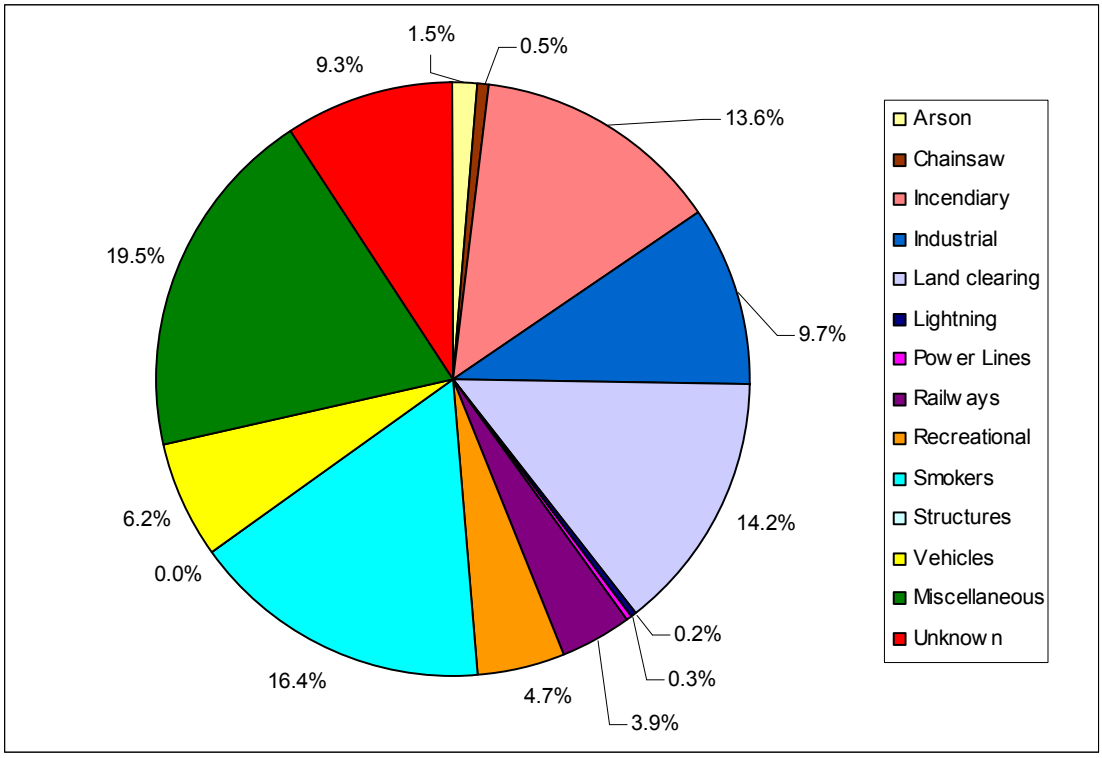


Figure CE7. Central North Island total area burned by cause from 1991/92 to 2006/07.

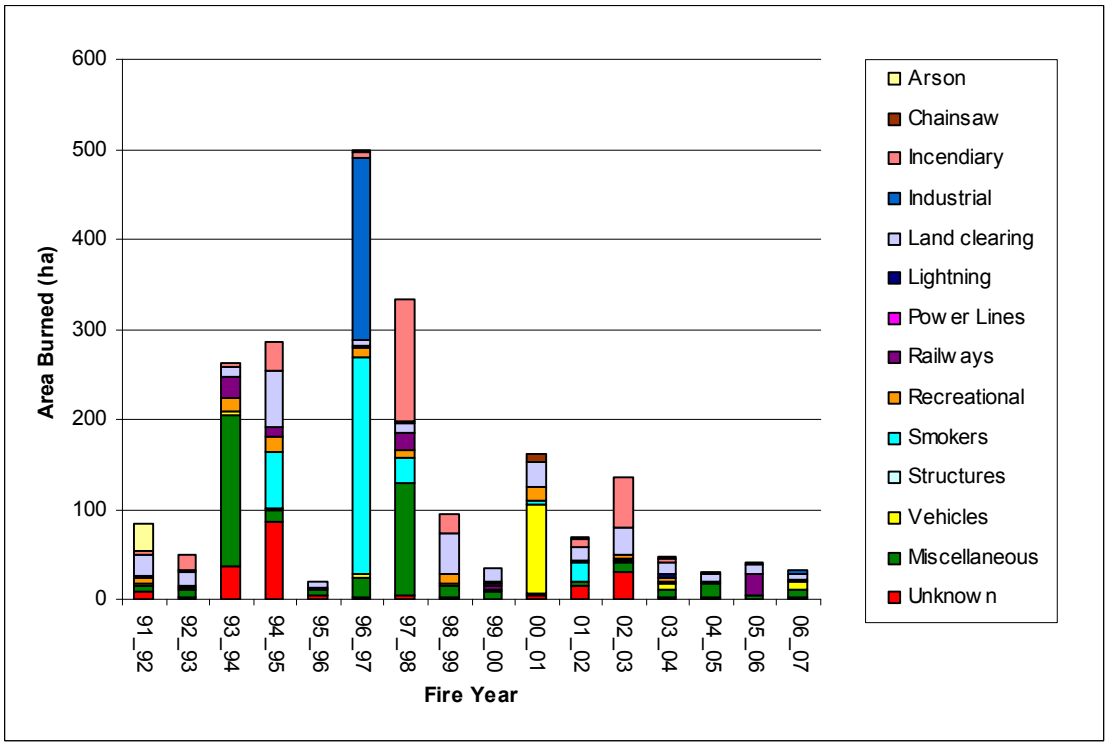


Figure CE8. Central North Island total area burned by cause from 1991/92 to 2006/07.

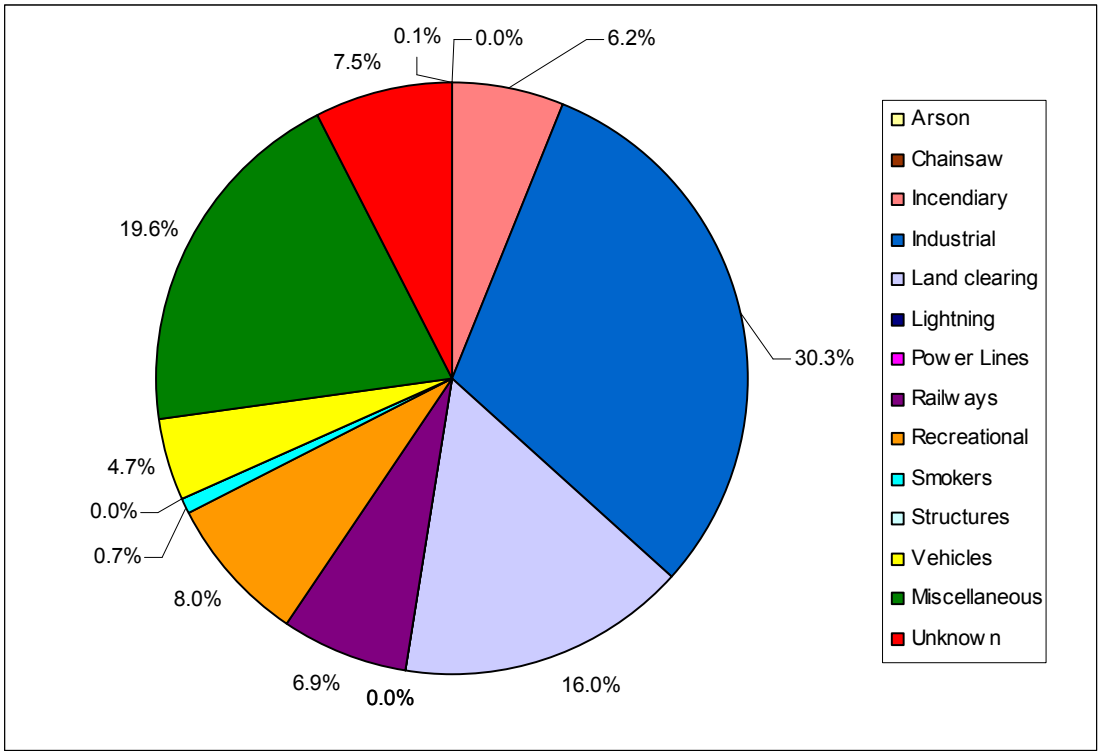


Figure CE9. Central North Island average total annual grass area burned from 1991/92 to 2006/07.

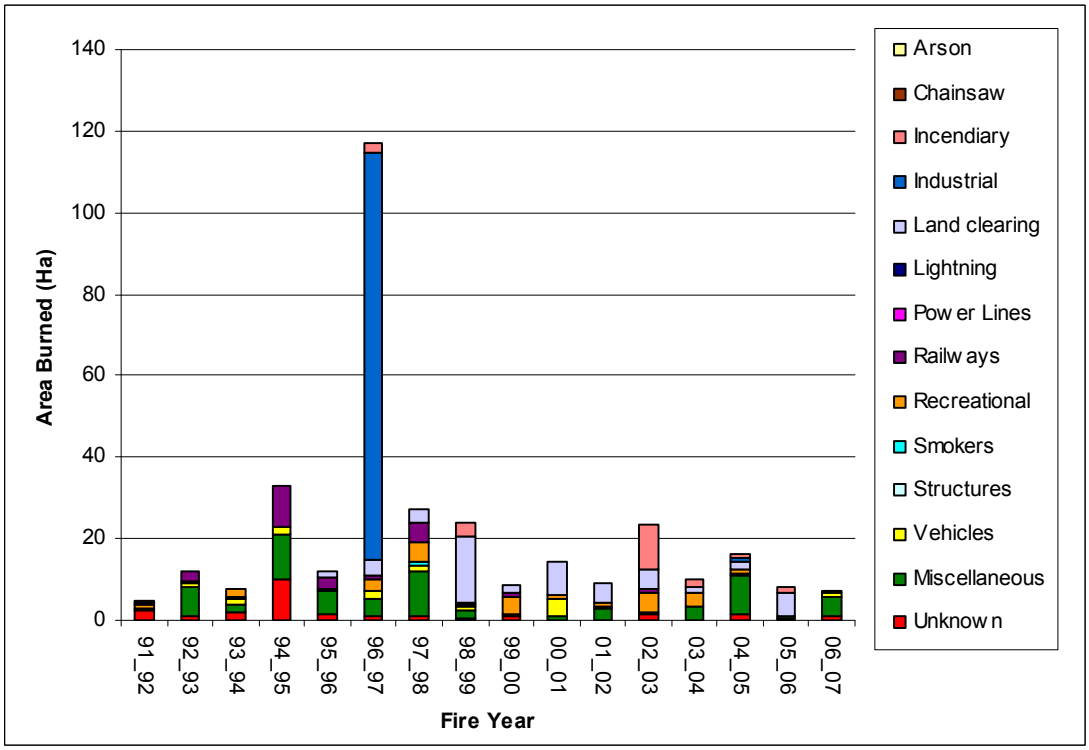


Figure CE10. Central North Island total grass area burned by cause from 1991/92 to 2006/07.

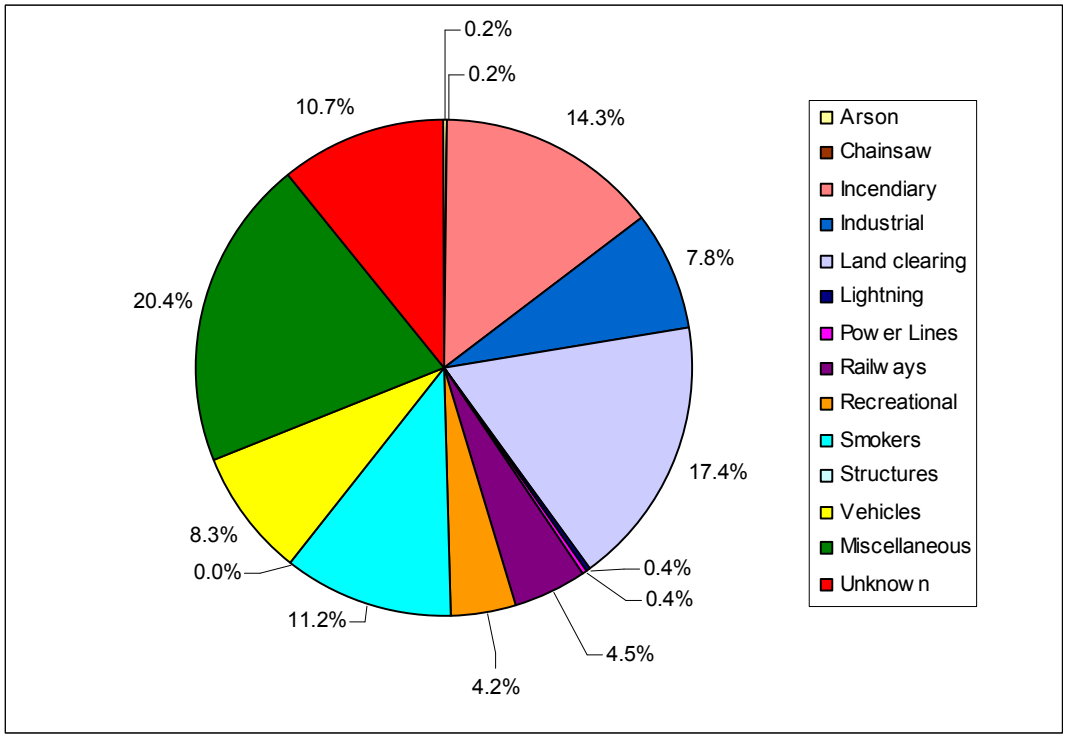


Figure CE11. Central North Island average total scrub area burned by cause from 1991/92 to 2006/07.

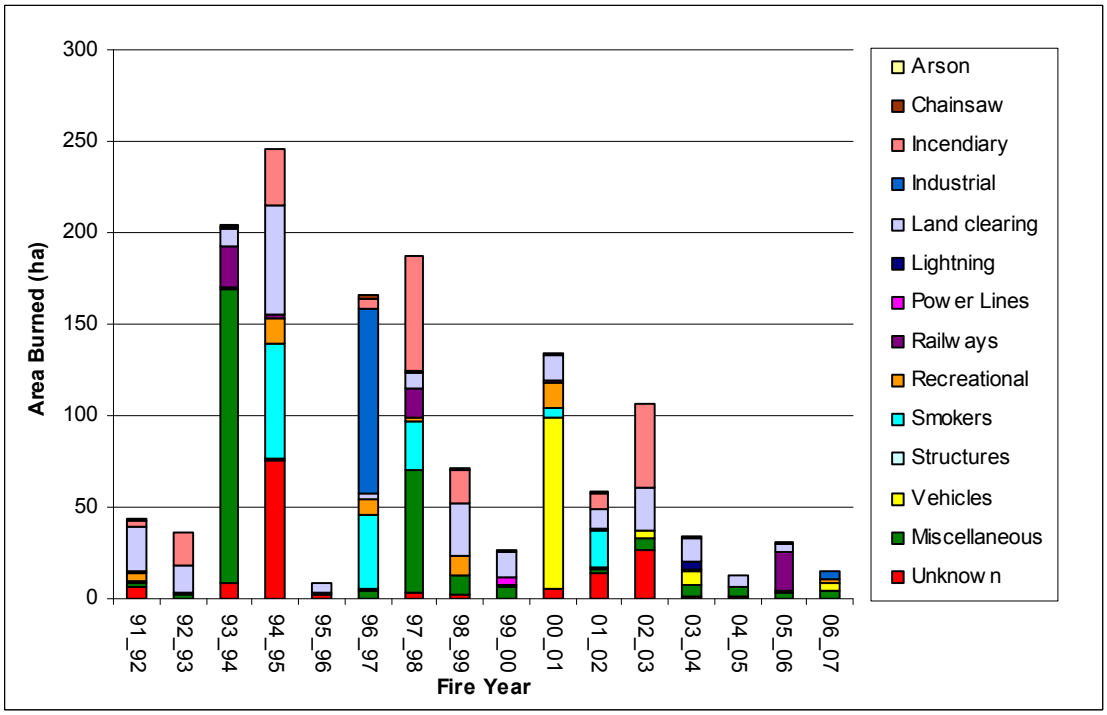


Figure CE12. Central North Island total scrub area burned by cause from 1991/92 to 2006/07.

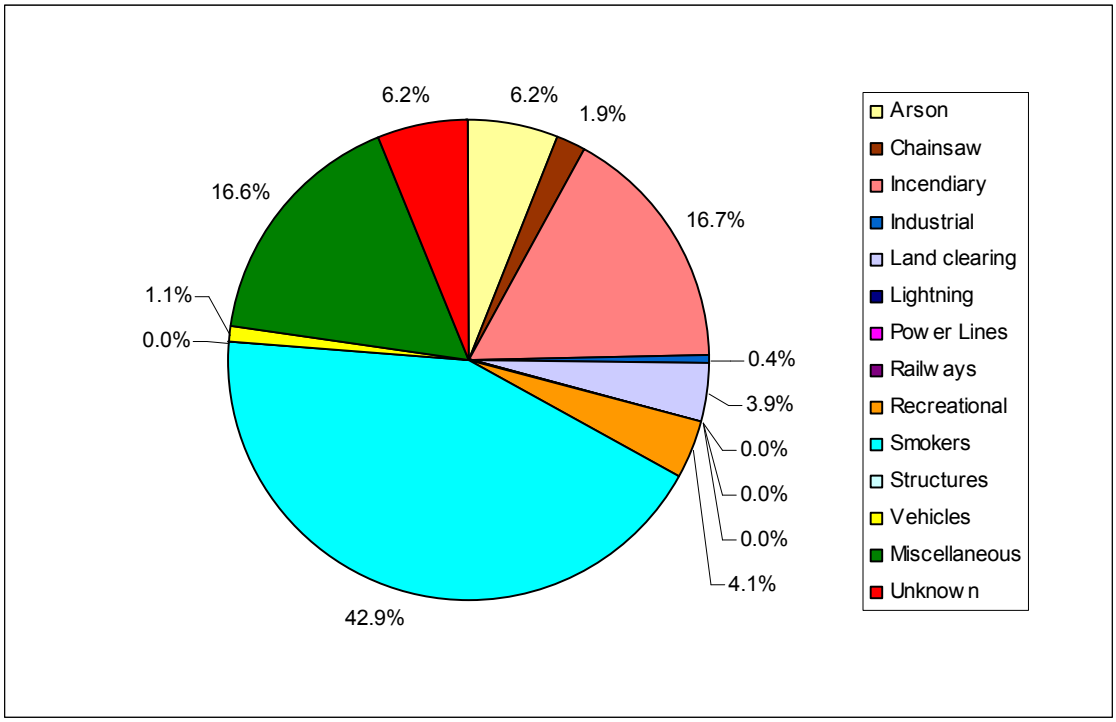


Figure CE13. Central North Island average total forest area burned by cause from 1991/92 to 2006/07.

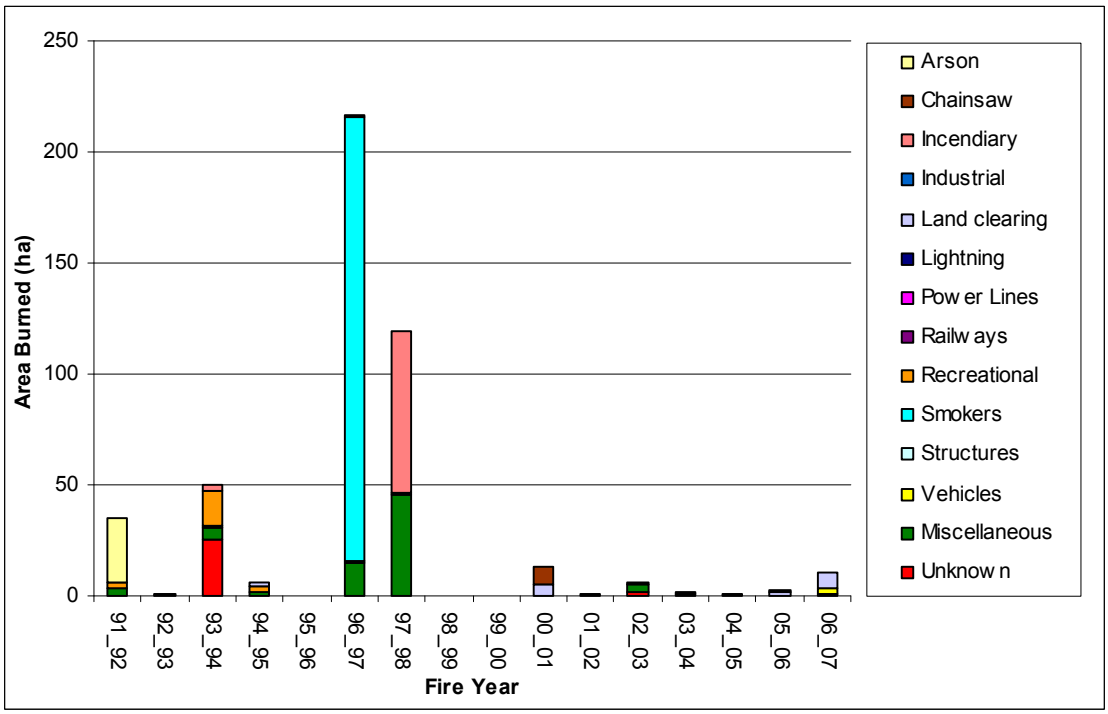


Figure CE14. Central North Island total forest area burned by cause from 1991/92 to 2006/07.

Appendix C6 Taranaki Region Fire Returns 1991/92 to 2006/07

Number of Fires (Figure T1):

- From 1991/92 to 2006/07 Taranaki had on average 84 fires annually (2.5% of the national).
- The total number of fires varied from just 2 fires in 1993/94 (0.1% of that years national) to 183 fires in 2006/07 (5% of that years national).
- The total number of fires for Taranaki shows a statistically significant positive trend over time (regression: ^{2} = 0.89; F-value = 117.63; P-value = <0.001). This positive trend was also reflected in the correlation between Taranaki's total number of fires and the increasing national trend (correlation coefficient = 0.826; P-value = <0.001).

Area Burned (Figure T2):

- The average annual total area burned for Taranaki was just 30 ha (1% of the national).
- The annual total area burned was small compared to other regions, varying from no recorded hectares burned in 1993/94 to 97ha (5% of that year's national) burned in 1999/2000.
- The total area burned for Taranaki showed no statistically significant positive or negative trend over time (regression: R^2 = 0.0831; F-value = 1.27; P-value = 0.28).

Number of Fires by Cause (Figures T3 and T4):

- 61% of the total annual number of fires were attributed to miscellaneous causes (annual average of 50 fires).
- The increase in the number of fires over time appeared to be primarily due to an increase in miscellaneous and vehicle caused fires.

Area Burned by Fuel type (Figures T5 and T6):

- Around 18% of the total area burned was grass; average annual total grass area burned was just 6 ha (0.2% of average national grass area burned).
- Around 54% of the total area burned was scrub; average total annual scrub area burned was 16 ha (1% of the national).
- Total forest area burned accounted for 28% of the Taranaki total area burned; average annual total forest area burned was 8 ha (about 5% of the national average total forest area burned).

Area Burned by Cause (Figures T7 and T8):

- In contrast to the total average number of fires by cause, the total average area burned by cause was dominated by land clearing (61%). However the average annual total area burned by land clearing was just over 18 ha. Whilst this appears significant, the low actual amount of area burned annually skewed the results

.

Area Burned by Cause and Fuel type (Figures T9, T10, T11, T12, T13, and T14):

- The average annual total grass area burned was almost entirely split between miscellaneous (46%, average just 3 ha), land clearing (38%, average just 2 ha) and railways (13%, or average of just 1 ha annually) causes.
- About 60% of Taranaki average annual total scrub are burned was attributed to land clearing (annual average just 10ha); unknown made up about 28% (annual average just 5 ha).
- About 80% of the average annual total forest area burned was attributed to land clearing (annual average of just 6 ha).
- The reported area burned for Taranaki was considerably low, and because of this single fire events had a greater bearing on averages and proportions. Figures T10, T12 and T14 clearly show that there are very few clear trends over time with relation to cause and fuel types.

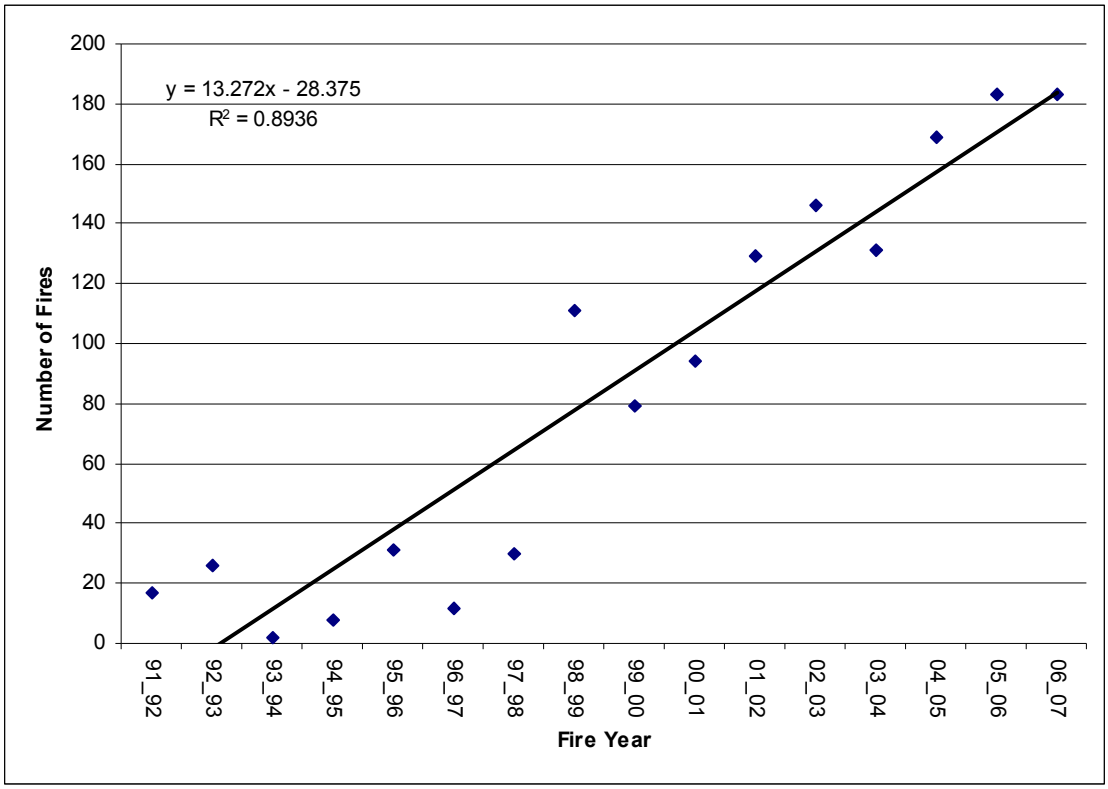


Figure T1. Taranaki total annual number of fires from 1991/92 to 2006/07.

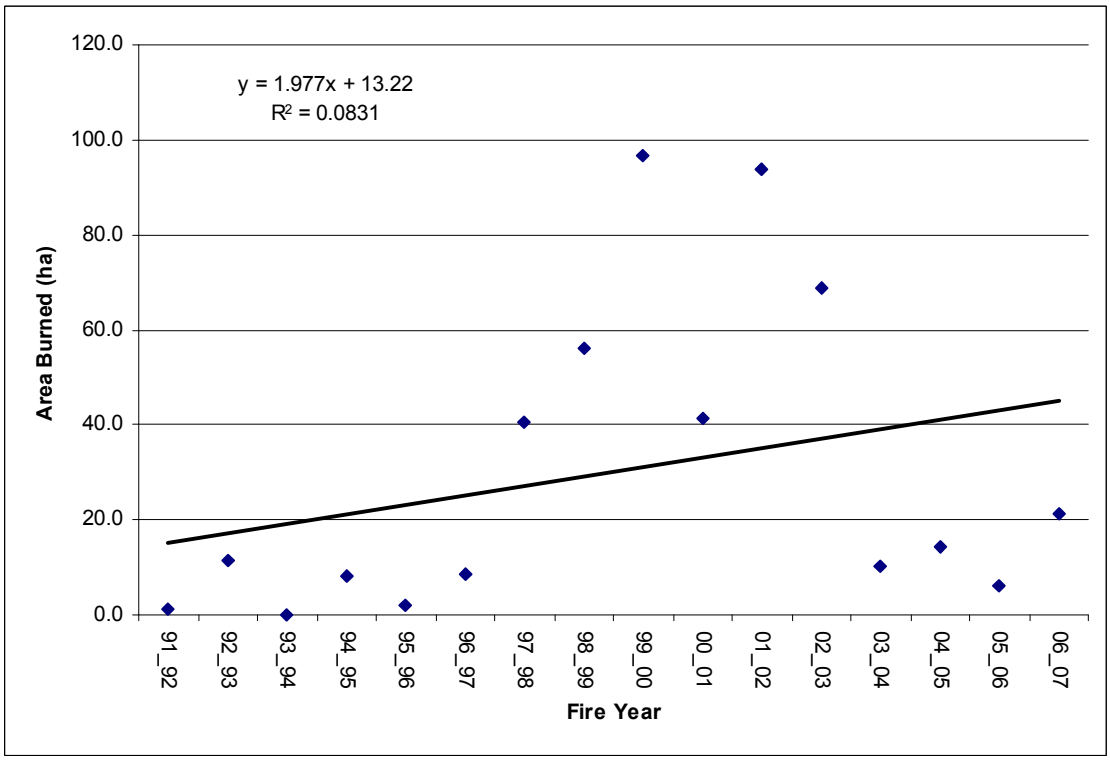


Figure T2. Taranaki total annual area burned from 1991/92 to 2006/07.

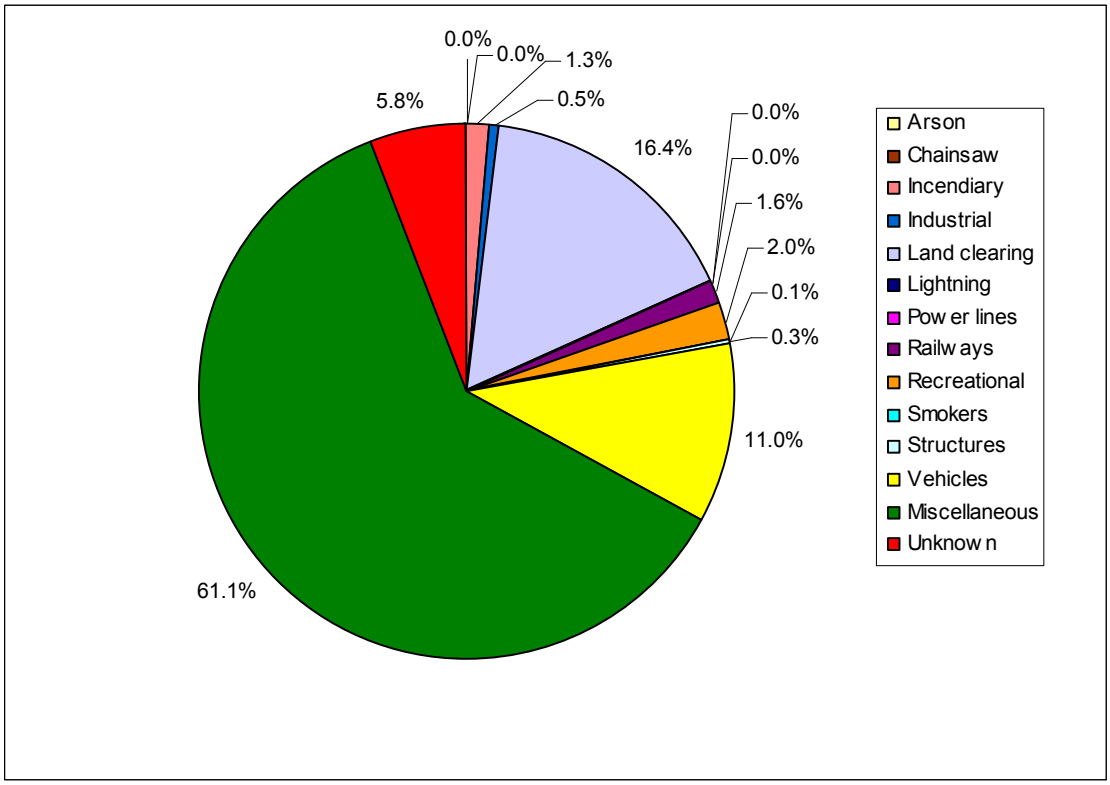


Figure T3. Taranaki average total number of fires by cause from 1991/92 to 2006/07.

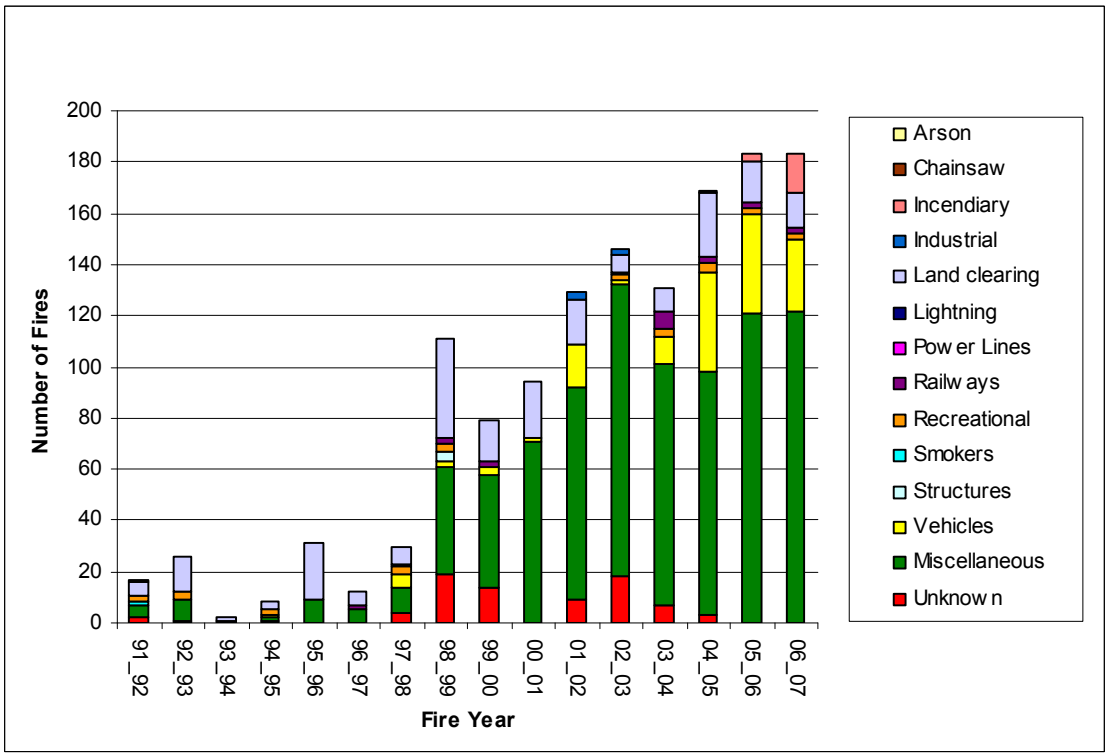


Figure T4. Taranaki total number of fires by cause from 1991/92 to 2006/07.

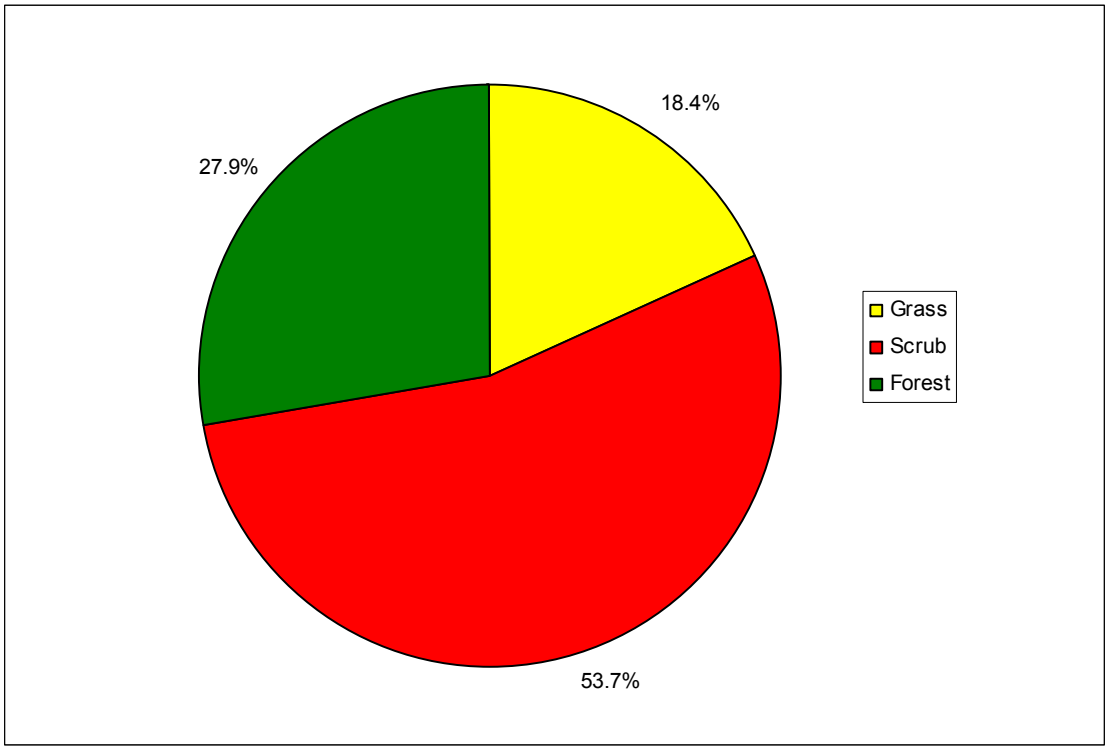


Figure T5. Taranaki total area burned by fuel type from 1991/92 to 2006/07.

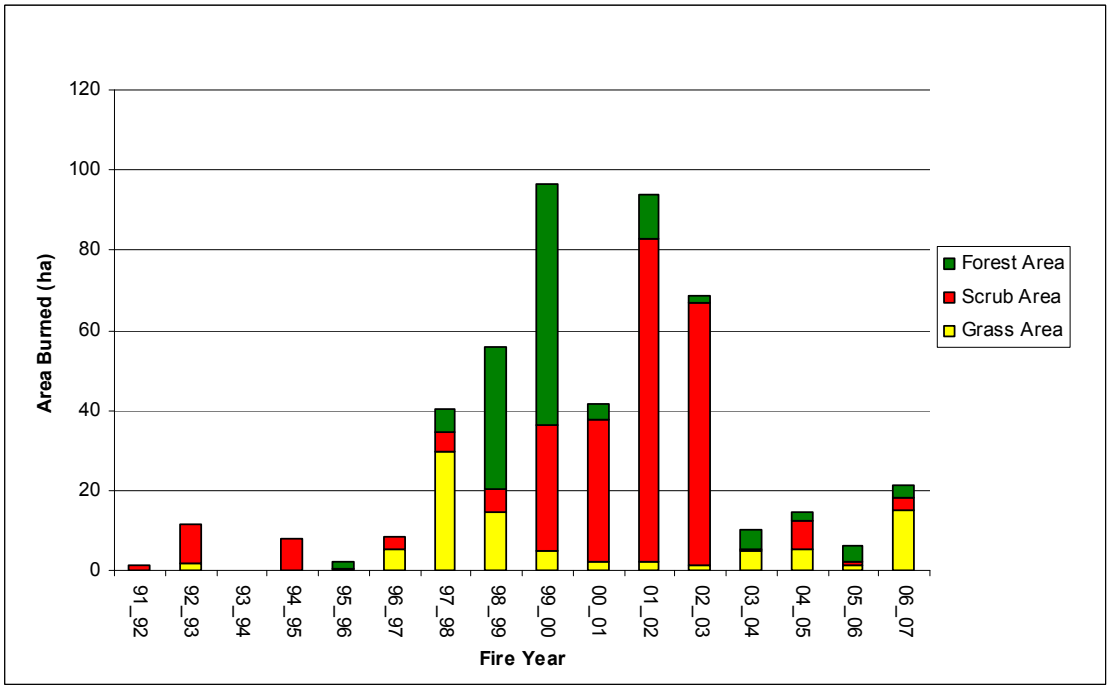


Figure T6. Taranaki Total area burned by fuel type from 1991/92 to 2006/07.

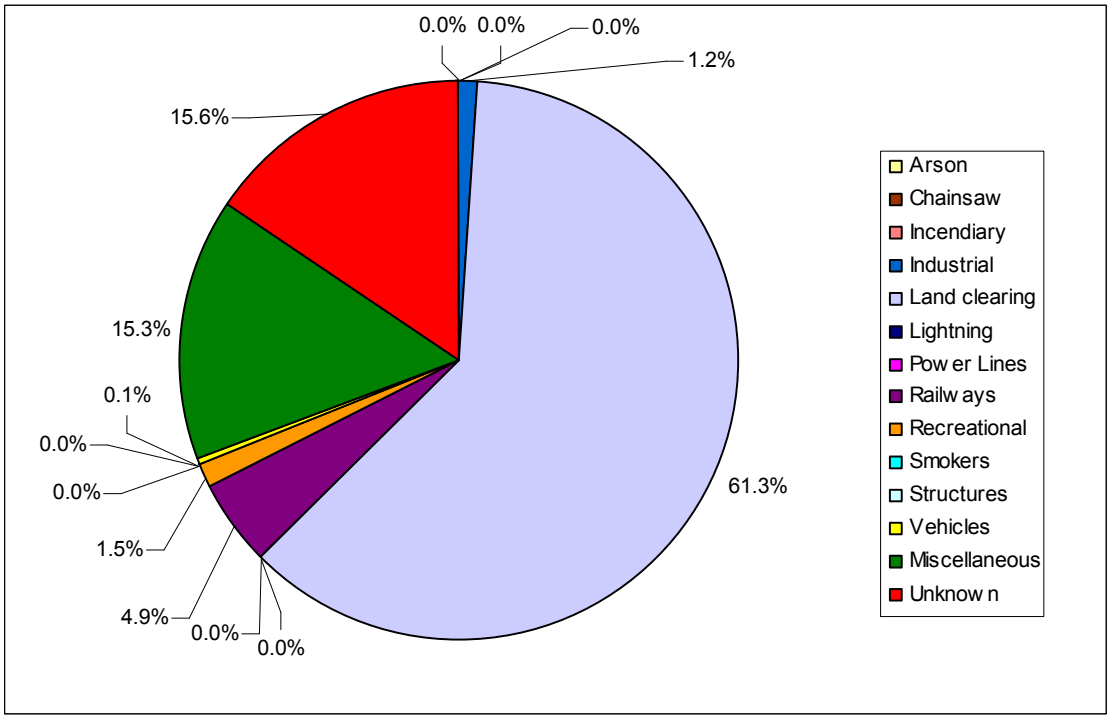


Figure T7. Taranaki average total area burned by cause from 1991/92 to 2006/07.

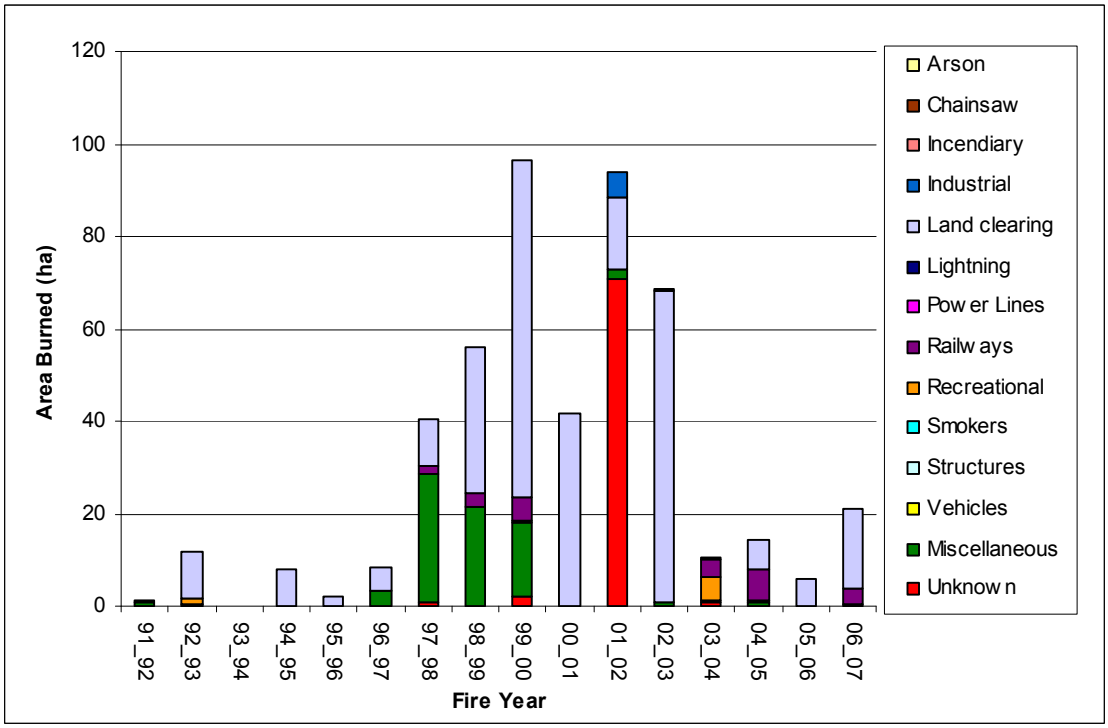


Figure T8. Taranaki total area burned by cause from 1991/92 to 2006/07.

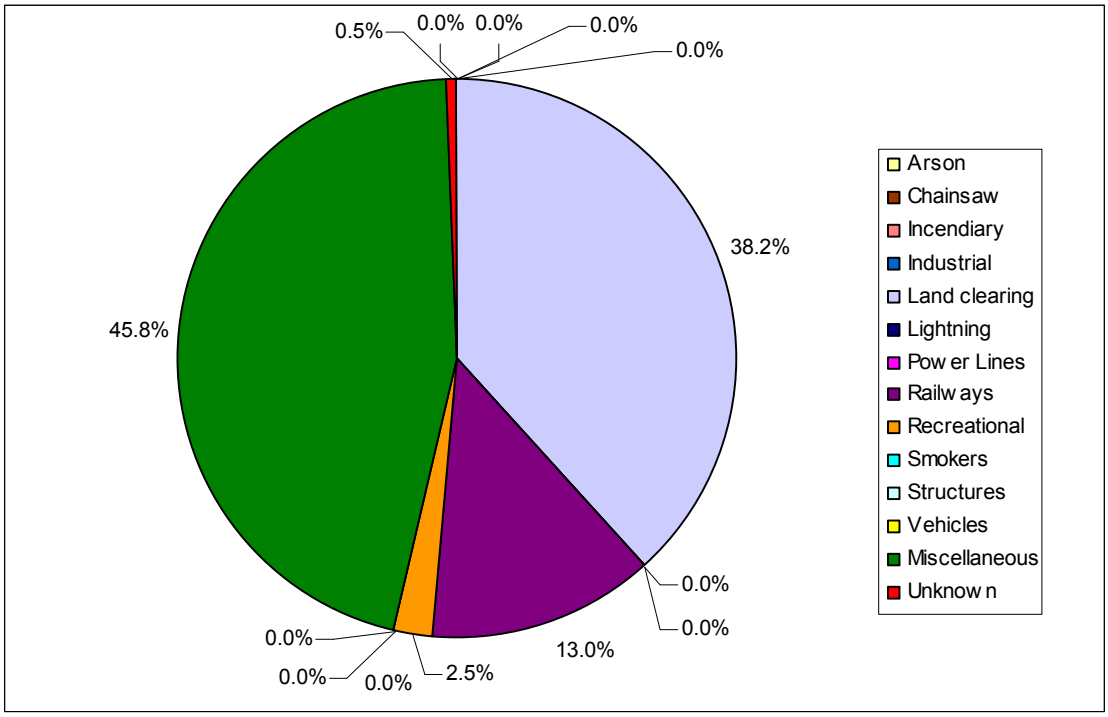


Figure T9. Taranaki average total annual grass area burned from 1991/92 to 2006/07.

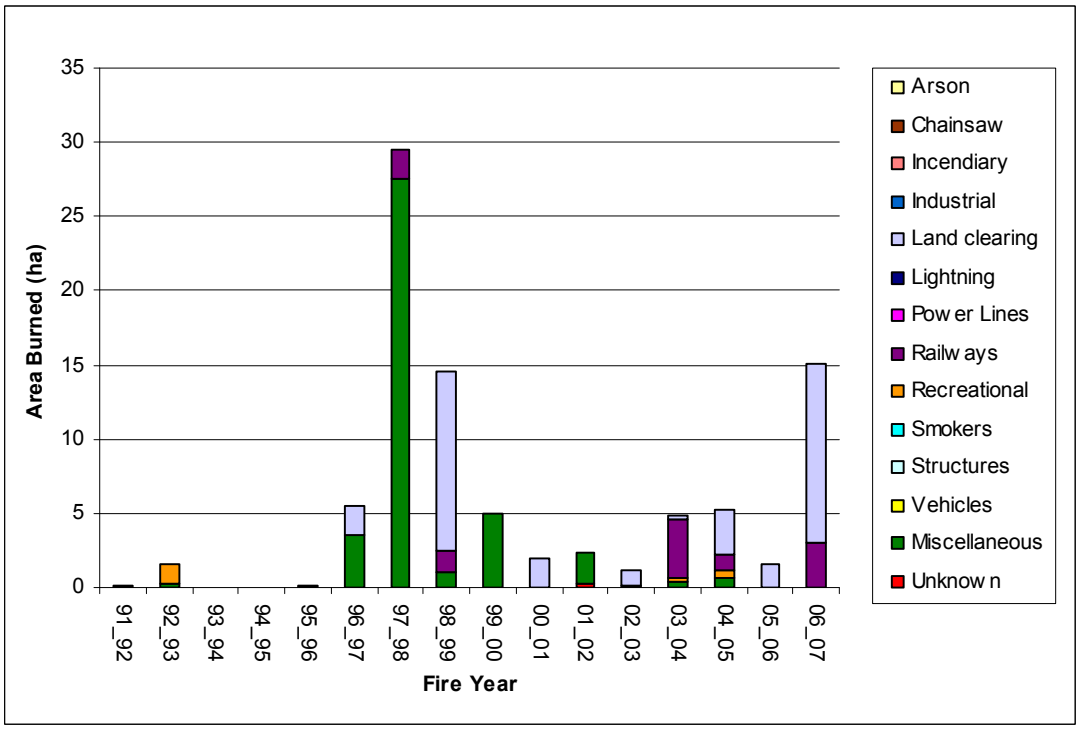


Figure T10. Taranaki total grass area burned by cause from 1991/92 to 2006/07.

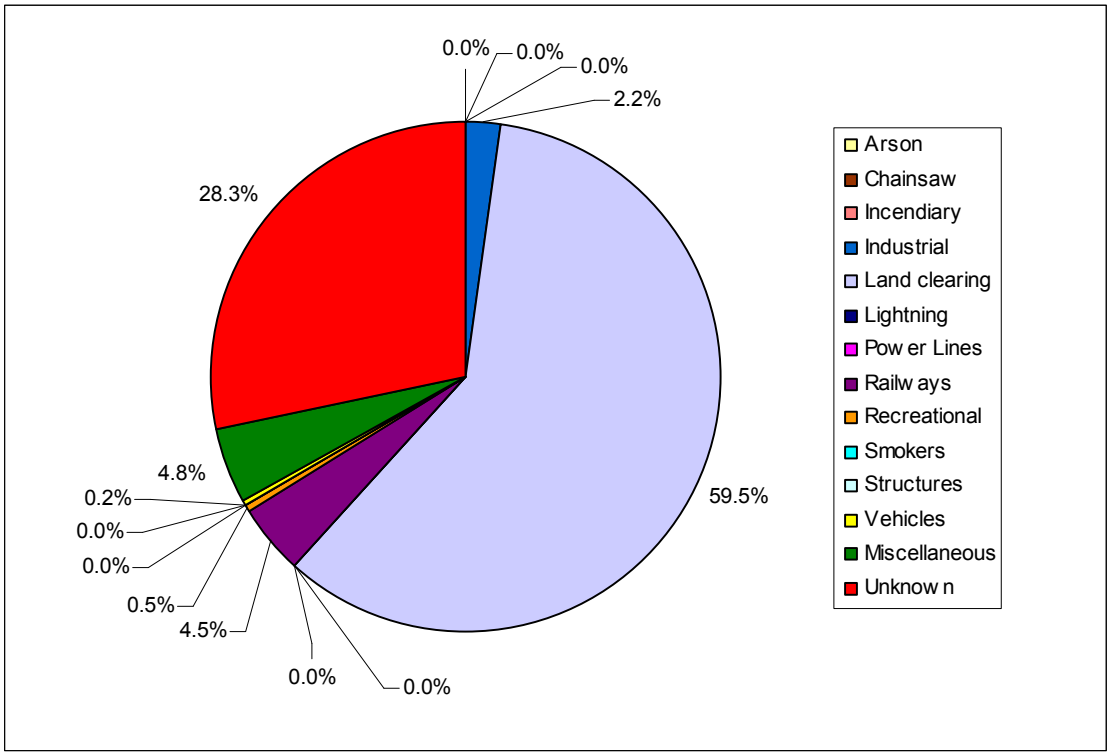


Figure T11. Taranaki average total scrub area burned by cause from 1991/92 to 2006/07.

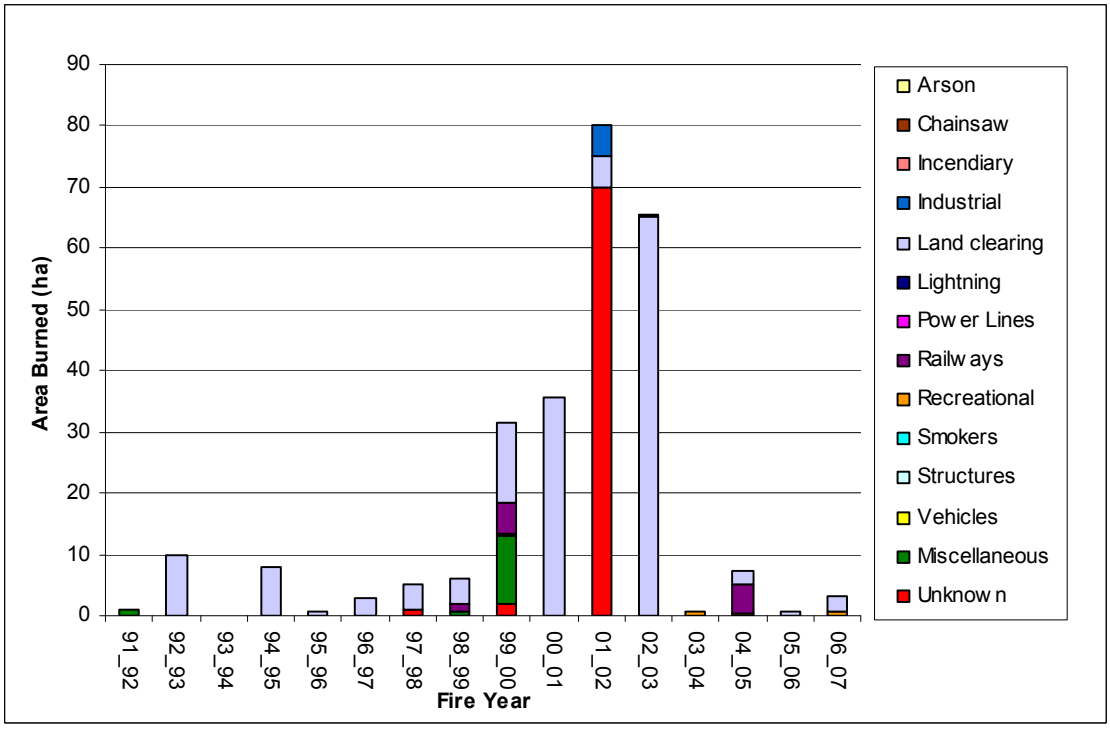


Figure T12. Taranaki total scrub area burned by cause from 1991/92 to 2006/07.

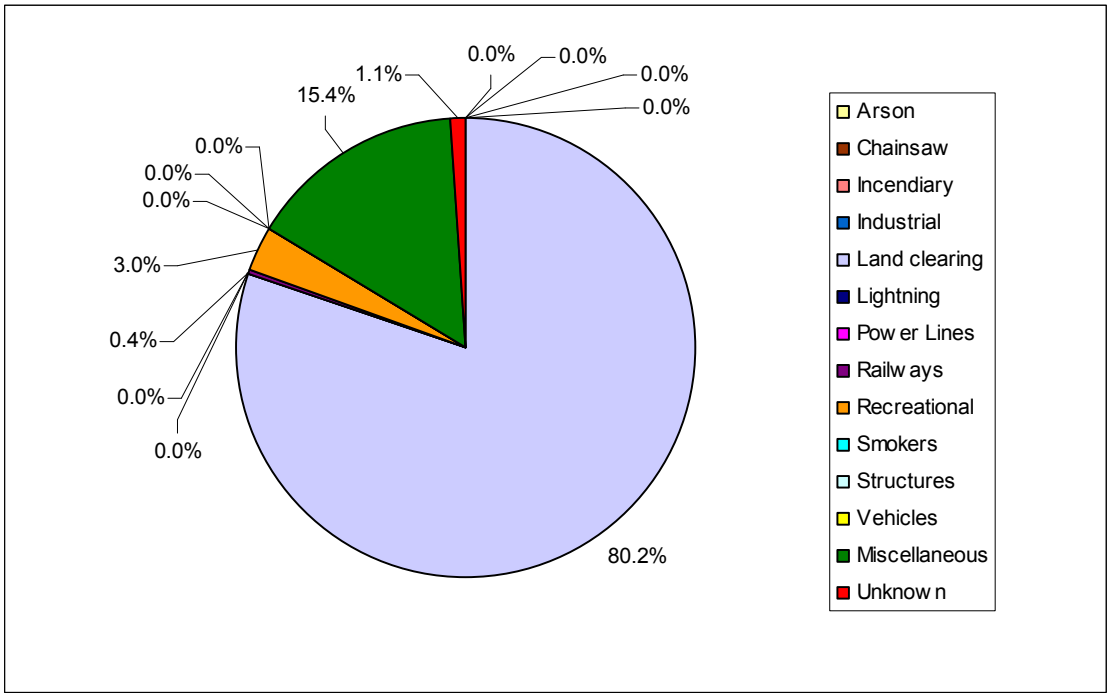


Figure T13. Taranaki average total forest area burned by cause from 1991/92 to 2006/07.

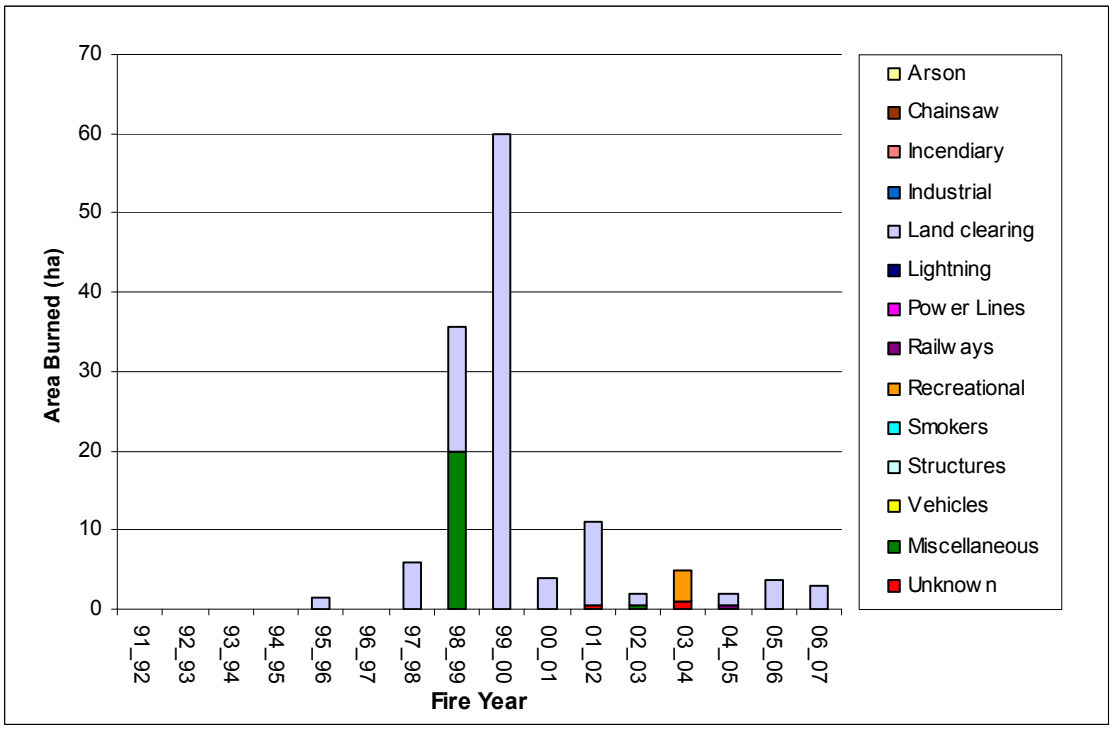


Figure T14. Taranaki total forest area burned by cause from 1991/92 to 2006/07.

Appendix C7 Eastern North Island Region Fire Returns 1991/92 to 2006/07

Number of Fires (Figure E1):

- The Eastern North Island had on average 429 fires annually (or about 13% of the national average number of fires) from 1991/92 to 2006/07.
- The annual total number of fires varied from 74 fires in 1991/92 (7% of that year's national) to 679 fires (15% of that year's national) in 2003/04.
- The annual total number of fires over time displayed a clear statistically significant positive trend (regression: R^2 = 0.7082; F-value = 33.89; P-value = <0.001).
- The total annual number of fires over time also correlated with the national trend (correlation coefficient = 0.889; P-value = <0.001).

Area Burned (Figure E2):

- The average annual area burned was 446 ha (9% of the national total area burned).
- The total annual area burned varied considerably over time, from just under 77 ha in 1992/93 (3% of that year's national) to 1,082 ha in 1997/98 (17% of that year's national).
- As with many other regions, the Eastern North Island's total annual area burned from 1991/92 to 2006/07 showed no statistically significant positive or directional trend over time (regression: R^2 = 0.0002; F-value 0.00; P-value = 0.961).

Number of Fires by Cause (Figures E3 and E4):

- Miscellaneous accounted for 42% of the average annual number of fires (actual average 180 fires); on average fires from unknown causes accounted for 8% (or on average 34 fires annually); combined 'unspecific' = 50% of fires.
- Land clearing accounted for 22% of the average annual number of fires (about 93 fires annually); vehicles accounted for 14% (or on average about 61 fires).
- The total annual number of fires varied between 1991/92 and 1996/97 from just under 100 fires to just over 200 fires, then in 1997/98 the total annual number of fires jumped to around 600 and has varied between around 500 and 700 since. This is primarily due to a four-fold increase in the number of miscellaneous fires; an up to three-fold increase in the number of vehicle fires; and up to a two-fold increase in land clearing fires.

Area Burned by Fuel type (Figures E5 and E6):

- Around 38% of the reported total area burned was grass; average annual grass area burned was 171 ha (or just under 8% of the national total grass area burned).
- Scrub made up about 45% of the total area burned; with an average annual total area burned of about 200 ha (or about 10% of the national average total scrub area burned).

- Forest made up the remaining 17% of the total area burned; average annual total forest area burned was 76 ha (or 15% of the national total forest area burned).
- In almost all years, scrub and grass made up the majority of the recorded annual total area burned; over 450 ha of forest reported burned in 1996/97; in 1996/97 and 1997/98 over 550 ha of scrub area burned; and 1998/99 recorded just under 700 ha of grass area burned.
- The Eastern North Island accounted for about 62% of the total forest area burned nationally in 1996/97 (459 ha) and 50% (214 ha) in 2004/05.

Area Burned by Cause (Figures E7 and E8):

- Around 44% of the average total annual area was attributed to land clearing (annual average of 194 ha). Land clearing accounted for most of the area burned in 1996/97, with over 900 ha burned.
- Around 14% (average about 62 ha) of the average total annual area burned was attributed to miscellaneous causes; about 18% to unknown (average 78 ha)
- Incendiary causes accounted for, on average, 10% (or 44ha) of the total annual area burned.

Area Burned by Cause and Fuel type (Figures E9, E10, E11, E12, E13, and E14):

- Over the 16 year period around 34% of the average annual total grass area burned was attributed to land clearing fires (annual average of about 59 ha).
- Miscellaneous causes accounted for 14% (about 23 ha), unknown 26% (45 ha), combined ('un-specified') 40% of the average annual total grass area burned.
- Around 9% (average of 16ha annually) of the average annual total grass area burned was accounted for by vehicles, and a further 9% (average of 16 ha annually) from incendiary causes.
- Higher areas of grass area burned in individual fire years were usually at least in part due to increased land clearing area burned; or in the case of 1998/99 a large grass area burned was attributed to unknown causes.
- Half of the average annual scrub area burned was attributed to land clearing; average annually of about 100 ha.
- Miscellaneous causes accounted for 16% (or 30 ha) of the average annual total scrub area burned; unknown about 11% (about 21 ha), and incendiary 12% (or 23 ha).
- Few clear individual cause trends were present in annual total scrub area burned. Land clearing made up much of the total scrub area burned in most years. 1996/97 had over 500 ha of scrub area burned mostly from land clearing. The exception was 1997/98 when around 600 ha burned mostly due to unknown and miscellaneous causes.
- The annual average total forest area burned was dominated by land clearing (with 48%, an annual average of 36 ha).
- Chainsaws accounted for about 18% (13 ha) of the annual average total forest area burned.

- Over a quarter of the annual average forest area burned was made up of miscellaneous (11% or 8 ha) and unknown (about 17% or about 13 ha) causes.
- The annual average forest area burned was mainly influenced by two causes. 1996/97 had over 400ha of forest area burned attributed to land clearing, 2004/05 had around 200ha attributed to chainsaw causes.

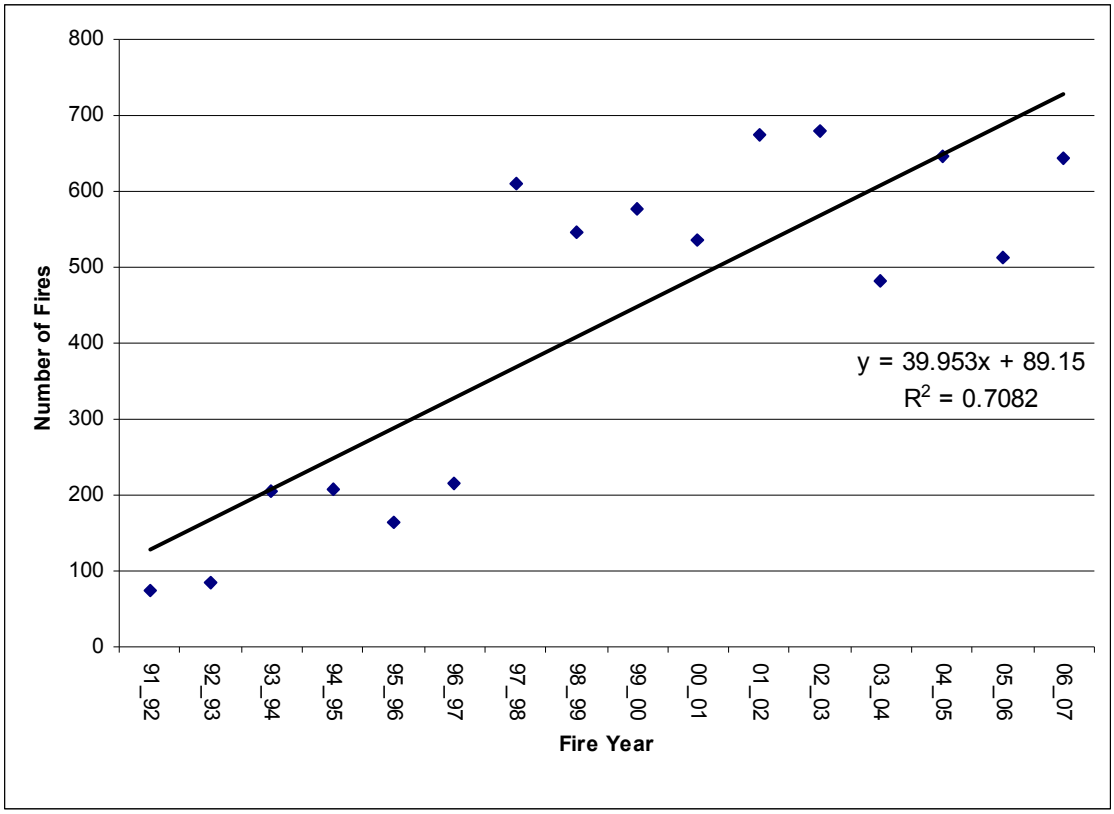


Figure E1. Eastern North Island total annual number of fires from 1991/92 to 2006/07.

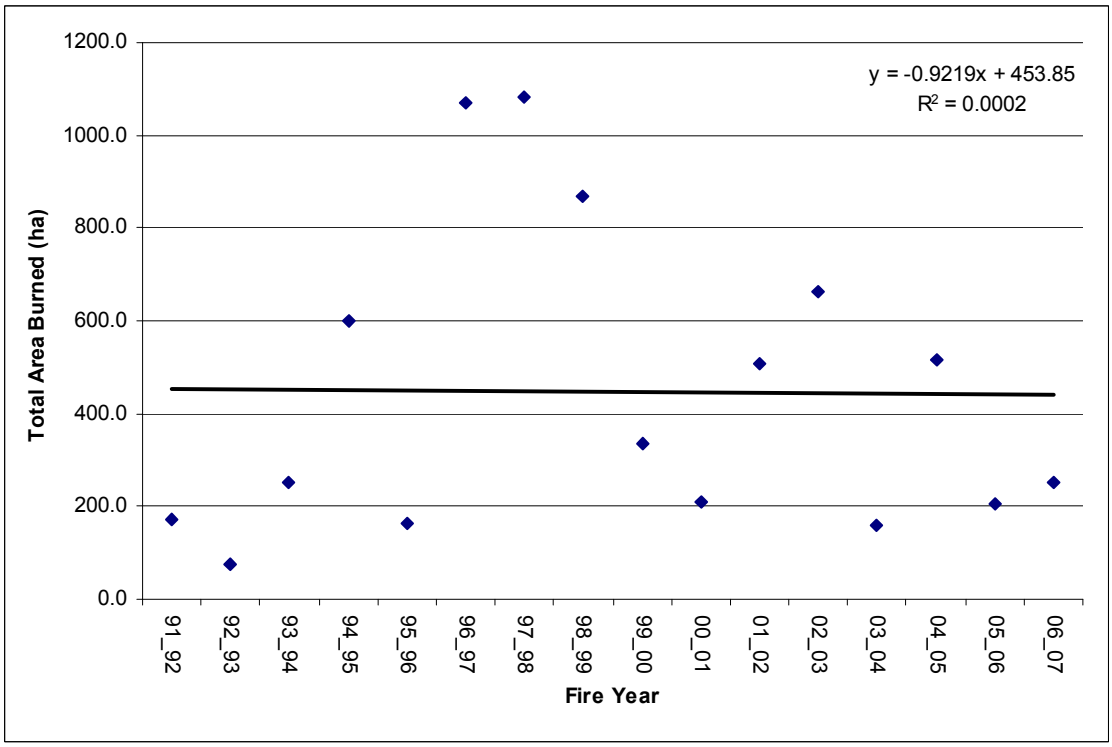


Figure E2. Eastern North Island total annual area burned from 1991/92 to 2006/07.

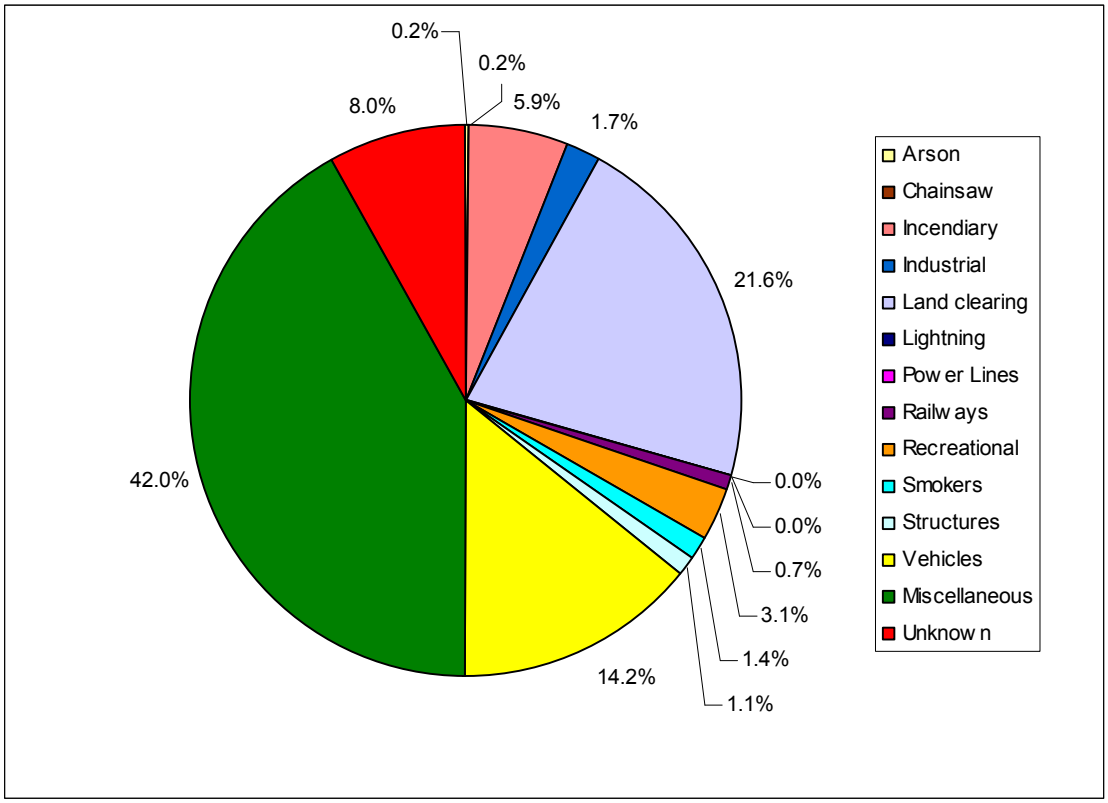


Figure E3. Eastern North Island total number of fires by cause from 1991/92 to 2006/07.

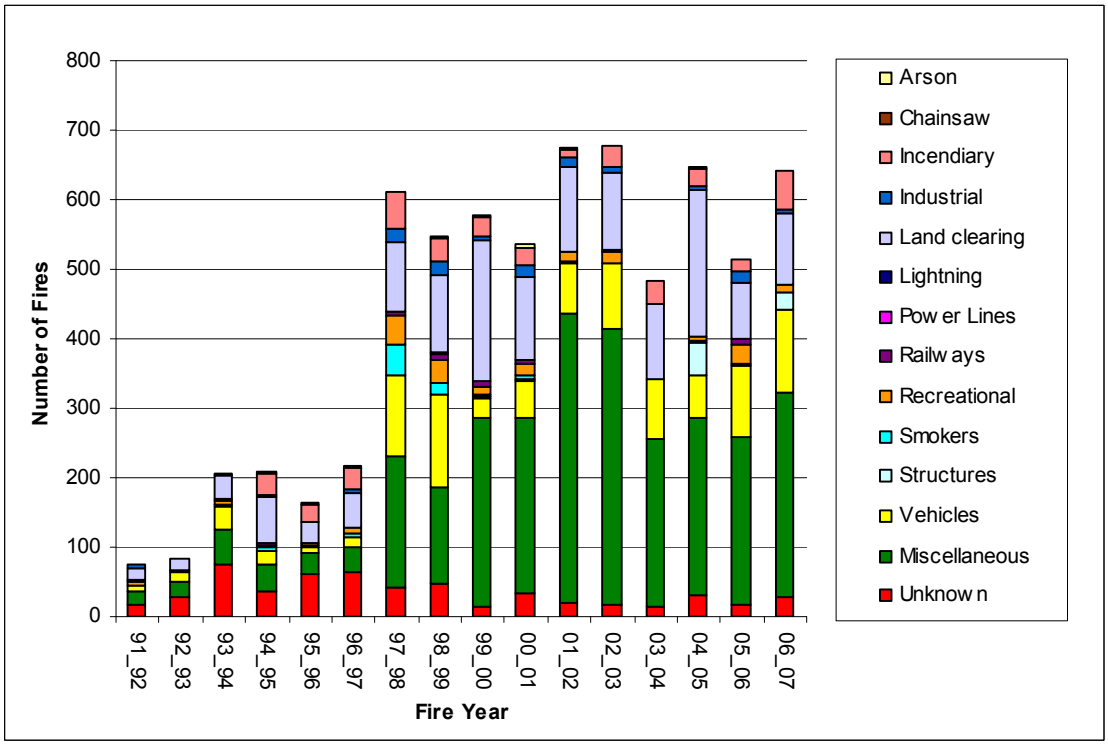


Figure E4. Eastern North Island total number of fires by cause from 1991/92 to 2006/07.

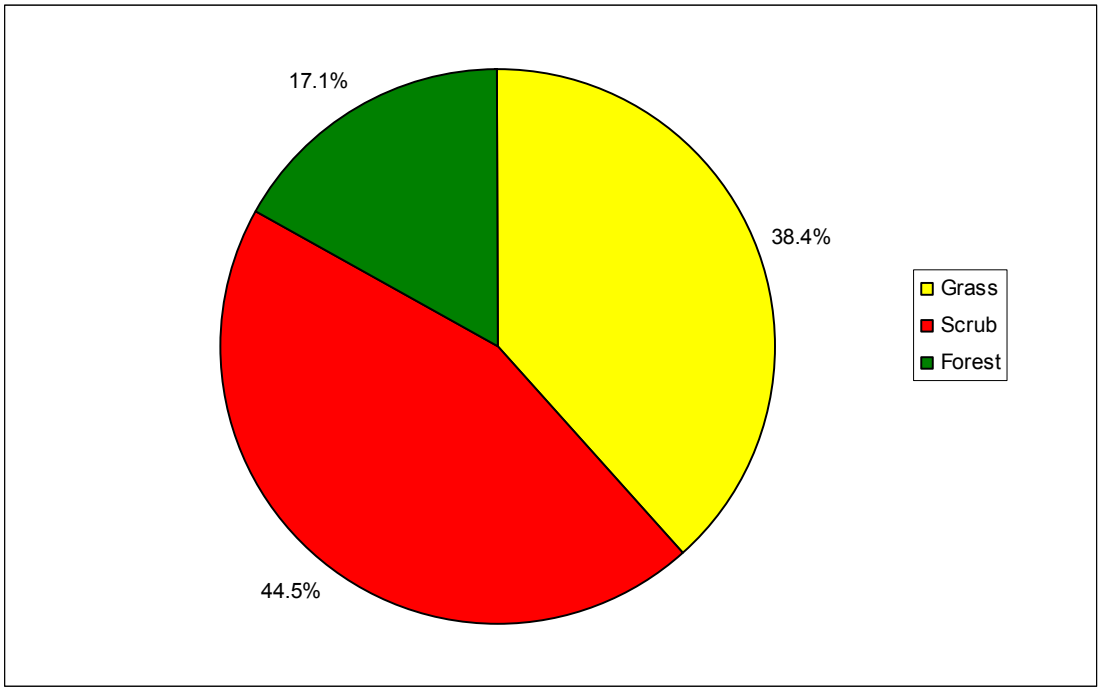


Figure E5. Eastern North Island total area burned by fuel type from 1991/92 to 2006/07.

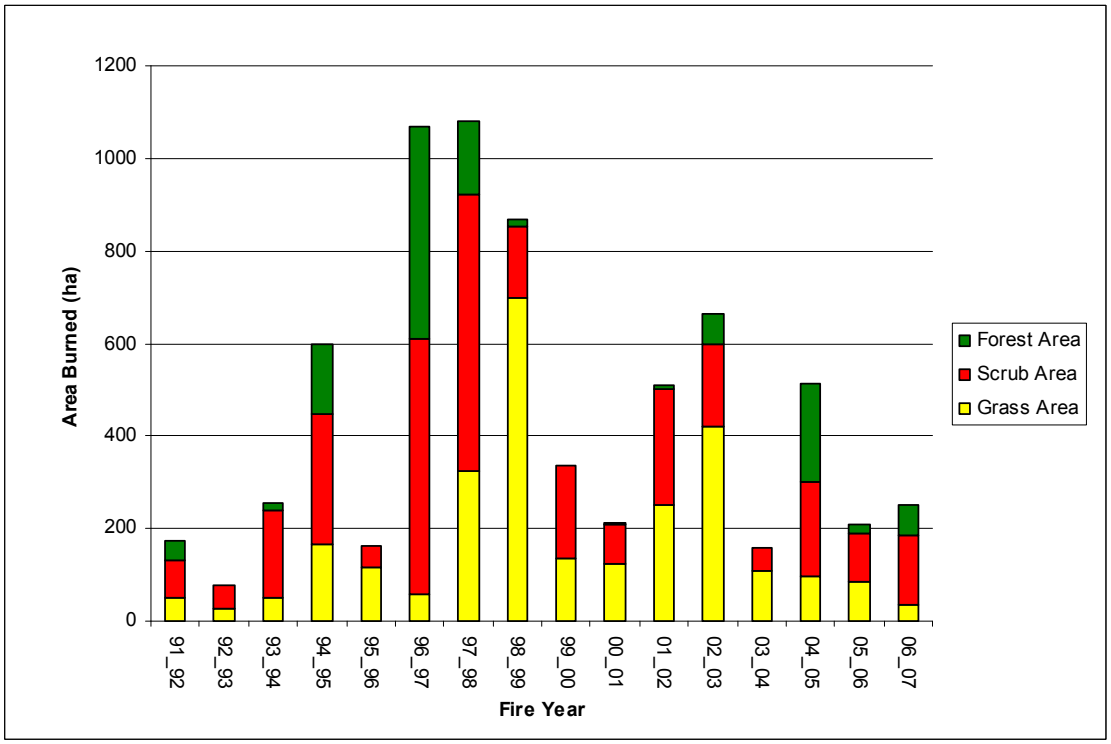


Figure E6. Eastern North Island total area burned by fuel type from 1991/92 to 2006/07.

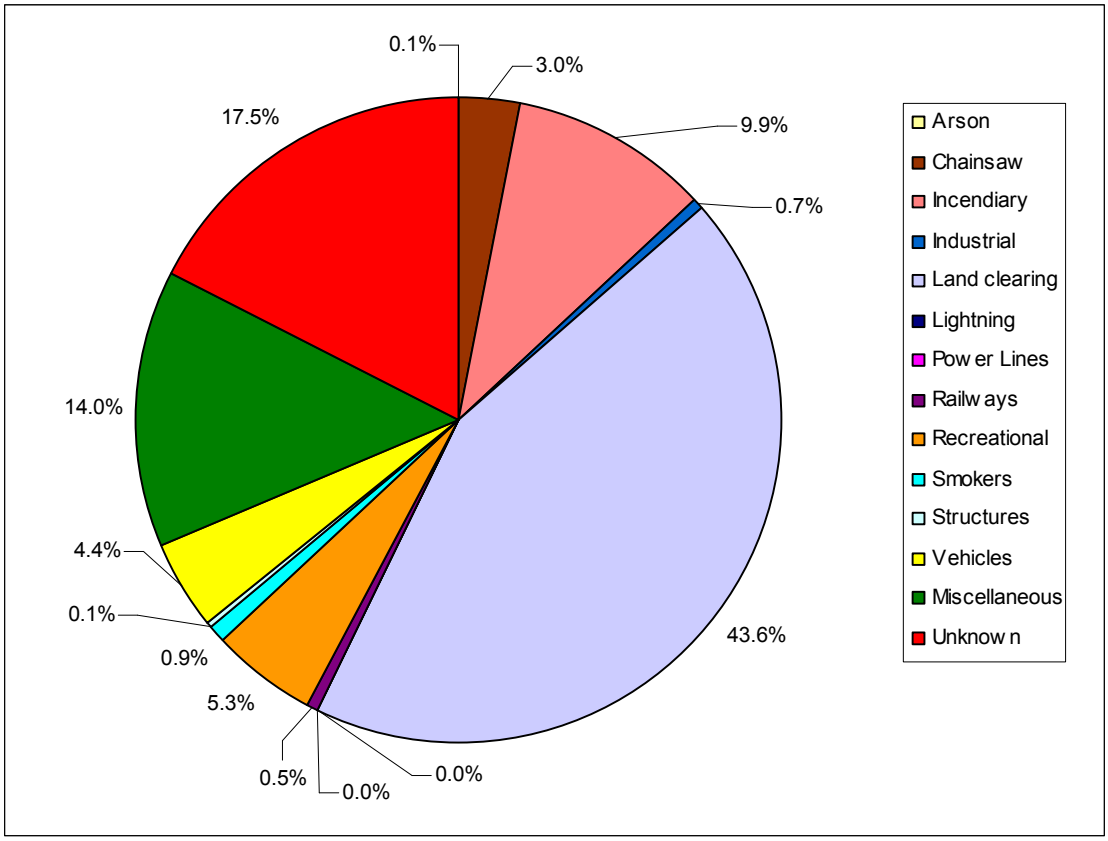


Figure E7. Eastern North Island total area burned by cause from 1991/92 to 2006/07.

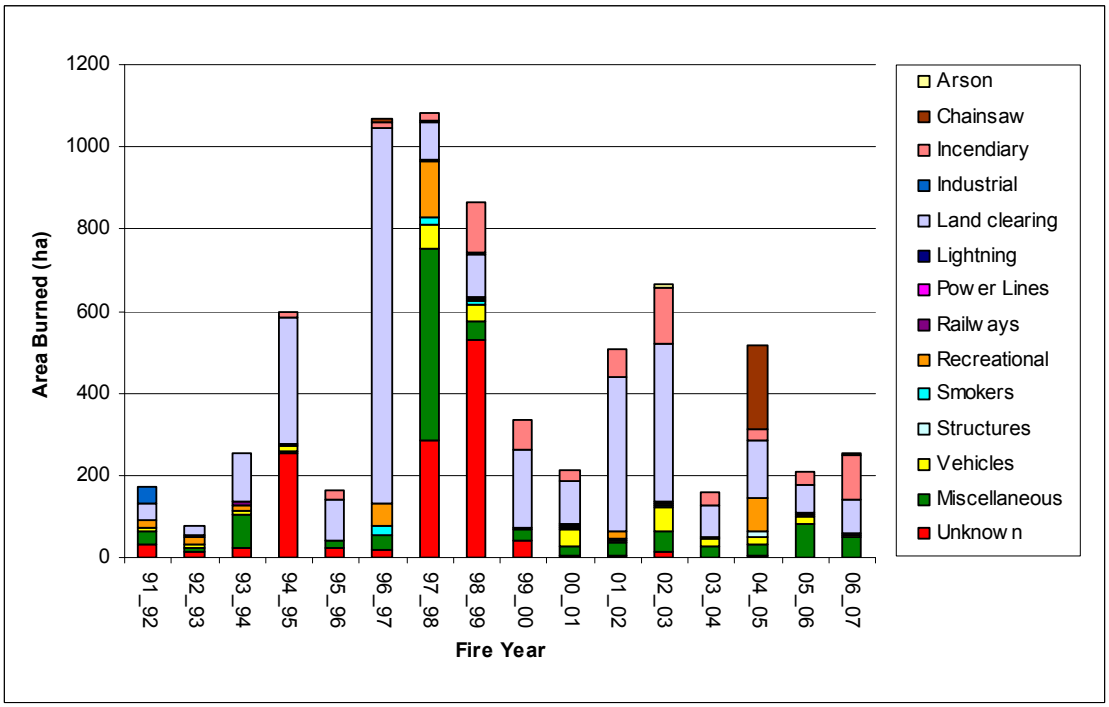


Figure E8. Eastern North Island total area burned by cause 1991/92 to 2006/07.

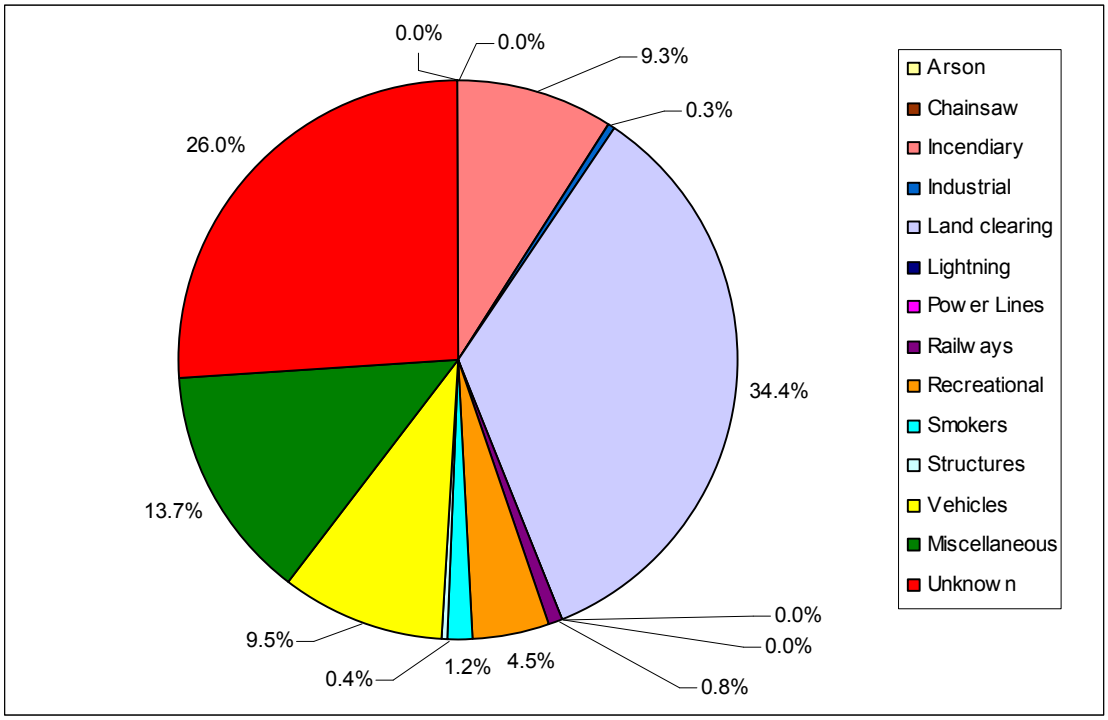


Figure E9. Eastern North Island average total annual grass area burned from 1991/92 to 2006/07.

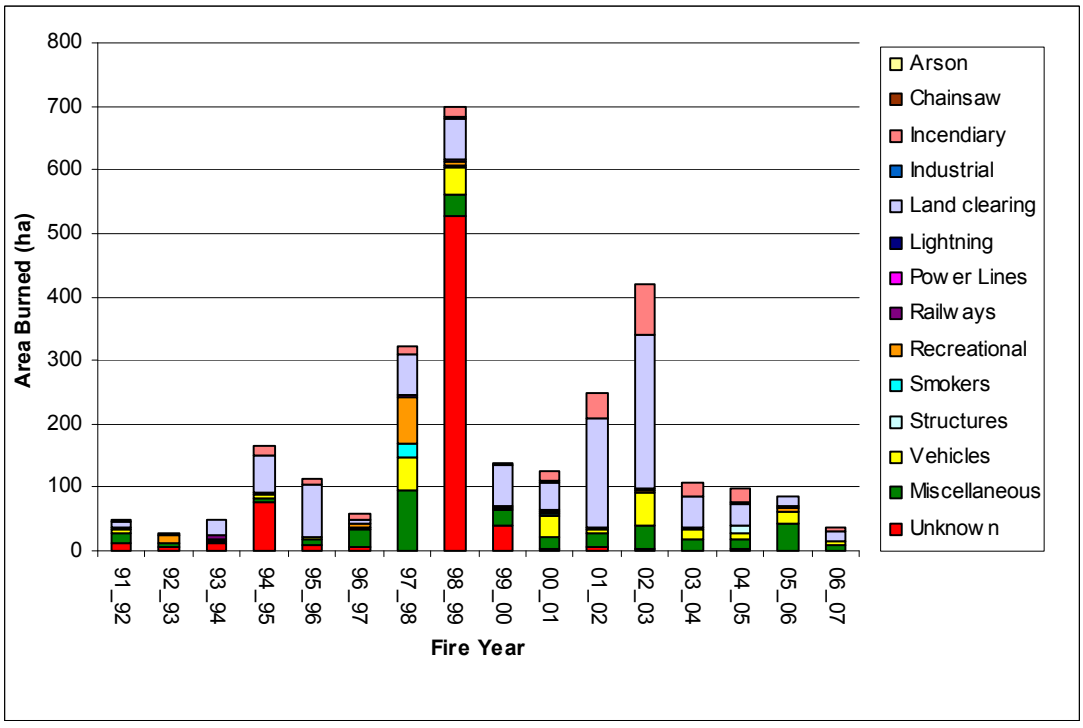


Figure E10. Eastern North Island total grass area burned by cause from 1991/92 to 2006/07.

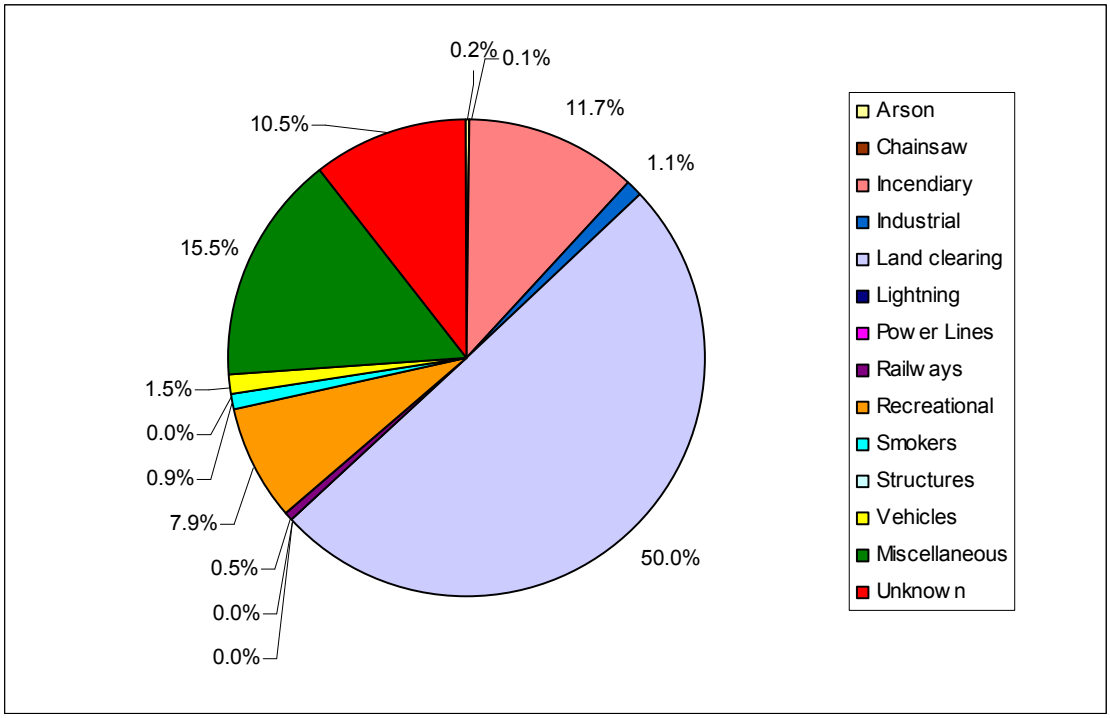


Figure E11. Eastern North Island average total scrub area burned by cause from 1991/92 to 2006/07.

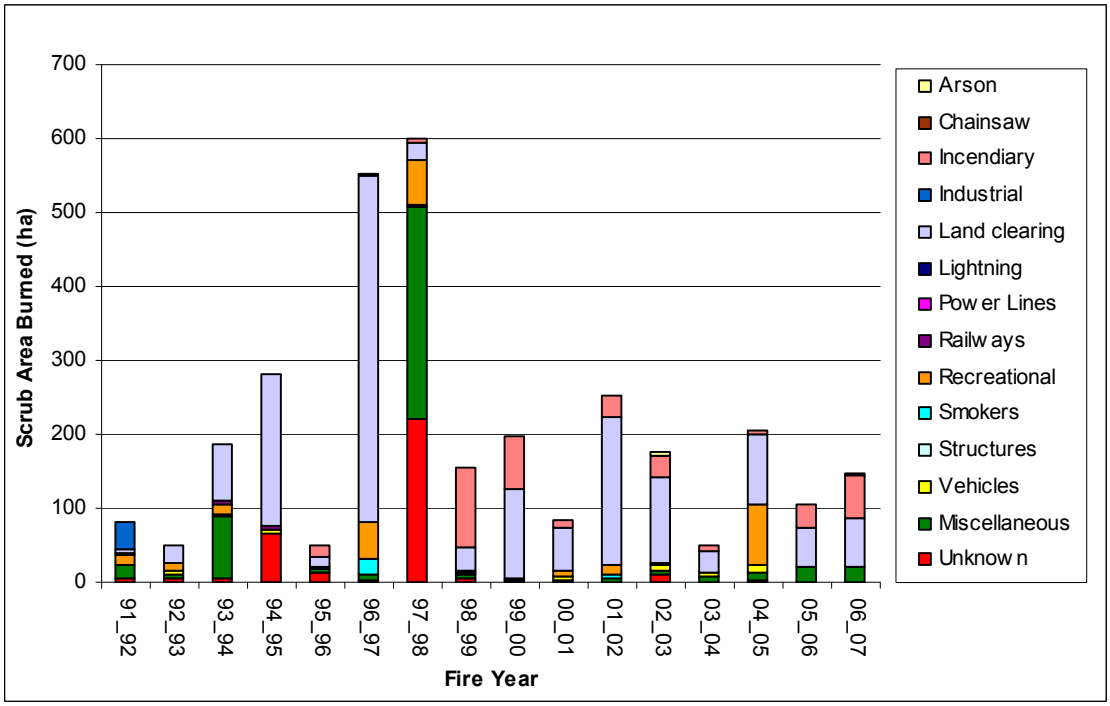


Figure E12. Eastern North Island Total scrub area burned by cause from 1991/92 to 2006/07.

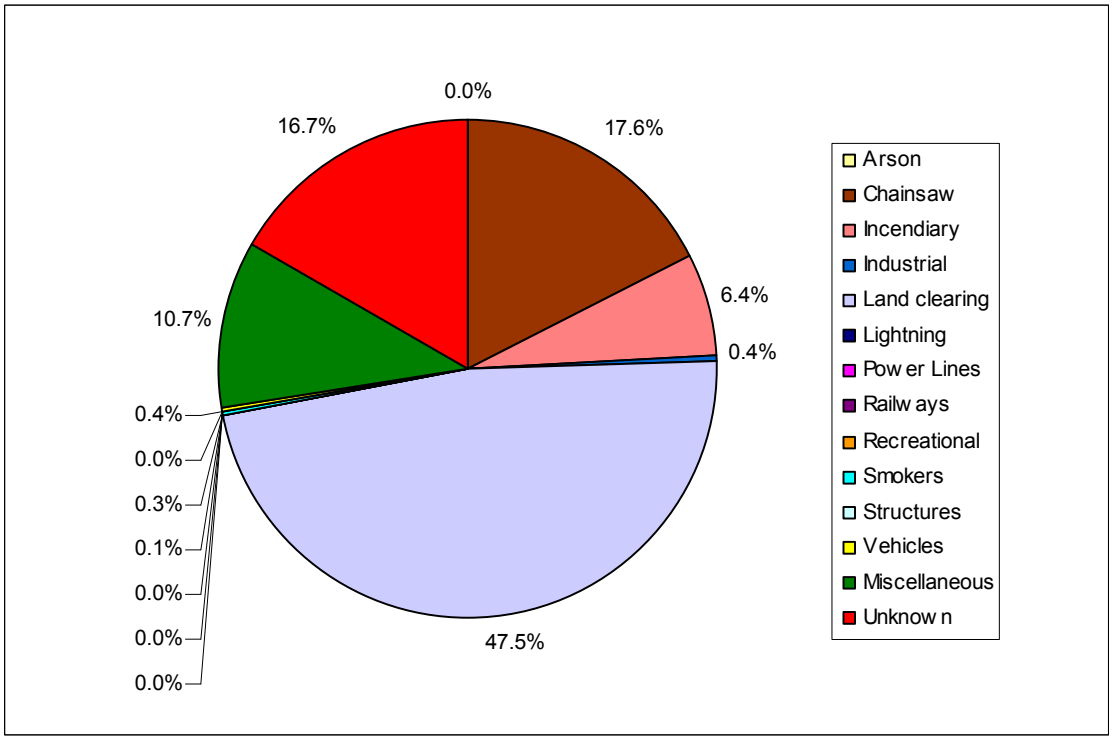


Figure E13. Eastern North Island average total forest area burned by cause 1991/92 to 2006/07.

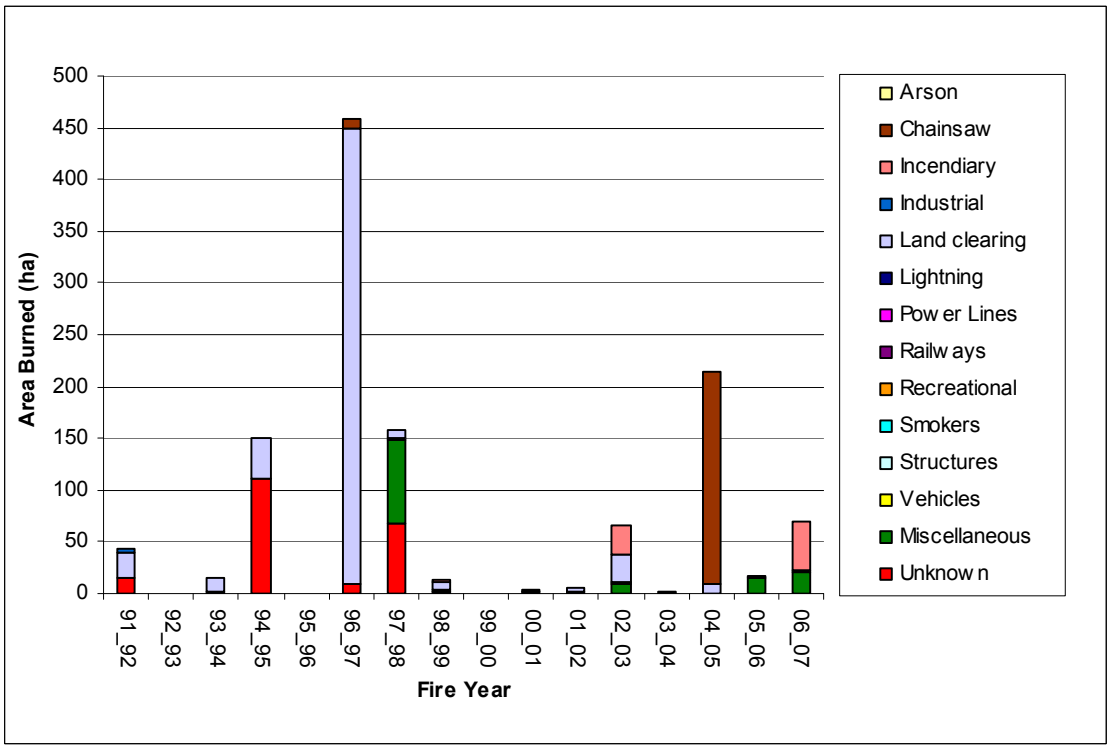


Figure E14. Eastern North Island total forest area burned by cause 1991/92 to 2006/07.

Appendix C8 Greater Wellington Region Fire Returns 1991/92 to 2006/07

Number of Fires (G1):

- Greater Wellington had from 1991/92 to 2006/07 around 173 fires annually (6% of the national number of fires).
- The number of fires varied from just 30 fires in 1991/92 (3% of that year's national total) to 458 fires in 2005/06 (10.6% of that year's national total).
- The total number of fires showed a significant increase over time (regression: $R^2 = 0.35$; F-value = 7.69; P-value 0.015). This also followed the national trend of increasing number of fires over time (correlation coefficient = 0.697; P-value = 0.003).

Area Burned (Figure G2):

- The average annual total area burned for Greater Wellington was about 138 ha (or 2% of the national total area burned).
- The total annual area burned over time varied from just 12 ha in 1991/92 (1% of that year's annual total) to 591 ha in 1997/98 (9% of that year's annual total).
- The total annual area burned from 1991/92 to 2006/07 showed a non-statistically significant negative trend with time (regression: $R^2 = 0.0198$; F-value = 0.28; P-value = 0.603).

Number of Fires by Cause (Figures G3 and G4):

- Miscellaneous causes made up about 30% of the average annual number of fires for Greater Wellington (or on average about 52 fires annually); and about 22% were due to unknown causes (annual average around 38 fires); combined 'unspecified' average annual number of fires was 52%.
- Around 14% of the annual average number of fires was attributed to land clearing (annual average of about 25 fires); incendiary accounted for around 10% (annual average of 18 fires); and another 10% was due to vehicle fires (annual average of 18 fires).
- Most cause classes featured annually in the total number of fires. The number of fires caused by miscellaneous and unknown causes fluctuate annually.

Area Burned by Fuel type (Figures G5 and G6):

- Grass made up 20% of the total area burned from 1991/92 to 2006/07. Average annual grass area burned was 27 ha.
- Around 65% of the total area burned was scrub. Average annual scrub area burned was around 90 ha.
- Forest area burned made up the remaining 15% of the total area burned; with the average annual forest area burned of 21 ha.
- The Greater Wellington total annual area burned by fuel type was mostly dominated by scrub; much of the total forest area burned occurred in 1997/98 when over 200ha of forest was reported burned

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Area Burned by Cause (Figures G7 and G8):

- While miscellaneous causes accounted for 30% of the average annual number of fires, they accounted for just 15% of the average annual total area burned (annual average 21 ha).
- Nearly 40% of the average annual total area burned was due to unknown causes (annual average 54 ha). This was in part due to relatively large areas of scrub and forest burned in 1997/98 from unknown causes.
- 15% of the total average annual area burned was attributed to land clearing (or average annually of 21 ha); incendiary causes accounted for nearly 16% of the total area burned (or annual average of 22 ha).

Area burned by Cause and Fuel type (Figures G9, G10, G11, G12, G13 and G14):

- The average annual total grass area burned was greatly influenced by miscellaneous causes in three fire years (1997/98, 1998/99, and 2002/03). A total of 37% of the average annual total grass area burned was assigned to miscellaneous causes (annual average just 10 ha).
- Around 10% (or on average 6 ha) of the average annual total grass area burned was attributed to unknown causes; 11 % (about 3 ha) attributed to incendiary; and another 11% attributed to land clearing (about 3 ha annually) causes.
- In comparison to other regions the actual total annual grass area burned was quite small (annually less than 100 ha for all fire years studied).
- Around 41% of the annual average total scrub area burned was attributed to unknown causes (actual average area burned about 37 ha); 10% to miscellaneous (average around 9 ha annually); combined 'unspecified' was just under 50% of the annual average total scrub area burned.
- Unlike other regions, incendiary causes played a more important role in total (and average) scrub area burned, with about 21% of the average annual total scrub area burned (about 19 ha annually) and occurs as a persistent cause in 1992/93, 1993/94, 1995/96, 1997/98, 1998/99, 1999/2000, 2000/01, 2005/06 and 2006/07.
- Land clearing accounted for about 12% of the average annual scrub area burned (about 11 ha annually); and was of high relative importance in 1992/93, 1993/94, 1995/96.
- The average annual forest area burned was greatly influenced by the relatively high area (over 150 ha) burned in 1997/98. Over half (54%) of the annual average total forest area burned was attributed to unknown causes (annual average about 11 ha). All other fire years reported less than 40 ha of forest area burned. However, over 200 ha was reported burned in 1997/98 mostly from unknown and land clearing causes.
- About 36% of the average annual total forest area burned was attributed to land clearing; most of this occurred in 1993/94, 1997/98, 2005/06 and 2006/07 fire years.

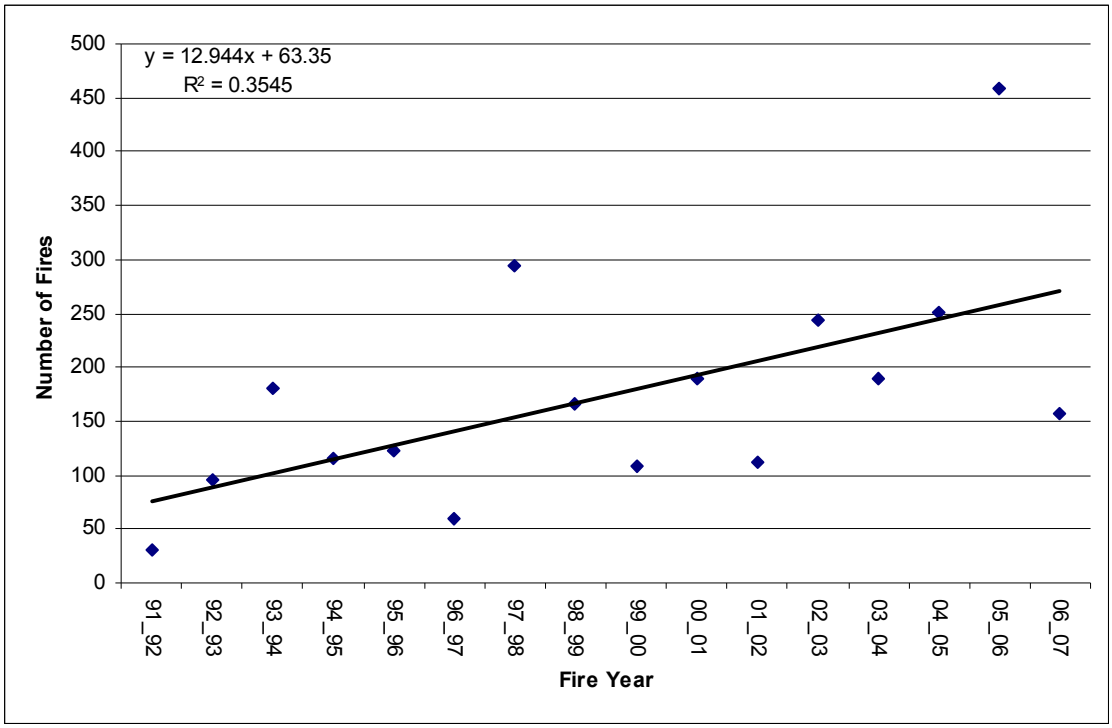

Figure G1. Greater Wellington total annual number of fires from 1991/92 to 2006/07.

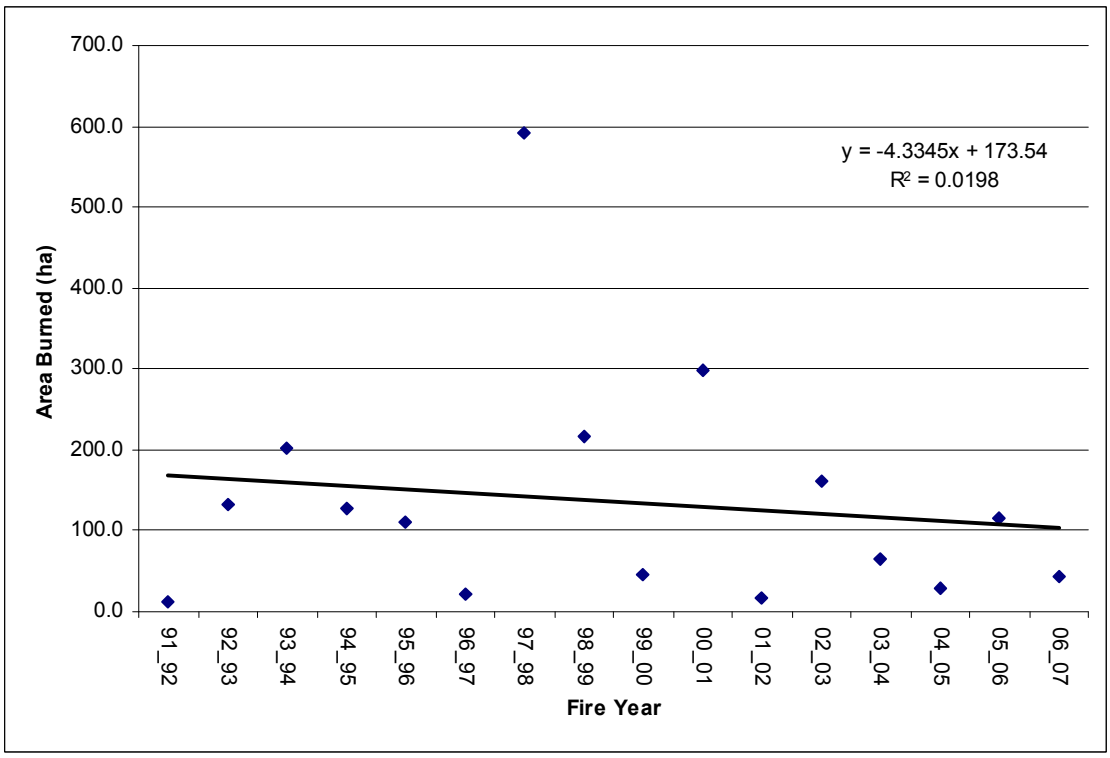

Figure G2. Greater Wellington total annual area burned from 1991/92 to 2006/07.

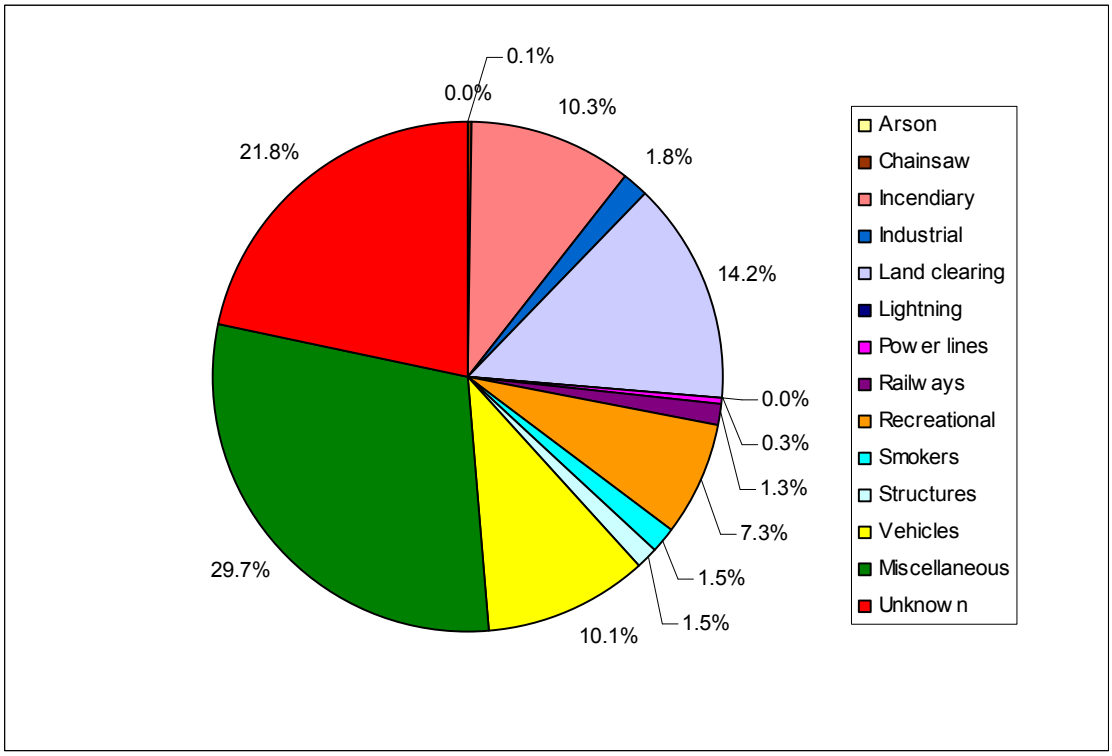

Figure G3. Greater Wellington total number of fires by cause from 1991/92 to 2006/07.

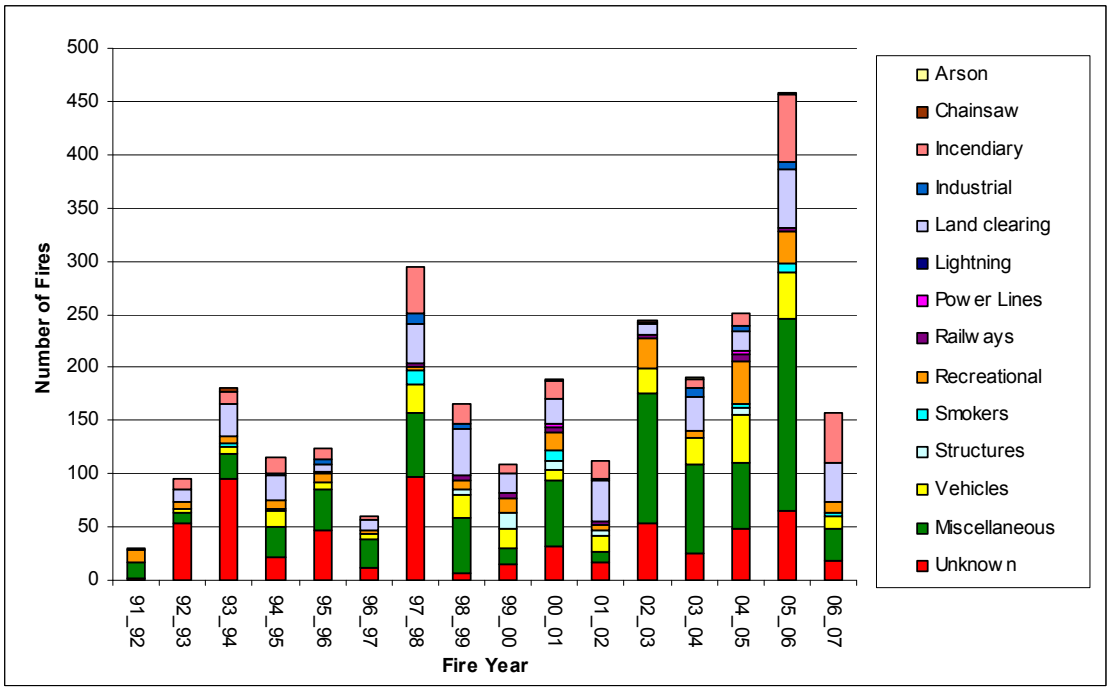

Figure G4. Greater Wellington total number of fires by cause from 1991/92 to 2006/07.

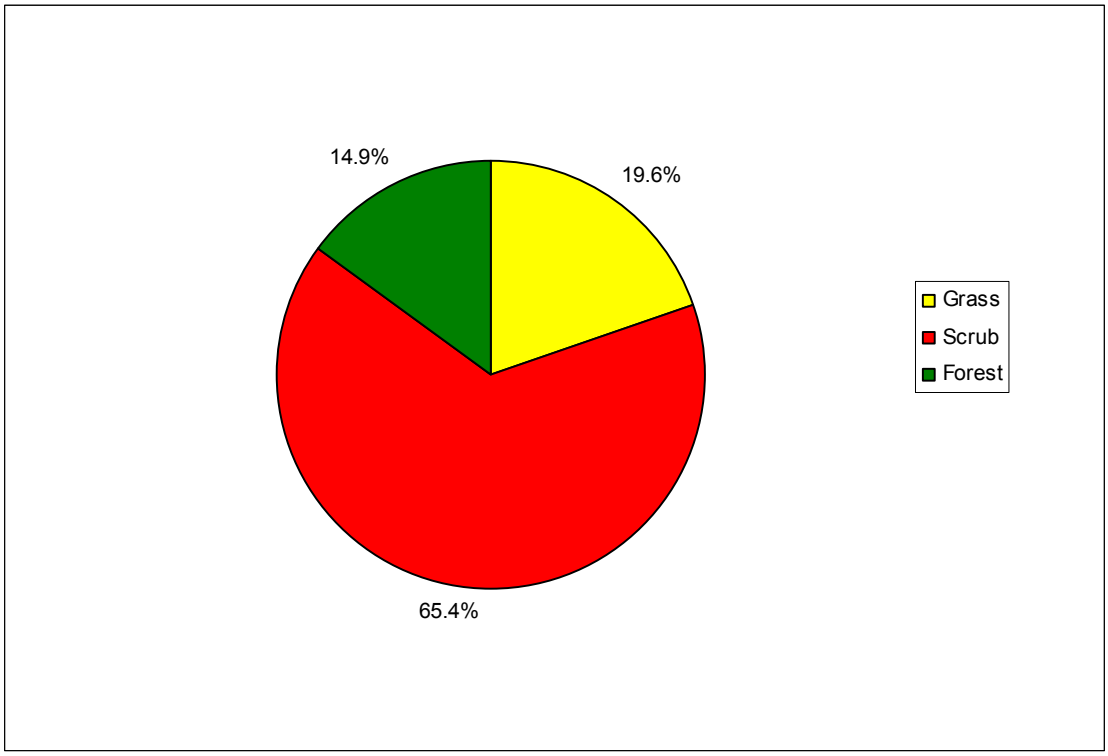

Figure G5. Greater Wellington total area burned by fuel type from 1991/92 to 2006/07.

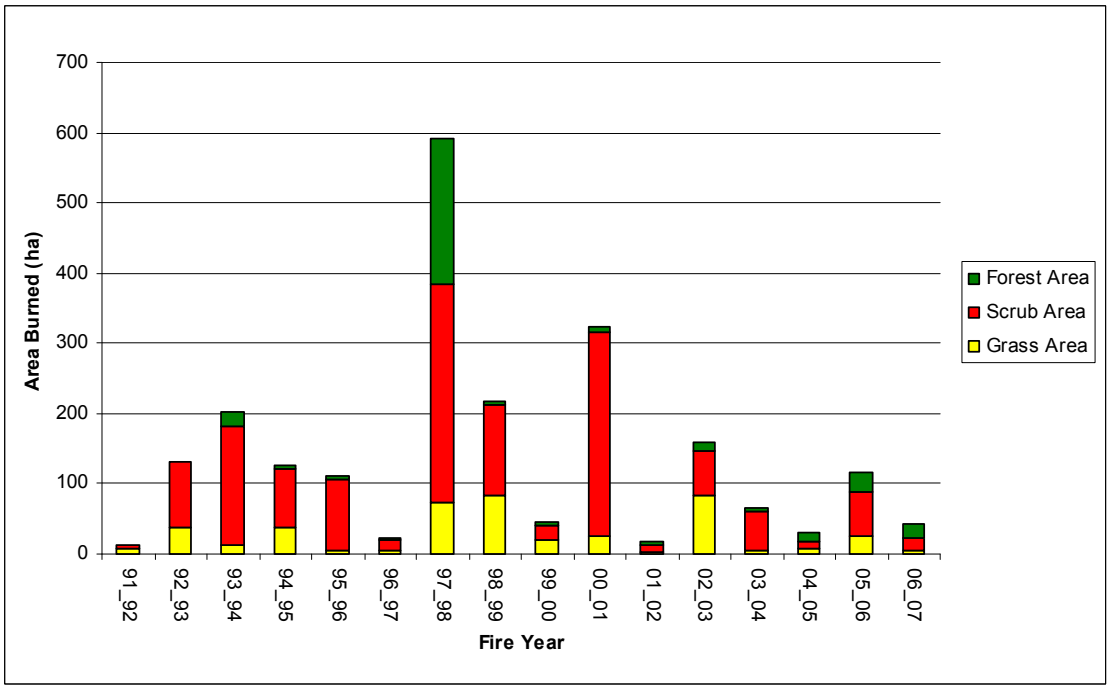

Figure G6. Greater Wellington total area burned by fuel type from 1991/92 to 2006/07.

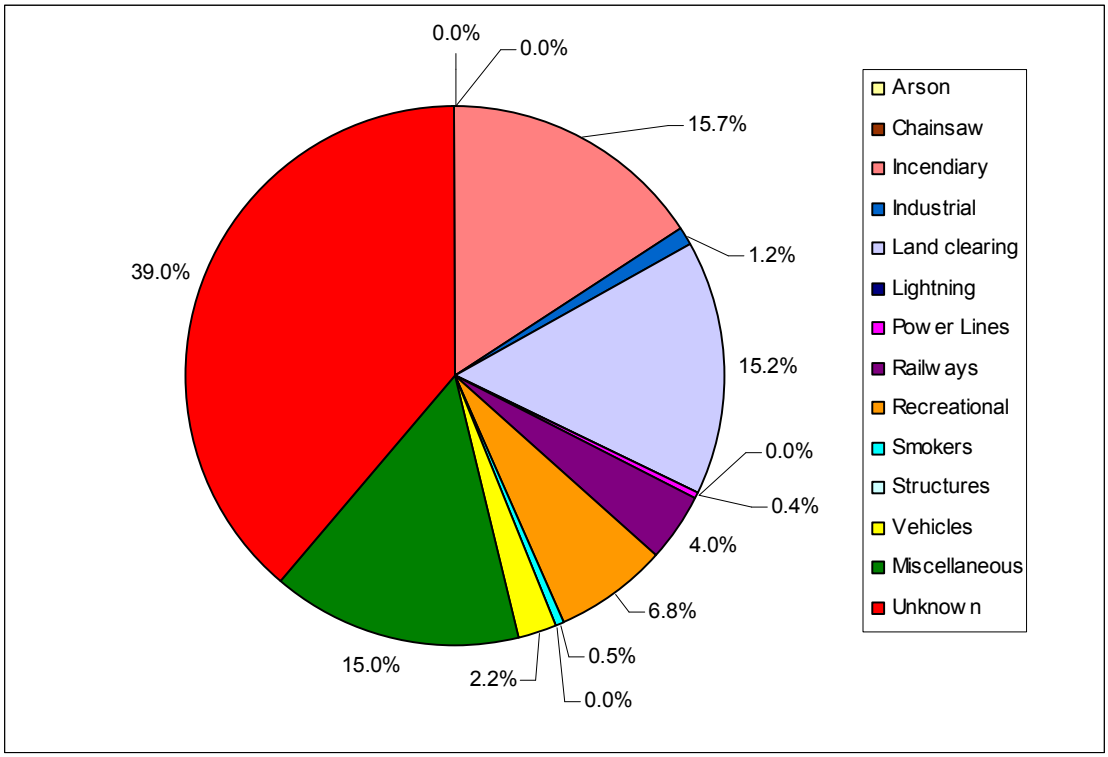

Figure G7. Greater Wellington total area burned by cause from 1991/92 to 2006/07.

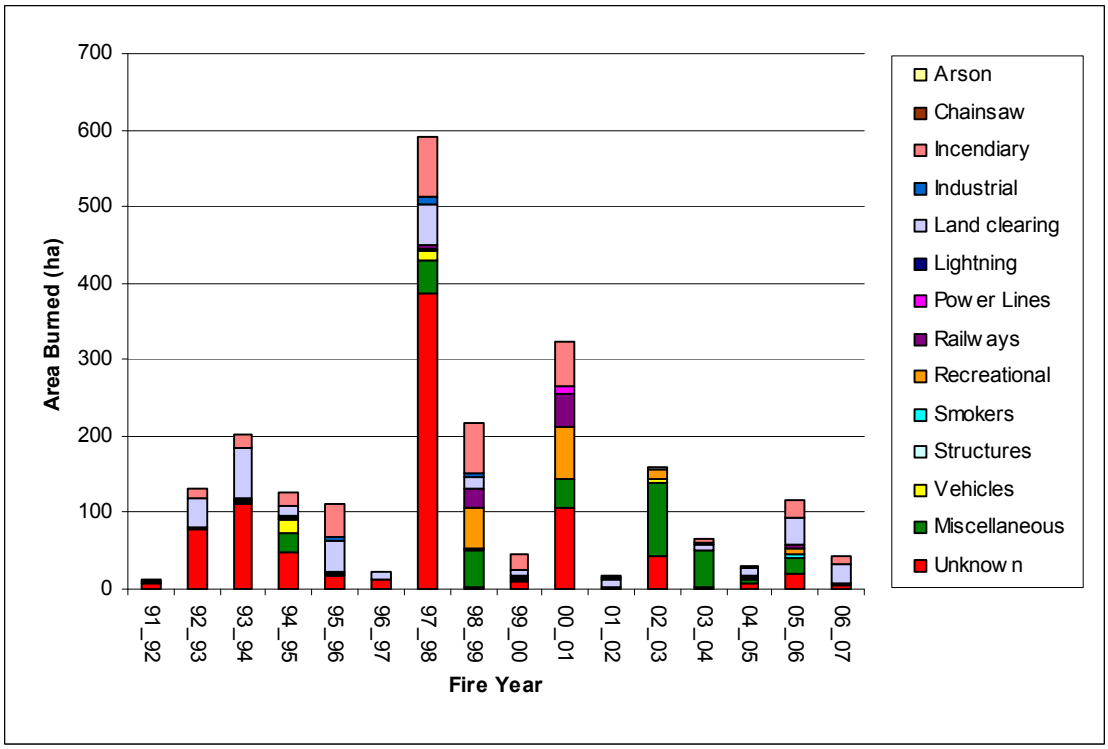

Figure G8. Greater Wellington total area burned by cause from 1991/92 to 2006/07.

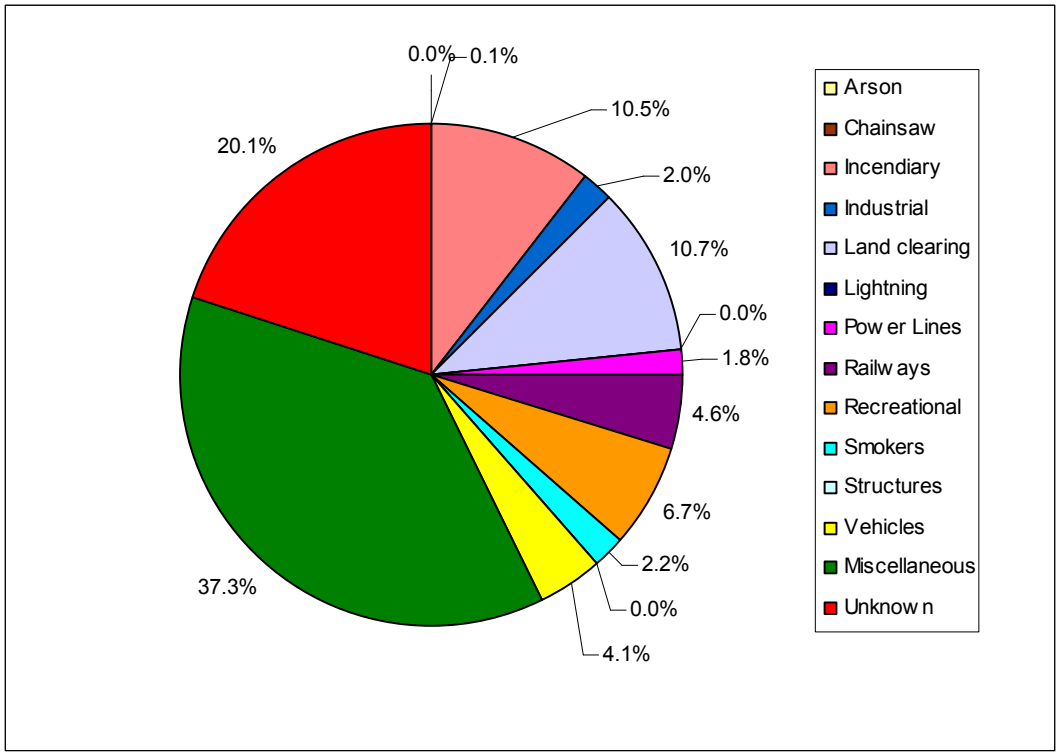

Figure G9. Greater Wellington average total annual grass area burned from 1991/92 to 2006/07.

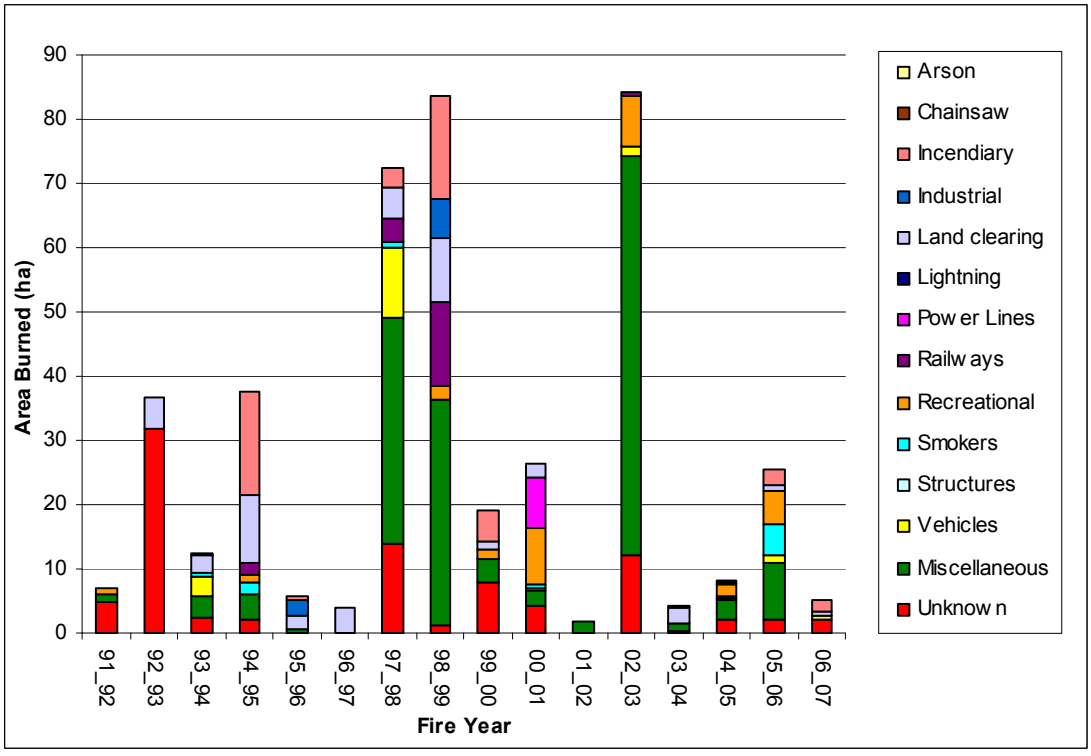

Figure G10. Greater Wellington total grass area burned by cause from 1991/92 to 2006/07.

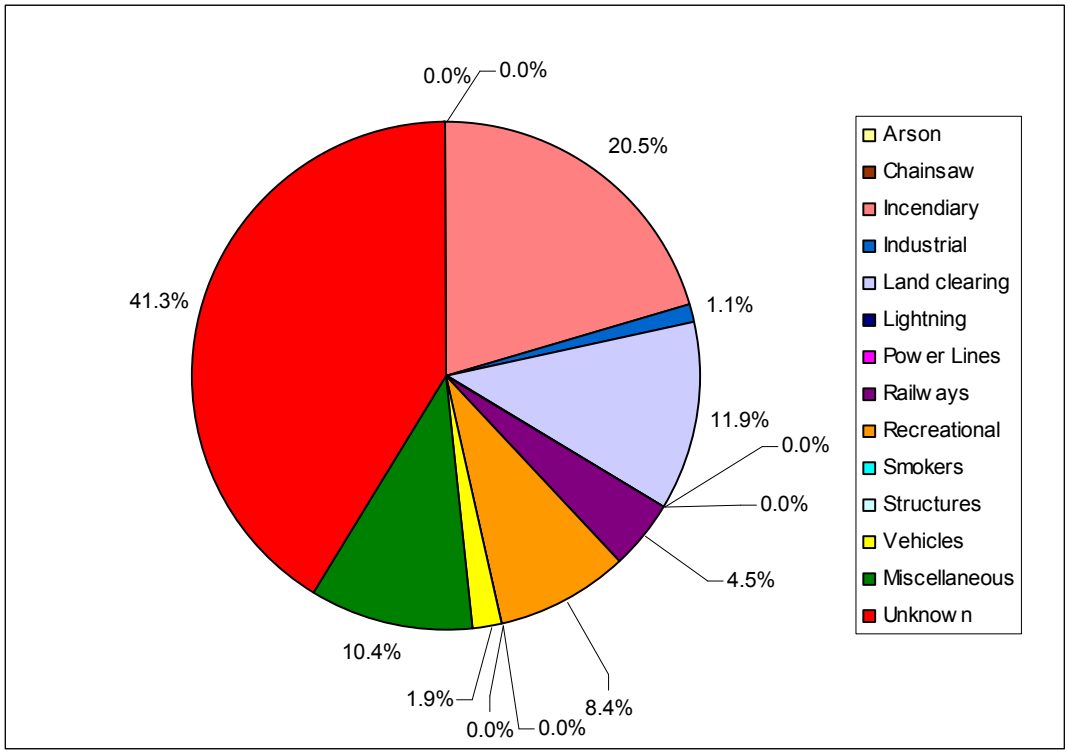

Figure G11. Greater Wellington average total scrub area burned by cause from 1991/92 to 2006/07.

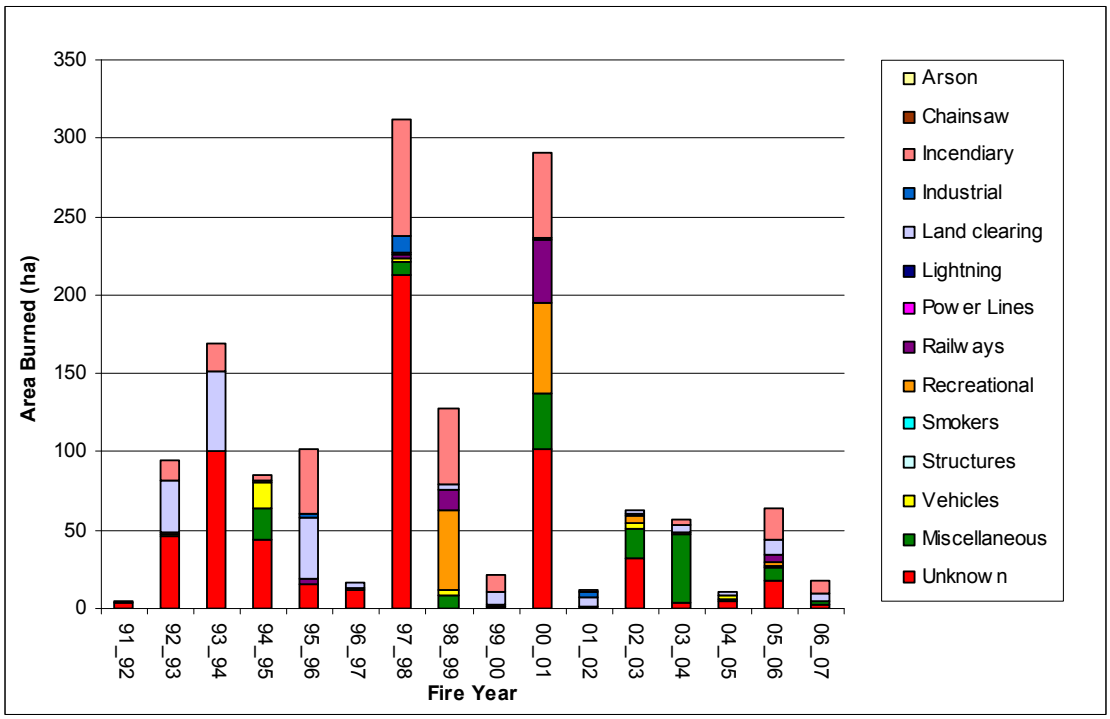

Figure G12. Greater Wellington total scrub area burned by cause from 1991/92 to 2006/07.

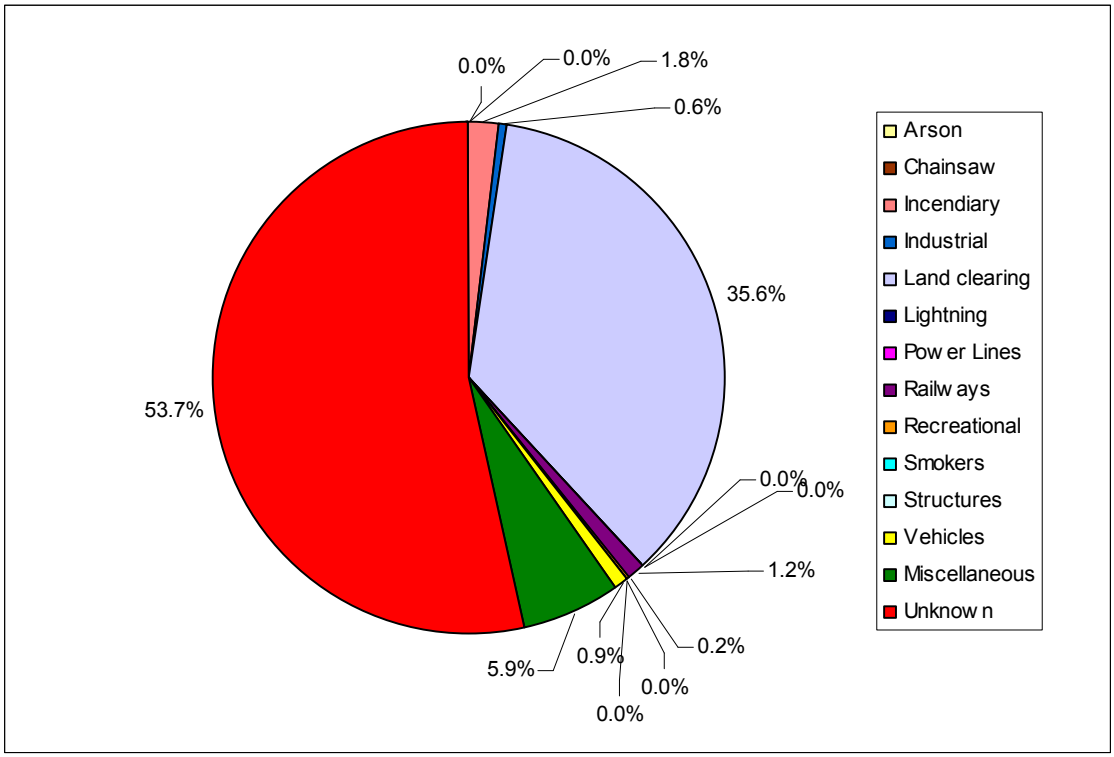

Figure G13. Greater Wellington average total forest area burned by cause 1991/92 to 2006/07.

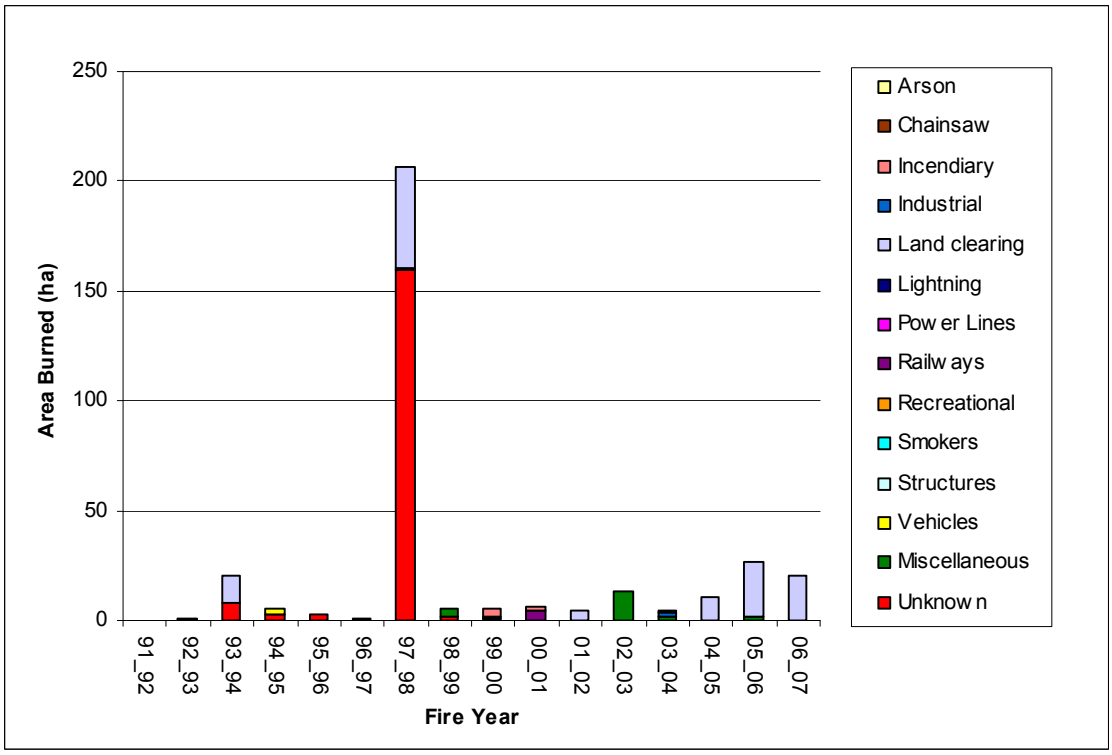

Figure G14. Greater Wellington total forest area burned by cause from 1991/92 to 2006/07.

Appendix C9 Nelson/Marlborough Region Fire Returns 1991/92 to 2006/07

Number of Fires (Figure NM1):

- Nelson/Marlborough had on average about 131 fires annually between 1991/92 and 2006/07 (or 4% of the national average total number of fires).
- The total annual number of fires varied from just 55 fires (3% of annual national total) in 1995/96 to 299 fires (6% of the annual national total) in 2004/05.
- The total number of fires for Nelson/Marlborough significantly increased over time (regression: $R^2 = 0.5955$; F-value = 20.61; P-value = <0.001). This correlated with the increasing national trend (correlation coefficient = 0.812; P-value = <0.001).

Area Burned (Figure NM2):

- The average annual total area burned for Nelson/Marlborough was 722 ha (around 10% of the national total area burned).
- The annual total area burned varied from just 93 ha (2% of that years annual total) in 1995/96 to 7,232ha (70% of that years' annual total) in 2000/01.
- The total area burned showed no statistically significant positive or negative trend over time (regression: $R^2 = 0.0038$; F-value = 0.05; P-value = 0.88).

Number of Fires by Cause (Figures NM3 and NM4):

- Miscellaneous causes accounted for about 25% of the average annual total number of fires (annual average of 31 fires); unknown accounted for about 7% (annual average of 9 fires) of the average annual total number of fires.
- Around 24% of the average annual total number of fires were attributed to land clearing (annual average of about 30 fires); around 12% were classed as vehicle fires (annual average of about 15 fires).
- Over the study period the number of land clearing fires appeared to be increasing.

Area Burned by Fuel type (Figures NM5 and NM6):

- Around 68% of the total area burned was grass; average annual total grass area burned was 491 ha.
- Around 20% of the total area burned was scrub; average annual total scrub area burned was 148 ha.
- The remaining 12% of total area burned was forest; average annual total forest area burned was about 83 ha.
- The total area burned from 1991/92 to 2006/07 was dominated by the Blenheim fires in 2000/01; with 6,000ha of grass, over 400ha of scrub and just under 300ha of forest for that fire year.

Area Burned by Cause (Figures NM7 and NM8):

- The average total annual area burned by cause was dominated by the 2000/01 fire year and the Blenheim fires, with nearly 60% of the average annual total area burned being attributed to unknown causes.
- Around 12% of the average total annual area burned was attributed to land clearing; annual average of 90 ha.
- Miscellaneous causes made up about 10% with an annual average of about 70 ha.

Area Burned by Cause by Fuel type (Figures NM9, NM10, NM11, NM12, NM13 and NM14):

- As with the total area burned, the average annual total grass area burned was dominated by unknown causes (80%) mostly due to the 2000/01 fires. The total grass area burned in other years was much lower at about 300 ha compared to over 6,000 ha.
- By contrast, the average annual total scrub area burned was made up of about 42% land clearing (annual average 62 ha); 22% (annual average 33 ha) vehicles; 10% (14 ha) miscellaneous; and 9% (13 ha) unknown.
- For most years, land clearing was the largest contributor to the annual total scrub area burned (1991/92, 1992/93, 1993/94, 1994/95, 1998/99, 1999/2000, 2001/02 and 2004/05).
- Relatively high levels of scrub area were burned in 1992/93 (predominantly land clearing and vehicles) and 2000/01 (predominantly vehicles).
- The annual total forest area burned was dominated by miscellaneous causes (about 56% or annual average of 46 ha); this primarily is a result of three fire years: in 1992/93 (66ha miscellaneous burned), 2005/06 (133 ha), and 1997/98 (525 ha burned).

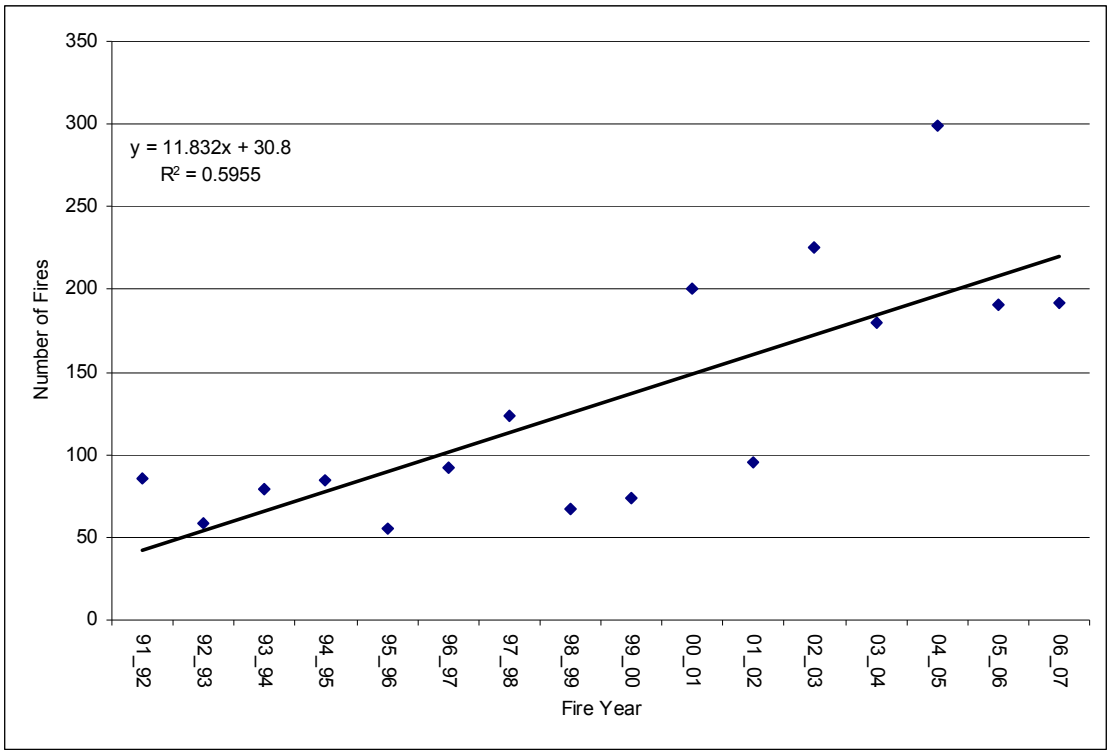

Figure NM1. Nelson/Marlborough total annual number of fires from 1991/92 to 2006/07.

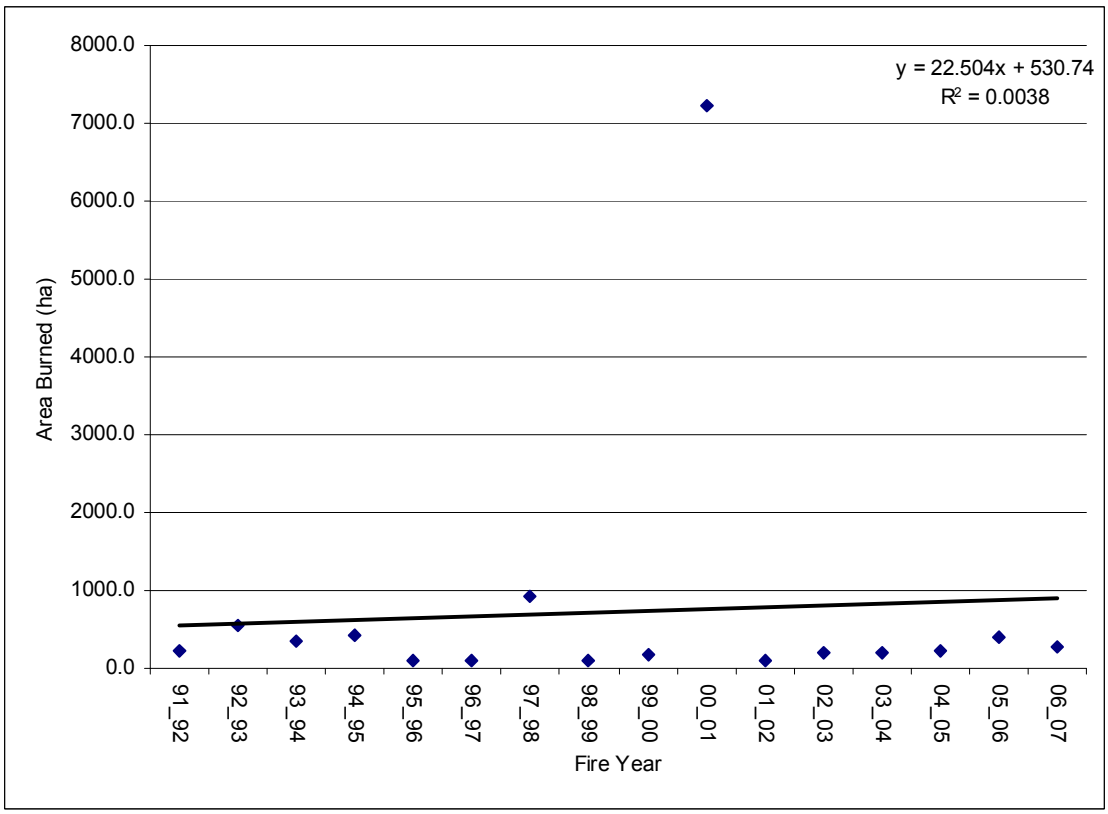

Figure NM2. Nelson/Marlborough total annual area burned from 1991/92 to 2006/07.

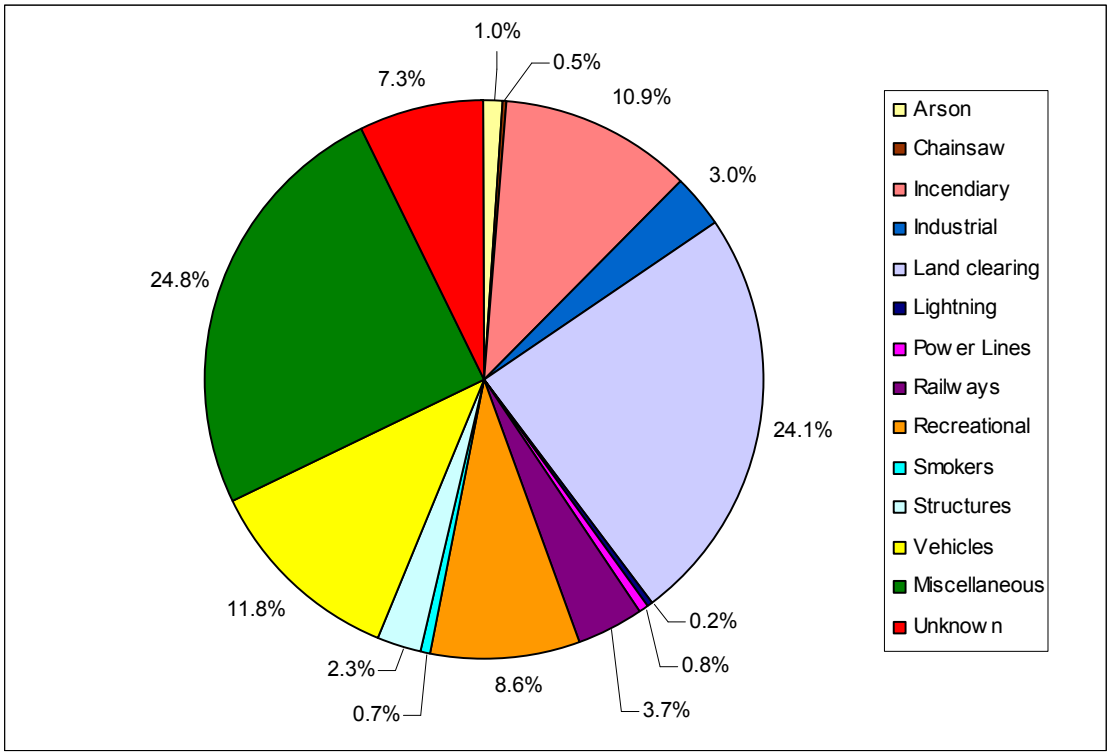

Figure NM3. Nelson/Marlborough total number of fires by cause from 1991/92 to 2006/07.

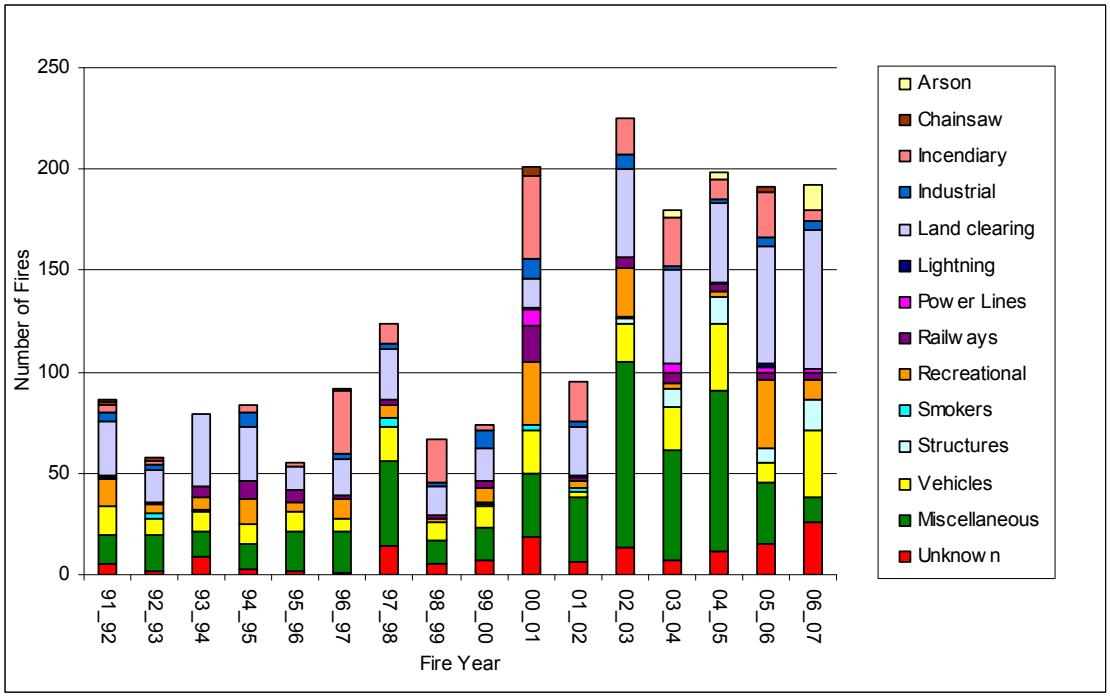

Figure NM4. Nelson/Marlborough total number of fires by cause from 1991/92 to 2006/07.

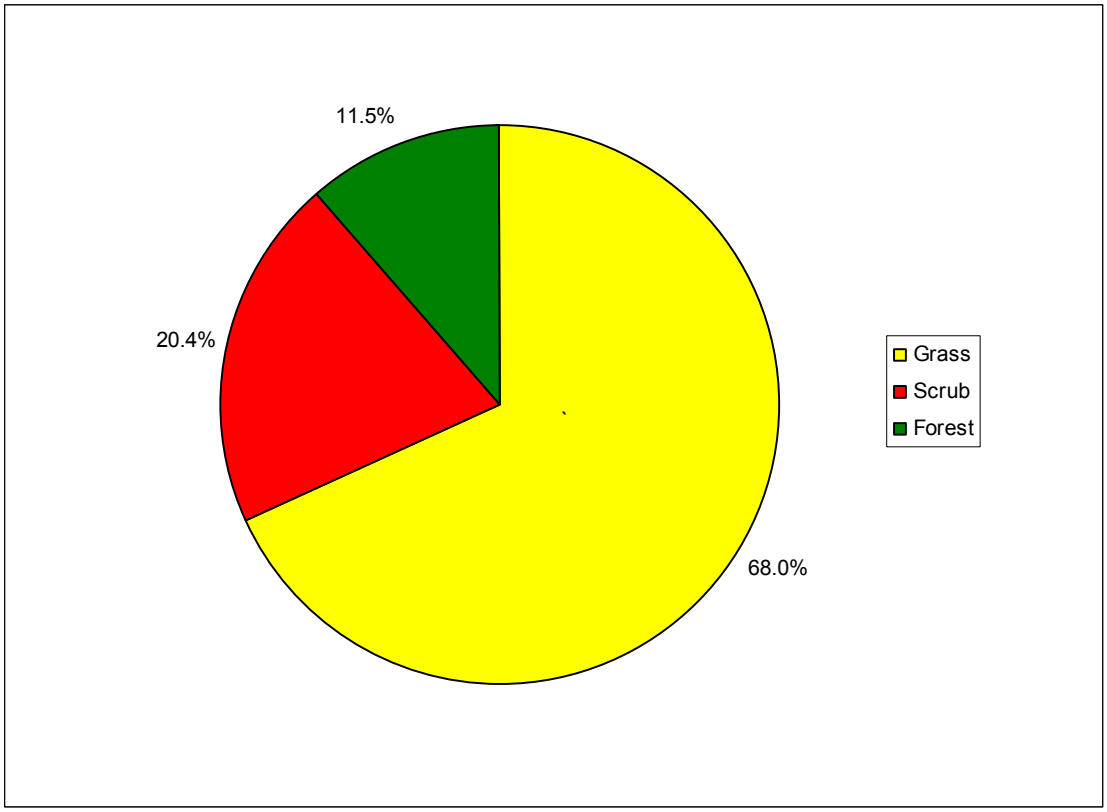

Figure NM5. Nelson/Marlborough total area burned by fuel type from 1991/92 to 2006/07.

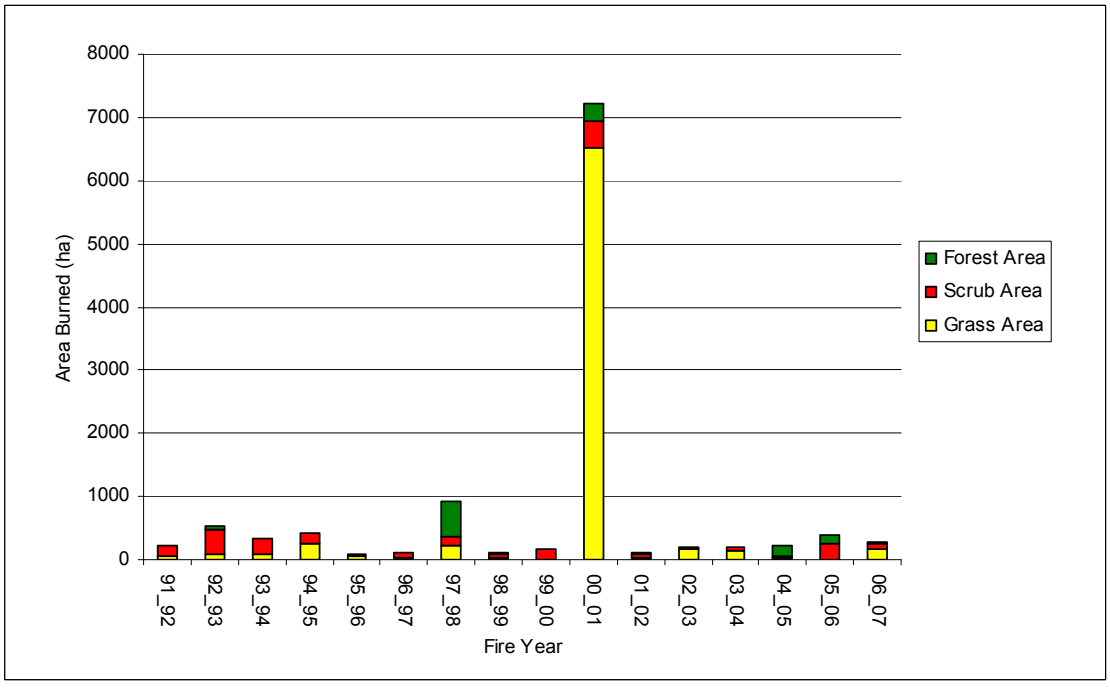

Figure NM6. Nelson/Marlborough total area burned by fuel type from 1991/92 to 2006/07.

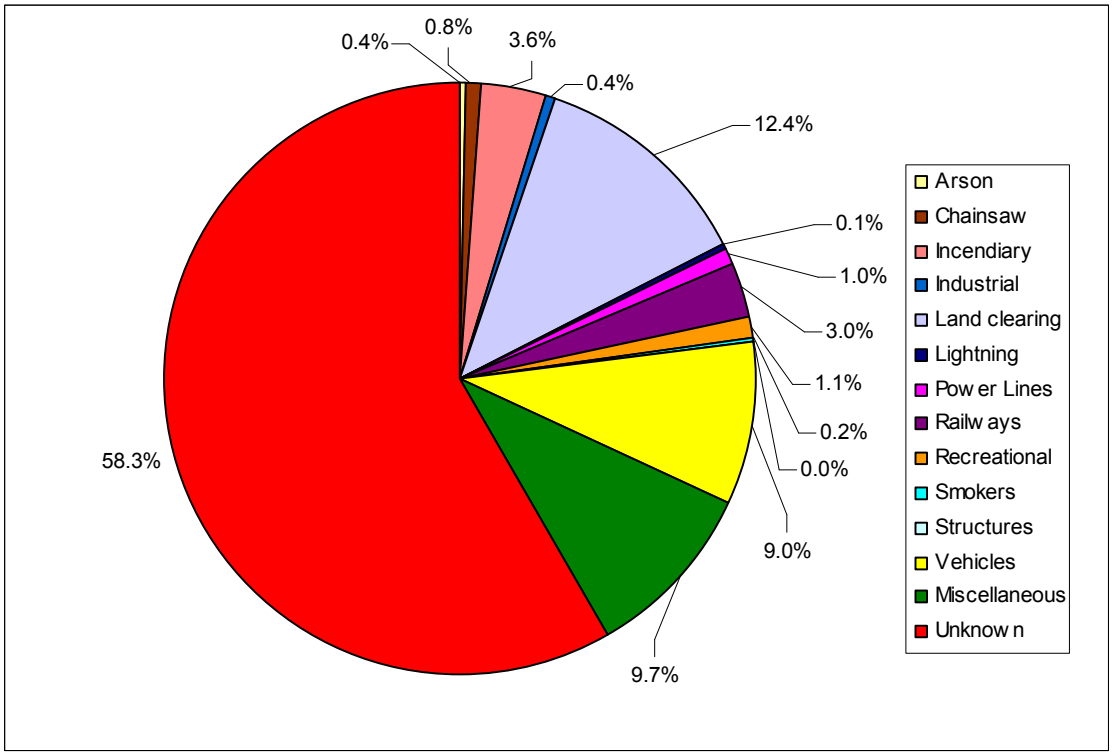

Figure NM7. Nelson/Marlborough total area burned by cause from 1991/92 to 2006/07.

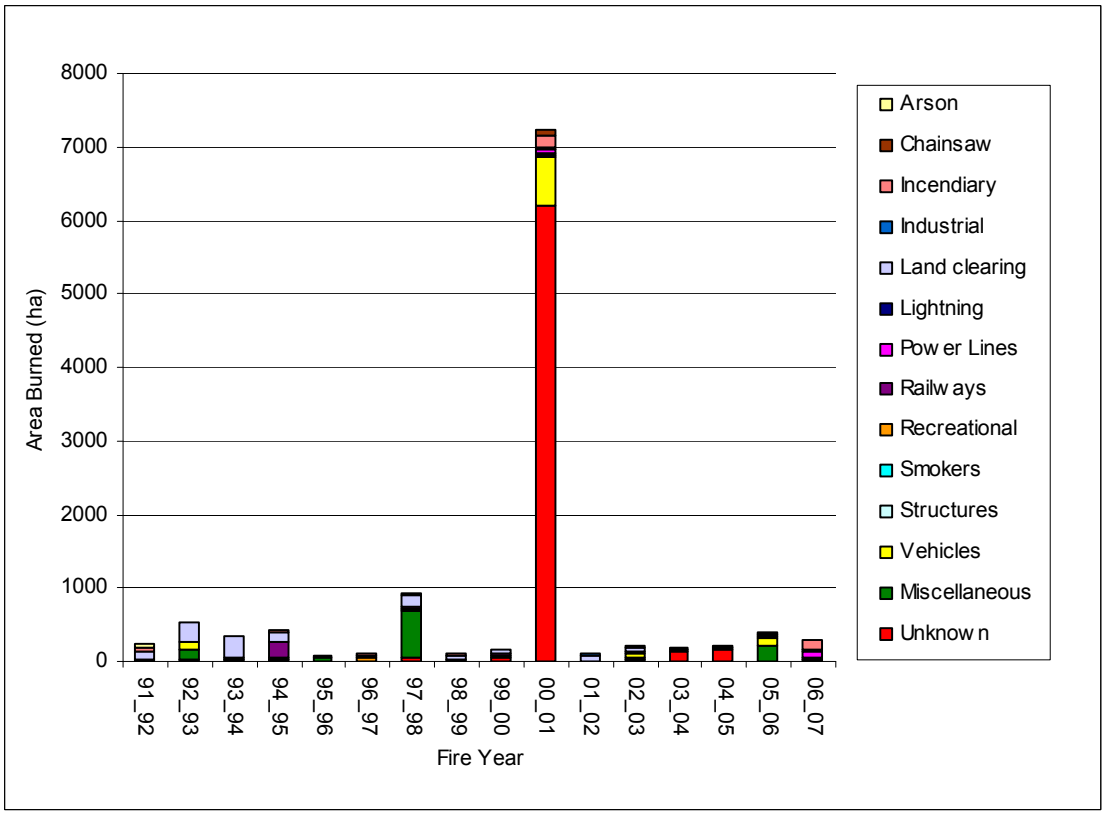

Figure NM8. Nelson/Marlborough total area burned by cause from 1991/92 to 2006/07.

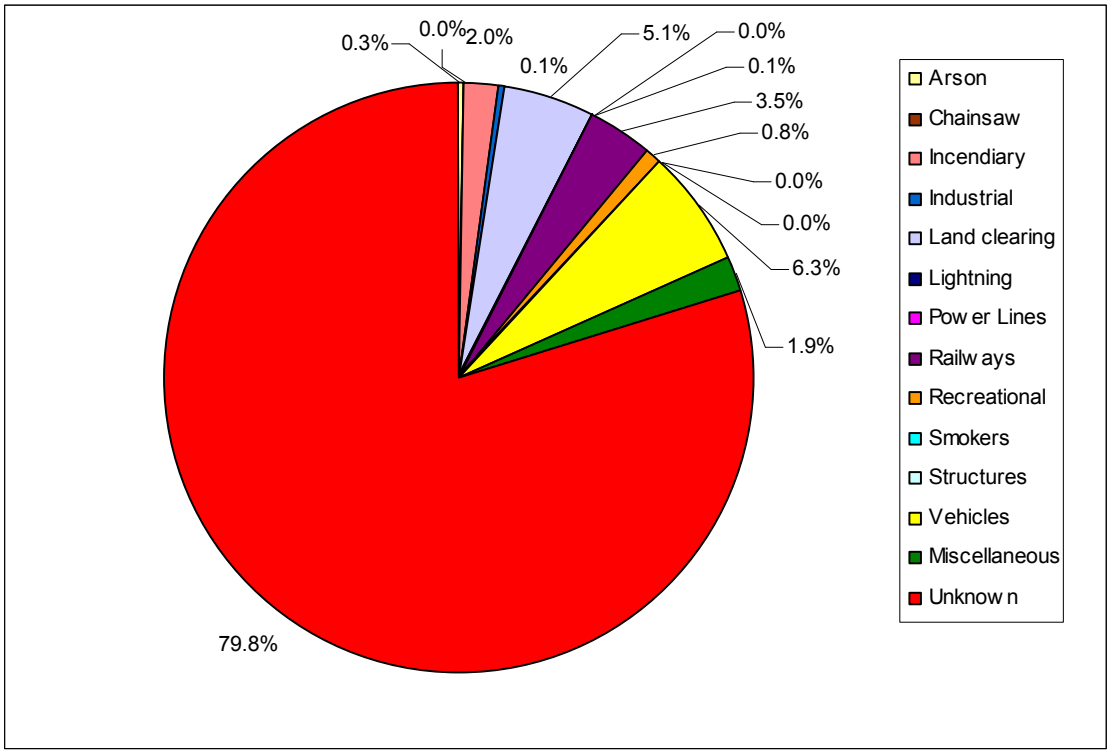

Figure NM9. Nelson/Marlborough Average Total Annual Grass Area Burned from 1991/92 to 2006/07.

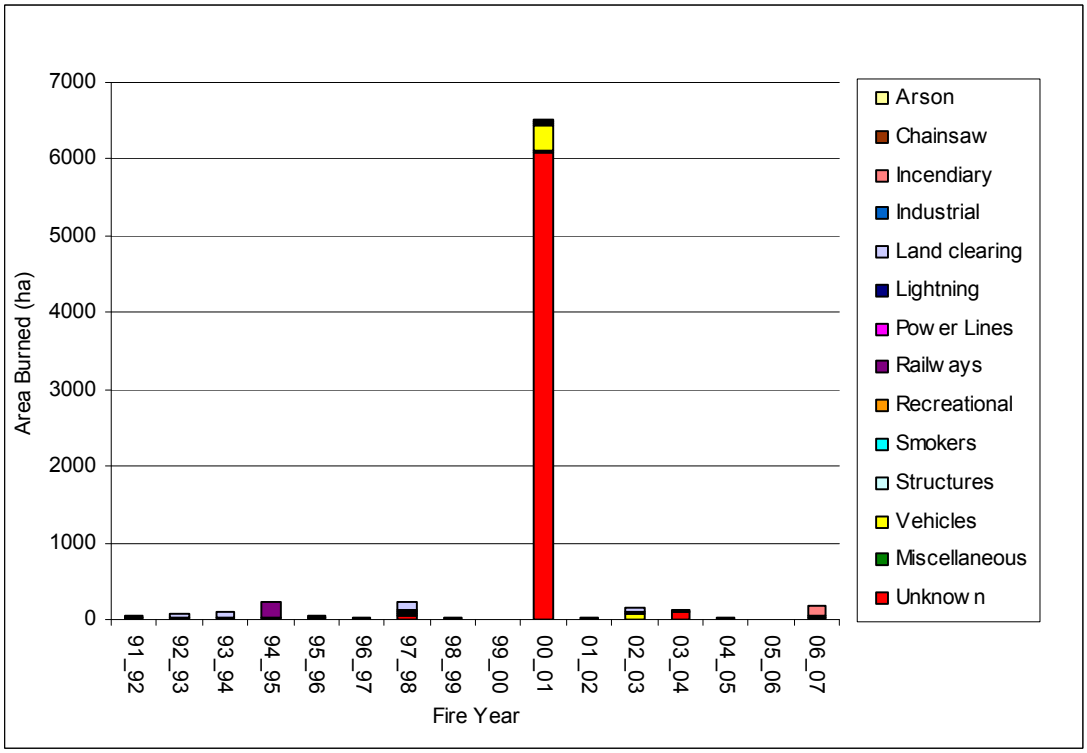

Figure NM10. Nelson/Marlborough Total Grass Area Burned by Cause from 1991/92 to 2006/07.

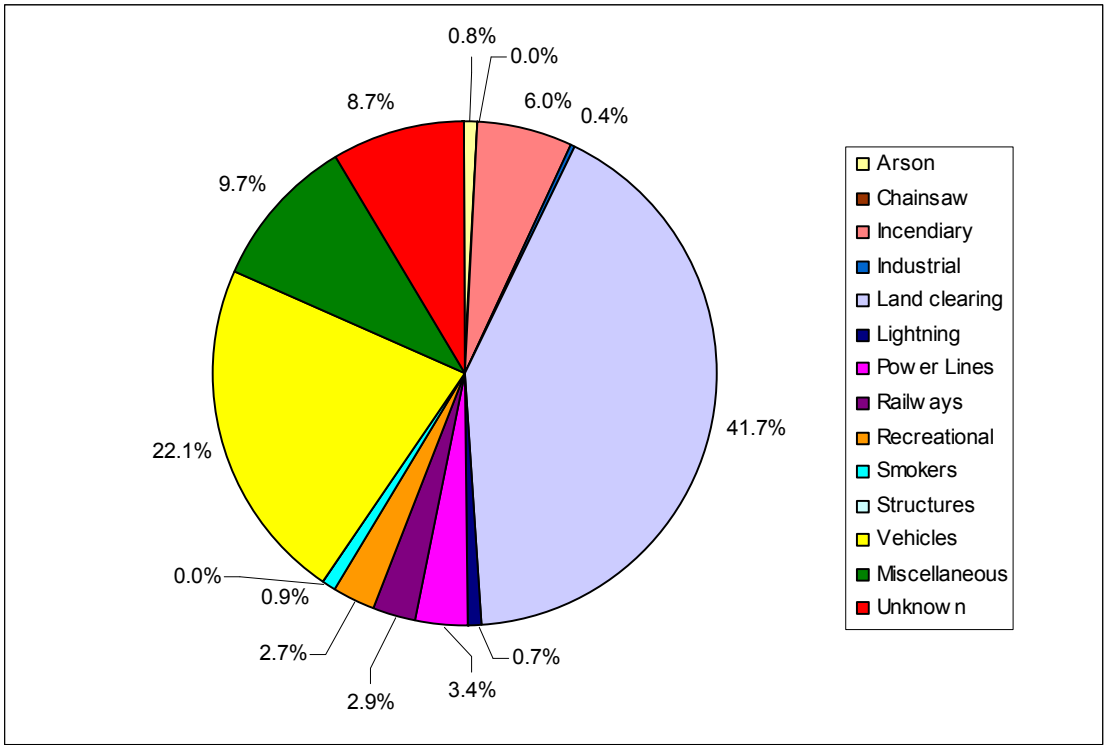

Figure NM11. Nelson/Marlborough average total scrub area burned by cause from 1991/92 to 2006/07.

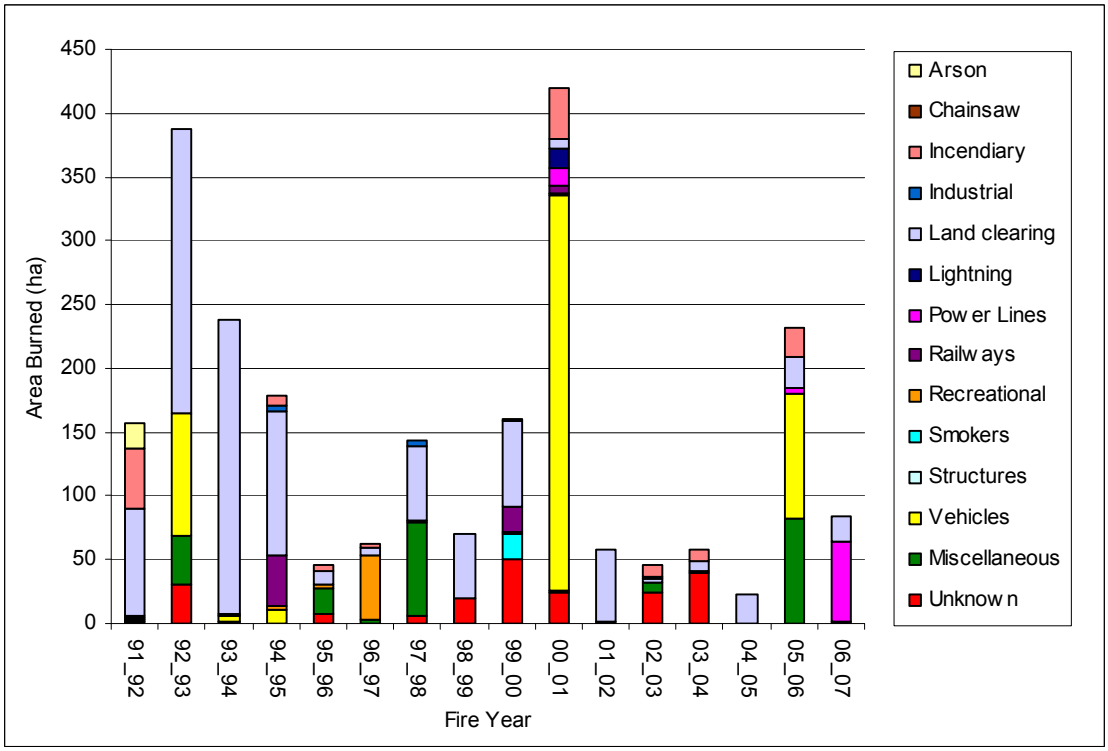

Figure NM12. Nelson/Marlborough total scrub area burned by cause from 1991/92 to 2006/07.

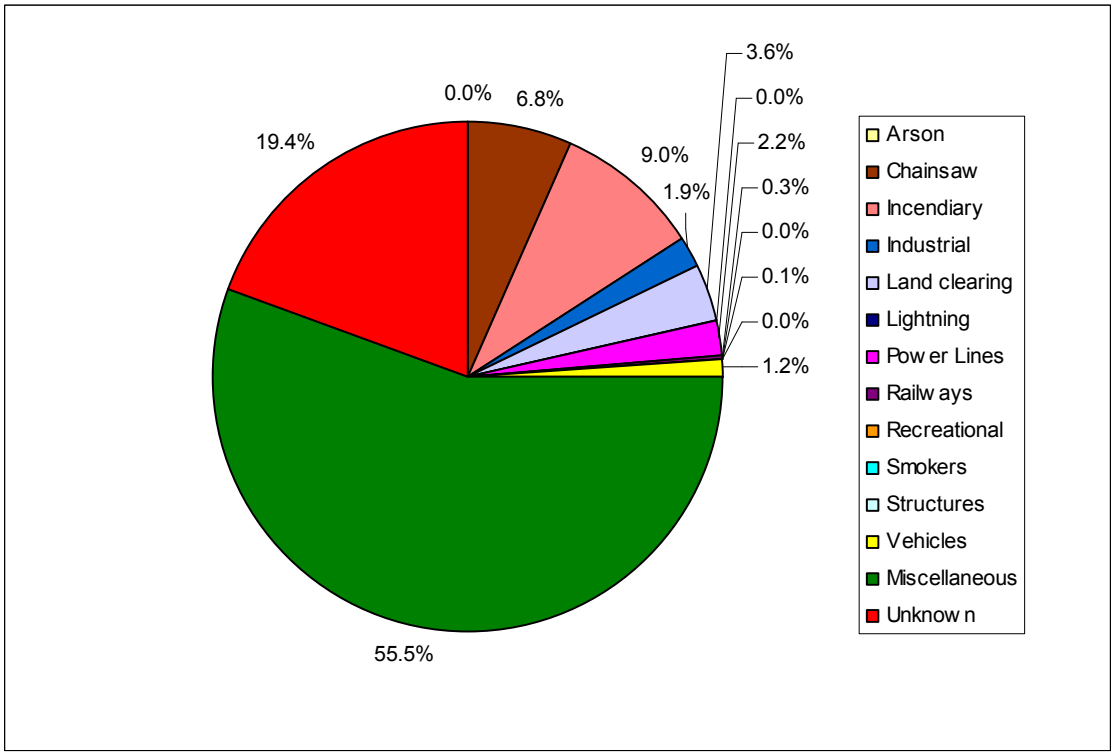

Figure NM.13 Nelson/Marlborough average total forest area burned by cause from 1991/92 to 2006/07.

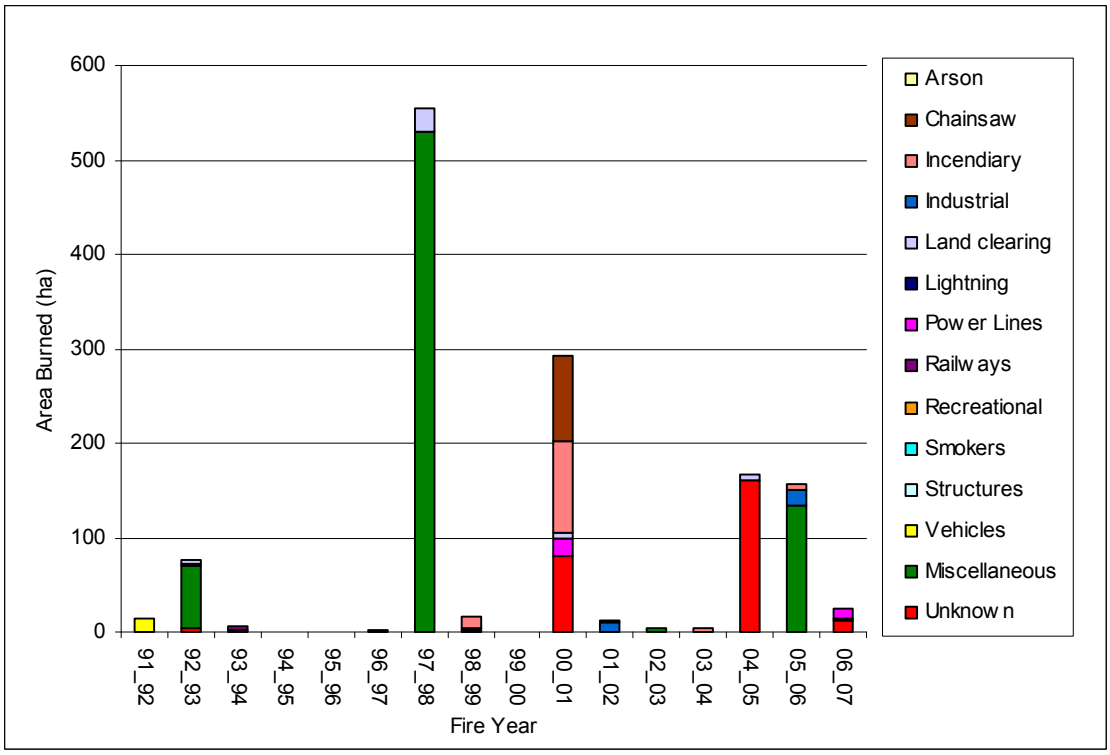

Figure NM14. Nelson/Marlborough total forest area burned by cause from 1991/92 to 2006/07.

Appendix C10 West Coast Regional Fire Returns 1991/92 to 2006/07

Number of Fires (Figure WC1):

- From 1991/92 to 2006/07, the West Coast had on average about 64 fires annually or around 3% of the total national number of fires.
- The number of fires varied from 22 in 1996/97 (about 1% of that year's total) to 115 fires in (or 4% of that year's annual total) 2000/01.
- The total annual number of fires did not display a statistically significant negative trend with respect to time (regression: R^2 = 0.1186; F-value = 1.88; P-value = 0.192). The total annual number of fires over time also did not significantly correlate with the national trend of increasing number of fires (correlation coefficient = -0.345; P-value = 0.190).

Area Burned (Figure WC2):

- The average annual total area burned for the West Coast was 249 ha (around 6% of the national).
- The total annual area burned varied considerably over time, from just 6 ha (0.1% of that year's annual national total) to 530 ha (3% of that year's national annual total). In addition, the West Coast made up just under 25% of the national total area burned with 446 ha in 1991/92.
- The total annual area burned from 1991/92 to 2006/07 for the West Coast showed a statistically insignificant negative trend (regression: R^2 = 0.0609; F-value = 0.91; P-value = 0.357).

Number of Fires by Cause (Figures WC3 and WC4):

- Around 35% (annual average of about 22 fires) of the West Coast's average number of fires for all years was attributed to unknown causes; and around 18% (annual average of about 12 fires) was attributed to miscellaneous causes; thus around 54% was on average accounted for by 'unspecific' causes.
- Around 13% of the average annual number of fires were due to land clearing (annual average just 8 fires). Incendiary made up about 11% of the average annual number of fires (annual average of just 7 fires).
- Much of the variation in the total annual area burned for the West Coast appeared to be driven by changes in the number of unknown, miscellaneous, and incendiary fires.

Area Burned by Fuel type (Figures WC5 and WC6):

- 83% of the total area burned was scrub (annual average of 206 ha); 13% was grass (annual average of 33 ha); and around 4% was forest (annual average of just 10 ha).
- In all but one fire year (1991/92), scrub dominated the total area burned.

Area Burned by Cause (Figures WC7 and WC8):

- Unlike many other regions, incendiary contributed highly to the average annual area burned on the West Coast. Around a third of the average

annual area burned was attributed to incendiary causes (or annually 83 ha).

- Around 22% (or about 55 ha annually) of the annual average total area burned was due to unknown causes; about 11% from miscellaneous causes; thus a third of the annual average total area burned was attributed to 'unspecific' causes.
- Land clearing made up 26% of the average annual total area burned (or 65 ha annually).
- The proportion and actual area burned varied considerably with respect to cause for different fire years. In 1991/92 and 1993/94 unknown and land clearing made up the majority of area burned; from 1998/99 onwards unknown causes barely featured; incendiary was the main cause of area burned in 1998/99, 2000/01, 2001/02 and 2003/04; and whilst hardly featuring from 1991/92 to 2004/05, miscellaneous accounted for most of the total area burned in 2005/06.

Area Burned by Cause and Fuel type (Figures WC9, WC10, WC11, WC12, WC13, and WC14):

- The average annual total grass area burned by cause was split between 45% land clearing and 47% unknown. However these averages were skewed due to the majority of the total grass area burned for the West Coast occurring in 1991/92 with over 350 ha. Few other fire years recorded more than 50 ha of grass burned.
- Most of the area burned attributed to incendiary causes appeared to be scrub. Around 39% of the average annual total scrub area burned was attributed to incendiary causes (annual average around 80 ha), with around 22% attributed to land clearing (actual average around 45 ha).
- Unknown causes accounted for around 19% of the average annual total scrub area burned (average annual about 40 ha); 13% (about 27 ha) from miscellaneous causes; combined 'unspecified' average annual total scrub area burned made up about 32%.
- Annual total scrub area burned for each year by cause varied considerably in 1991/92, 1995/96, 1997/98, 1999/2000, 2004/05 and 2006/07 the annual total scrub area burned less than 100 ha. 1992/93, just over 300 ha of scrub area burned, more or less split between unknown, land clearing and incendiary causes. In 1993/94 over 400 ha of total scrub area was reported burned, over 200 ha from land clearing; and over 150ha from unknown. Most of the scrub area burned in 1994/95, 1996/97 and 1997/98 was from unknown causes. Incendiary causes accounted for high total scrub area burned in 1998/99, 2001/02 and 2003/04. In 2005/06 the majority of the total scrub area burned on the West Coast was attributed to miscellaneous causes.
- The annual average total forest area burned was greatly influenced by individual fire years, with one or two main fire causes. Most of the average annual total forest area burned (56%) was attributed to land clearing (actual average figure just 6 ha annually); about 27% was attributed to incendiary causes (annual average about 3 ha).

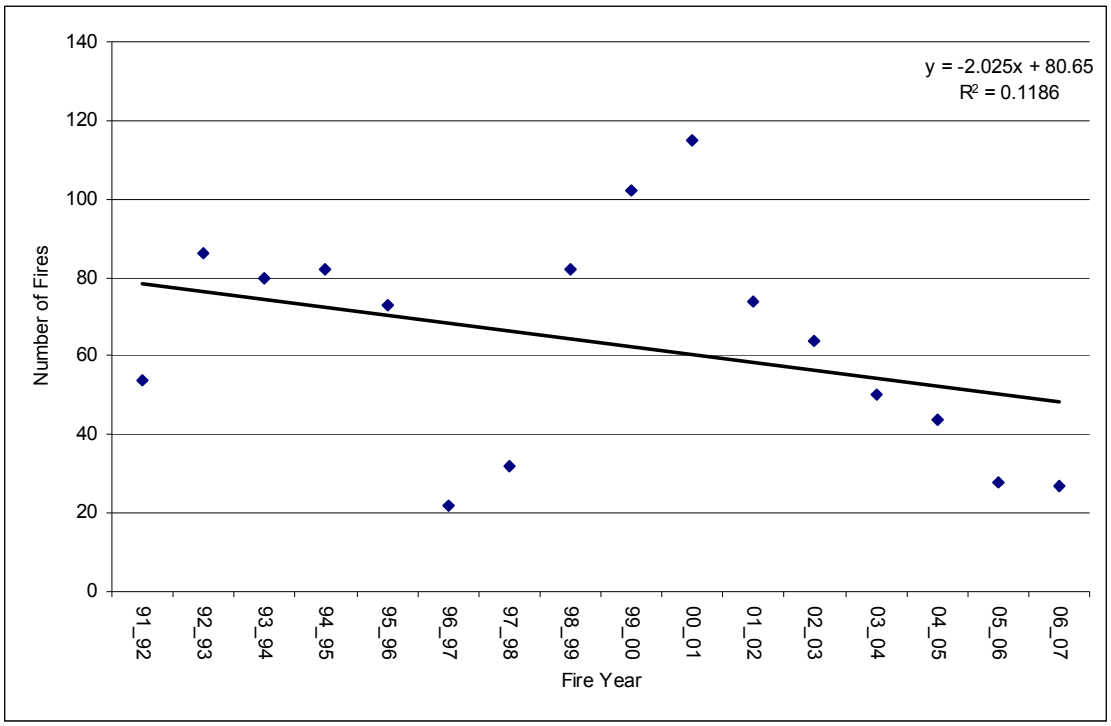

Figure WC1. West Coast total annual number of fires from 1991/92 to 2006/07.

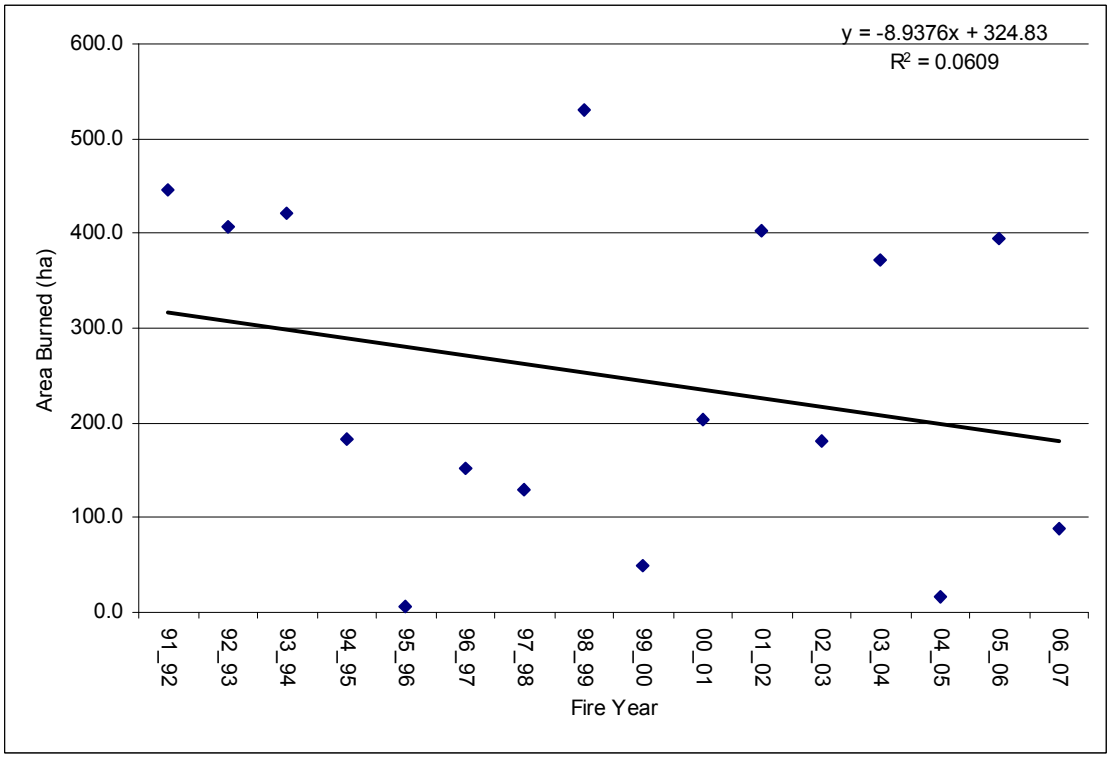

Figure WC2. West Coast total annual area burned from 1991/92 to 2006/07.

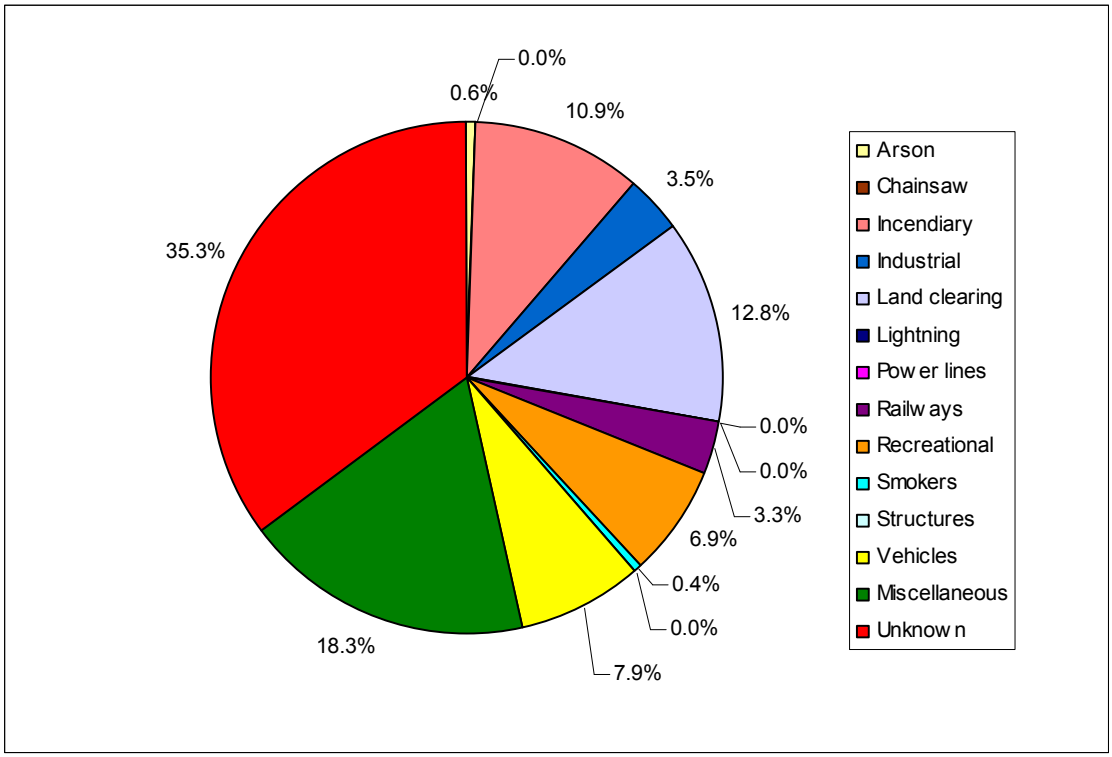

Figure WC3. West Coast total number of fires by cause from 1991/92 to 2006/07.

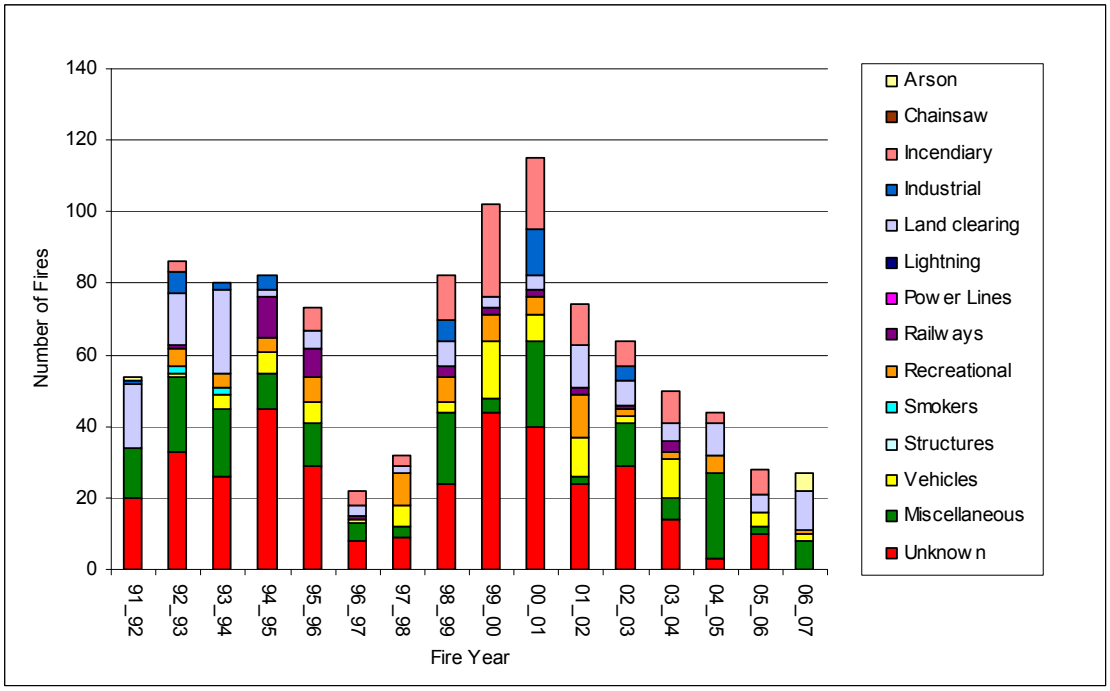

Figure WC4. West Coast total number of fires by cause from 1991/92 to 2006/07.

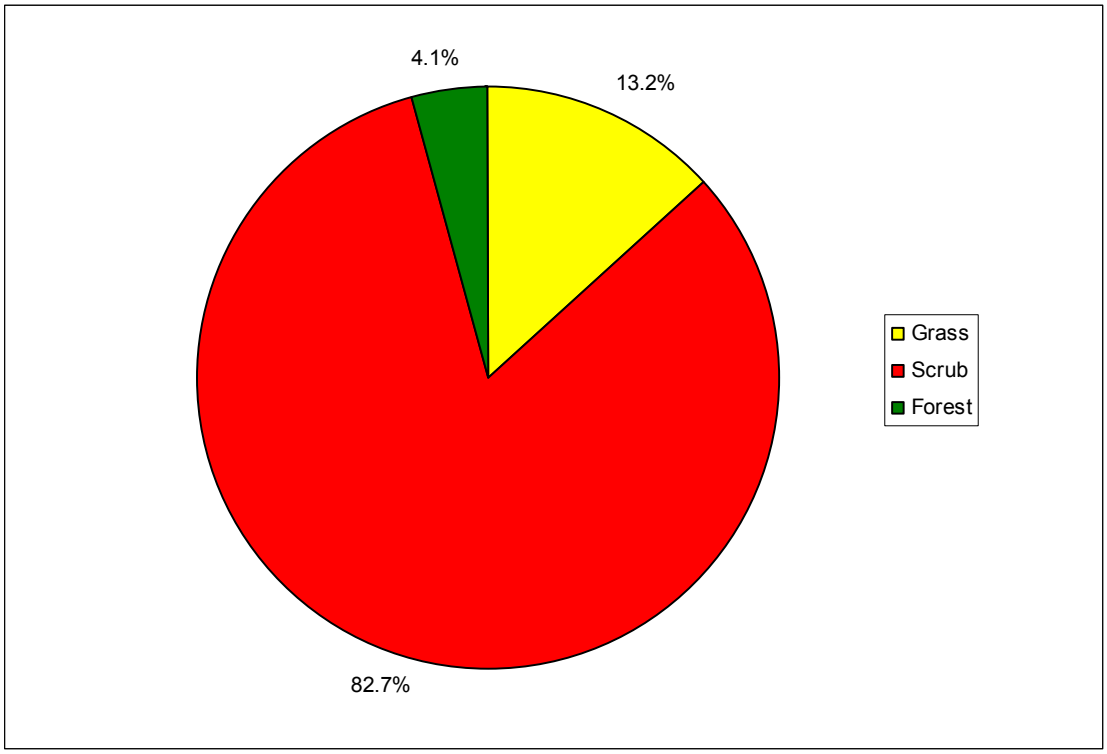

Figure WC5. West Coast total area burned by fuel type from 1991/92 to 2006/07.

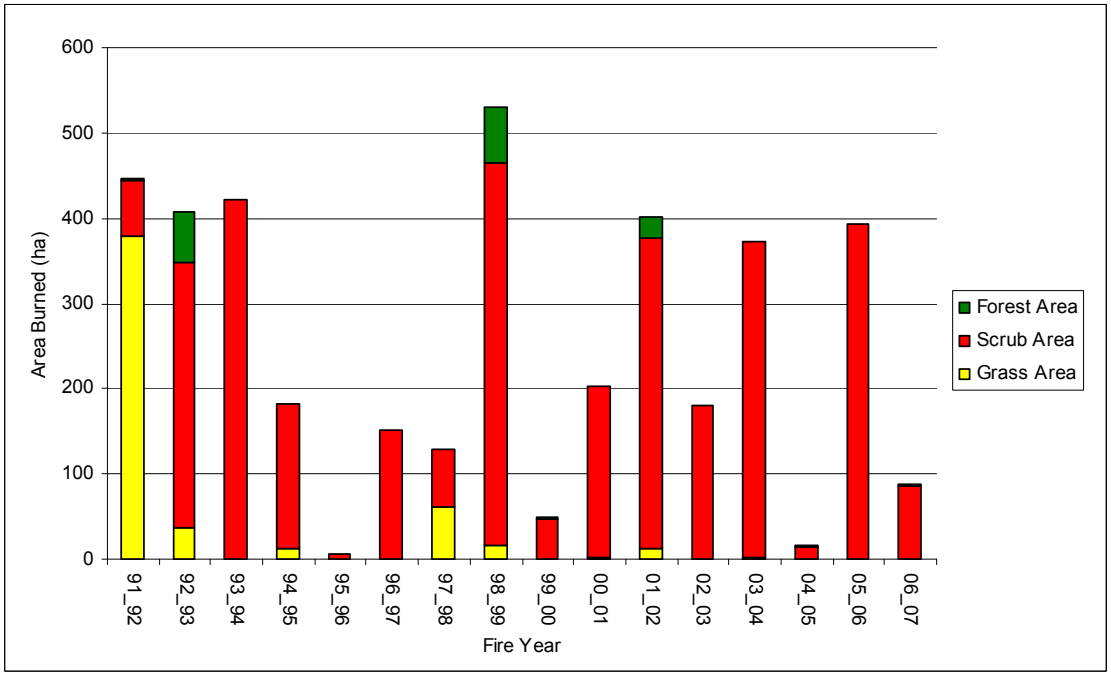

Figure WC6. West Coast total area burned by fuel type from 1991/92 to 2006/07.

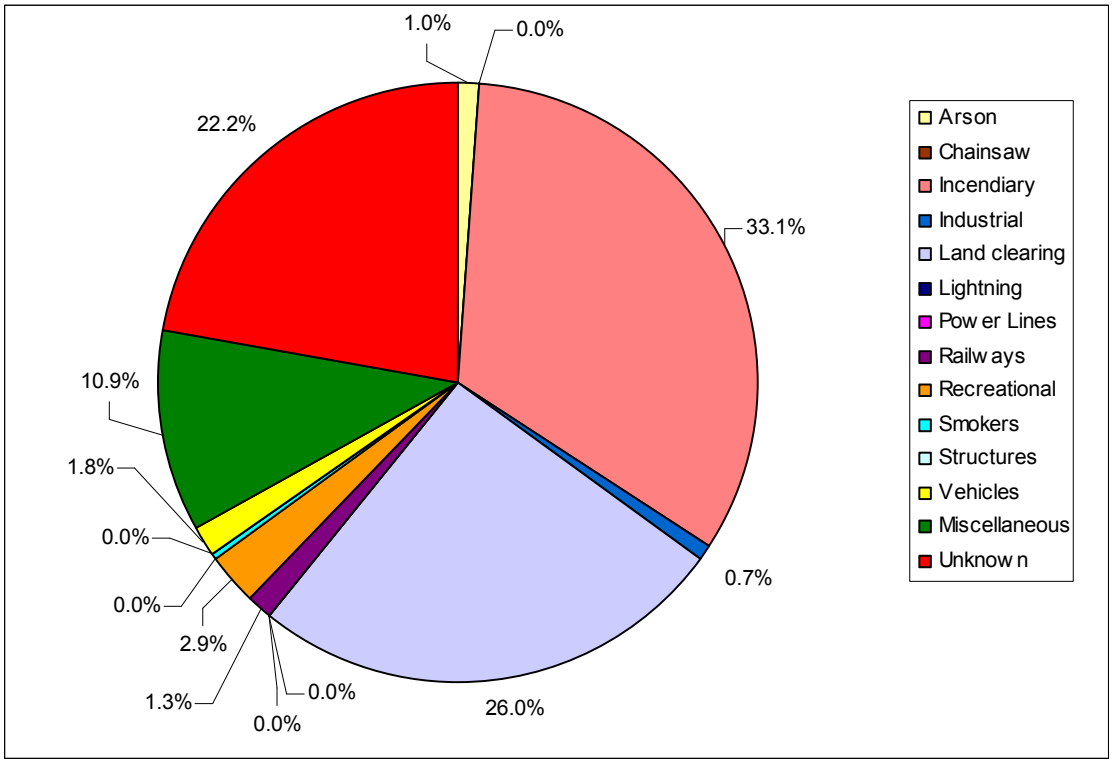

Figure WC7. West Coast total area burned by cause from 1991/92 to 2006/07.

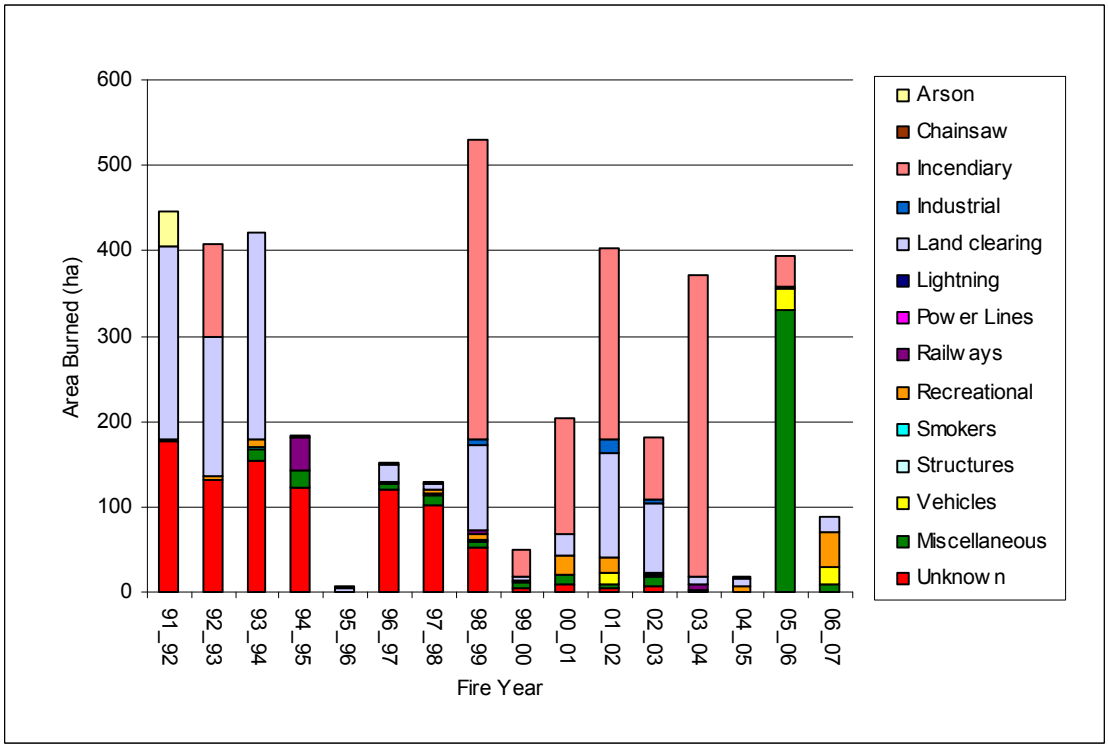

Figure WC8. West Coast Total area burned by cause from 1991/92 to 2006/07.

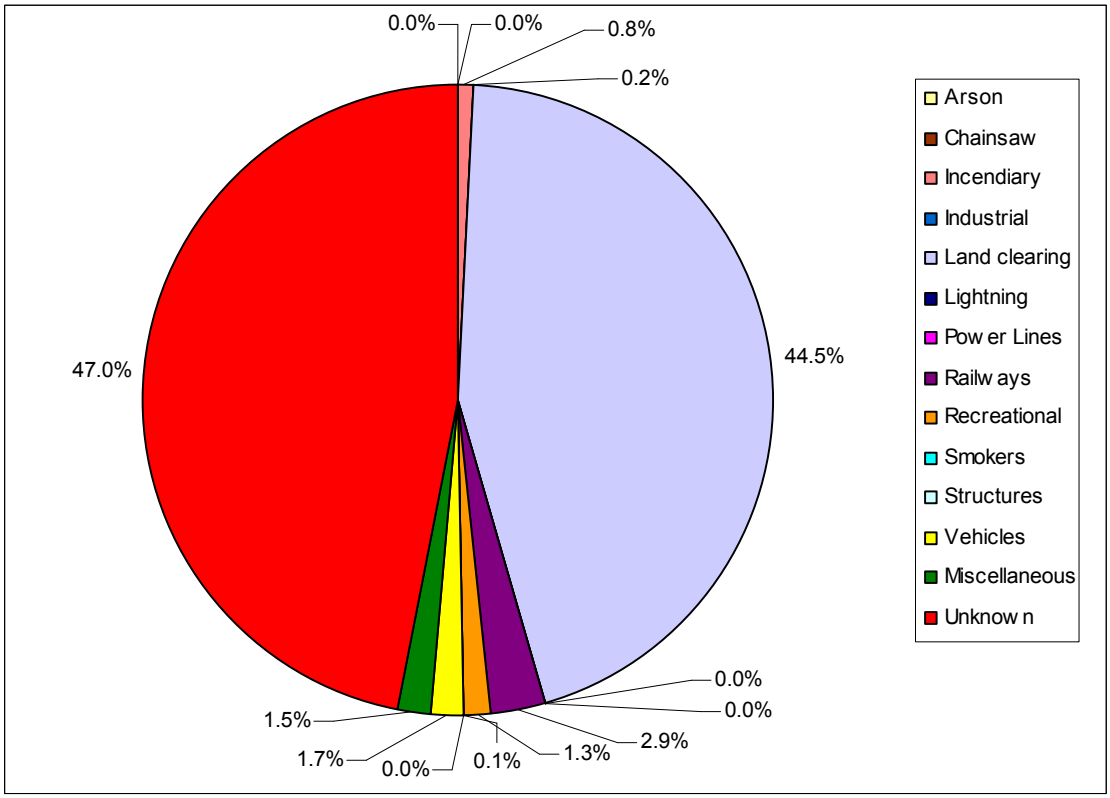

Figure WC9. West Coast average total annual grass area burned from 1991/92 to 2006/07.

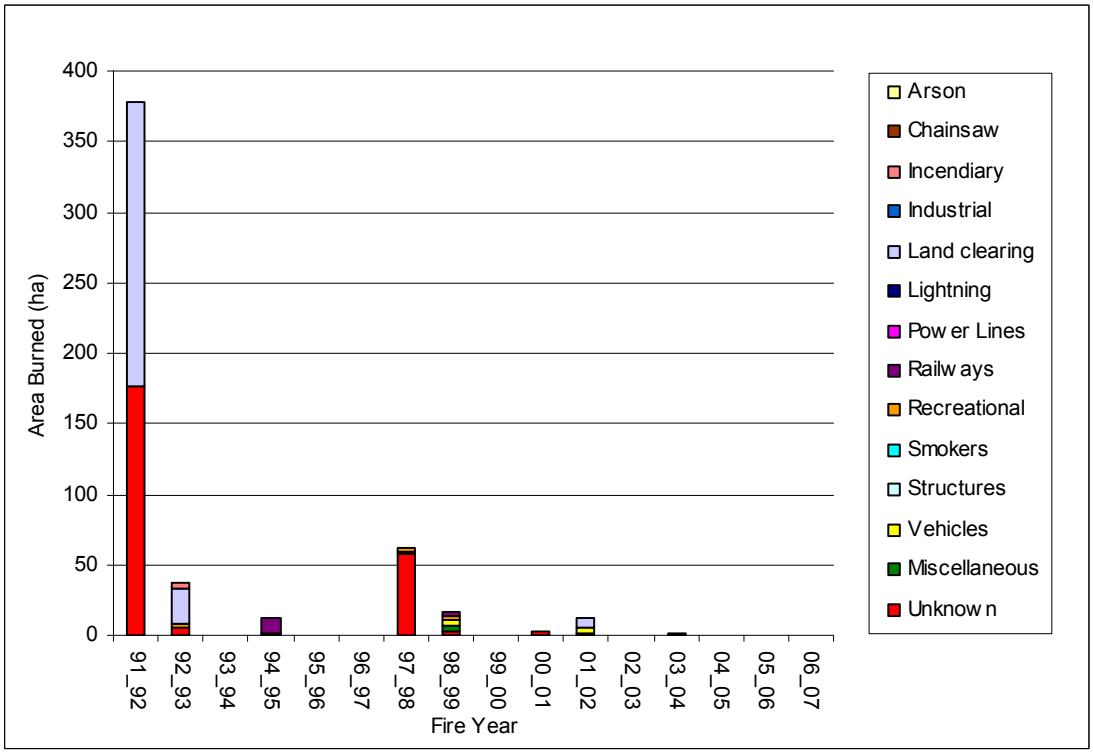

Figure WC10. West Coast total grass area burned by cause from 1991/92 to 2006/07.

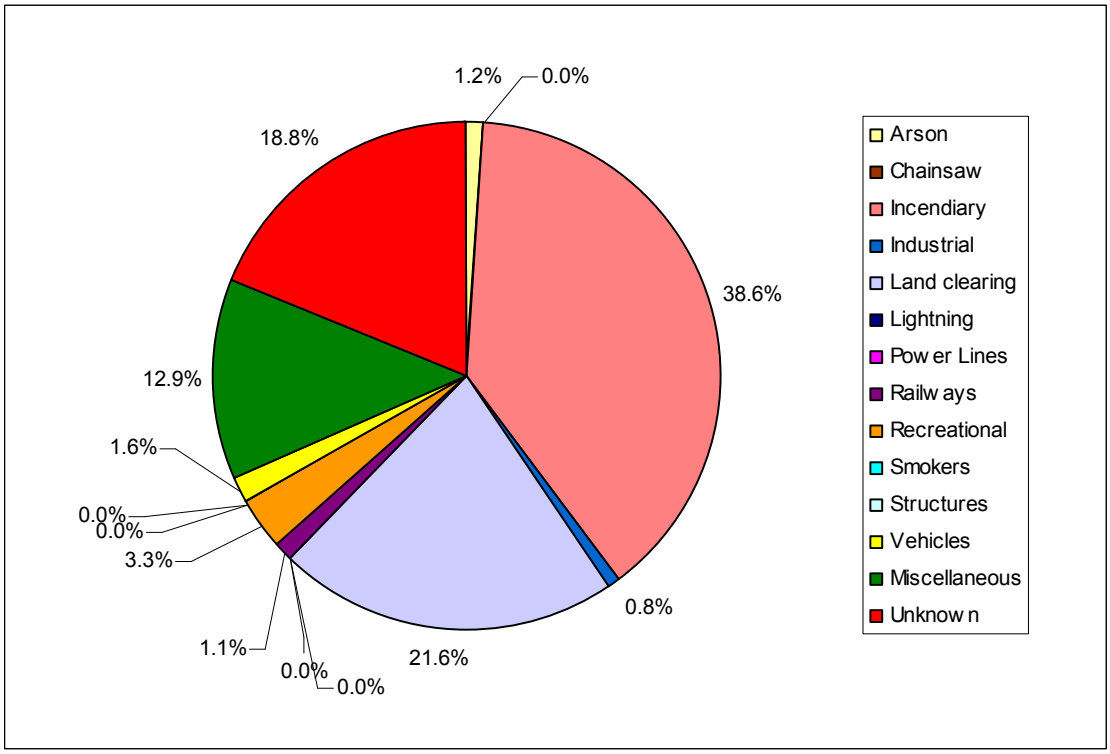

Figure WC11. West Coast average total scrub area burned by cause from 1991/92 to 2006/07.

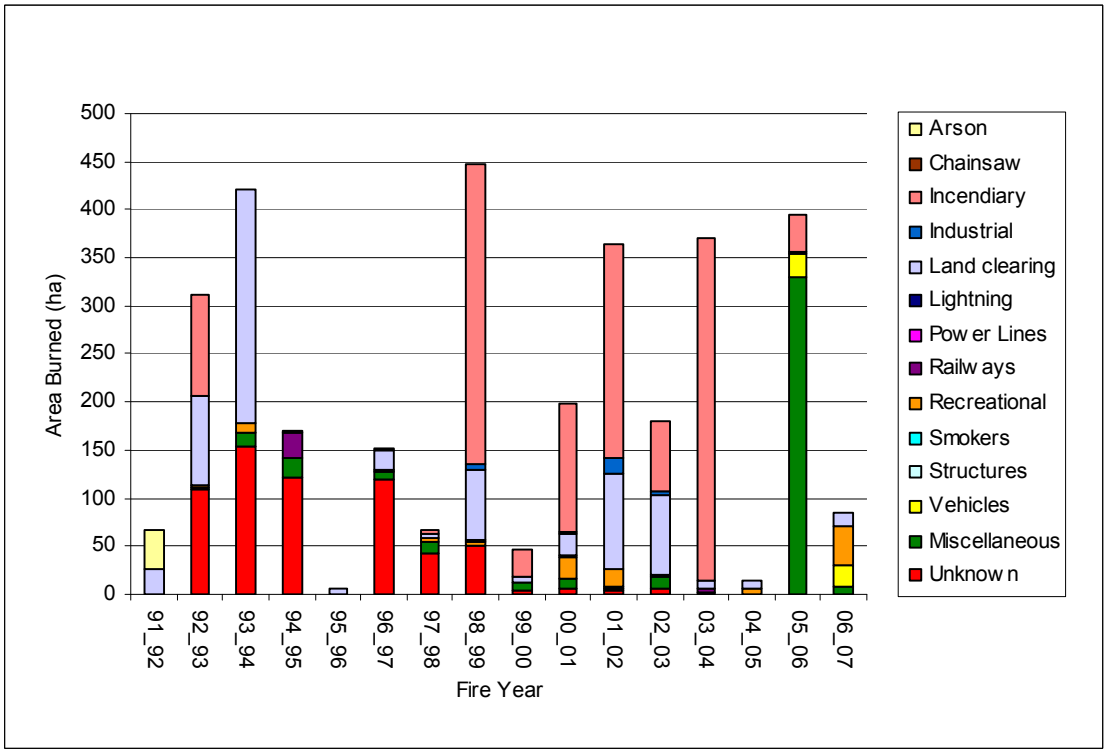

Figure WC12. West Coast total scrub area burned by cause from 1991/92 to 2006/07.

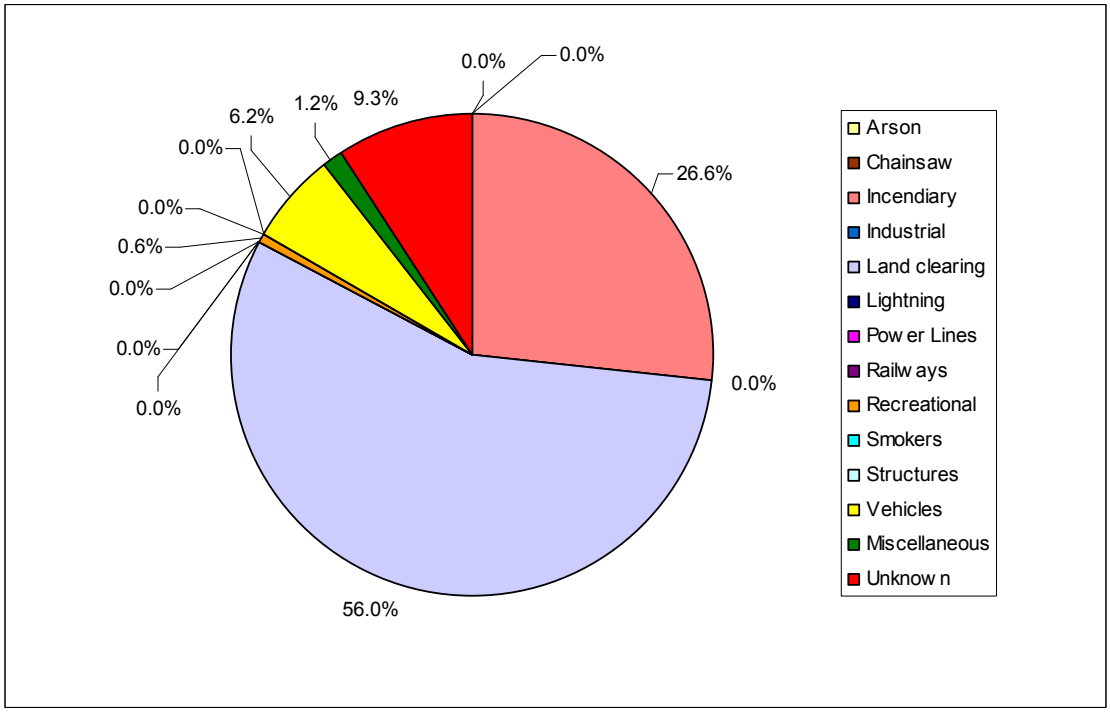

Figure WC13. West Coast average total forest area burned by cause from 1991/92 to 2006/07.

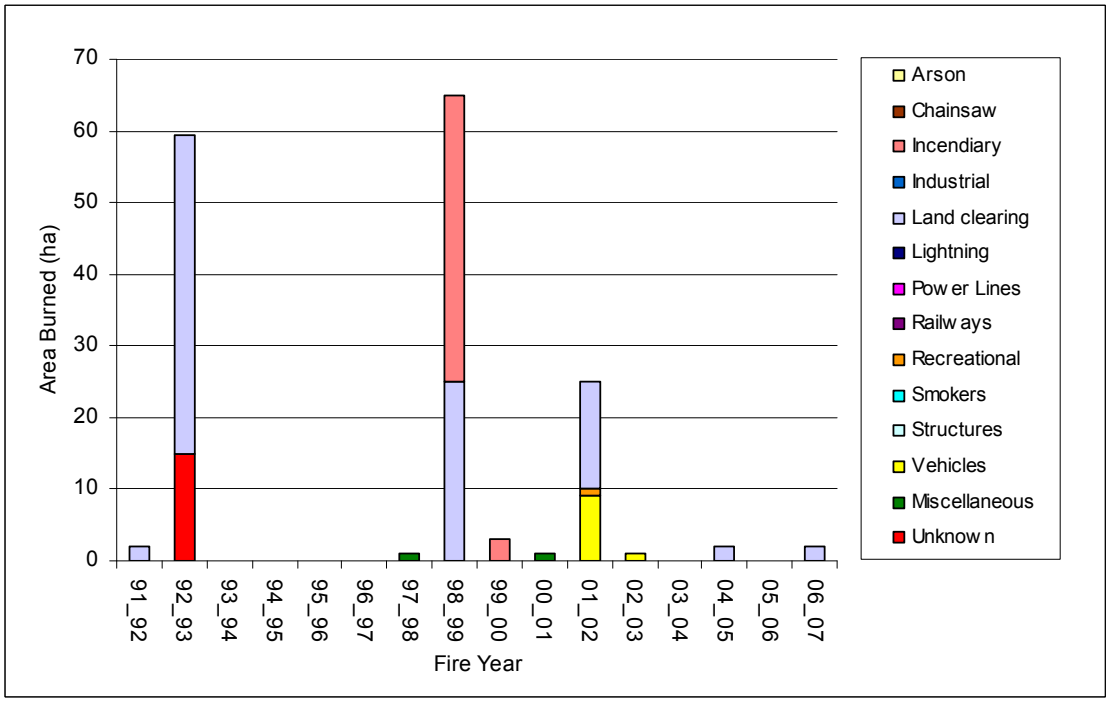

Figure WC14. West Coast total forest area burned by cause from 1991/92 to 2006/07.

Appendix C11 Canterbury Region Fire Returns 1991/92 to 2006/07

Number of Fires (Figure C1):

- From 1991/92 to 2006/07 Canterbury had, on average, 553 fires annually or around 18% of the total national number of fires.
- The total annual number of fires varied from just 133 fires in 1992/93 (14% that year's national) to 1,274 fires in 2003/04 (about 30% of that year's national).
- The total number of fires from 1991/92 to 2006/07 displayed a clear statistically significant positive (increasing) trend (regression: $R^2 = 0.65$; F-value = 27.07; P-value = <0.001). The total annual number of fires also significantly correlated with the national increasing trend (correlation coefficient = 0.876; P-value = <0.001).

Area Burned (Figure C2):

- The average annual total area burned for Canterbury was 668 ha (around 11% of national).
- The total annual area burned for Canterbury varied considerably from just 57 ha in 1991/92 (3% of that years' national) to 2,321 ha in 1995/96 (51% of that year's national total).
- The total area burned for Canterbury 1991/92 to 2006/07 showed no statistically significant trend (regression: F-value = 0.00; P-value = 0.991).

Number of Fires by Cause (Figures C3 and C4):

- Around 38% of the average annual total number of fires for Canterbury from 1991/92 to 2006/07 were attributed to miscellaneous causes (annual average around 212 fires); unknown causes accounted for just under 13% of the average annual total number of fires (annual average 70 fires); making 51% of the average annual total number of fires due to combined 'unspecified' causes.
- Land clearing accounted for around 21% of the average annual total number of fires.
- Around 15% of the average annual total number of fires were attributed to vehicle causes (annual average of 80 fires).
- The increase in annual number of fires over the study period appeared to be due to an increase in the number of miscellaneous, vehicle, and land clearing fires.

Area Burned by Fuel type (Figures C5 and C6):

- Around 51% of the Canterbury total area burned from 1991/92 to 2006/07 was grass; average annual total grass area burned was 343 ha (11% of national).
- Around 43% of the total area burned was scrub; average annual total scrub area burned was 286 ha (13% of national).
- Forest made up just 6% of the total area burned; average annual total was just 40 ha (12% of national).

- Canterbury accounted for 92% of the national annual forest area burned in 1995/96.

Area Burned by Cause (Figures C7 and C8):

- The area burned by cause in Canterbury was significantly different to the number of fires by cause.
- Around 44% of the average annual total area burned (average 293 ha) was attributed to land clearing; therefore on average 21% of the fires accounted for 44% of the area burned. In addition, years with high number of land clearing fires did not always correspond with years, when large areas were burned from land clearing.
- Large areas burned by railway fires occurred in 1995/96 and 2003/04. Railway made up 21% (annual average 140 ha) of the annual average total area burned but accounted for just 2% of the annual average number of fires.
- Miscellaneous causes accounted for 7% (45 ha) of the annual average total area burned but 38% of the annual average total number of fires.
- The trend of increasing number of fires over time from miscellaneous, vehicle, and land clearing causes was not seen in the area burned. Year-on-year no clear trends were present for the area burned other than the fact that land clearing featured in most years and is usually a large component of the area burned.

Area Burned by Cause and Fuel type (Figures C9, C10, C11, C12, C13, and C14):

- The average annual total grass area burned was dominated (49%; or around 170 ha annually) by land clearing.
- Around 14% (48 ha) of the average annual total grass area burned was attributed to railways.
- 9% of the average annual total grass area burned was also attributed to unknown (average annually 32 ha), 9% vehicles (average annually 32 ha), and 9% to miscellaneous causes (average annually 29 ha).
- Large grass areas burned from land clearing occurred in 1994/95 and 1997/98; and railways in 2003/04. As with the annual total area burned, annual total grass area burned was almost always largely due to land clearing fires (1992/93, 1995/96, 1997/98, 1999/2000, 2000/01, 2001/02, 2004/05, 2005/06 and 2006/07).
- Canterbury's average annual total scrub area burned was 41% from land clearing (average annually 117 ha); 29% (average annually 83 ha) from railways; and 18% (average annually of 52 ha) from unknown causes.
- No clear year-on-year trends were evident in annual scrub area burned by cause. Most of the scrub area burned attributed to railways occurred in 1995/96.
- 29% of forest area burned was attributed to incendiary, followed closely by 24% due to railways.
- The average annual forest area burned by cause was greatly influenced by individual causes in individual years. In 1995/96, 150 ha was attributed

to railways and 149 ha was attributed to incendiary. Significant forest area burned from vehicle causes occurred in 1994/95, 2000/01 and 2002/03. Most other causes barely featured.

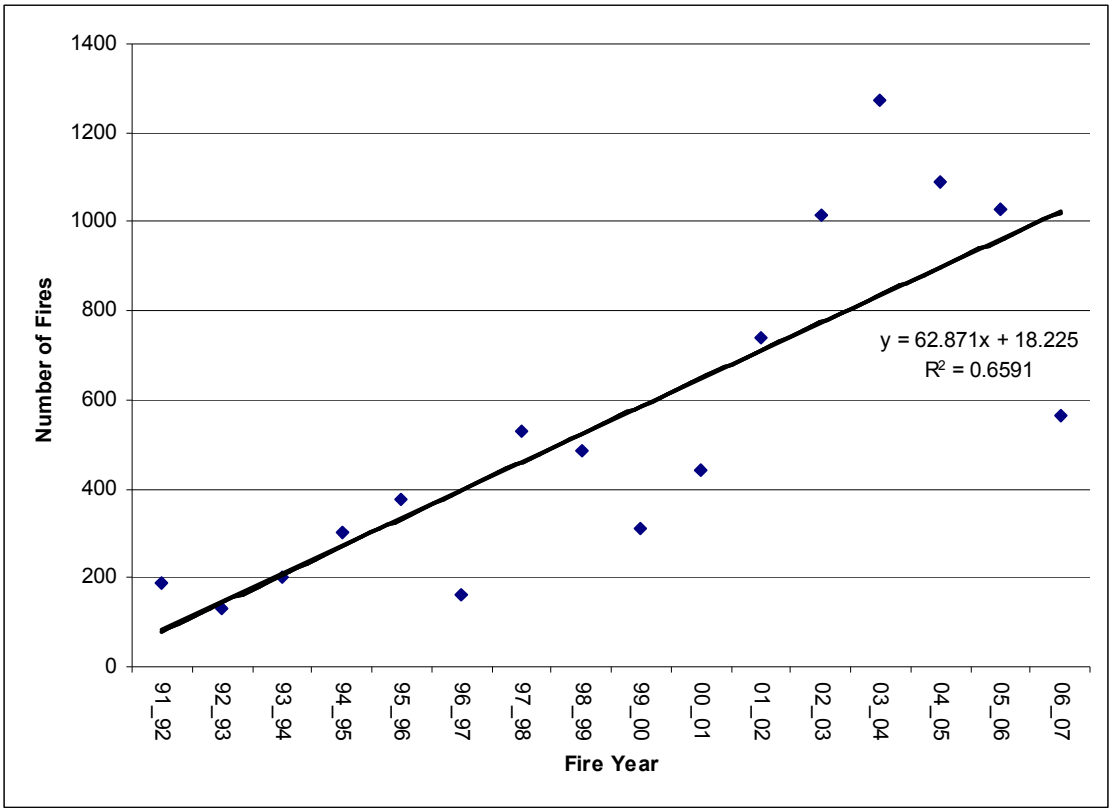

Figure C1. Canterbury Total annual number of fires from 1991/92 to 2006/07.

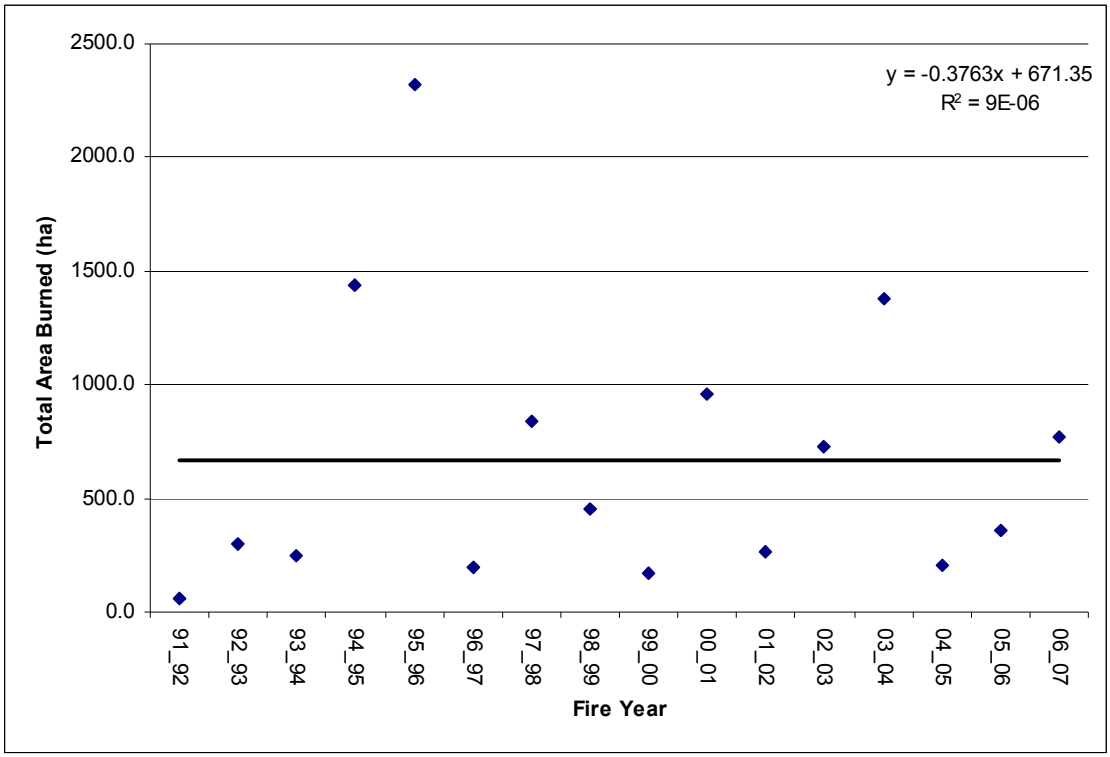

Figure C2. Canterbury total annual area burned from 1991/92 to 2006/07.

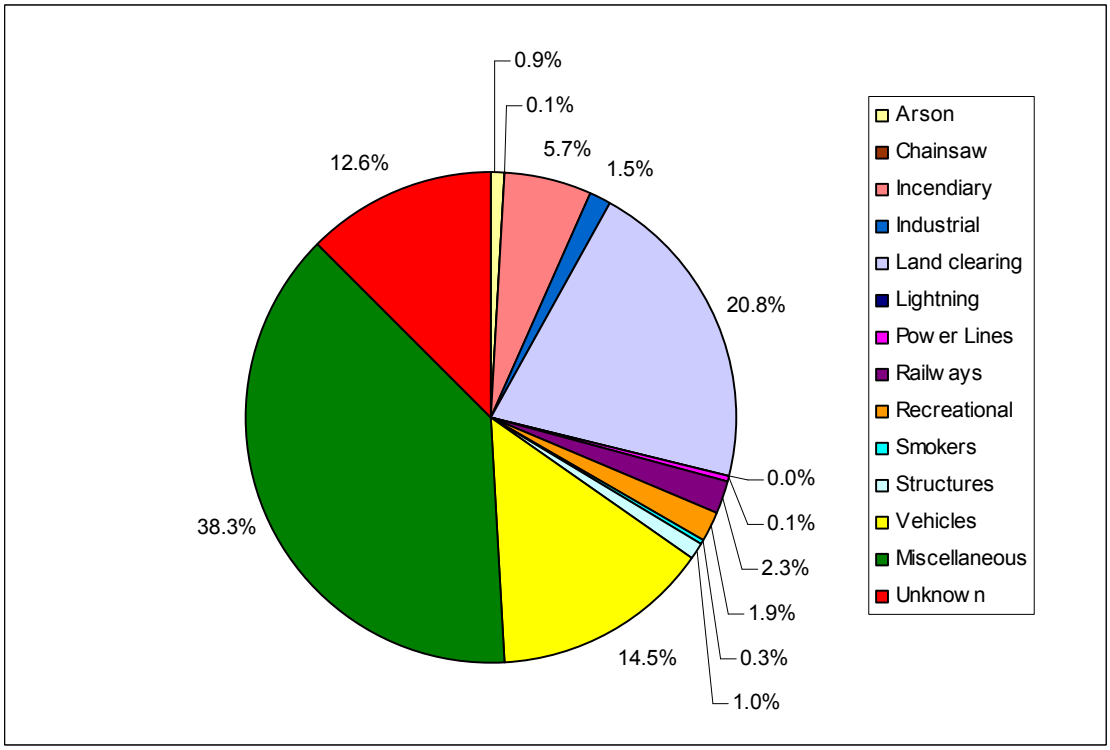

Figure C3. Canterbury total number of fires by cause from 1991/92 to 2006/07.

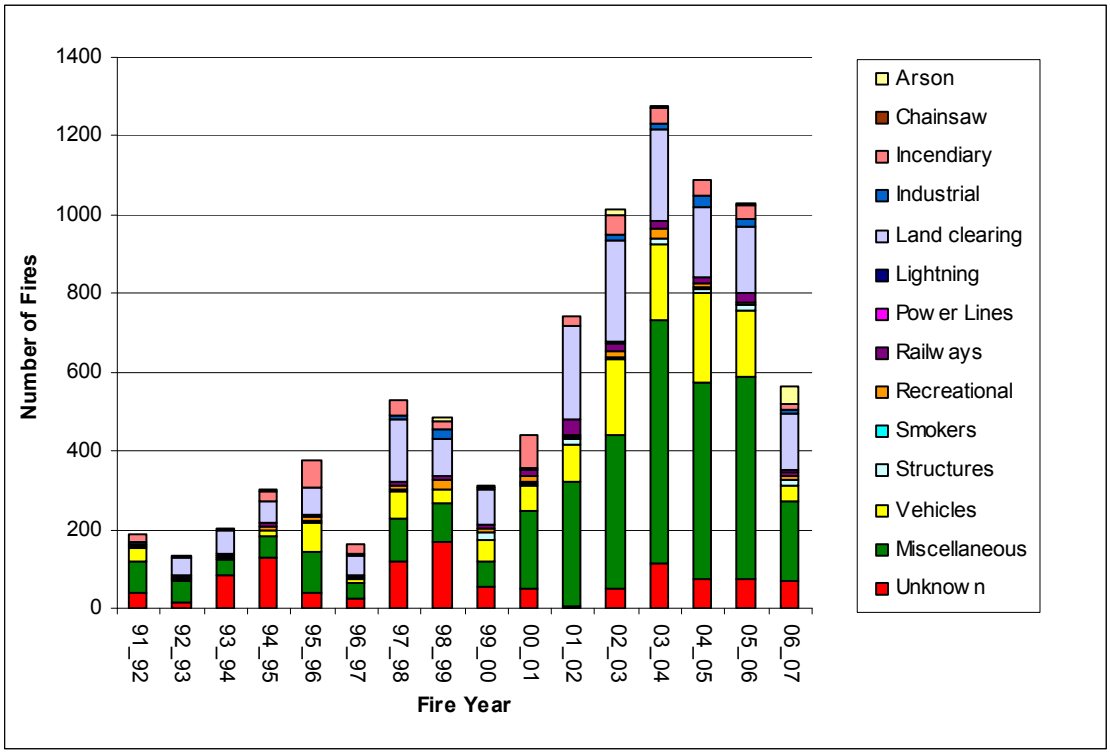

Figure C4. Canterbury total number of fires by cause from 1991/92 to 2006/07.

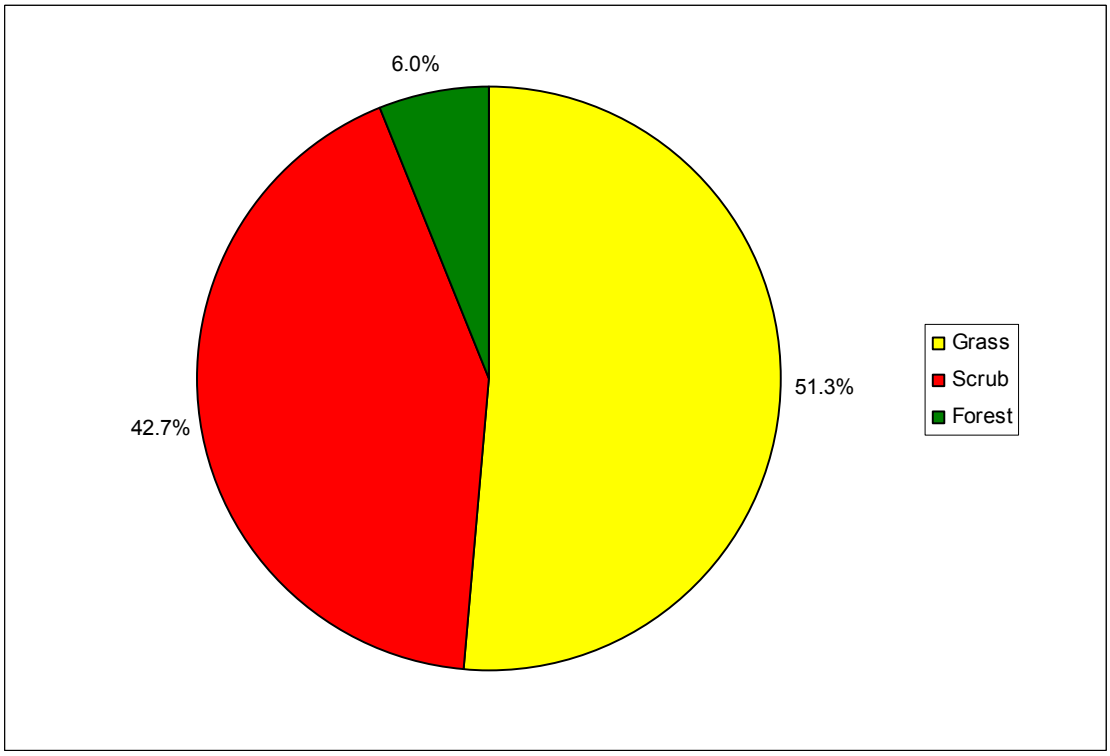

Figure C5. Canterbury total area burned by fuel type from 1991/92 to 2006/07.

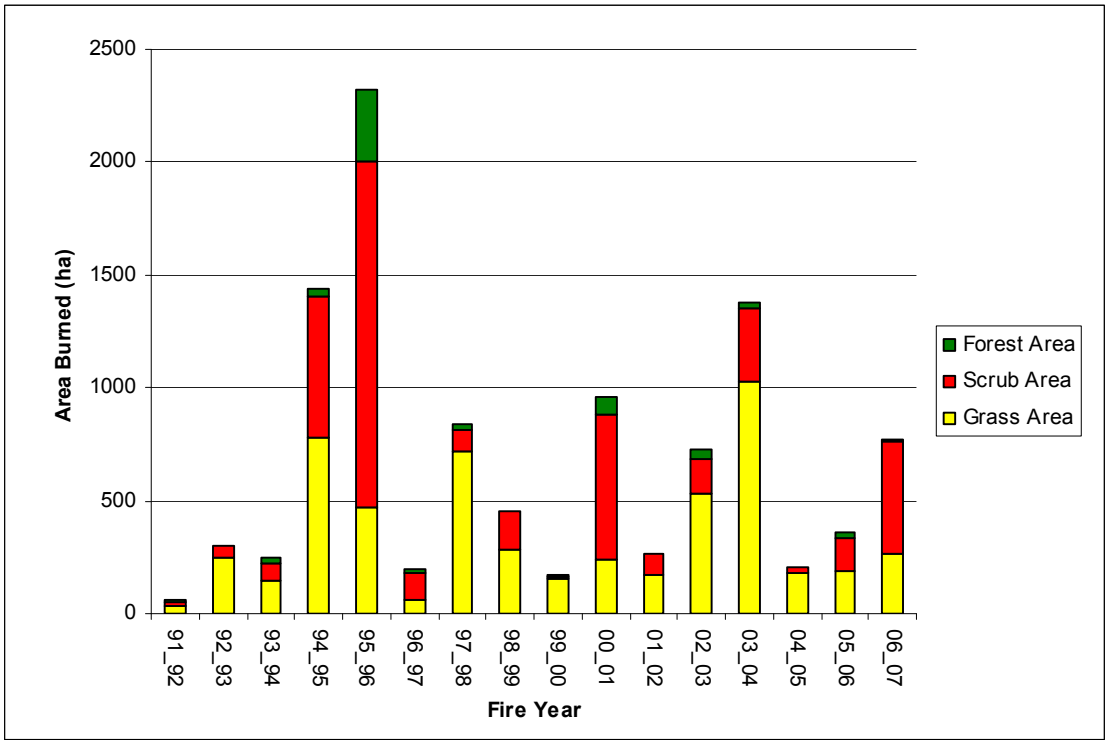

Figure C6. Canterbury total area burned by fuel type from 1991/92 to 2006/07.

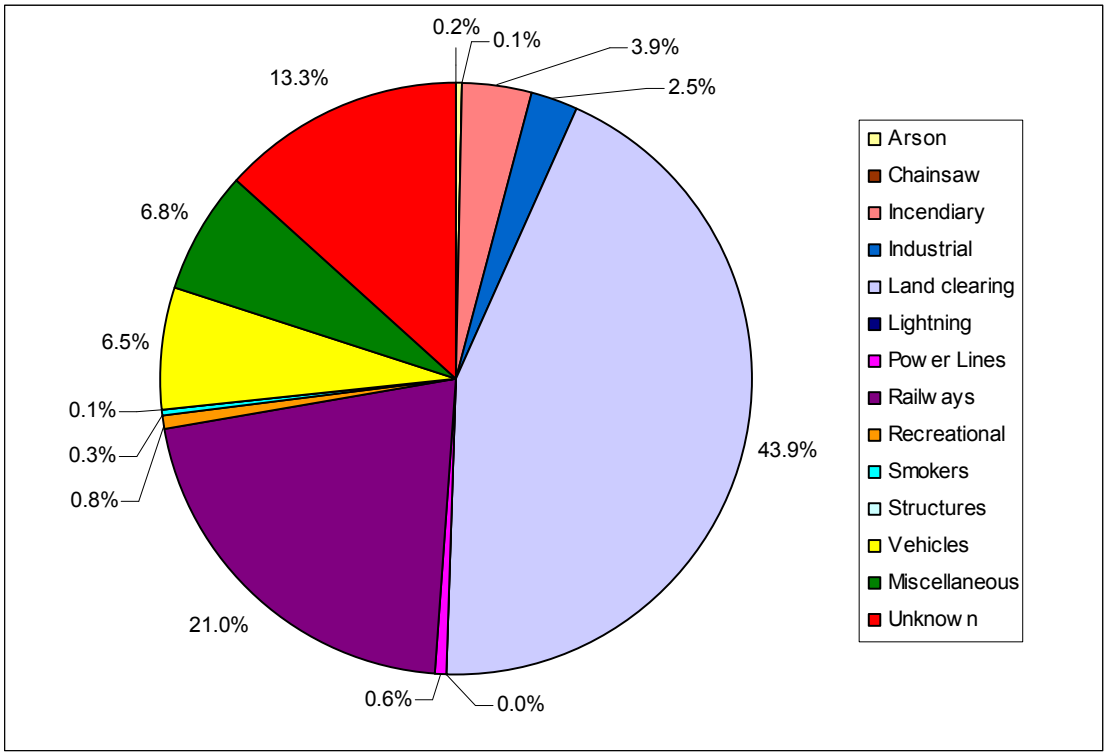

Figure C7. Canterbury total area burned by cause from 1991/92 to 2006/07.

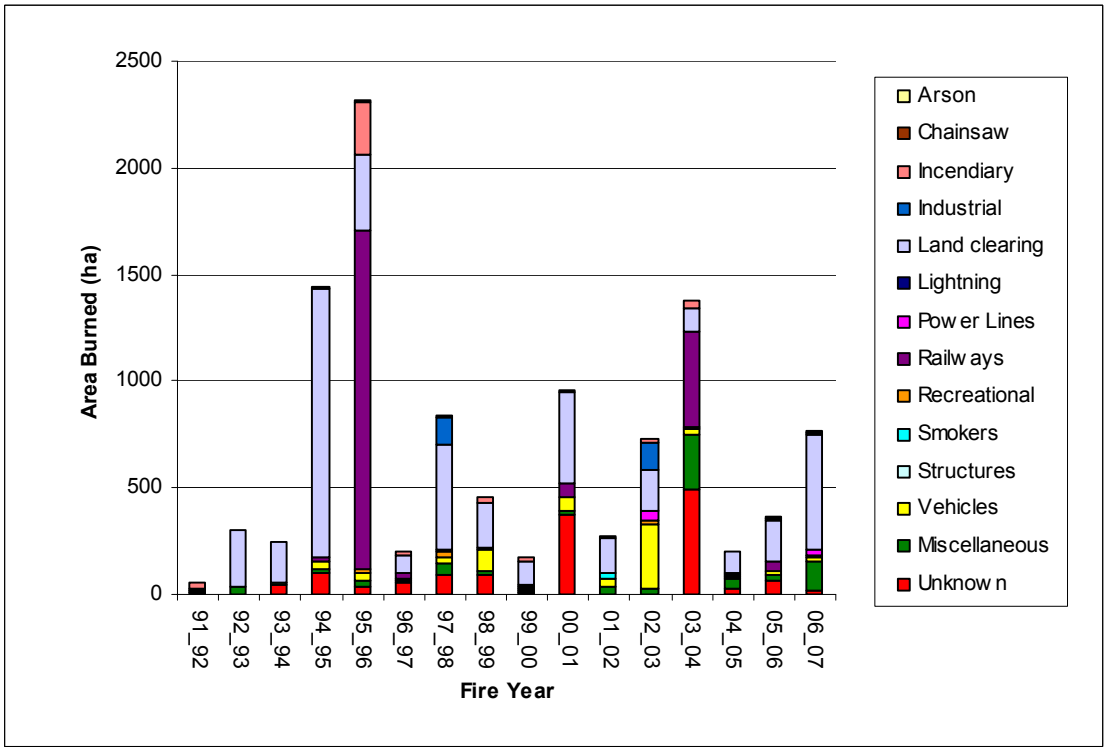

Figure C8. Canterbury total area burned by cause from 1991/92 to 2006/07.

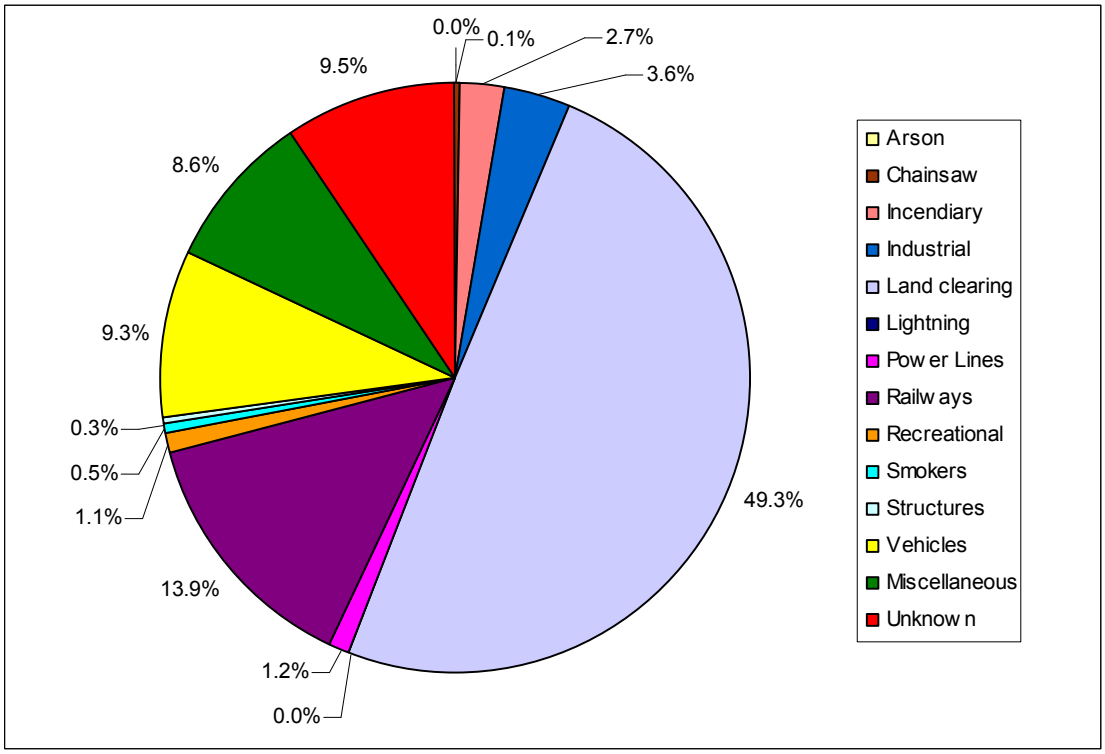

Figure C9. Canterbury average total annual grass area burned from 1991/92 to 2006/07.

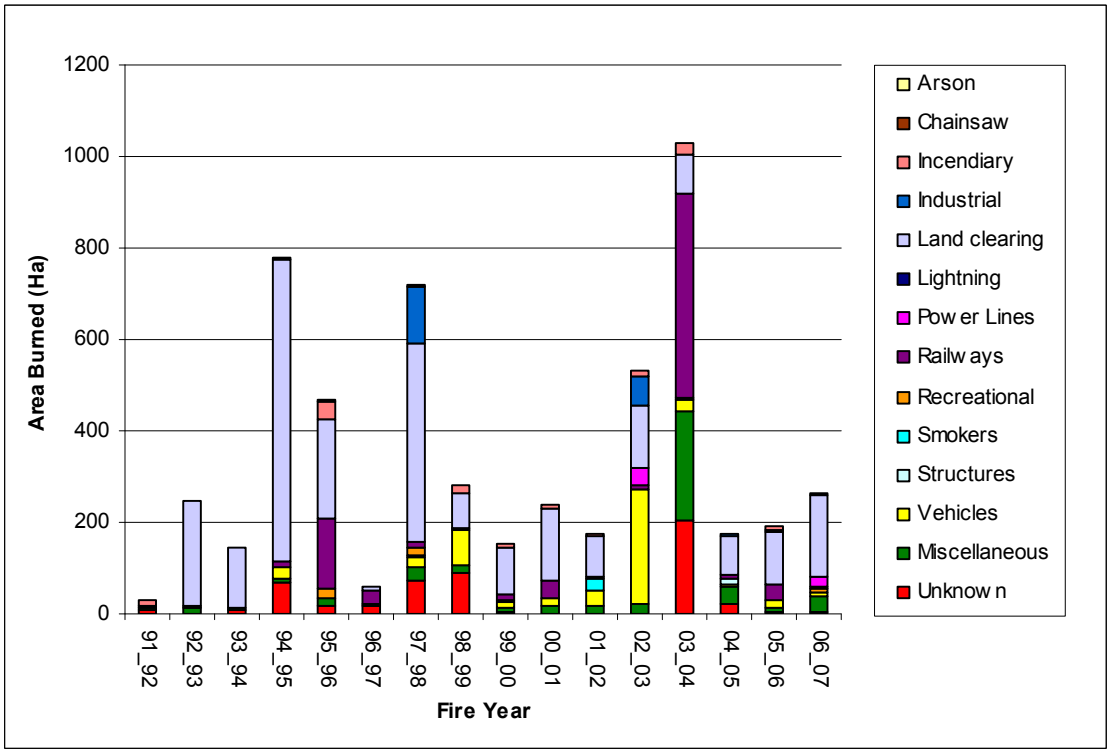

Figure C10. Canterbury total grass area burned by cause from 1991/92 to 2006/07.

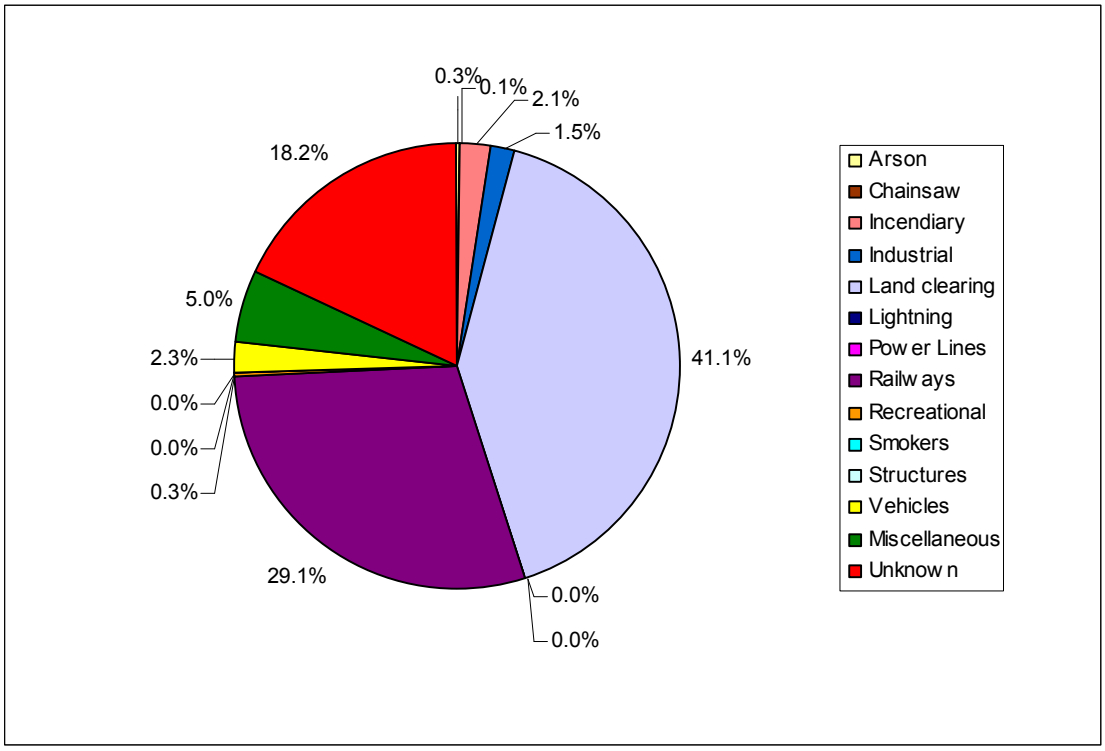

Figure C11. Canterbury average total scrub area burned by cause from 1991/92 to 2006/07.

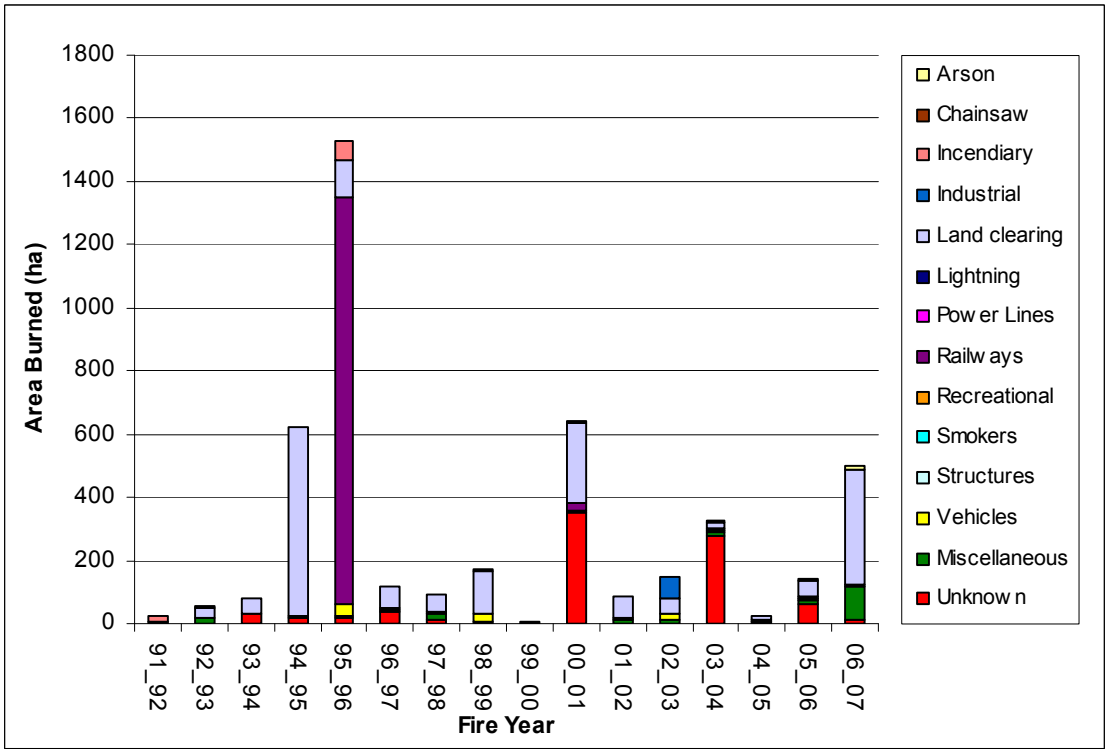

Figure C12. Canterbury total scrub area burned by cause from 1991/92 to 2006/07.

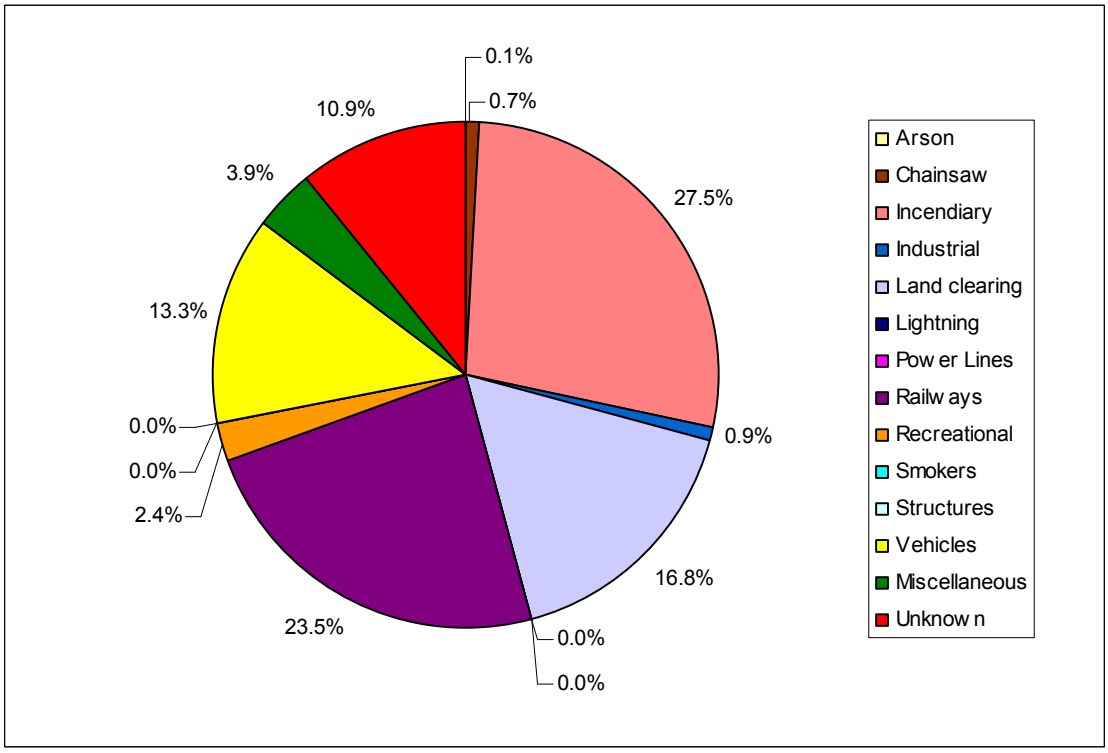

Figure C13. Canterbury average total forest area burned by cause 1991/92 to 2006/07.

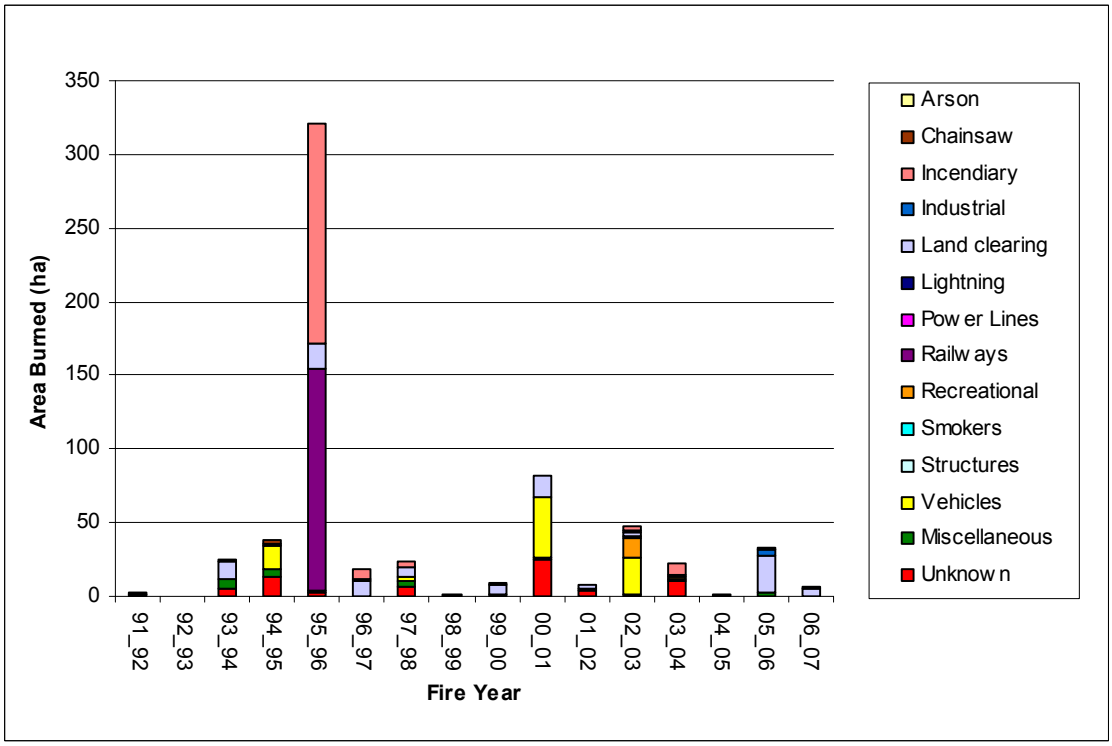

Figure C14. Canterbury total forest area burned by Cause from 1991/92 to 2006/07.

Appendix C12 Otago Region Fire Returns 1991/92 to 2006/07

Number of Fires (Figure O1):

- From 1991/92 to 2006/07 Otago averaged 188 fires annually, or around 6% of the national average annual number of fires.
- The total annual number of fires varied considerably, from just 33 fires in 1993/94 (1.5% of that year's national total) to 382 fires in 2003/04 (about 9% of that year's national total). Otago accounted for the highest proportion of any year's national total in 1999/2000 when 268 fires (or 9% of the national total number of fires) occurred there.
- Otago's total number of fires from 1991/92 to 2006/07 showed a statistically significant increase over time (regression: $R^2 = 0.7885$; F-value = 52.2; P-value = 0.00). This increasing trend correlates with the national trend in total number of fires (correlation coefficient = 0.880; P-value = <0.001).

Area Burned (Figure O2):

- The average annual total area burned for Otago was 2,459 ha (on average proportionally about 33% of the annual national total area burned and 41.5% of the national total area burned over the entire study period).
- The total annual area burned varied from 426 ha in 2005/06 (10% of that year's national total) to 14,637 ha in 1998/99 (83% of that year's national total).
- Otago accounted for its lowest proportion of any year's national total area burned in 2000/01 with just 8%.
- The total area burned varied considerably and showed no statistically significant positive or negative trend over time (1991/92 to 2006/07) (regression: $R^2 = 5^{E-06}$; F-value = 0.00; P-value 0.993).

Number of Fires by Cause (Figures O3 and O4):

- As in most other regions, miscellaneous and unknown causes accounted for a considerable proportion of Otago's number of fires. Around 30% (actual average 55 fires) of the average annual total number of fires was attributed to miscellaneous causes; unknown accounted for 10% (an average of 19 fires) of the average annual total number of fires; average annual combined 'unspecified' proportion of total number of fires for Otago was just under 40%.
- Land clearing accounted for about 30% (or annually an average of 57 fires) of the average annual total number of fires.
- Around 13% of the average annual total number of fires were due to vehicles causes (annual average of 25 fires).
- Before 1997/98 the reported number of fires occurring in Otago was less than 100 fires annually, and from 1997/98 the number of fires doubled and has fluctuated since. From 1997/98 the number of fires being attributed to vehicles and land clearing increased.

Area Burned by Fuel Type (Figures O5 and O6):

- Around 72% of the total area reported burned in Otago was grass; average annual total grass area burned was 1,781 ha; 57% of the national total grass area burned from 1991/92 to 2006/07 occurred in Otago.
- Around 26% of the total area burned in Otago was scrub; average annual total scrub area burned was 631 ha (22% of the national annual scrub area burned).
- Forest made up the remaining 2% of total area burned; average annual total forest area burned was 47 ha (12% of the national annual average).
- The area burned by fuel type showed no clear directional trend over time; large areas were burned in 1998/99 (more than twice the area burned of any other year studied) in both grass and scrub fuels.

Area Burned by Cause (Figures O7 and O8):

- Area burned by cause was significantly different to number of fires by cause.
- Land clearing accounted for 30% of the average total annual number of fires, but 64% of the average annual total area burned (an average of 1,576 ha annually burned for the study period).
- Around 21% of the average total area burned was attributed to unknown causes (512 ha annually average). Miscellaneous causes accounted for only 2% of the average total area burned (average annually of 60 ha).
- The total area burned by cause was dominated each year by land clearing, and years with a high total area burned usually had most of their area burned attributed to land clearing.
- In 1998/99 over 14,000 ha were burned; over 4,000 ha land clearing, over 6,000 ha from unknown causes, over 2,000 ha from power lines, and around 1,000ha attributed to vehicle fires.

Area Burned by Cause by Fuel type (Figures O9, O10, O11, O12, O13, and O14):

- Around 68% of the average annual total grass area burned (1,204 ha averaged annually) was attributed to land clearing.
- Around 20% of the average annual total grass area burned (362 ha averaged annually) was attributed to unknown causes.
- Around 6% of the average annual total grass area burned (average annually 114 ha) was attributed to power lines.
- Since grass area burned made up the largest fuel type reported in Otago, the annual trend for grass area burned mirrored that of the total area burned.
- Land clearing dominated the average total scrub area burned at 56% (annual average of 355 ha burned).
- Around 23% of the average annual total scrub area burned was attributed to unknown (147 ha) causes.

- Around 9% of the average annual total scrub area burned was attributed to power lines (average annually 55 ha).
- The trend for annual total scrub area burned again mirrored the total area burned trend with land clearing accounting for the greatest proportion of the area burned in most years.
- The average annual total forest area burned was greatly influenced by single causes that made up most of the forest area burned in different years; miscellaneous in 1994/95, 2004/05 and 2005/06; land clearing in 2006/07; incendiary in 1997/98; and unknown in 1998/99.
- Around 43% of the average annual total forest area burned was attributed to miscellaneous causes (average annually 20 ha) mostly in 1994/95; 35% to land clearing (average annually 16 ha); and 9% attributed to incendiary causes (4ha).

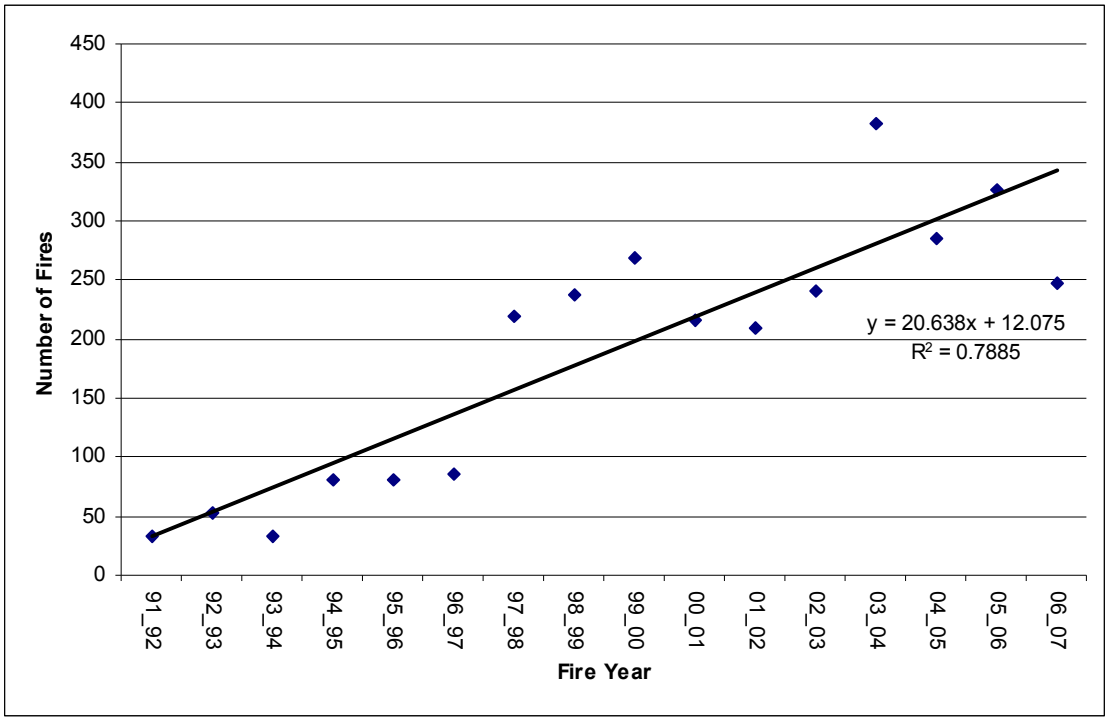

Figure O1. Otago total annual number of fires from 1991/92 to 2006/07.

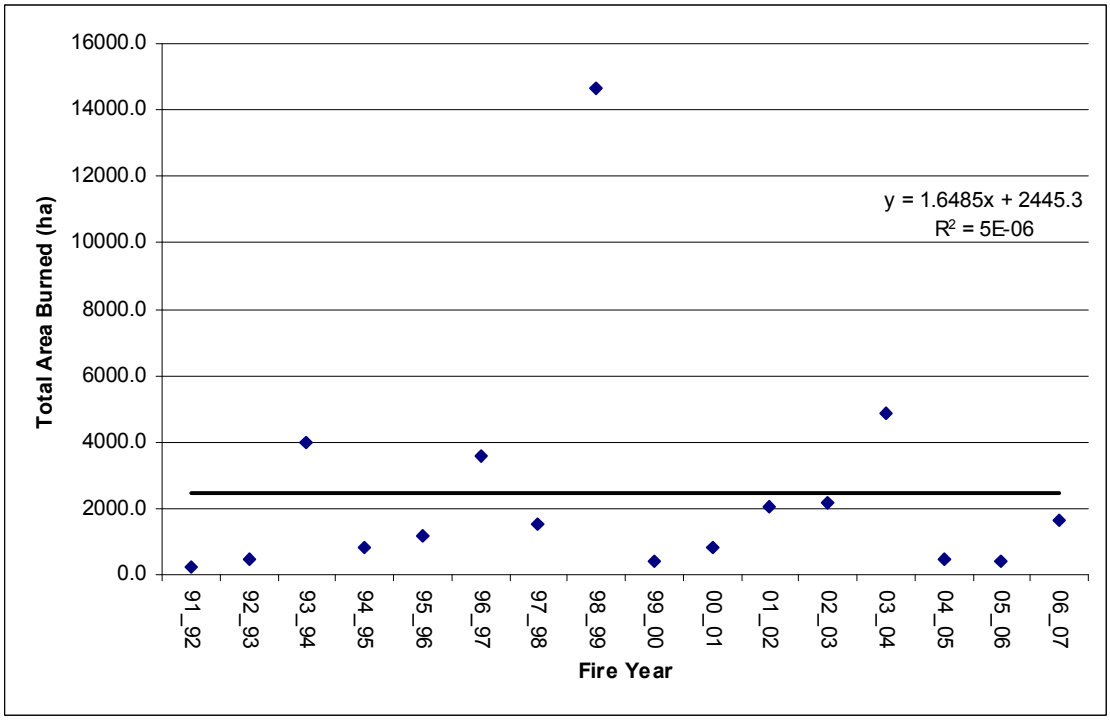

Figure O2. Otago total annual area burned from 1991/92 to 2006/07.

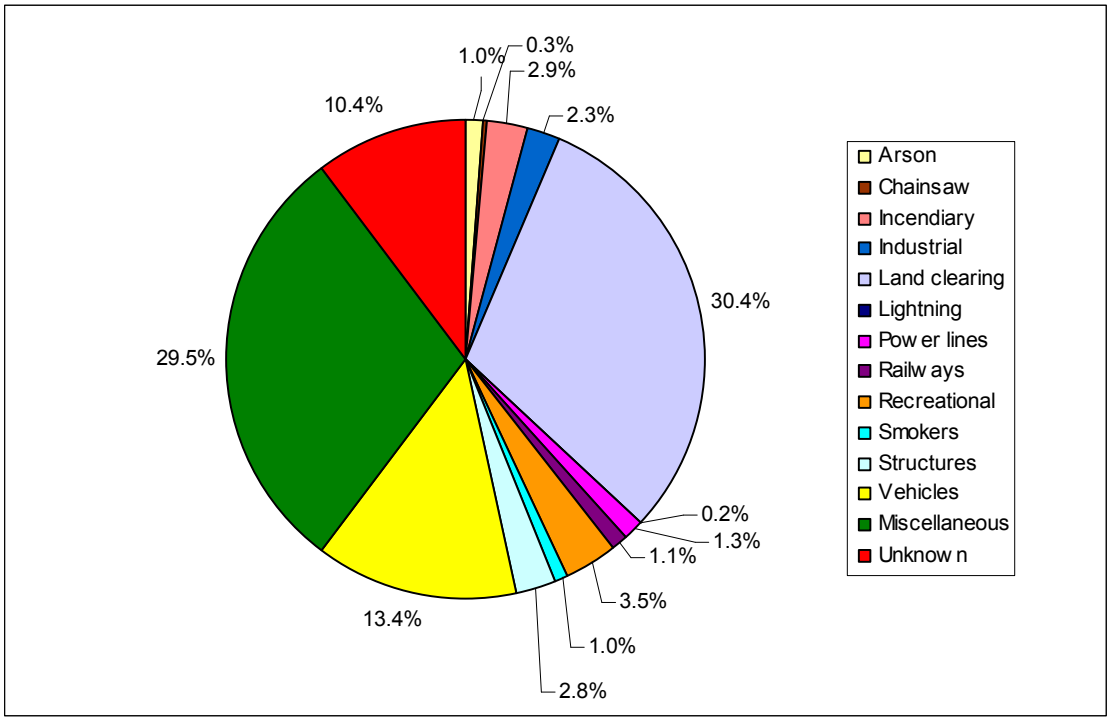

Figure O3. Otago average total number of fires by cause from 1991/92 to 2006/07.

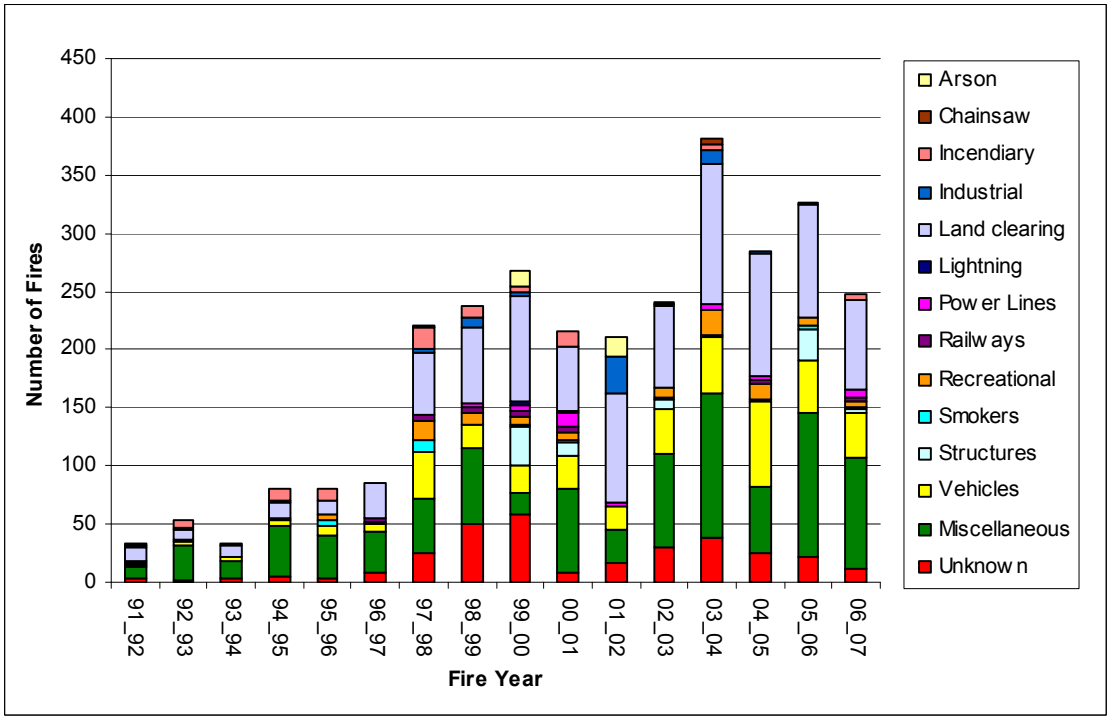

Figure O4. Otago total annual number of fires by cause from 1991/92 to 2006/07.

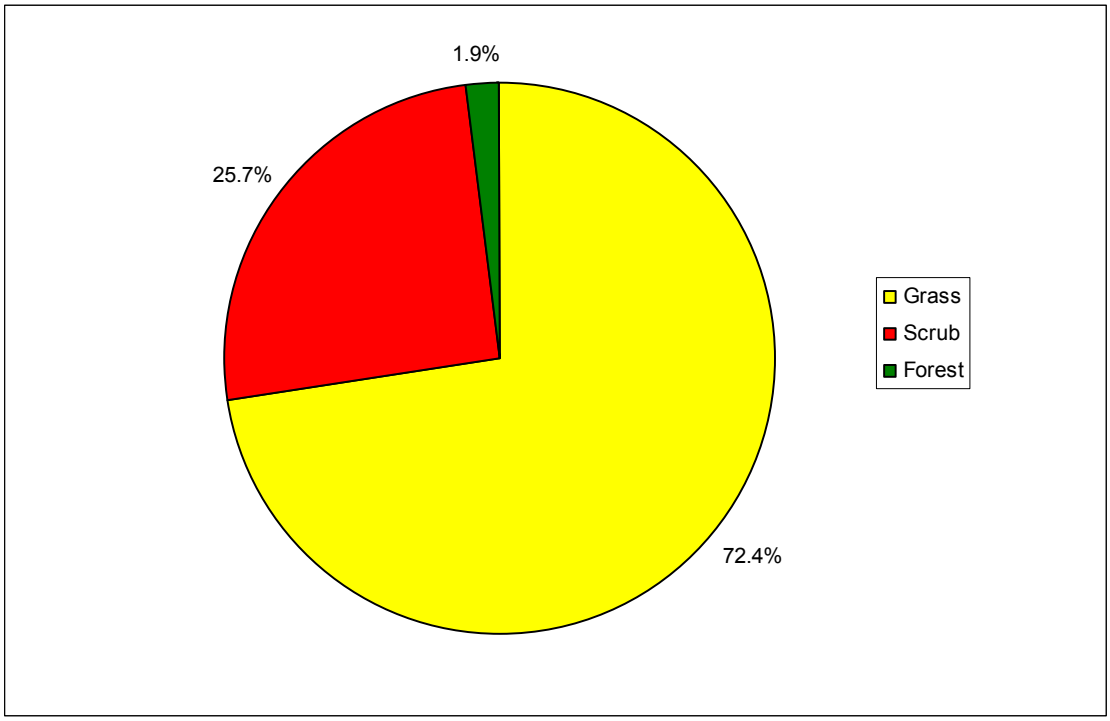

Figure O5. Otago total area burned by fuel type from 1991/92 to 2006/07.

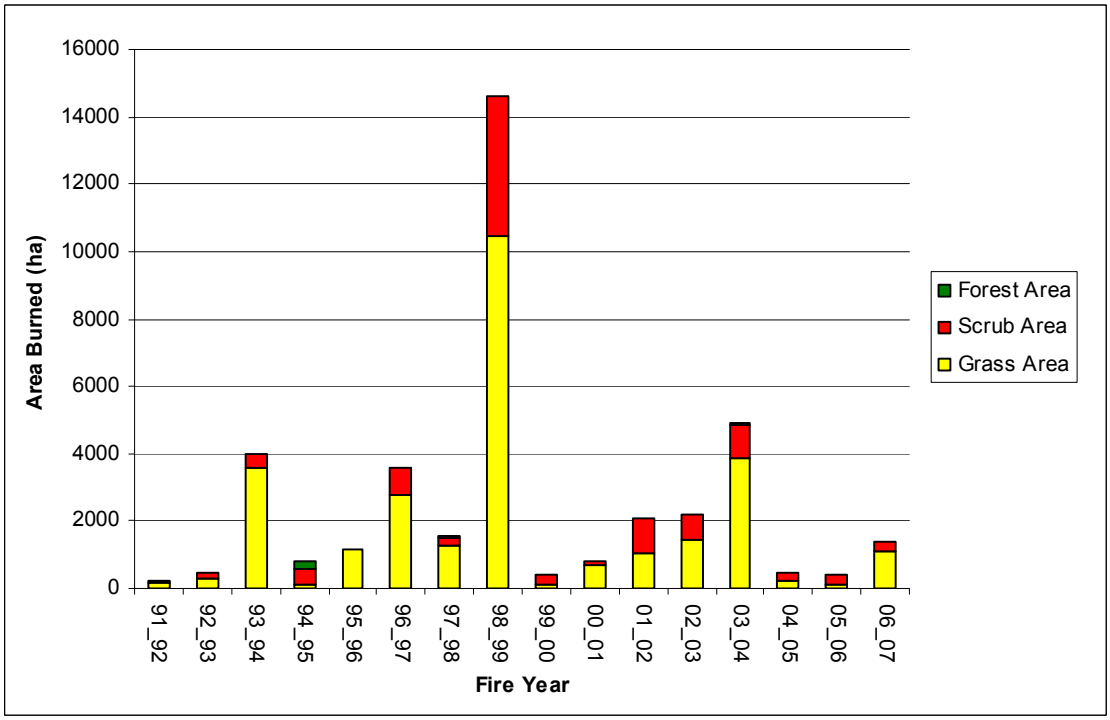

Figure O6. Otago total annual area burned by fuel type from 1991/92 to 2006/07.

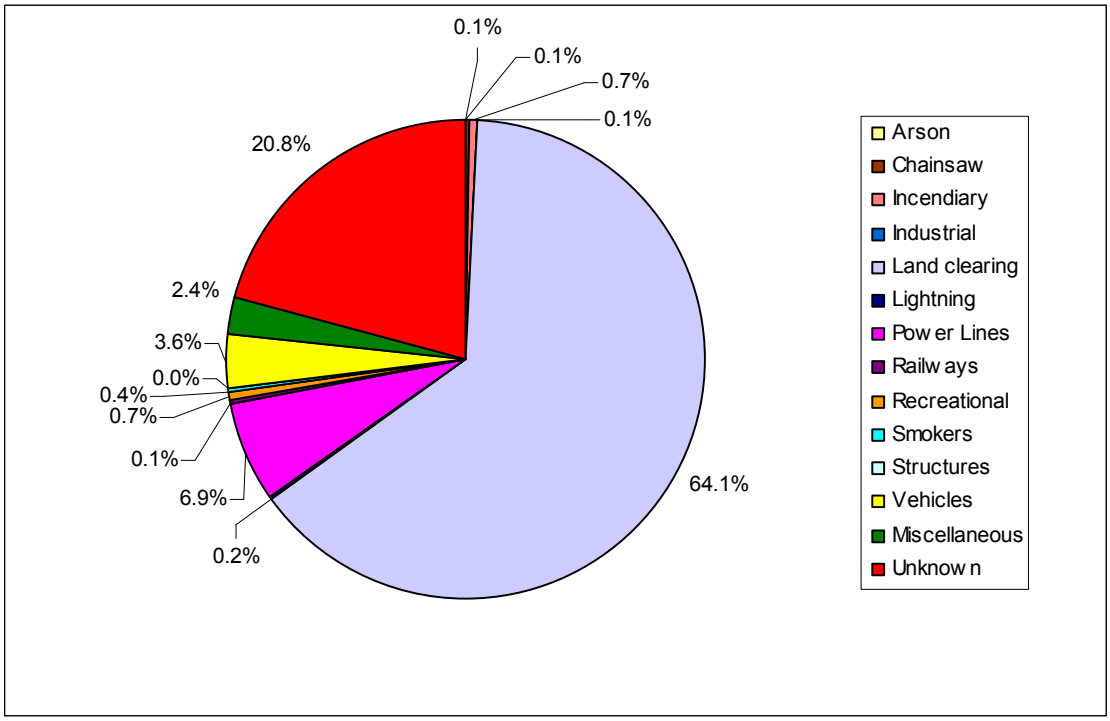

Figure O7. Otago average total area burned by cause from 1991/92 to 2006/07.

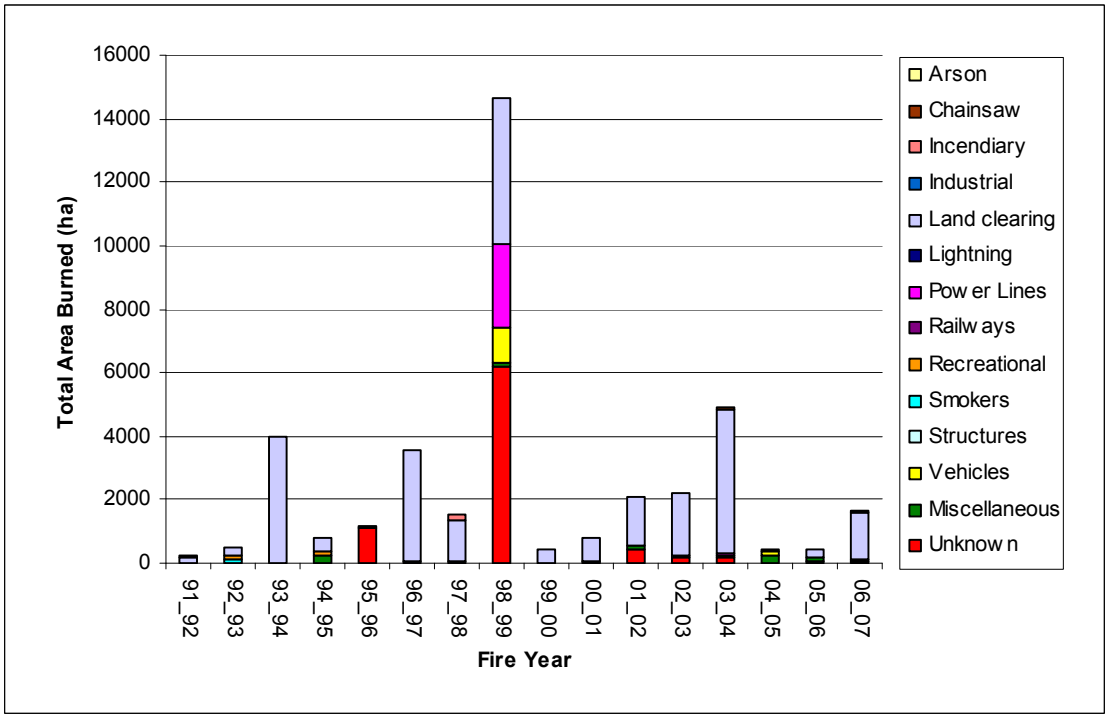

Figure O8. Otago total annual area burned by cause from 1991/92 to 2006/07.

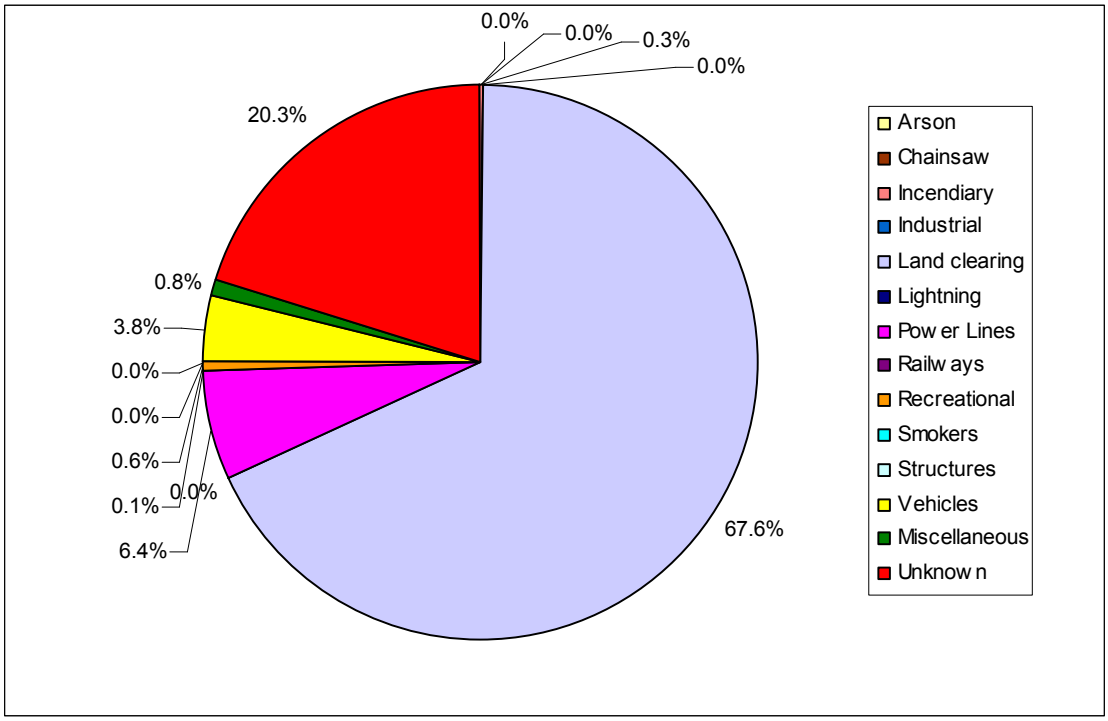

Figure O9. Otago average total grass area burned by cause from 1991/92 to 2006/07.

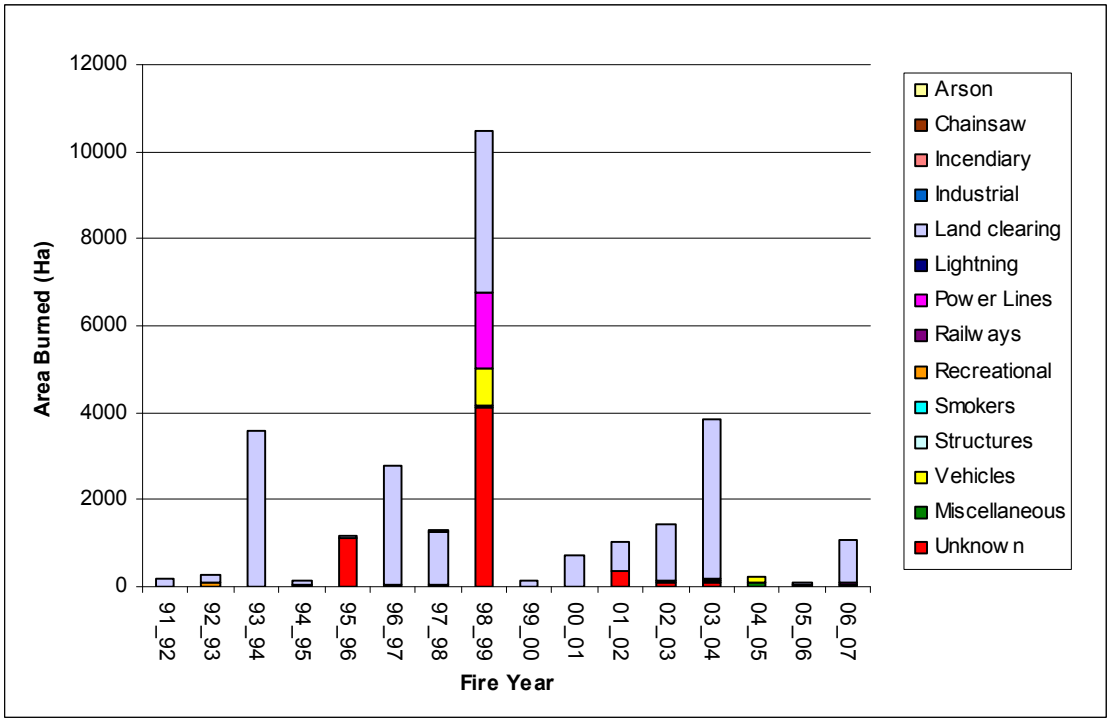

Figure O10. Otago total annual grass area burned by cause from 1991/92 to 2006/07.

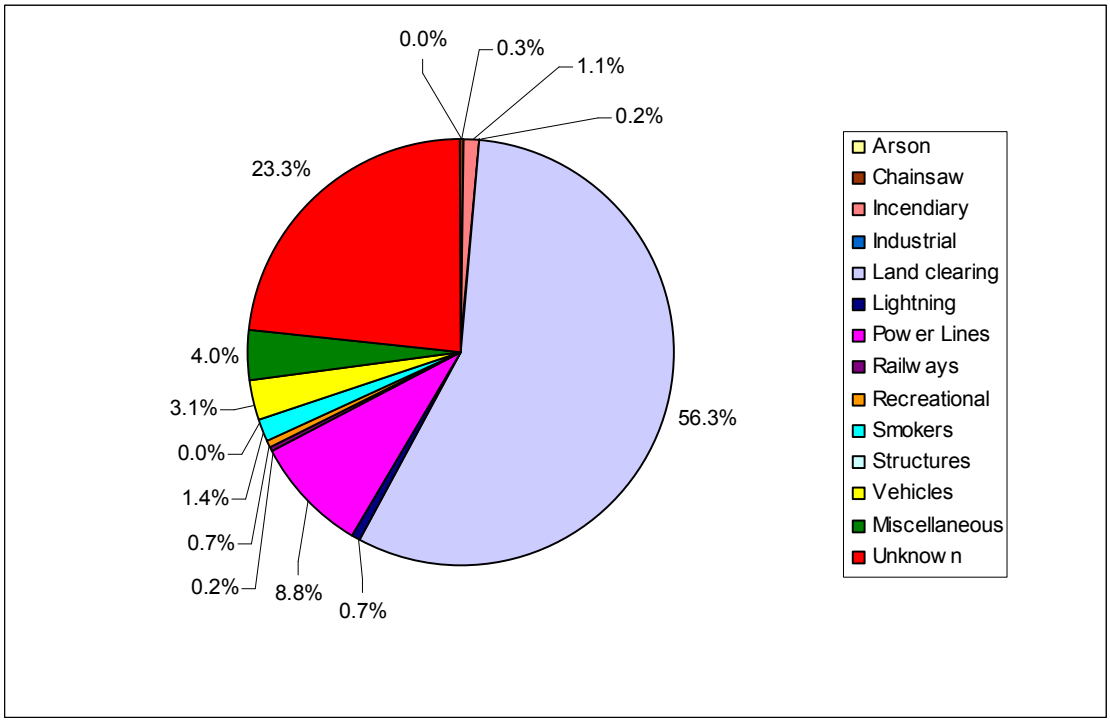

Figure O11. Otago average total scrub area burned by cause from 1991/92 to 2006/07.

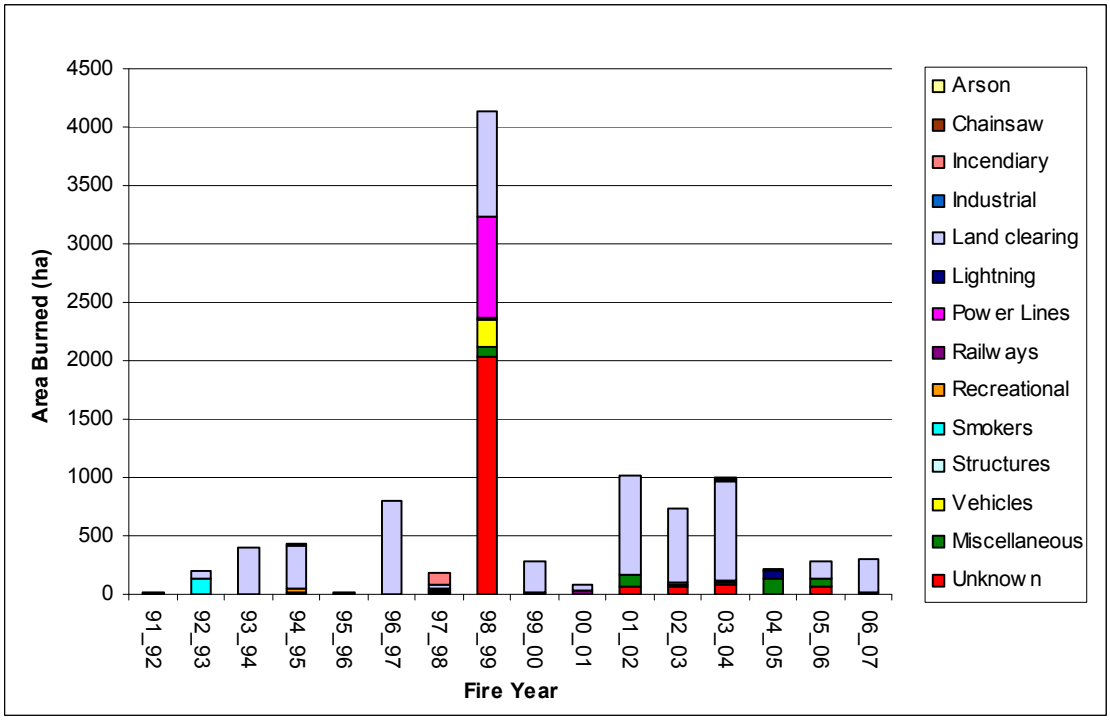

Figure O12. Otago total annual scrub area burned by cause from 1991/92 to 2006/07.

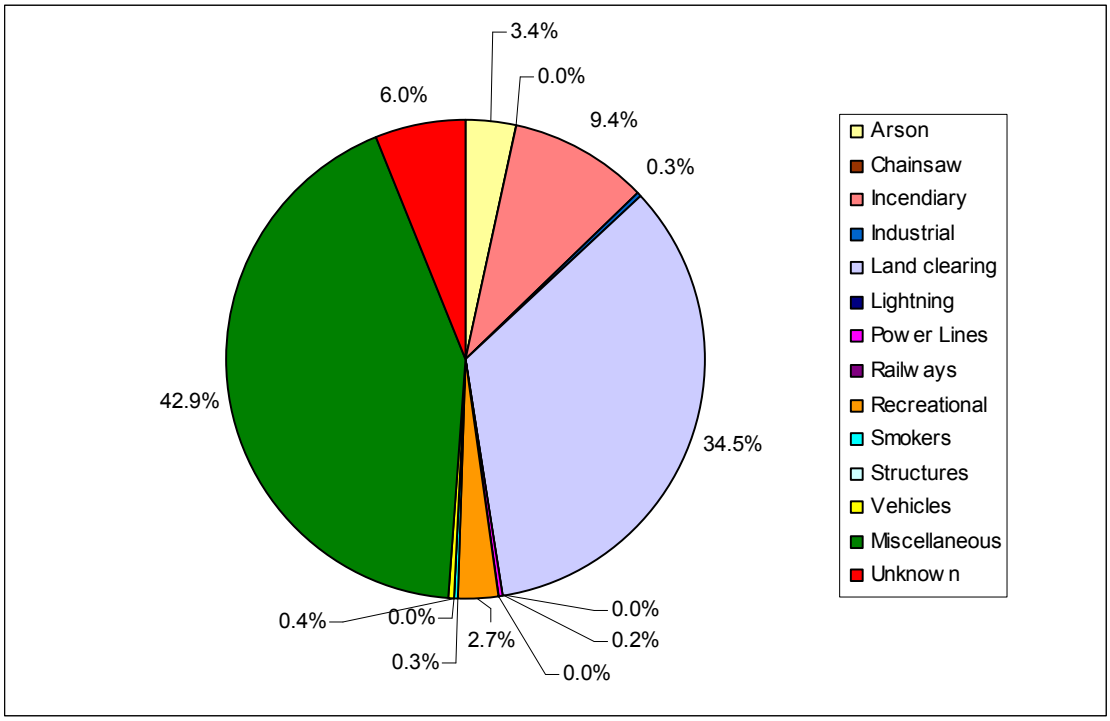

Figure O13. Otago average annual total forest area burned by cause from 1991/92 to 2006/07.

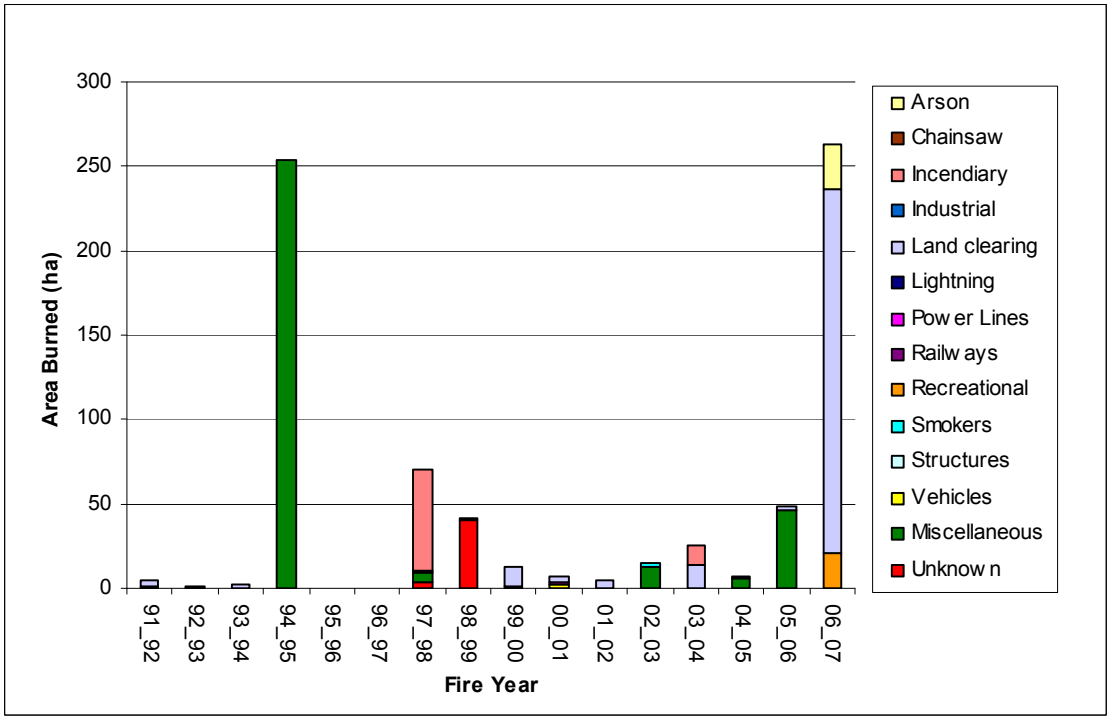

Figure O14. Otago total annual forest area burned by cause from 1991/92 to 2006/07.

Appendix C13 Southland Region Fire Returns 1991/92 to 2006/07

Number of Fires (Figure S1):

- Southland had an annual average of 105 fires, or about 4% of the total number of fires nationally.
- The total annual number of fires varied from 9 fires in 1996/97 (0.4% of that year's national total) to 270 fires in 2006/07 (about 7% of that year's national).
- The trend in the number of fires annually over time generally increased; (regression: $R^2 = 0.68$; F-value = 32.2; P-value = <0.001). Southland's total annual number of fires also significantly correlated with the increasing national trend (correlation coefficient = 0.748; P-value = 0.001).

Area Burned (Figure S2):

- The average annual area burned for Southland from 1991/92 to 2006/07 was 326 ha and averaged around 6% of the national total area burned.
- The total annual area burned varied from just 3 ha in 1995/96 (0.1% of that year's national) to 1,395 ha in 2005/06 (35% of that years national).
- The total area burned for Southland showed a clear significant increasing trend over time (regression: $R^2 = 0.3067$; F-value = 6.19; P-value = 0.02).

Number of Fires by Cause (Figures S3 and S4):

- The average annual number of fires by cause for Southland was more varied than other regions.
- Around 22% of the average number of fires was attributed to land clearing (actual average 23 fires); 22% to structures (annual average 23 fires); and around 16% to vehicle causes (annual average of 16 fires).
- The average annual number of fires from unspecified causes made up 34%: 19% miscellaneous (annual average of 20 fires), and 15% unknown (annual average 15 fires).
- The cause of the majority of fires varied considerably from 1991/92 to 1997/98, and from 1998 onwards unknown, miscellaneous, vehicles, land clearing and structures began to feature in high numbers regularly. High numbers of fires attributed to structures occurred in 1998/99, 2004/05, 2005/06 and 2006/07, this differs from many other regions where hardly any fires were attributed to this class annually.

Area Burned by Fuel Type (Figures S5 and S5):

- Around 58% of the total area burned from 1991/92 to 2006/07 was scrub; average annual total scrub area burned was 185 ha (around 7% of the national on average).
- Around 41% of the total area burned was grass; average annual total grass area burned was 133 ha or about 6% of the national.

- The remaining 3% of the total area burned was forest; average annual total forest area burned was 9 ha or 5% of the national average total forest area burned.
- The trend for total annual area burned by fuel type showed little consistency, individual years were usually dominated by a single fuel type being burned; 1992/93, 1993/94, 1994/95, 1998/99, 1999/2000, 2000/01, 2001/02, 2003/04 and 2005/06 were all dominated by scrub; 1996/97, 1997/98, 2004/05, 2006/07 were dominated by grass.

Area Burned by Cause (Figures S7 and S8):

- The Southland results emphasize the need to consider both number of fires and area burned by cause.
- While land clearing accounted for on average 22% of the number of fires, it accounted for 82% of the total area burned (annual average 266 ha).
- Structure fires made up 22% of the average annual number of fires but does not feature at all in the average annual total area burned; vehicles made up 16% of the average number of fires by only 6% of the average total area burned.
- This disparity between the average annual number of fires and the average annual total area burned was (as with other regions) due to single causes dominating some years, and three years of large areas burned from 2004/05 to 2006/07 were due to land clearing occurred.

Area Burned by Cause and Fuel Type (Figures S9, S10, S11, S12, S13, and S14):

- 96% of the annual total grass area burned was attributed to land clearing (annual average was 127 ha). However, this almost complete domination by land clearing was due to hardly any grass area recorded burned from 1991/92 to 2003/04, and the over 1,300 ha reported in 2004/05 and 600 ha in 2005/06.
- The average annual total scrub area burned was again dominated by land clearing at 73% (average annually of 134 ha); 11% was attributed to vehicles (20 ha). Unknown causes made up 8% (annual average 14ha); and miscellaneous accounted for 5% (annual average of 9 ha).
- Again no clear trend was present for any causes in the total annual scrub area burned.
- Southland's average annual total forest area burned was split with 57% (annual average just 5 ha) from land clearing, 40% from (annual average 3 ha) chainsaws, and the remainder from other causes. The annual total forest area burned was very low, at most around 65 ha (in 2003/04), and most of the forest area burned was attributed to land clearing (1991/92, 1998/99, 1999/2000, 2000/01, 2005/06 and 2006/07), chainsaws accounted for over 50 ha in 2003/04 (most of that year's forest area burned).

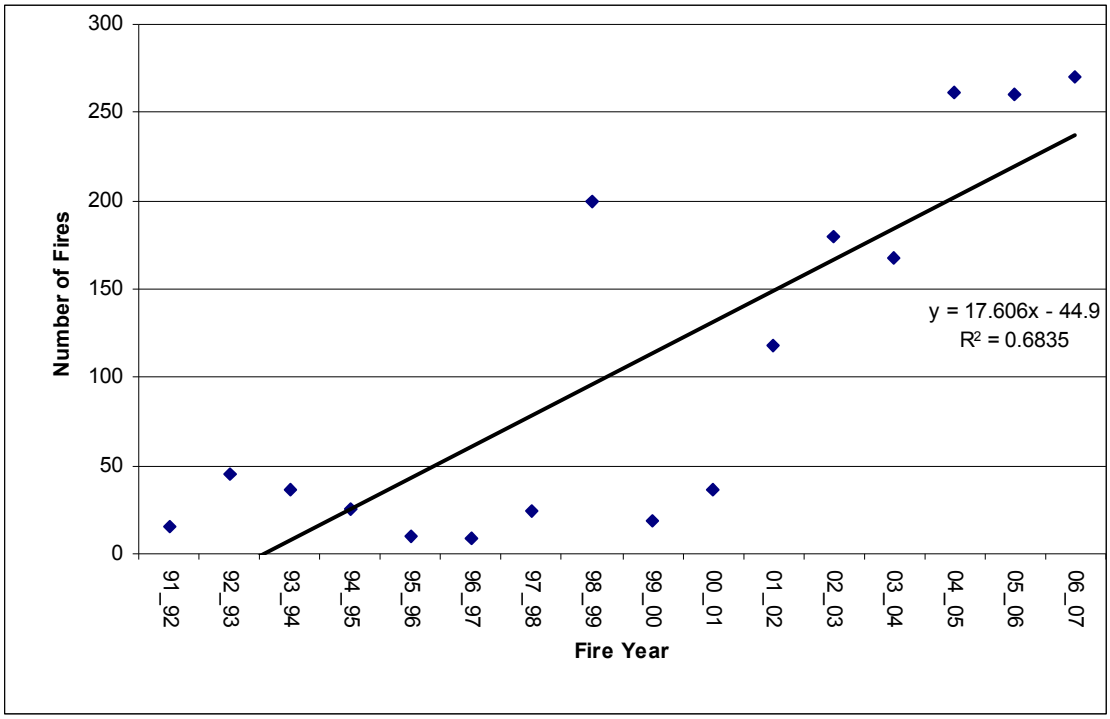

Figure S1. Southland total annual number of fires from 1991/92 to 2006/07.

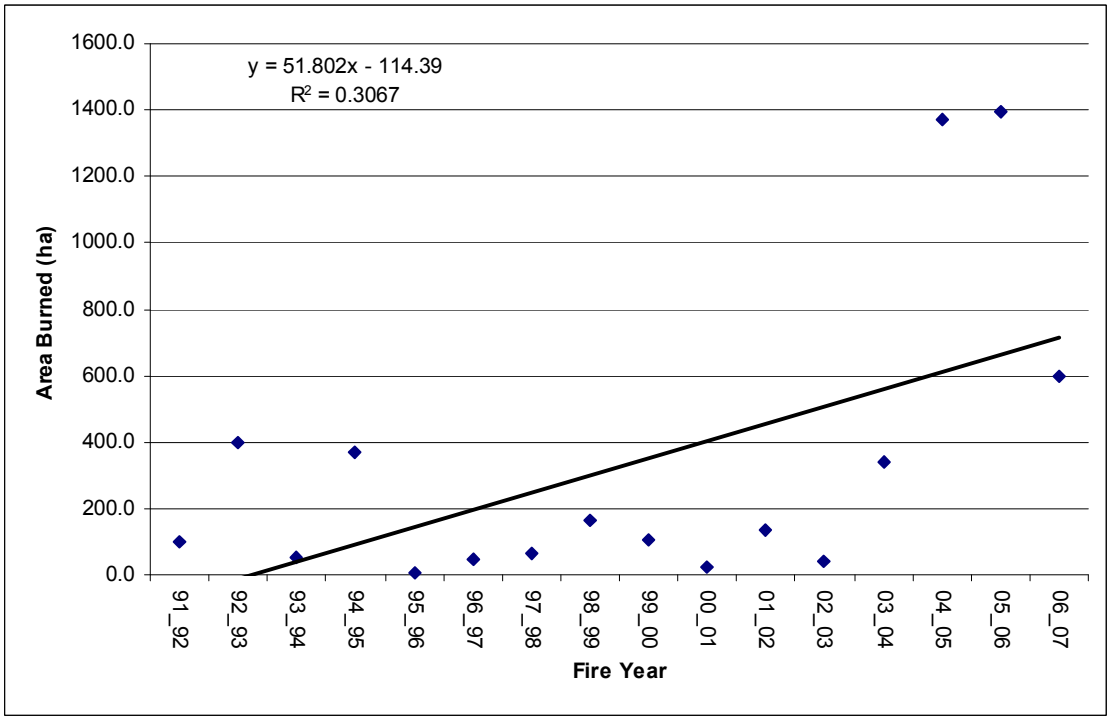

Figure S2. Southland total annual area burned from 1991/92 to 2006/07.

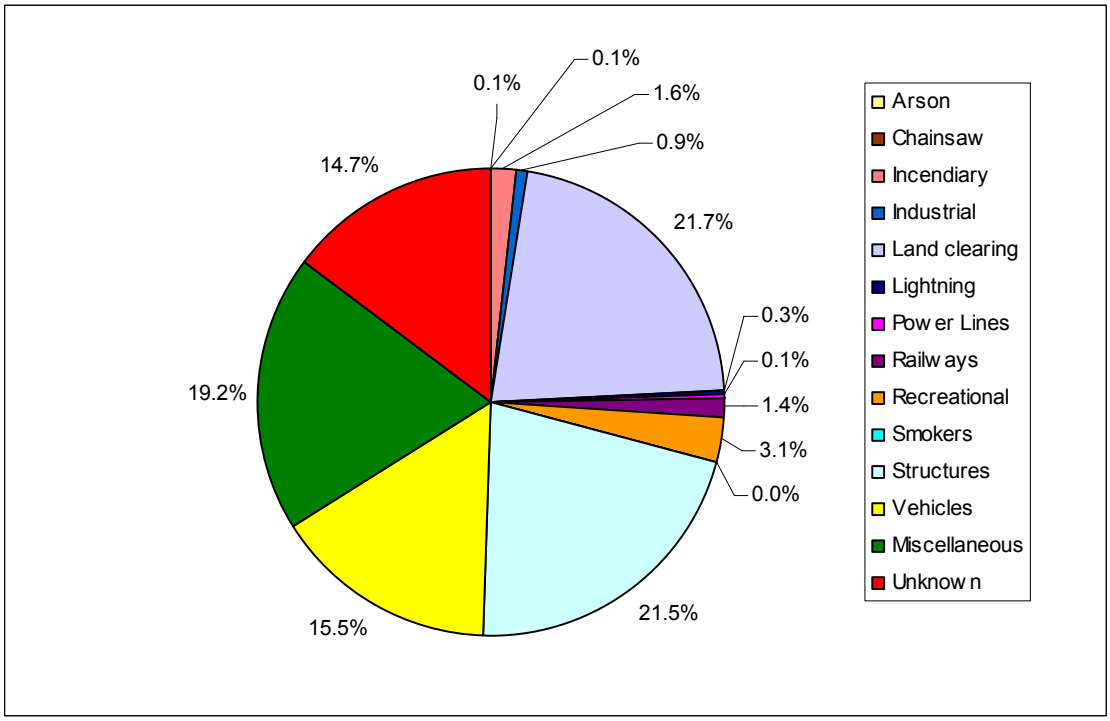

Figure S3. Southland average total number of fires by cause from 1991/92 to 2006/07.

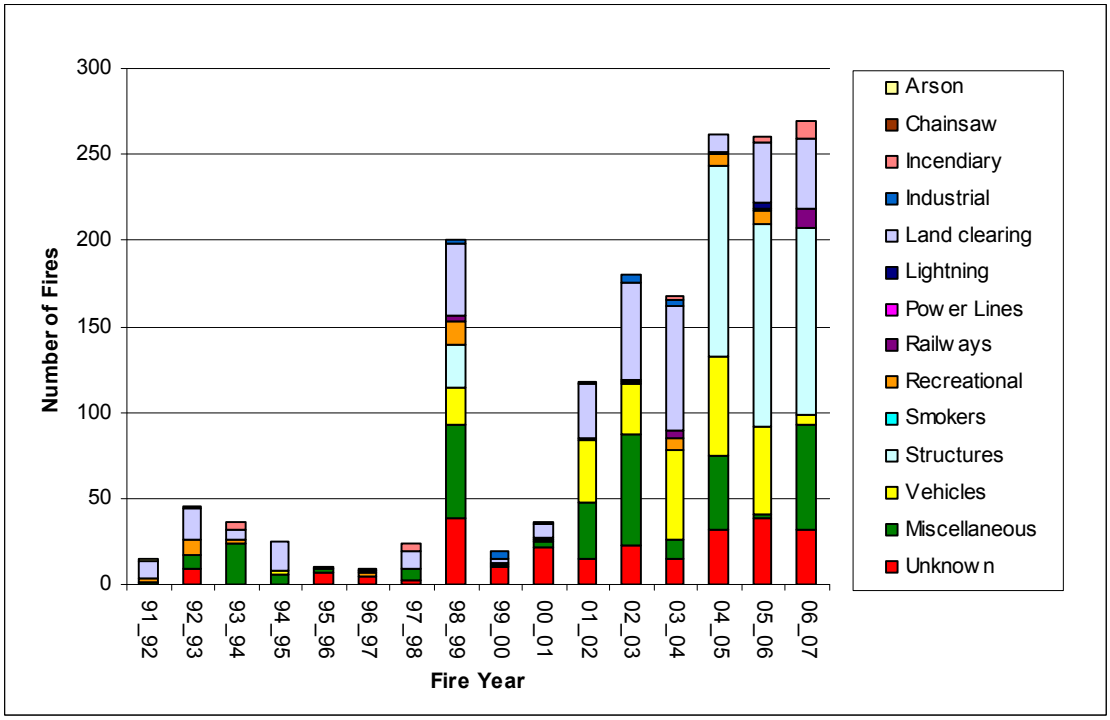

Figure S4. Southland total annual number of fires by cause from 1991/92 to 2006/07.

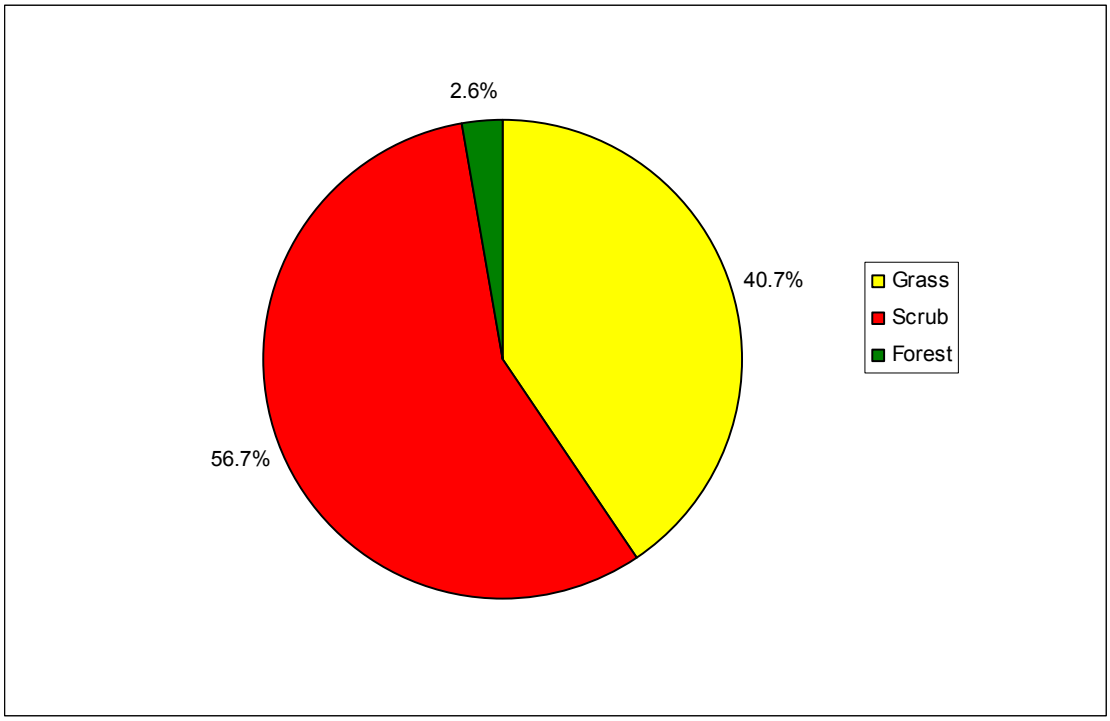

Figure S5. Southland total area burned by fuel type from 1991/92 to 2006/07.

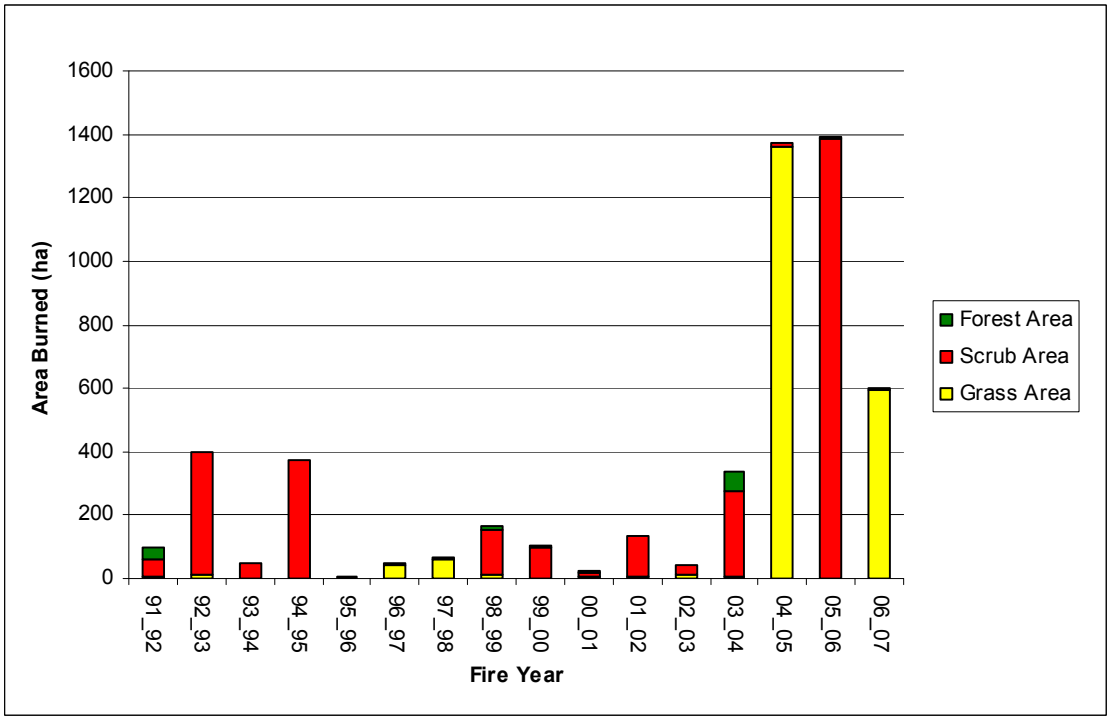

Figure S6. Southland total annual area burned by fuel type from 1991/92 to 2006/07.

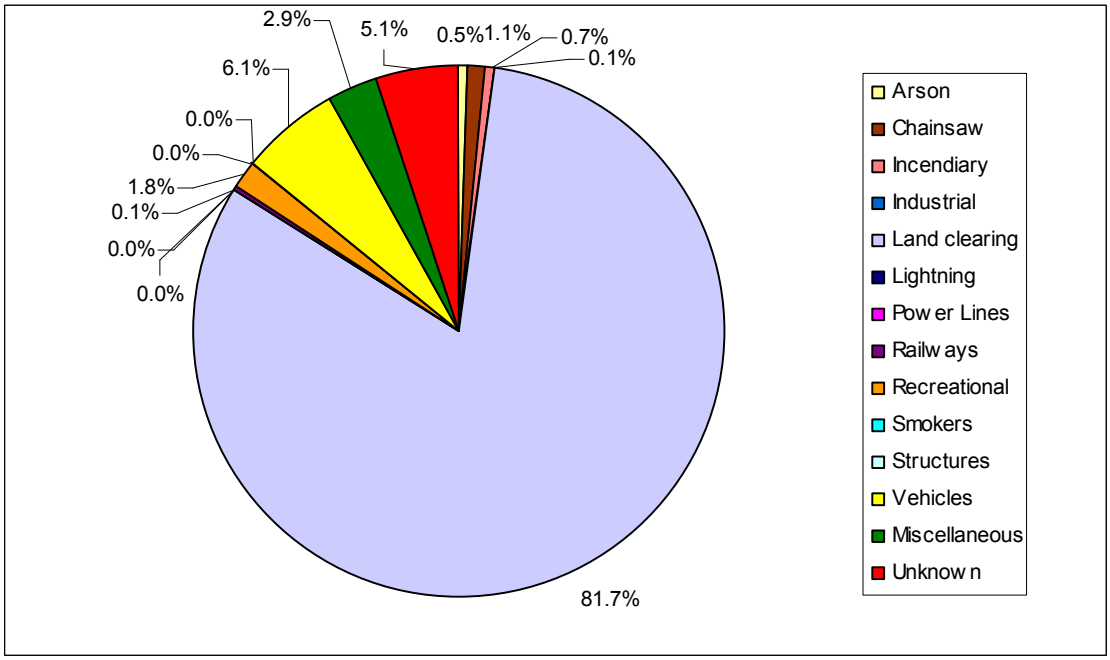

Figure S7. Southland average total area burned by cause from 1991/92 to 2006/07.

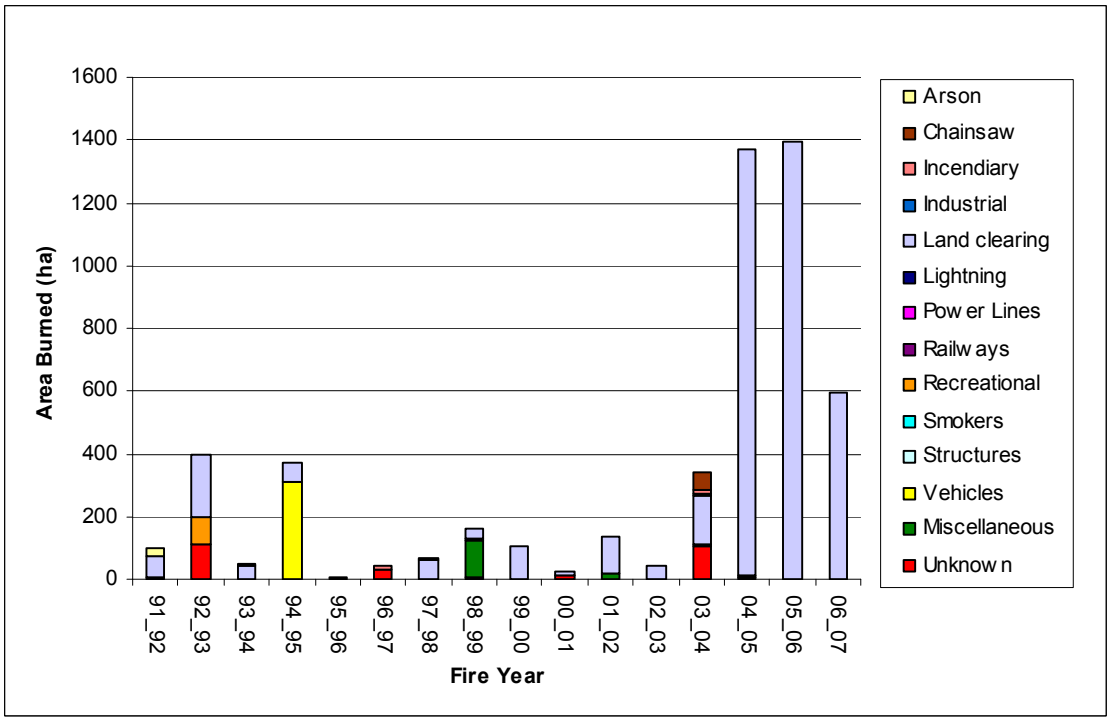

Figure S8. Southland total annual area burned by cause from 1991/92 to 2006/07.

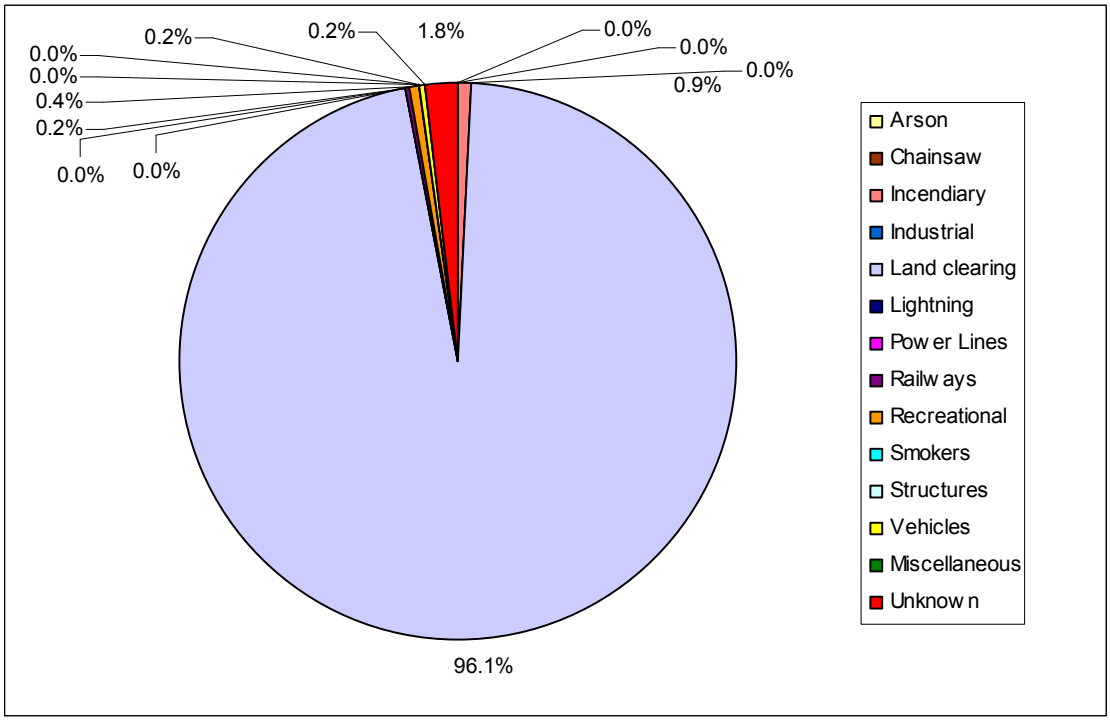

Figure S9. Southland average total grass area burned by cause from 1991/92 to 2006/07.

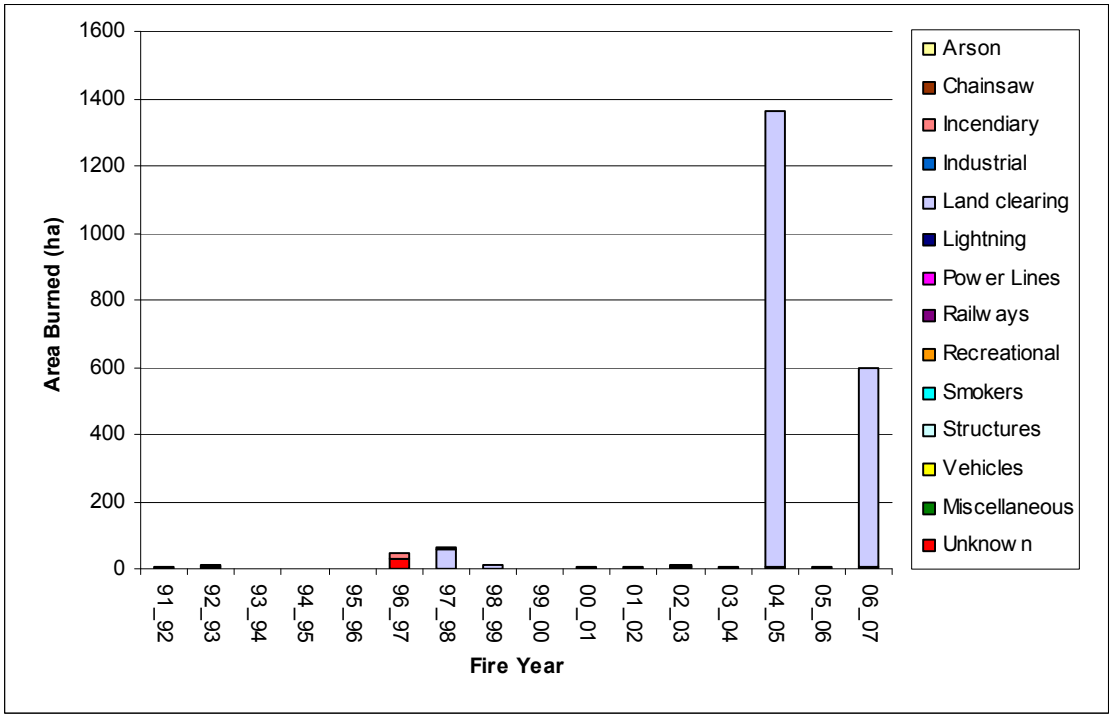

Figure S10. Southland total annual grass area burned by cause from 1991/92 to 2006/07.

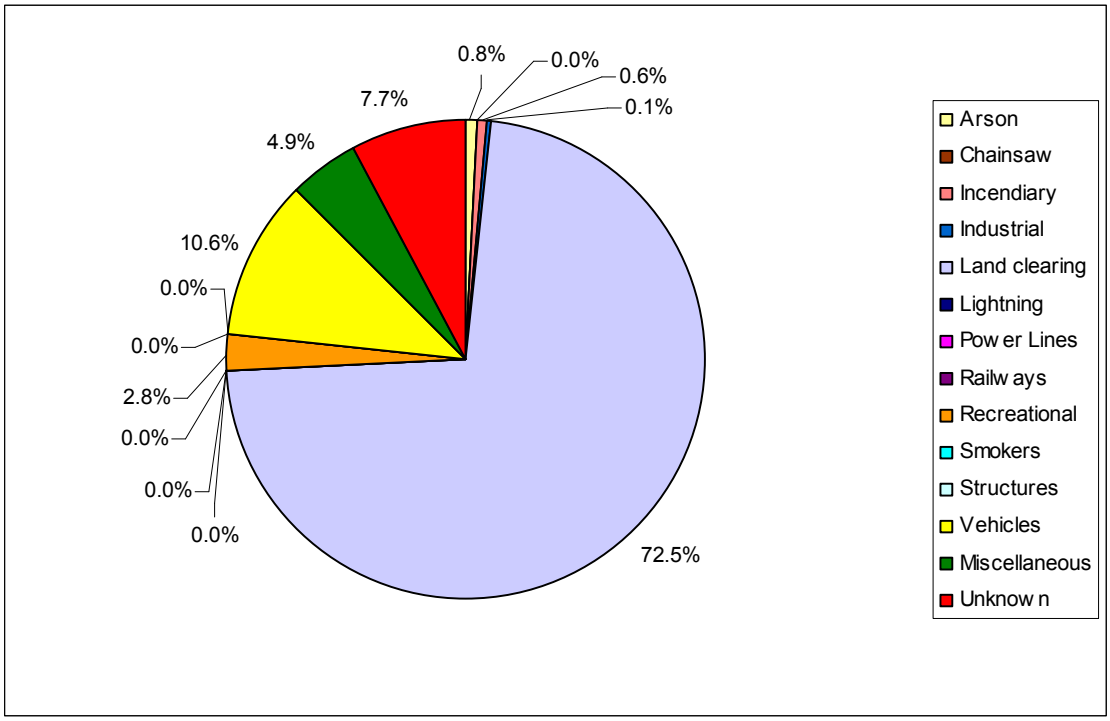

Figure S11. Southland average total scrub area burned by cause from 1991/92 to 2006/07.

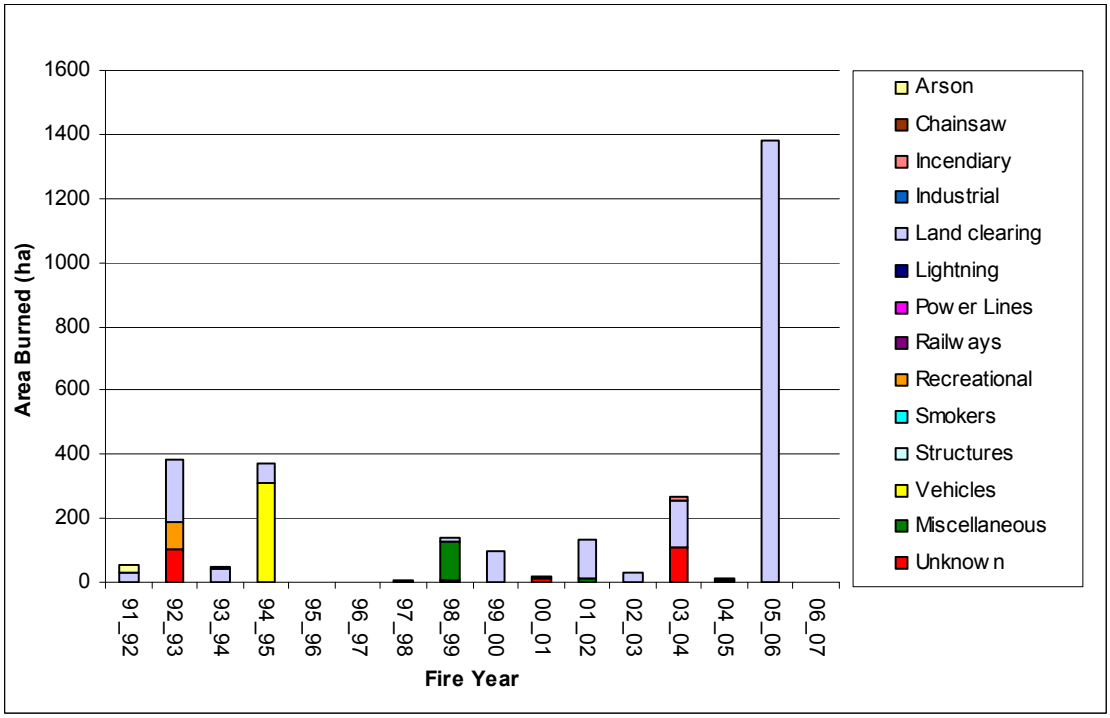

Figure S12. Southland total annual scrub area burned by cause from 1991/92 to 2006/07.

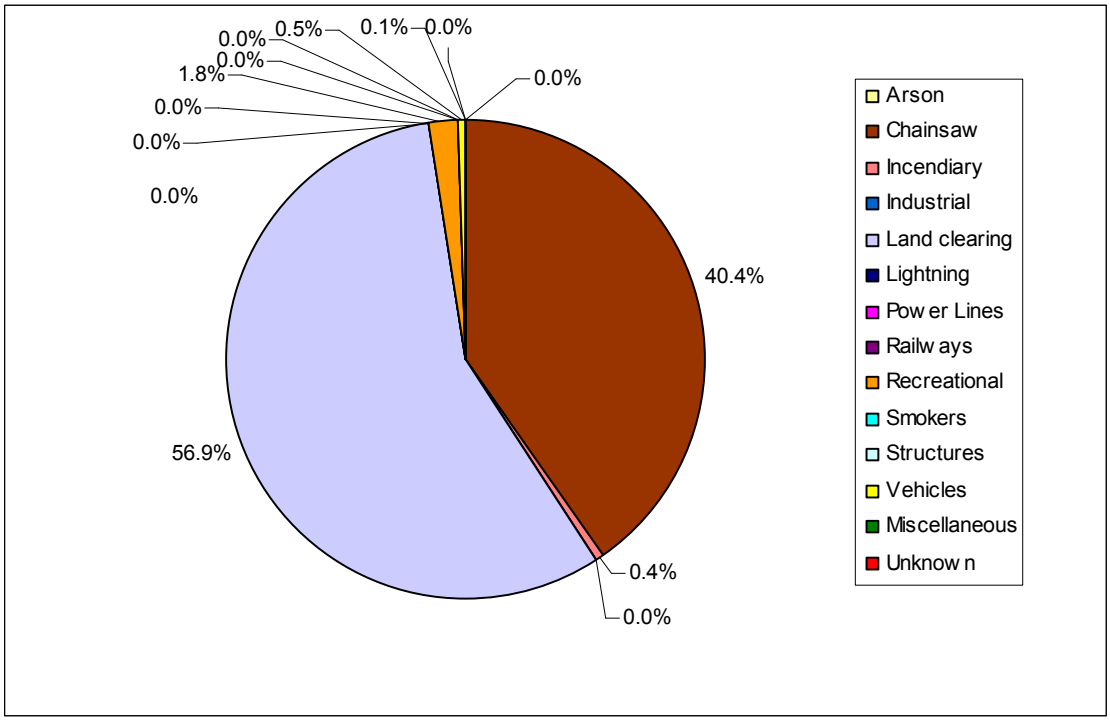

Figure S13. Southland average annual total forest area burned by cause from 1991/92 to 2006/07.

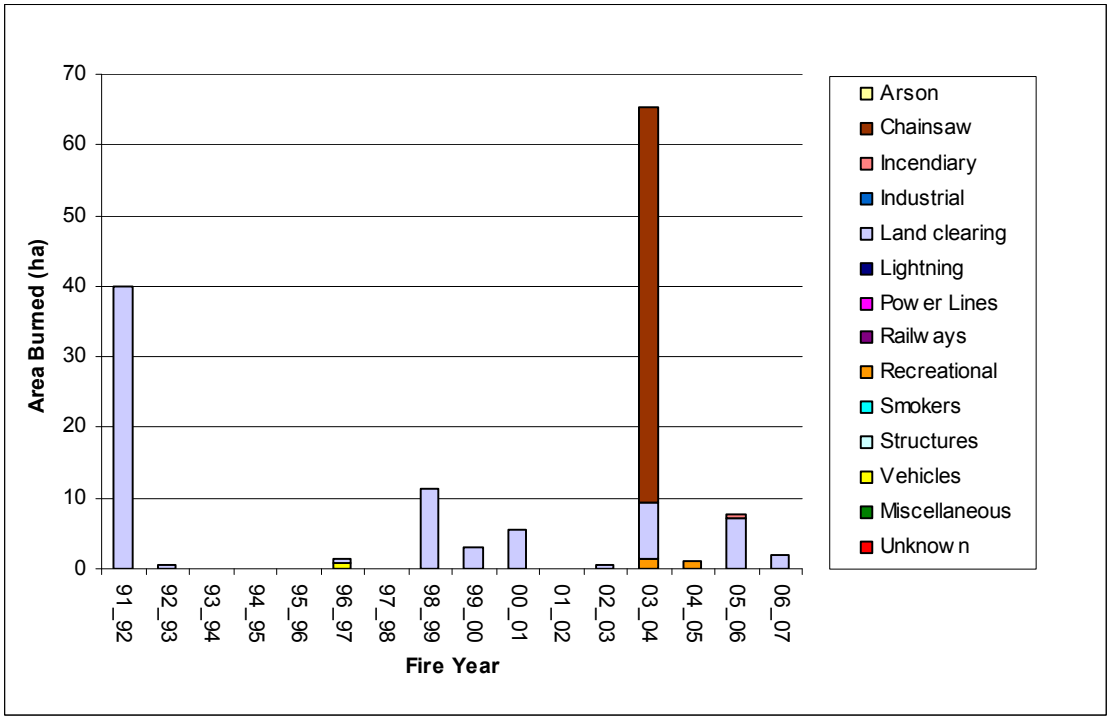

Figure S14. Southland total annual forest area burned by cause from 1991/92 to 2006/07.