Fire Research Report

Impact of Changes in New Zealand's Demographic Profile on Fire Outcomes

BERL

October 2010

This project aimed to quantify the link between improved fire outcomes and demographic changes, with a specific focus on urbanisation. Sources of demographic data that may be linked to fire outcome improvements were identified and quantified. The investigation into the relationships between a range of demographic variables and fire outcomes in different areas of New Zealand, found no single demographic factor reduced the average rate of fires and structural fires, but rather a group of factors influence fire outcomes. Additionally four case studies were also examined. These case studies illustrated how fire outcomes have changed in response to demographic factors in a major urban, secondary urban and rural setting. They provide examples of how the needs of communities change as their demographic profiles change.

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Report to:

New Zealand Fire Service Commission

THE IMPACT OF CHANGES IN NEW ZEALAND'S DEMOGRAPHIC PROFILE ON FIRE OUTCOMES

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The impact of changes in New Zealand's demographic profile on fire outcomes

1 Executive summary

This project investigated the relationships between a range of demographic variables and fire outcomes in different areas of New Zealand. It found no single demographic factor reduces the average rate of fires and structural fires, but rather a group of factors influence fire outcomes.

Independent variables explored in this research were demographic factors that were believed to be linked to fire outcomes. These demographic factors were selected from the Statistics New Zealand Census of Population and Dwellings. Data from the 1991, 1996, 2001 and 2006 Censuses were obtained.

Dependent variables were defined as the total number of fires, the number of structural fires, the number of fire fatalities, and the number of fire injuries. This annual fire outcome data was sourced from the NZFS. Although the number of structural fires is a subset of the number of all fires, this project separately analysed the number of all fires and the number of structure fires. Structural fires are those that involve housing units as well as fires in other types of property.

Regression analysis identified four significant demographic variables and one area variable that could explain fire outcomes. However, each of these demographic factors alone did not explain an improvement (or deterioration) in fire outcomes.

The following factors were linked to an **increase** in all fires and structural fires:

- increased population density
- increased use of gas as fuel for heating
- a higher proportion of residents with school only (or less) qualifications.

The following factors were linked to a **decrease** in all fires and structural fires:

- an increased proportion of household living in separate dwelling units
- a higher proportion of residents aged between 45 and 64 years old.

Using the results of the regression analysis we also identified fire station areas as case studies. These were Karori, Wellington Area 16 (Metro Area); Manurewa, Counties-Manukau Area 5 (Metro Area); Dannevirke, Hawke's Bay Area 11 (Secondary/Provincial Area); and Darfield, Mid-Canterbury Area 20 (Rural Area).

These case studies illustrate how fire outcomes have changed in response to demographic factors in a major urban, secondary urban and rural setting. They provide examples of how the needs of communities change as their demographic profiles change.

The policy and strategy implications of our findings suggest NZFS should:

- continue to be innovative in the reduction of the incidences and consequences of fire
- consider how various demographic factors work together to influence fire outcomes
- work on the demographic factors that they can influence to improve fire outcomes.

To do this, the NZFS needs to consider how they target groups that are closely related to the variables highlighted by our findings, and how the results of this project fit with previous research completed as part of the contestable research fund.

2 Introduction

The average rate of fires, fire fatalities, structural fires and fire injuries per 100,000 populations has fallen in recent years. Some of these improvements may be the direct result of New Zealand Fire Service (NZFS) action such as advertising and awareness campaigns and better readiness and response to fires, while others may be due to external factors such as changing demographics.

This project aims to quantify the link between improved fire outcomes and demographic changes, with a specific focus on urbanisation. It will ensure the NZFS has a better understanding of some of the factors outside the NZFS sphere of influence and the role these factors can play in the overall improvement of fire outcomes. This project will therefore inform and support strategic decisions on the appropriate role, resource allocation, and approach of the NZFS. It will also help to inform NZFS decision-making regarding advertising and awareness campaigns, and strategy.

2.1 Research objectives and questions

This project has the following objectives:

1. To increase understanding about the factors outside the NZFS sphere of influence that improve fire outcomes. This will make a major contribution to organisational knowledge, allowing the NZFS to evaluate the value of its advertising and awareness campaigns and strategies employed to achieve better fire outcomes.
2. To inform resource positioning. This project considers the likely demographic trends in specific fire regions, station areas or Census Area Units (CAUs). It will allow the NZFS to consider the level of appropriate resource required based on an understanding of the demographic links to fire outcomes.
3. To support innovation. This project will provide a better understanding of how other factors influence fire outcomes allowing the NZFS to use innovation to reduce the incidence and consequence of fire.
4. To guide strategic decision-making regarding the appropriate role and approach of the NZFS. This project looks at how communities and the role of the NZFS are changing.

To meet these objectives, this project addresses the following questions:

1. If a large portion of improved fire outcomes can be explained by urbanisation, what does this mean for NZFS advertising and awareness campaigns?
2. If a large portion of improved fire outcomes can be explained by urbanisation, what does

this mean for the positioning of NZFS resources?

3. Where and what level of need will different communities have for NZFS services in the future?

4. If this project finds very little of the improvement in fire outcomes is linked to demographic change, what other factors might the NZFS need to examine?

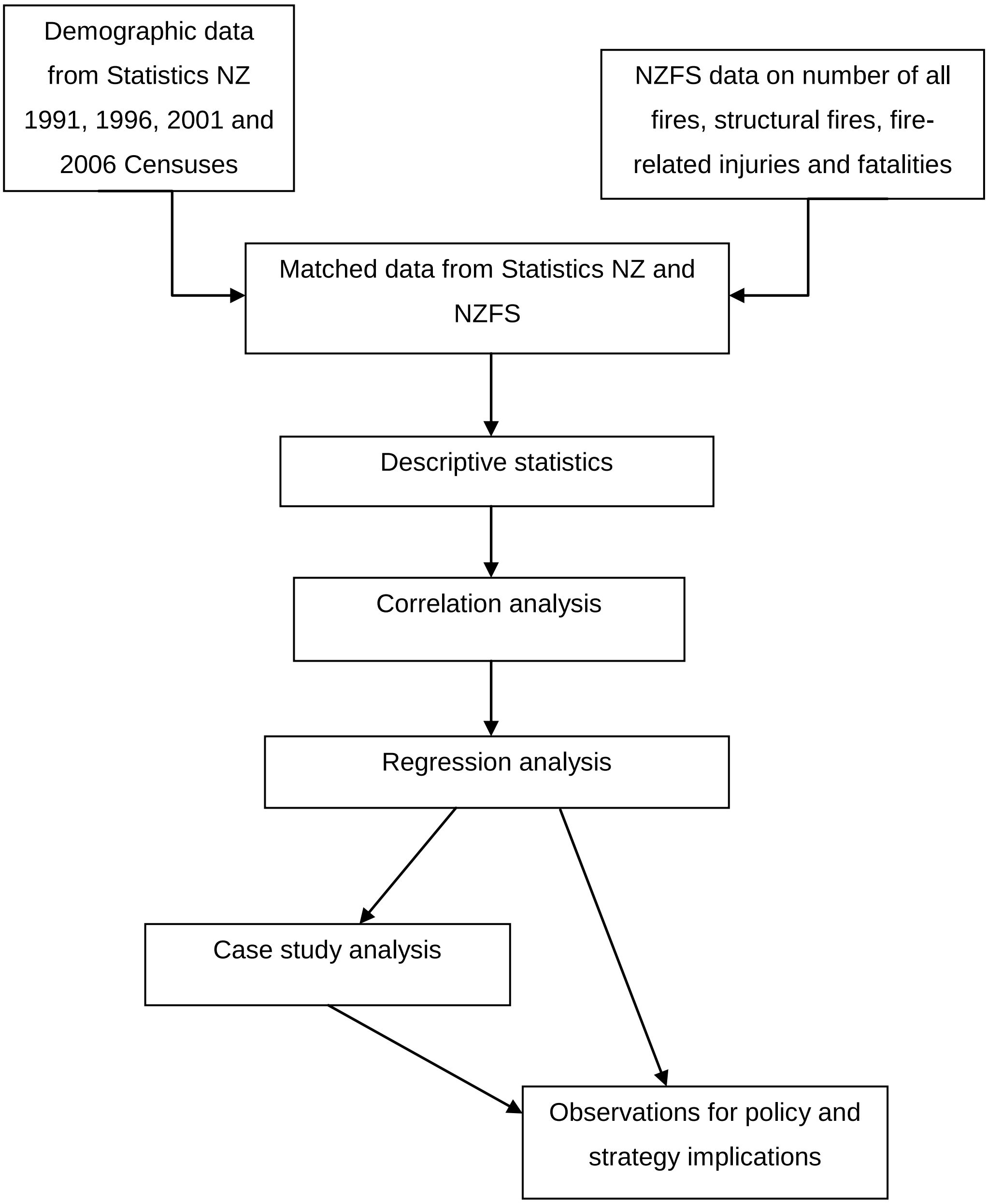
2.2 Overview of approach

The diagram below presents the general approach undertaken for this project. We used conventional econometric tools of analysis to identify and quantify the potential relationships between fire outcomes and the demographic characteristics of a population.

We gathered a wide range of demographic data from Statistics New Zealand, which we considered as the independent variables. Dependent variable information – that is, the data series we are attempting to explain – was sourced from the NZFS.

Datasets from Statistics New Zealand are available in meshblocks and census area units (Appendix 1 contains relevant definitions). On the other hand, the NZFS data is available on each of the fire stations (Appendix 2 contains details). These two sets of variables were matched to ensure that the datasets were of the same level (i.e. whether both have meshblocks or census area units). NZFS has a dataset that provides information on which census area units are classified in the different fire stations.

Most of the demographic factors have more than two classifications or groupings (refer to Appendix 3). Descriptive statistics were computed in order to evaluate the variability of the data. We decided to collapse (or aggregate) some of the classifications to minimise the number of cells with 0 or observations that were suppressed by Statistics NZ due to confidentiality reasons. Inasmuch as we have more than 30 demographic variables for each census year, correlation analysis was undertaken in order to see the highly correlated independent variables. In such cases, we chose just one of the two highly correlated variables to be included in the regression model. Consequently, we focussed on 30 demographic variables for initial inclusion in the regression analysis.


Demographic data from Statistics NZ 1991, 1996, 2001 and 2006 Censuses
NZFS data on number of all fires, structural fires, fire-related injuries and fatalities
Matched data from Statistics NZ and NZFS
Descriptive statistics
Correlation analysis
Regression analysis
Case study analysis
Observations for policy and strategy implications

3 Methodology

To meet our research objectives and address our research questions, this project examined the relationships between demographic factors (independent variables) and fire outcomes (dependent variables), and how these relationships can change over time.

To do this the project was broken down into four stages:

- Identify and source a range of demographic factors (independent variables) that may be linked to fire outcomes (dependent variables).
- Estimate the statistical relationships between the demographic factors and the fire outcomes.
- Illustrate these relationships through four case studies that include two metro areas, one secondary/provincial area, and one rural area.
- Discuss the strategic and policy implications of the project findings.

3.1 Stage one: Identify and source variables

3.1.1 Independent variables

Independent variables in this research are defined as demographic factors that may be linked to improved fire outcomes. These variables were selected from the Statistics New Zealand Census of Population and Dwellings. This census data provides a snapshot of various demographic factors.

From the census data, we selected the following 19 demographic factors: sex; yearly age groups up to 65 years old and over; median age; birthplace; ethnic group classifications; smoking behaviour; highest qualification; work and labour force status; total personal income groupings; sources of personal income; occupation based on the New Zealand Standard Classification of Occupations 1999 (NZSCO99) major groups; industry based on the Australian and New Zealand Standard Industrial Classification 1996 (ANZSIC96) division; workplace area; dwelling type; number of bedrooms and mean number of bedrooms; fuel type used to heat dwelling; household composition; total household income classifications; and tenure of household.

We also considered population density as an area variable.

Appendix 3 presents the different classifications under each of these 19 demographic factors.

Our original intention was to gather data on demographic factors over a 20 year period. However, the 1986 census data was collated under different meshblock boundaries than the data available for the 1991, 1996, 2001 and 2006 censuses. We were unable to develop a concordance to match 1986 boundaries to 2006 boundaries, so we refocused the project to look at changes between 1991 and 2006.

3.1.2 Dependent variables

Dependent variables in this research are derived from NZFS fire outcome data. This data is an annual count (calendar year) that is classified as administrative data. The NZFS data available to monitor fire outcomes includes the total number fires; the number of structural fires; the number of fire fatalities and the number of fire injuries.

The number of structural fires is a subset of the number of all fires. However, in this study we have separately analysed the number of all fires and the number of structural fires. Structural fires are defined as those fires that involve housing units as well as fires in other types of property.

The NZFS was able to provide fire outcomes data linked with both fires station areas and Census Area Units (CAUs) between 1991 and 2006. This allowed us to link fire outcomes data with a fire station and independent variables. However, some data manipulation was required to link fire outcomes to the appropriate NZFS fire station due to changes within the NZFS.

In 1991 and 1996, the classification of a fire station was based on a four digit NZFS dispatch zone number and the dispatch area. This was also the basis in the database for the number of fires and number of incidents. The zone number was unique for any one of the 44 dispatch areas but not between dispatch areas. This means different geographical areas could have the same four digit number but be in different dispatch areas.

As incidents were recorded by the station which first attended the incident, there could be some ambiguity where a fire station attended an incident in a neighbouring dispatch area. This ambiguity primarily occurred in metropolitan areas where the dispatch areas were much smaller and responding fire appliances frequently crossed dispatch area boundaries. For example, the Khandallah fire station no longer exists. To compare fire outcomes over time, its historical fires had to be assigned to the Johnsonville, Karori and Thorndon fire stations. However, the data for 2001 and 2006 were spatially referenced based on geographic location of the incident.

The fire outcome data focused on NZFS fire stations and excluded stations under the National Rural Fire Authority. In total we examined fire outcomes data from 438 NZFS fire stations that covered 98.9 percent of the New Zealand population.

3.2 Stage two: Estimate statistical relationships

In stage two econometric analysis was used to establish what relationships exist between the independent and dependent variables. This allowed us to investigate, for example, whether an X% change in urban density is associated with a Y% change in the number of fires.

3.2.1 Descriptive statistics

We began this stage of the project by analysing how fire outcomes changed between 1991 and 2006, and the demographic factors that also changed significantly during this period.

We also conducted a correlation analysis, which allowed us to summarise which variables seemed to move in step, both in a positive and a negative direction, with the other variables.

This process helped us to identify the variables that may be reflecting similar influences. In these cases we did not include both variables in the model. The process also assisted in the identification of variables that may prove to explain the changes in fire outcomes. This allowed us to decrease our initial 120 variables down to 30 independent variables from which to develop a model to explain fire outcomes. Having identified 30 independent variables we then began our initial regression analysis using ordinary least squares (OLS) to explain fire outcomes.[1]

Table 3.1 below presents the two fire outcome variables and the demographic characteristics considered in the regression analysis. The numbers in the table represent the mean value across the 438 fire station areas (for each year) for each of the stated variables. These are the variables we tried to put together in the initial regression runs. Following this process we identified five variables that were significant in explaining differences in fire outcomes both across areas and over time. These five are discussed in the succeeding sections and next chapter.

Based on the results of the descriptive statistics, we hypothesize that as population, population density, percent of households using electricity and the percent of born overseas increases, the number of fires increases. On the other hand, we suggest that as the percent of households in owner-occupied housing (i.e. their own 'units') decreases, the number of fires increases.

[1] Details on the OLS methodology is available from the authors upon request.

Table 3.1 Fire outcomes and demographic characteristics considered in the regression analysis

Characteristics	1991	1996	2001	2006
ALL FIRES	44.67	42.84	50.35	54.87
STRUCTURAL FIRES	15.51	14.84	16.04	14.49
population	7620.16	8166.51	8434.93	9093.36
population density	1.49	1.65	1.74	1.93
occupied private dwelling unit	2659.4	2880.1	3067.58	3320.71
% hhlds own unit	72.34	70.67	71.03	55.01
number of bedrooms	2.98	3.08	3.14	3.14
% electricity	41.54	37.44	34.76	36.15
% gas	6.48	14.53	18.42	18.38
% wood/coal	48.23	43.8	41.65	39.84
% separate house	86.78	88.79	79.85	83.76
% unemployment	5.86	4.54	4.32	2.85
% skilled	26.46	25.35	27.88	30.1
% unskilled	8.98	11.12	11.93	12.54
% 1 family household	74.83	71.93	69.83	69.38
% 1 person household	19.17	19.58	22.6	22.89
% with LE 20,000 hhld income	34.54	29.62	25.42	17.25
% with GE 70,000 hhld income	8.77	12.92	18.65	29.05
% with LE 5,000 personal income	15.53	16.41	13.79	12.41
% with GE 50,000 personal income	3.44	6.16	10.22	15.67
% male	51.03	50.98	50.37	50.42
% of children	25.01	24.54	23.62	22.18
% of 25 to 44 y.o.	30.94	30.6	29.07	27.03
% of 45 to 64 y.o.	19.3	21.24	24.24	26.81
% of senior citizens	9.99	10.72	11.55	12.06
% overseas born	10.68	11.48	12.31	14.36
% European	83.39	80.79	80.04	66.83
% Maori	13.43	14.98	14.93	15.1
% Pacifika	1.82	2.17	2.22	2.39
% Asian	1.26	1.84	2.3	2.95
% with no qualifications	38.66	42.33	32.43	29.47
% with LE HS	26.74	30.36	38.6	34.07

Source: Stats NZ, BERL Calculations

3.2.2 Initial regression analysis

The fire outcomes examined were all fires, structural fires, and fire casualties. Our initial plan, to examine fire fatalities and fire injuries separately, was not possible given the small numbers of fire fatalities and injuries spread across the 438 fire stations being examined.

Alternatively, we developed a 'new' fire outcome variable called fire casualty, where a fatality received a weighting 10 times that of a fire injury. Out of the 1,752 observations (i.e., coming from the 438 fire stations in four census years) for this study, there are 1,648 observations with no fatality from all fires or 94.1%. In the case of number of injuries in all fires, 1,381 observations have no injury of 78.8%. Likewise, the number of fatalities in structural fires is very insignificant since almost 96% of the 1,752 observations have no fatality (1,681 observations). Regarding the number of injuries coming from structural fires, 1,435 observations have no occurrence of injury or almost 82%.

Given the “irregularity” of fire casualties (fire fatalities and injuries) we were still unsuccessful in establishing a model to explain the fire casualties variable.

We ran the analysis using a range of data groupings. These included: all four censuses in one group of data (i.e., 1,752 observations of each variable, given 438 fire stations); each census year individually (i.e. 1991, 1996, 2001, and 2006 fire outcomes as a function of socio-economic variables in each of those years); and repetition of each of the above analyses, but grouping the fire stations into 25 fire districts.

3.2.3 Identification of significant variables

Our initial analysis identified several variables to explain all fires and structural fires. These include:

- Population density. Areas with higher density (population per hectare) have a higher number of fires.
- Type of dwelling. Areas with a larger share of separate dwellings tend to have better fire outcomes than those with a higher proportion of flats or apartments.
- Fuel types. Areas with a larger proportion of houses using gas had a higher number of fires.
- Qualifications. Areas with a higher proportion of people having only high school or lower qualifications had a higher number of fires.
- Age: Areas with a higher proportion of people aged 45 to 64 years old had a lower number of fires.

A further variable that was identified was ethnicity. Areas with a higher share of the population identifying themselves as Asian tended to have poorer fire outcomes. The share of the population identifying as Asian tended to explain structural fire outcomes better than urban density. But there is a strong correlation (0.76) between urban density and where people identifying as Asian live. This may mean that the variation around urban density is being captured by the ethnicity variable rather than the urban density variable. On the basis of close correlation between ethnicity and urban density, we decided to forego the ethnicity variable and retained the urban density variable as an explanatory in our model.

3.3 Stage three: Illustrate the relationships through four case studies

In stage three we identified four areas with differing demographic profiles to use as case studies to illustrate the relationships identified in stage two. The four fire stations we chose were: Karori, Wellington Area 16 (Metro Area); Manurewa, Counties-Manukau Area 5 (Metro Area); Dannevirke, Hawke's Bay Area 11 (Secondary/Provincial Area); and Darfield, Mid-Canterbury Area 20 (Rural Area).

We chose these areas by using the results of the regression analysis, where we computed for the estimated fire outcomes based on the model, and then computed for the residuals (a measure of the fire outcomes not explained by the regression models) for each fire station.

These case studies illustrate how fire outcomes have changed in response to demographic factors in a major urban, secondary urban and rural setting. The aim of the case studies is to help the NZFS gain a better understanding, using real-life examples, of how the needs of communities change as their demographic profiles change. The case studies are examined in more detail in Chapter 5.

3.4 Stage four: NZFS strategy and policy implications

Having shown the links between changing demographics and fire outcomes in stage two, we discuss the implications for NZFS strategy and policy in stage four.

4 Demographic characteristics affecting fire outcomes

We begin with around 30 independent variables to possibly explain the fire outcomes, specifically the number of all fires and the number of structural fires. Using standard regression analysis techniques, we identified four demographic variables and one area variable that were found to be significant in explaining the two fire outcomes. These five variables are discussed in this chapter. This process effectively takes data from the four census years covered in the study and determines a 'national average' model explaining fire outcomes. Applying this model to specific fire station areas is covered in the next chapter.

4.1 Model results

As listed in the previous chapter, we identified four demographic and one area variable to explain the number of all fires and the number of structural fires. These are population density; the proportion of households with separate house as their type of dwelling unit; the proportion of households using gas for heating; the proportion of people having only secondary school or lower qualifications; and the proportion of people aged 45 to 64.

Allowing for these variables and including 'dummy' variables to proxy trends over time, the model for all fires is:

$$y = 110.27YR91 + 88.36YR96 + 82.98YR01 + 101.5YR06 + 6.06DENSITY \\ + 2.51GAS - 1.12SEPARATE - 2.09ADULTS + 0.71\,EDUC$$

where

y =	Number of all fires
YR91 =	1, if data is in year 1991; 0, otherwise
YR96 =	1, if data is in year 1996; 0, otherwise
YR01 =	1, if data is in year 2001; 0, otherwise
YR06 =	1, if data is in year 2006; 0, otherwise
DENSITY =	Population density (number of residents per hectare)
GAS =	% of households using gas as fuel for heating
SEPARATE =	% of households living in a separate house
ADULTS =	% of population aged 45 to 64

EDUC =	% of population whose educational level is less than or equal to high school

The model above confirms our hypothesis that as the population density increases, the number of all fires increases. The same confirmation is true for the percentage of households using gas as fuel for heating and the proportion of residents whose educational level is less than or equal to secondary school. The directions of these influences appear appropriate as appliances using gas as fuel are likely to carry a higher risk of fire, while people with lower education may exhibit riskier fire behaviour or, perhaps, be less knowledgeable of the existence of such risk.

In contrast, as the proportion of households living in a separate house and the proportion of adults aged 45 to 64 increases, it is expected that the number of fires decreases. This direction of influence may also be appropriate as living in a separate house will also be related to ownership behaviour, and people may spend more on fire safety equipment and/or adopt more safe practices to ensure their own home is safe from fire. Similarly, more people in the 45 to 64 year olds group may have a greater sense of responsibility or, perhaps, exhibit less risky fire behaviour.

Interpreting the model, this means that (taking all terms individually):

a. A one unit increase in population density (i.e. one more resident per hectare) would result in six more fires per annum in that area.

b. A one percentage point increase in the % of households using gas as fuel for heating would result in 2.5 more fires per annum in that area.

c. A one percentage point increase in the % of households living in a separate house would result in 1.1 less fires per annum in that area.

d. A one percentage point increase in the % of population aged 45 to 64 would result in 2.1 less fires per annum in that area.

e. A one percentage point in the % population with less than or equal to secondary school as level of education would lead to 0.7 more fires per annum in that area.

f. Holding other factors constant, the average number of fires in 1991 was 110 per fire station.

g. Holding other factors constant, the average number of fires in 1996 was 88 per fire station.

h. Holding other factors constant, the average number of fires in 2001 was 83 per fire station.

i. Holding other factors constant, the average number of fires in 2006 was 101 per fire station.

The model for structural fires is:

$$y = 41.83YR91 + 35.45YR96 + 32.11YR01 + 35.93YR06 + 2.1DENSITY + 0.67GAS - 0.47SEPARATE - 0.66ADULTS + 0.3EDUC$$

y =	Number of structural fires
YR91 =	1, if data is in year 1991; 0, otherwise
YR96 =	1, if data is in year 1996; 0, otherwise
YR01 =	1, if data is in year 2001; 0, otherwise
YR06 =	1, if data is in year 2006; 0, otherwise
DENSITY =	Population density (number of residents per hectare)
GAS =	% of households using gas as fuel for heating
SEPARATE =	% of households living in a separate house
ADULTS =	% of population aged 45 to 64
EDUC =	% of population whose educational level is less than or equal to high school

Similar to the model for all fires, the structural fires model shows the same expected directions or signs for the five significant independent variables. Differences are in the values of the coefficients for each of the variables. Both models produced the same group of significant variables that affected fire outcomes and – importantly – the signs (and hence directions of influence) remain similar for both models. Core model diagnostics are provided in Appendix 4.

4.2 The time variable

The coefficients on the 'time dummy' variables indicate how fire outcomes (whether all fires or structural fires) would have changed over time, if there was no change in any of the demographic and area variables. In particular, the coefficients suggest that the number of fires (without the impact of the other variables) would have declined from 1991 through to 2001, but thereafter increased to 2006. This observation stands for all fires and structural fires.

4.3 Population density

There is an increasing trend over time on the population density. There are two fire stations that have the lowest density of 0.0008, namely Fox Glacier and Little Wanganui, both in West Coast Area 18. The highest density is in Auckland City with 50.1793.

The final regression model which is based on the 438 fire stations from the census years 1991, 1996, 2001 and 2006 showed that an increase in population density will increase the number of all fires. A similar behaviour is true in the case of the number of all structural fires. However, comparing the trend of the population density with that of the actual number of all fires (i.e., Table 1) the data show that the latter has a relatively increasing trend except in 1996 where it went down to 42.84. In terms of the actual number of structural fires, the figure has fluctuated more. These observations indicate there are other demographic characteristics that interplay in affecting the actual number of all fires and structural fires.

Table 4.1 Descriptive statistics on population density

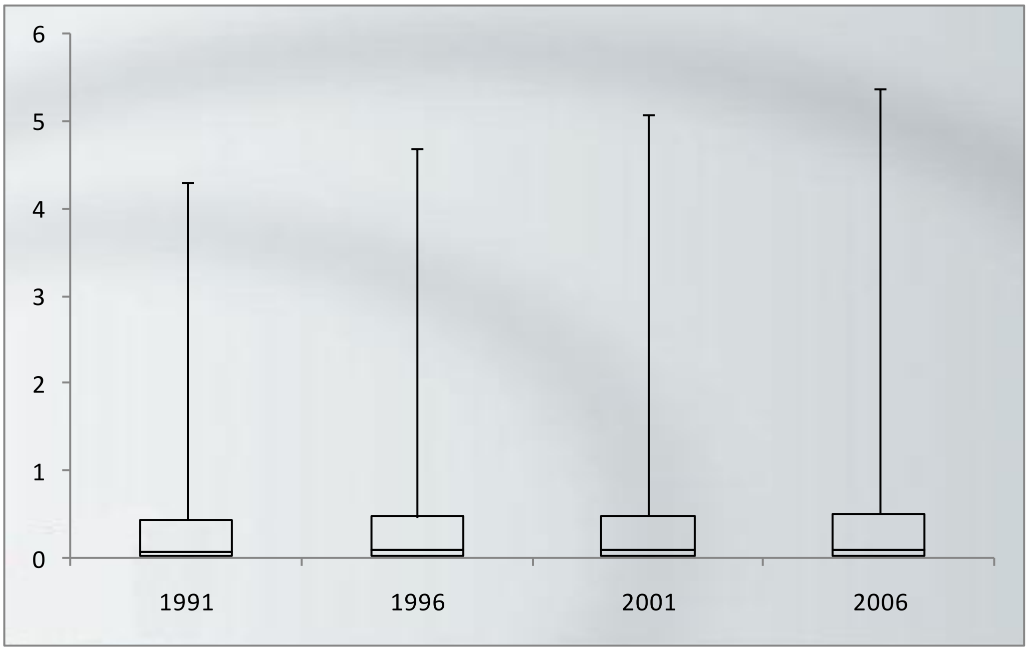
Descriptive statistics	1991	1996	2001	2006
average	1.49	1.65	1.74	1.93
minimum	0.0008	0.001	0.001	0.0008
maximum	29.3345	32.5614	33.5285	50.1793
SD	4.15	4.6333	4.95	5.69

Source: Stats NZ, BERL Calculations

Figure 1 depicts the distribution over the 438 fire station areas of the population density variable for each of the four census years. The 'box' in the diagram indicates the upper quartile for the value of the population density variable, with the horizontal line inside the box indicating the median value. The vertical line above the box extends to the 90th percentile for the variable.

This figure shows clearly a large majority of fire station areas had a population density below 0.5 residents per hectare. The most noticeable change in this distribution has been the increase in the 90th percentile. In 1991 that 90% of fire station areas had density below 4.3 residents per hectare, but this had risen to a density of 5.4 in 2006. Consequently, three were very few fire station areas with density near the maxima noted in Table 4.1.

Figure 1 Population density median and quartile values per census years



4.4 Separate dwellings (housing units)

The percentage of households living in separate dwellings (or separate housing units) averaged 87% in 1991 across the 438 fire station areas, falling to 84% in 2006. Figure 2 shows the distribution of this variable over the fire station areas. Similar to Figure 1 above, in this case the 'box' indicates the upper and lower quartiles, and median values, with the vertical line depicting the range for the 10th percentile and the 90th percentile. In 2006 12 out of the 438 fire stations had 100% of their households living in separate housing units.[2]

The pattern of change in this characteristic has been erratic, with the most noticeable difference being the fall experienced between 1996 and 2001. This fall (implying a rise in the proportion of households living in flats or multi-storey apartments) is consistent with the model relationship of an increase in the number of fires over this period. However, the relationship is not that clear in other years, suggesting other factors are also at play here.

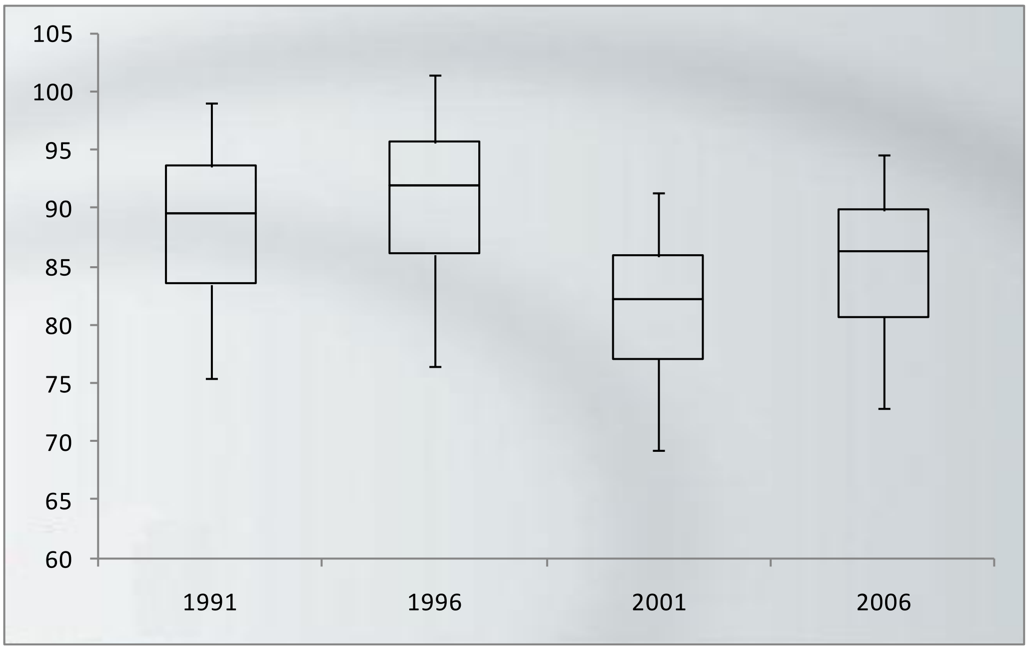
[2] The 0% minima in Table 5 relates to the proportion in the Kinleith Pulp and Paper Mill Fire Station Area, which is not a residential area.

Table 4.2 Descriptive statistics percentage of households with separate housing units

Descriptive statistics	1991	1996	2001	2006
average	86.78	88.79	79.85	83.76
minimum	0	0	0	6.72
maximum	100	100	94.67	100
SD	11.39	11.52	10.63	10.76

Source: Stats NZ, BERL Calculations

Figure 2 Percentage of households with separate housing units, median and quartile values, census years



4.5 Gas as fuel for heating

There has been an increasing trend over time on the percentage of households using gas as fuel for heating (i.e., combined total for reticulated gas and bottled gas). Figure 3 depicts the distribution over the fire station areas of this variable. The 1991 proportion more than doubled in 1996. This figure suggests a broad spread of areas with between 12% and 23% of households using gas in 2006. The chart also suggests relatively few areas close to the maximum of 46% in 2006 (Table 4.3), with 90% of areas having a proportion below 28%. There were 11 fire stations where no households used gas as fuel for heating. On the other hand, the highest proportion is found in Hawera in the Taranaki area with 50.17%.[3]

As per our modelling, an increase in gas use is related to an increase in the number of fires (both all fires and structural fires). While consistent with the increased number of fires actually recorded, the fluctuations between the years again suggests that there were other

[3] Again, the 0% minima in Table 6 relates to the proportion in the Kinleith Pulp and Paper Mill Fire Station Area.

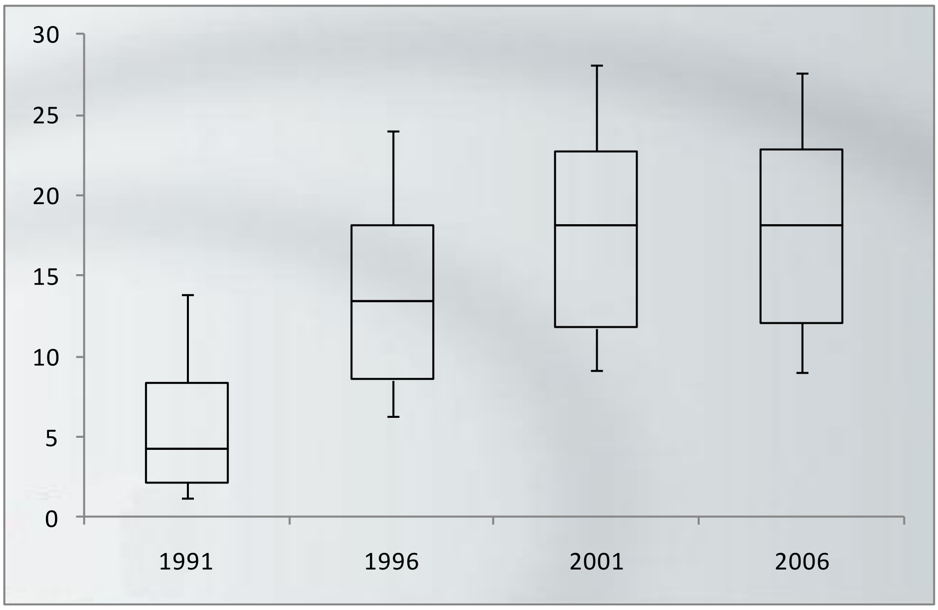
demographic characteristics that interplay in affecting the actual number of all fires and structural fires. It is also noteworthy that the use of gas as heating is not available throughout New Zealand. The significance of this particular variable is worth investigating further in future research undertaken.

Table 4.3 Descriptive statistics on percentage of households using gas as heating

Descriptive statistics	1991	1996	2001	2006
average	6.48	14.53	18.42	18.38
minimum	0	0	0	0
maximum	45.36	47.53	50.17	45.57
SD	6.7	7.7	8.02	7.69

Source: Stats NZ, BERL Calculations

Figure 3 Percent of households using gas as heating, median and quartile values per census year



4.6 The adult population

Figure 4 clearly shows an increasing trend over time in the percentage of residents aged 46 to 64 years old. The figure shows a relatively narrow distribution, with 80% of fire station areas having between 22% and 32% of their residents aged between 46 to 64 years old (in 2006). On the other hand, the highest percentage of residents within the 45 to 64 age group is Little Wanganui in the West Coast area with 52.6%.

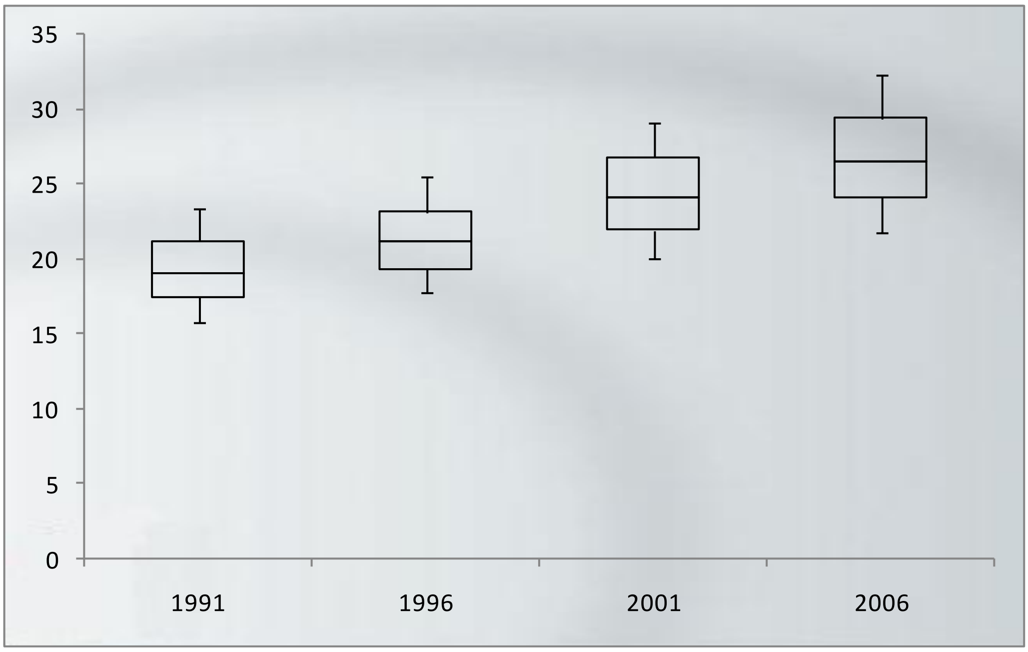
Our model equations suggest that on its own, this increasing trend would result in a reduction in the number of fires. But the increase in the actual number of fires reinforces the interplay of other demographic characteristics in affecting the actual number of all fires and structural fires.

Table 4.4 Descriptive statistics, percentage of resident population 45 to 64 years old

Descriptive statistics	1991	1996	2001	2006
average	19.3	21.24	24.24	26.81
minimum	0	0	0	0
maximum	31.72	37.66	34.88	52.63
SD	3.55	3.63	4.05	4.74

Source: Stats NZ, BERL Calculations

Figure 4 Proportion of residents aged 45-64 years old, median and quartile values per census year



4.7 School qualifications only

Figure 5 shows the percentage of residents with school qualifications only peaked in 1996 but continuously decreased over the next two census periods. For this variable there is a relatively broad range of variables, with 80% of fire station areas recording between 52% and 73% of their resident population in 2006 in this category. On the other hand, the highest figure is again in Little Wanganui with 92.31% in 2001.[4]

The generally declining trend in the percentage of residents with school qualifications only is consistent with that of the actual number of all fires (i.e., Table 1). However, the role of other demographic variables is relevant in explaining the movements over the intervening years.

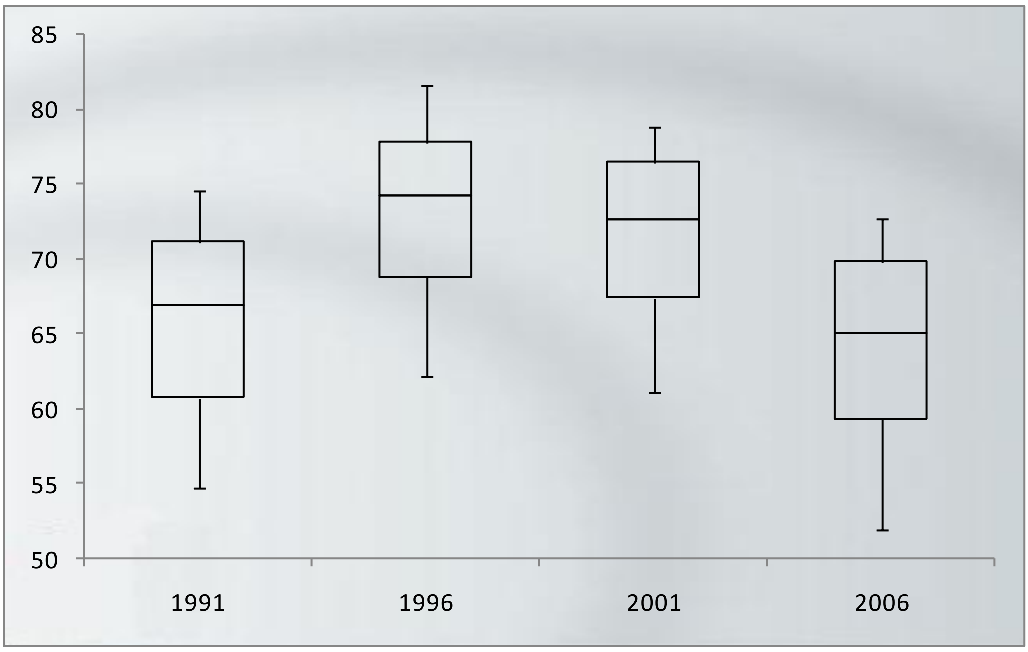
[4] Again, the 0% minima in Table 8 relates to the proportion in the Kinleith Pulp and Paper Mill Fire Station Area.

Table 4.5 Descriptive statistics on resident population with school qualifications only

Descriptive statistics	1991	1996	2001	2006
average	65.4	72.69	71.02	63.54
minimum	0	0	0	0
maximum	82.87	91.22	92.31	83.34
SD	8.51	8.76	8.28	8.86

Source: Stats NZ, BERL Calculations

Figure 5 Proportion of resident population with school qualifications only median and quartile values per census years



5 Case studies of fire stations

Using the results of the regression analysis we computed for the estimated fire outcomes based on the model. These computed values were compared with actual fire numbers for each of the fire station areas. This procedure helped identify the fire station areas where the model equations were relatively close to the actual data in determining fire outcomes. This, in turn, assisted in identifying possible case study areas.

5.1 Selection of fire station areas

We identified two fire stations that are classified as within major urban areas, one within a secondary urban area and another in a rural area.

The four fire stations we have identified are those in Karori, Wellington Area 16 (Metro Area); Manurewa, Counties-Manukau Area 5 (Metro Area); Dannevirke, Hawke's Bay Area 11 (Secondary/Provincial Area); and Darfield, Mid-Canterbury Area 20 (Rural Area).

The next eight tables show the actual fire outcomes and explanatory variables, as well as other demographic characteristics for each fire station. The last table in this chapter presents the comparison of the demographic characteristics across the areas.

5.2 Karori, Wellington Area 16

The resident population in 2006 in this area was 25,275. The number of all fires in Karori decreased from 1991 to 2001, but went up in 2006. This pattern mirrors that for the national average. In the case of structural fires, there was an increase between 1991 and 1996, before a decline.

The percentage of households using gas as fuel for heating increased over time. Similarly, the percentage of the population aged 45 to 64 increased over this period. Trends for the other two explanatory variables were not as clear.

The average number of all fires for this fire station area was above those of the national mean. This is consistent with the relatively high population density, the higher proportion of people using gas for heating, and the lower proportion of separate houses in this fire station area. The increase in all fires between 2001 and 2006 (as per the national trend) is compounded in this area by the increase in population density over this period, but tempered by the reduced proportion of people with lower qualification levels.

Table 5.1 Model variables for Karori, Wellington Area 16, 1991-2006

Variables	1991	1996	2001	2006	*National mean*
Dependent Variables (Fire Outcomes)					
Number of all fires	85	82	75	85	*48.2*
Number of structures fires	20	28	23	18	*15.2*
Explanatory variables					
density (residents per ha)	2.2	2.3	2.2	2.4	*1.7*
% of households using gas	17.2	22.0	25.9	25.4	*14.5*
% of households with separate house	73.3	73.6	70.4	71.8	*84.8*
% of population aged 45 to 64	17.7	20.2	22.0	23.5	*22.9*
% with school quals only	39.1	42.5	43.1	36.9	*68.2*

Source: Stats NZ, BERL Calculations

The table below presents some of the other demographic characteristics for the Karori area. The percentage of households owning in their own homes, the unemployment rate, and the percentage of people identifying with the European ethnic group decreased between 1991 and 2006. The opposite trend is observed in the percentage of overseas born as well as the percentage of people who identified with the Asian ethnic group. Regarding the proportion of children, it is almost flat throughout the four censuses. The percentage of households using electricity decreases until 2001, then slightly increased in 2006. The percentage of skilled workers dropped in 1996, but steadily increased until 2006.

Although these other demographic variables are not found to be significant in our national model for all fires and structural fires, the observations are consistent with a lower percentage of people owning their own homes resulting in an increase in the number of fires.

Table 5.2 Other demographic characteristics, Karori, 1991-2006

Characteristics	1991	1996	2001	2006
% owning housing units	71.20	71.06	67.92	56.14
% of households using electricity	56.49	50.93	49.95	51.78
% unemployment	4.75	4.20	3.92	3.35
% of skilled workers	49.29	46.90	50.03	53.85
% of children	19.39	19.11	18.96	19.20
% of overseas born	24.50	24.60	24.86	27.63
% Europeans	85.42	83.70	82.33	70.30
% Asians	7.03	8.02	8.53	10.45

Source: Stats NZ, BERL Calculations

5.3 Manurewa, Counties-Manukau Area 5

The resident population in this area in 2006 was 77,328. The number of all fires also increased in Manurewa across the period 1991 to 2006. However, there was no clear trend in the number of structural fires.

The population density, the proportion of households using gas for heating and the proportion of people with school only qualifications for this fire station area were (for most time periods) above the national mean. Further, the proportion of households living in separate houses and the proportion of people aged 45 to 64 were below the national average. Each of these factors is consistent with the number of fires being above the national mean for this fire station area.

In addition, the percentage of households using gas for heating and the population density of this area increased over the period examined. This again is consistent with the increasing number of fires in this fire station area.

Table 5.3 Model variables for Manurewa, Counties-Manakau Area 5, 1991-2006

Variables	1991	1996	2001	2006	*National mean*
Dependent Variables (Fire Outcomes)					
Number of all fires	261	331	349	359	*48.2*
Number of structures fires	91	68	137	81	*15.2*
Explanatory variables					
density (residents per ha)	11.0	12.3	13.9	16.3	*1.7*
% of households using gas	7.8	18.7	25.7	25.8	*14.5*
% of households with separate house	86.7	88.6	80.2	80.0	*84.8*
% of population aged 45 to 64	14.8	16.5	18.0	19.3	*22.9*
% with school quals only	68.1	77.6	76.9	70.3	*68.2*

Source: Stats NZ, BERL Calculations

The table below presents some of the other demographic characteristics for Manurewa. The percentage of households living in their own home decreased over time. It can be observed that there is a decreasing trend in the percentage of Europeans while there is a substantial increase in the percentage of Asians. However, the proportion of children in the residential population has been relatively stable over the four census periods. The unemployment rate varied over time, while the percentage of skilled workers decreased in 1996 but increased in the following two censuses. The percentage of households using electricity decreased until 2001, but slightly increased in 2006.

Similar to the Karori area, the other demographic variables for Manurewa seem to provide an interesting relationship with the number of all fires and the number of structural fires even if these are not found to be significant predictors. In particular, the observations indicate the lower percentage of households living in their own home results in an increase in the number of fires in the area. On the other hand, the number of fires appears to follow the proportion of people who were born overseas in the resident population.

Table 5.4 Other demographic characteristics, Manurewa, 1991-2006

Characteristics	1991	1996	2001	2006
% owning housing units	77.32	71.12	63.24	52.20
% of households using electricity	56.96	45.94	42.17	45.60
% unemployment	8.52	6.64	7.81	5.22
% of skilled workers	33.69	29.81	31.12	32.38
% of children	28.32	28.72	28.79	28.83
% of overseas born	20.16	21.10	23.62	29.32
% Europeans	62.00	55.94	48.25	36.05
% Asians	4.07	5.66	7.70	11.15

Source: Stats NZ, BERL Calculations

5.4 Dannevirke, Hawke's Bay Area 11

The resident population in 2006 in this area was 8,019. The number of fires (all fires and structural fires) did not exhibit a clear trend in Dannevirke over the time period observed.

The number of fires is close to the national average in this fire station area. However, with population density well below the national average, we might be led to expect (on this factor alone) the number of fires to be lower than the national average. But, of the other factors, it appears the relatively high proportion using gas (as well as the higher proportion with school only qualifications) has influenced fire outcomes in this area back towards the national average.

Table 5.5 Model variables for Dannevirke, Hawkes Bay Area 11: 1991-2006

Variables	1991	1996	2001	2006	*National mean*
Dependent Variables (Fire Outcomes)					
Number of all fires	50	28	41	44	*48.2*
Number of structures fires	16	16	14	18	*15.2*
Explanatory variables					
density (residents per ha)	0.1	0.1	0.1	0.1	*1.7*
% of households using gas	10.5	19.8	22.1	21.8	*14.5*
% of households with separate house	90.8	92.5	83.6	88.2	*84.8*
% of population aged 45 to 64	18.3	19.8	22.1	23.2	*22.9*
% with school quals only	69.0	76.7	75.5	70.6	*68.2*

Source: Stats NZ, BERL Calculations

Regarding some of the other demographic characteristics for Dannevirke, the data revealed that the percentage of households living in their own home, the percentage of households using electricity, the unemployment rate, the percentage of children, and the percentage of the resident population who identified with the European ethnic group all decreased between 1991 and 2006.

On the other hand, the percentage of the resident population born overseas and the percentage of the resident population who identified with the Asian ethnic group increased. The percentage of skilled workers also dropped in 2001, but picked up again in 2006.

Although these other demographic variables are not found to be significant in our national model, the observations again show a decrease in the proportion of households living in their own home relates to an increase in the number of fires.

Table 5.6 Other demographic characteristics, Dannevirke, 1991-2006

Characteristics	1991	1996	2001	2006
% owning housing units	75.21	72.46	70.65	53.90
% of households using electricity	39.18	35.53	31.93	31.08
% unemployment	5.11	3.99	3.49	2.74
% of skilled workers	25.81	23.48	22.16	24.08
% of children	26.62	26.58	25.65	23.95
% of overseas born	6.20	6.30	6.65	7.99
% Europeans	80.52	78.27	77.52	64.94
% Asians	1.03	1.28	1.23	1.60

Source: Stats NZ, BERL Calculations

5.5 Darfield, Mid-Canterbury Area 20

The resident population of Darfield in 2006 was 2,697. There was an increasing trend in the number of all fires in Darfield from 1991 to 2006, while the number of structural fires was the same in 1996 to 2006, except in 1991.

The relatively low population density, along with a lower than average proportion of households using gas for heating, along with a higher than average proportion of households living in separate dwellings is consistent with a lower than average number of fires in this station area. However, the increasing trend over time in the number of fires would appear to be linked to the large increase in the proportion of households using gas for heating, as well as the declining proportion of separate dwellings.

Table 5.7 Model variables for Darfield, Mid-Canterbury Area 20: 1991-2006

Variables	1991	1996	2001	2006	*National mean*
Dependent Variables (Fire Outcomes)					
Number of all fires	11	19	24	28	*48.2*
Number of structures fires	3	4	4	4	*15.2*
Explanatory variables					
density (residents per ha)	0.1	0.1	0.1	0.1	*1.7*
% of households using gas	2.2	9.7	13.8	13.6	*14.5*
% of households with separate house	94.5	95.9	90.5	91.9	*84.8*
% of population aged 45 to 64	20.3	20.5	21.6	25.4	*22.9*
% with school quals only	66.3	71.3	68.8	62.6	*68.2*

Source: Stats NZ, BERL Calculations

Among the other demographic characteristics for Darfield, we note a decreasing trend in the percentage of households owning their own home, the percentage of households using electricity, the unemployment rate, the percentage of children, and the percentage of the resident population identifying with the European ethnic group. On the other hand, the percentage of the resident population who is overseas born has increased over time, while the percentage of skilled workers fell in 2001 but picked up again in 2006.

Similar to the first three case study areas, the other demographic variables for Darfield provide an interesting relationship with the number of all fires and structural fires, despite their insignificance from the perspective of our strict modelling criteria. The observations again reflect a link between lower home ownership and a higher number of fires.

Table 5.8 Other demographic characteristics, Darfield, 1991-2006

Characteristics	1991	1996	2001	2006
% owning housing units	77.60	79.91	80.70	66.67
% of households using electricity	40.38	39.55	38.11	40.58
% unemployment	3.55	1.78	2.00	2.02
% of skilled workers	27.41	28.36	30.69	32.14
% of children	23.69	25.04	25.85	22.33
% of overseas born	6.27	7.67	8.96	11.75
% Europeans	97.48	94.55	93.53	71.57
% Asians	0.34	0.29	1.32	1.28

Source: Stats NZ, BERL Calculations

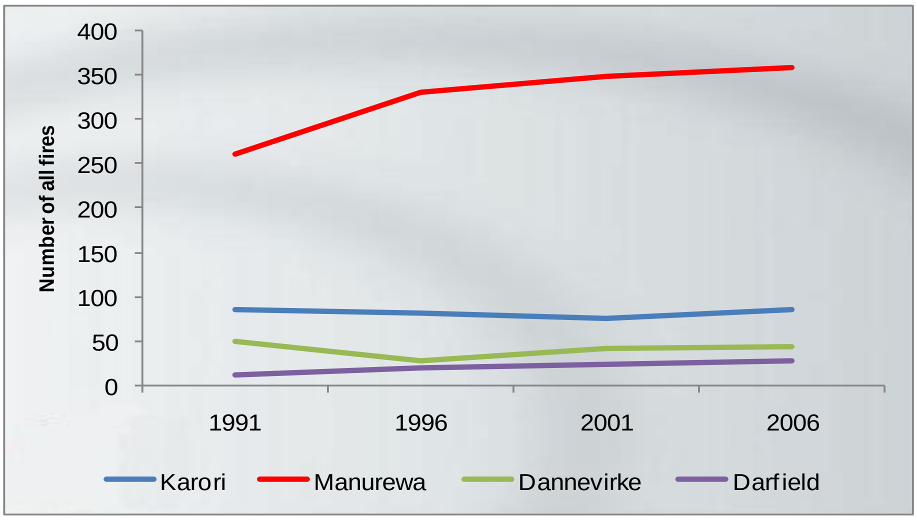
5.6 Comparison of the four fire station areas

This section compares the four fire areas in terms of the two fire outcomes and its five explanatory variables over the four census years. Towards the end of this section, we also compare the fire areas in terms of the other demographic characteristics over the four census years, and in relation to the national average.

5.6.1 Number of fires

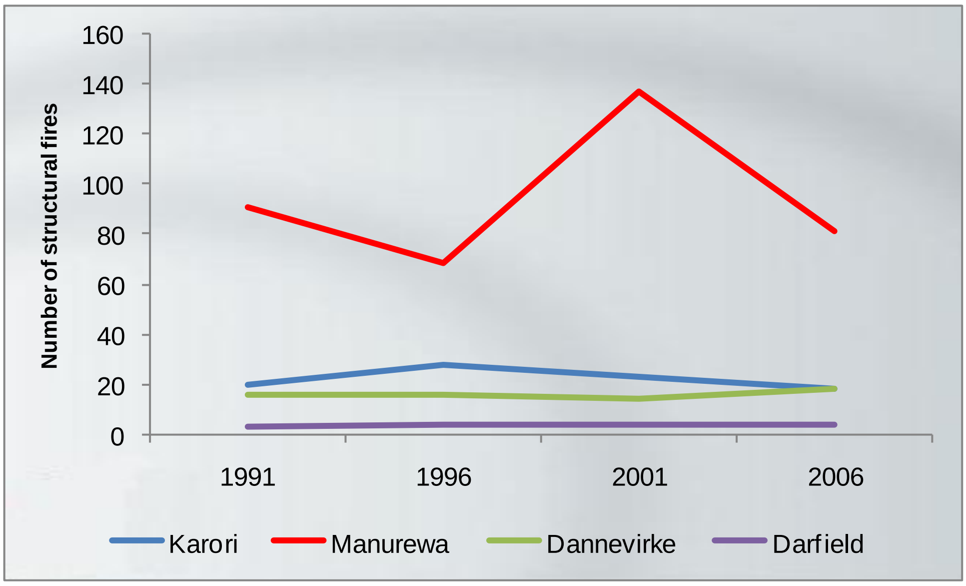
The number of fires in the Manurewa fire area for all census years was above the number of fires in the other three fire station areas. All four fire station areas experienced an increase in the number of fires between 2001 and 2006. This is consistent with the national picture. However, the rate (and consistency) of increase is most noticeable in the Manurewa fire area.

Figure 6 Number of all fires, selected stations, 1991-2006



Similar to the number of all fires, Manurewa had the highest number of structural fires compared to the three other fire station areas.

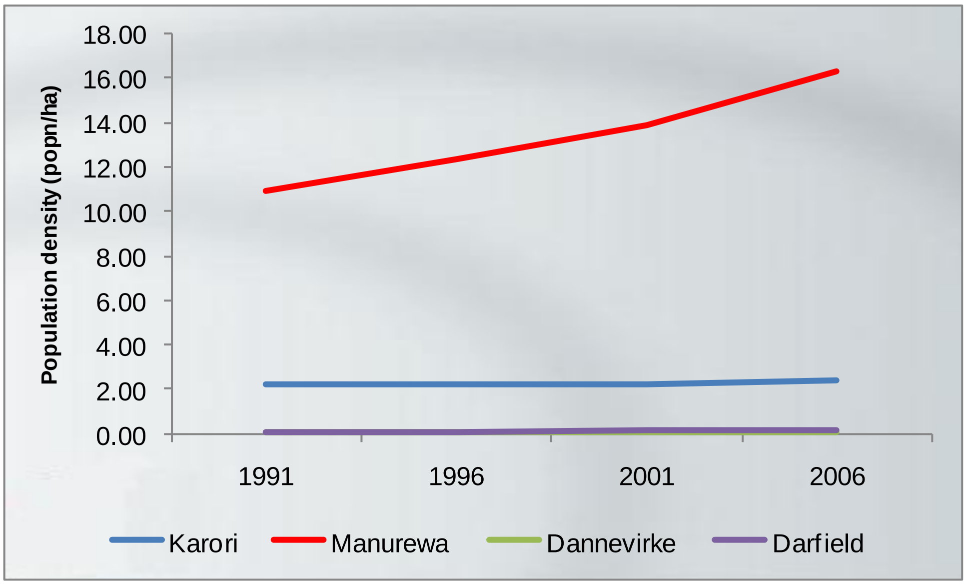
Figure 7 Number of structural fires, selected stations, 1991-2006



5.6.2 Area characteristics

The Manurewa fire area had the highest population density of the four fire areas investigated. It also had a remarkable increase in population density over the census years. In conntrast, Dannevirke, Darfield, and Karori fire areas experienced little change in population density over the census periods.

Figure 8 Population density, selected stations, 1991-2006



This density variable is the main characteristic distinguishing Manurewa from the other three fire areas. Of the other significant variables, the percentage of households living in separate dwellings and the proportion of people aged 45 to 64 years old, were similar across all the fire areas.

Of interest, however, is the percentage using gas for heating – which distinguishes Darfield from the other three and shows the Manurewa fire area experiencing a relatively greater rate of change. In addition, the proportion of the resident population with school only qualifications distinguishes the Karori fire area from the others– with a proportion much lower than the other three areas.

Figure 9 Households using gas for heating, selected stations, 1991-2006

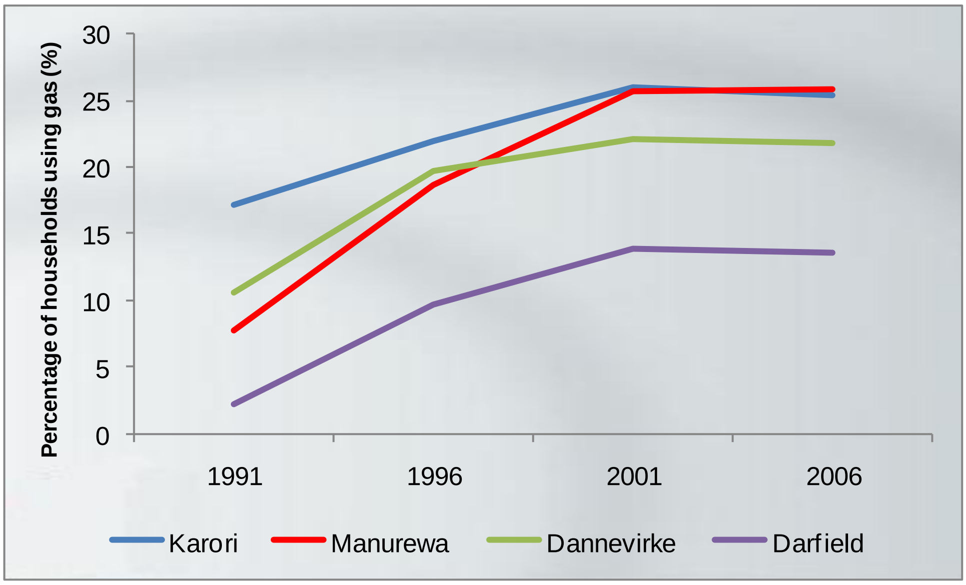
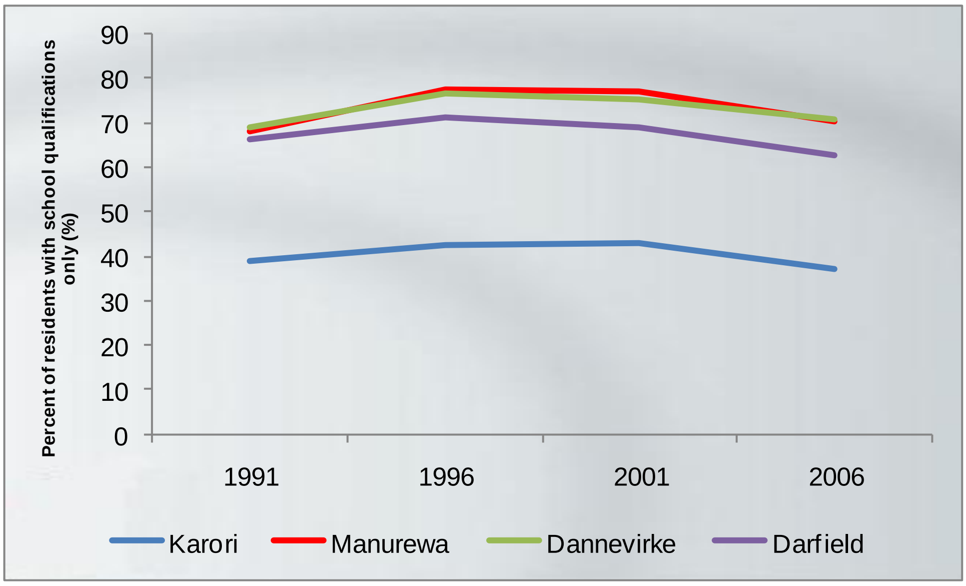


Figure 10 Resident population with school only qualifications, selected stations, 1991-2006



5.6.3 Implications

From a comparison of the demographic characteristics and fire outcomes of the four case study areas, the following can be highlighted

- The effect of higher population density is apparent in the higher number of fires in Manurewa compared to the other areas.

- The increase over time in the number of fires in Manurewa also appears to be related to the increased population density, as well as the growing proportion of households using gas for heating in this area.

- The relatively higher population density in the Karori fire area, along with a relatively higher proportion of households using gas for heating, would suggest a higher number of fires in this area than is actually recorded (compared to the other case study areas). However, it appears that the relatively lower proportion of residents with school only qualifications is the factor reducing the number of fires in this area (again, in comparison to those in the other fire areas).

6 Policy and strategy implications

In previous research work, BERL defined the capability and readiness of the NZFS as their ability to complete tasks efficiently and be prepared to fight fires and other emergencies. This project builds on the capability and readiness of the NZFS by quantifying the link between improved fire outcomes and demographic changes. Our regression analysis indicates that no one demographic factor influences fire outcomes.

This project found five demographic factors can be linked to fire outcomes. Population density, gas as fuel for heating, and people having only school qualifications (or less) can be linked to an increase in all fires and structural fires. In contrast, living in separate dwelling units and a higher proportion of residents aged between 45 and 64 years old can be linked to a decrease in all fires and structural fires.

Each of these demographic factors alone cannot explain an improvement (or deterioration) in fire outcomes. Rather it is the combined effect of these demographic factors (and, no doubt, others not identified) that impact on the actual number of fires. Therefore, no one single factor can be highlighted as reducing the average rate of fires and structural fires, but rather a range of demographic factors that work together.

Each of these demographic factors is outside of the sphere of influence of the NZFS. As such, we recommend that the NZFS work on the demographic factors that they can influence to improve fire outcomes. To do this, the NZFS should consider how they target groups that are closely related to factors influencing the five demographic factors highlighted in this study. The NZFS should consider how various demographic factors work together and how this fits in with previous research completed as part of the contestable research fund.

For example, advertising and awareness campaigns could focus on people who live in densely populated areas in apartments. These campaigns could highlight relevant fire safety messages and behaviour that may increase fire risks, focus on the importance of fire prevention, and the actions that need to be taken in the event of fire.

The NZFS is aware from previous research completed as part of the contestable research fund that the dominant fire-spread mechanism for urban buildings is via non-fire rated roofs or openings in walls and that vegetation (between buildings and suburbs) also facilitates fire-spread where it may not have otherwise occurred. Our modelling indicates that population density increases fire outcomes.

This information, and previous research completed on fire spread in and around urban centres, could be combined to inform NZFS resource positioning. This modelling could also be modified to look at fire spread in less densely populated areas that may have large amounts of vegetation or trees that are highly flammable.

Fatal fire incidents occur predominantly at night and in the weekend. In addition, our analysis indicates that households that used gas for heating were more likely to have fires. This, combined with previous research that found fatal fires most commonly started in a bedroom, sleeping area, kitchen or lounge, indicates that the NZFS should focus their fire safety or fire prevention advertising campaigns or education programmes on gas heating in these areas of the house. These campaigns and programmes could be similar to the kitchen fire advertising campaigns.

Fire prevention research has also identified that the most common type of stove-top fire is associated with the ignition of food, grease or cooking oils, and the most costly was unattended cooking fires. Unattended cooking and gas heating may also be a combination that the NZFS consider in their fire safety or fire prevention programmes.

Death due to fire is often the consequence of habitual behaviours, short-term or chronic incapacity, or irrational behaviour that directly contributed to the fatal outcome. The NZFS may consider advertising campaigns and education programmes that target the general public to ensure that the number of fires and structural fires in areas with high population density decreases.

However, the NZFS may also need to consider whether their target of 'vulnerable groups' in the community is extended to people with low or no qualifications to improve fire outcomes amongst this group. The combination of people with little or no qualifications, households using gas for heating and those not living in separate dwellings may need to considered. Our modelling suggests that these households are more likely to be in the 'higher fire risk' group and as such campaigns could be put in place to target this group.

By targeting resources for fire safety and fire prevention, noting the influence of a variety of key demographic characteristics and the changes occurring in New Zealand, the NZFS can continue to actively improve fire outcomes.

7 Appendix 1: Definitions

7.1 Area units

Area units are aggregations of meshblocks. They are non-administrative areas that are in between meshblocks and territorial authorities in size. Area units must either define or aggregate to define: regional councils; territorial authorities; urban areas; and statistical areas. Each area unit must be a single geographic entity with a unique name referring to a geographical feature. Area units of main or secondary urban areas generally coincide with suburbs or parts thereof.Area units within urban areas normally contain a population of 3,000–5,000 people, though this can vary due to such things as industrial areas, port areas, and rural areas within the urban area boundaries. In rural areas, the straddling of some territorial authorities over regional boundaries has resulted in a number of area units having only two or three meshblocks and a very low population count.

7.2 Meshblocks

Meshblocks are the smallest geographic unit for which statistical data is collected by Statistics New Zealand. Meshblocks vary in size from part of a city block to large areas of rural land. Each meshblock abuts another to cover all of New Zealand, extending out to the 200-mile economic zone (approximately 320 kilometres). Meshblocks aggregate to build larger geographic areas, such as area units, territorial authorities, and regional councils.

8 Appendix 3: Classifications of variables

Appendix 3 - Classifications for each of the variable

	Variable	Stats NZ Classification	Classification used in this project
1	sex	male	male
		female	female
2	yearly age groups	0-4 Years	children
		5-9 Years	children
		10-14 Years	children
		15-19 Years	students
		20-24 Years	students
		25-29 Years	adults group 1
		30-34 Years	adults group 1
		35-39 Years	adults group 1
		40-44 Years	adults group 1
		45-49 Years	adults group 2
		50-54 Years	adults group 2
		55-59 Years	adults group 2
		60-64 Years	adults group 2
		65 Years and Over	senior
3	median age	as is	as is
4	birthplace	NZ born	NZ born
		Overseas born	Overseas born
5	ethnic group classifications	European Ethnic Groups	European Ethnic Groups
		Mäori Ethnic Group	Mäori Ethnic Group
		Pacific Peoples' Ethnic Groups	Pacific Peoples' Ethnic Groups
		Asian Ethnic Groups	Asian Ethnic Groups
		MELAA Ethnic Groups	Others
		Other Ethnic Groups	Others
6	smoking behaviour	regular smoker	regular smoker
		ex-smoker	ex-smoker
		never smoke regularly	never smoke regularly
7	highest qualifications	No Qualification	No Qualification
		Level 1 Certificate Gained at School	School qualifications
		Level 2 Certificate Gained at School	School qualifications
		Level 3 or 4 Certificate Gained at School	School qualifications
		Overseas Secondary School Qualification	School qualifications
		Level 1, 2 or 3 Certificate Gained Post-school	Post-school qualifications
		Level 4 Certificate Gained Post-school	Post-school qualifications
		Level 5 Diploma	Post-school qualifications
		Level 6 Diploma	Post-school qualifications
		Bachelor Degree and Level 7 Qualifications	Tertiary education
		Postgraduate and Honours Degrees	Tertiary education
		Masters Degree	Tertiary education
		Doctorate Degree	Tertiary education

	Variable	Stats NZ Classification	Classification used in this project
8	w ork and labour force status	Employed Full-time	Employed Full-time
		Employed Part-time	Employed Part-time
		Unemployed	Unemployed
		Not in the Labour Force	Not in the Labour Force
		Work and Labour Force Status Unidentifiable	Work and Labour Force Status Unidentifiable
		Paid Employee	Paid Employee
		Employer	Employer
		Self-Employed and Without Employees	Self-Employed and Without Employees
		Unpaid Family Worker	Unpaid Family Worker
9	total personal income groupings	$5,000 or Less	$5,000 or Less
		$5,001 - $10,000	$5,001 - $10,001
		$10,001 - $20,000	$10,001 - $20,001
		$20,001 - $30,000	$20,001 - $30,001
		$30,001 - $50,000	$30,001 - $50,001
		$50,001 or More	$50,001 or More
10	sources of personal income	Wages, Salary, Commisions, Bonuses, etc	Wages, Salary, Commisions, Bonuses, etc
		Self-employment or Business	Self-employment or Business
		Interest, Dividends, Rent, Other Invest.	Interest, Dividends, Rent, Other Invest.
		Payments from a Work Accident Insurer	Payments from a Work Accident Insurer
		NZ Superannuation or Veterans Pension	NZ Superannuation or Veterans Pension
		Other Super., Pensions, Annuities	Other Super., Pensions, Annuities
		Unemployment Benefit	Unemployment Benefit
		Sickness Benefit	Sickness Benefit
		Domestic Purposes Benefit	Domestic Purposes Benefit
		Invalids Benefit	Invalids Benefit
		Student Allow ance	Student Allow ance
		Other Govt Benefits, Payments or Pension	Other Govt Benefits, Payments or Pension
		Other Sources of Income	Other Sources of Income
		No Source of Income During That Time	No Source of Income During That Time
11	occupation based on NZSCO99	Managers	Managers
		Professionals	Professionals
		Technicians and Trades Workers	Technicians and Trades Workers
		Community and Personal Service Workers	Community and Personal Service Workers
		Clerical and Administrative Workers	Clerical and Administrative Workers
		Sales Workers	Sales Workers
		Machinery Operators and Drivers	Machinery Operators and Drivers
		Labourers	Labourers

	Variable	Stats NZ Classification	Classification used in this project
12	industry based on the ANZSIC9	Agriculture, Forestry and Fishing	Agriculture, Forestry and Fishing
		Mining	Mining
		Manufacturing	Manufacturing
		Electricity, Gas, Water and Waste Services	Electricity, Gas, Water and Waste Services
		Construction	Construction
		Wholesale Trade	Wholesale Trade
		Retail Trade	Retail Trade
		Accommodation and Food Services	Accommodation and Food Services
		Transport, Postal and Warehousing	Transport, Postal and Warehousing
		Information Media and Telecommunications	Information Media and Telecommunications
		Financial and Insurance Services	Financial and Insurance Services
		Rental, Hiring and Real Estate Services	Rental, Hiring and Real Estate Services
		Professional, Scientific and Technical Services	Professional, Scientific and Technical Services
		Administrative and Support Services	Administrative and Support Services
		Public Administration and Safety	Public Administration and Safety
		Education and Training	Education and Training
		Health Care and Social Assistance	Health Care and Social Assistance
		Arts and Recreation Services	Arts and Recreation Services
		Other Services	Other Services
13	workplace area	Not available in all census years	-
14	dwelling type	separate house	separate house
		other private dwelling unit	other private dwelling unit
		non-private dwelling unit	non-private dwelling unit
		others	others
15	number of bedrooms and mean	number of bedrooms and mean number od bedrooms	number of bedrooms and mean number od bedrooms
16	fuel type used to heat dwelling	Electricity	Electricity
		Mains Gas	Mains Gas
		Bottled Gas	Bottled Gas
		Wood	Wood
		Coal	Coal
		Solar Power	Solar Power
		Other Fuel(s)	Other Fuel(s)
17	household composition	One-family household	One-family household
		Two-family household	Two-family household
		Three or more family household	Three or more family household
		Other Multi-Person Household	Other Multi-Person Household
		One Person Household	One Person Household
18	total household income classific	$20,000 or Less	$20,000 or Less
		$20,001 - $30,000	$20,001 - $30,001
		$30,001 - $50,000	$30,001 - $50,001
		$50,001 - $70,000	$50,001 - $70,001
		$70,001 - $100,000	$70,001 - $100,001
		$100,001 or More	$100,001 or More
19	tenure of household	Owned or Partly Owned	Owned or Partly Owned
		Not Owned	Not Owned
		Dwelling Held in a Family Trust	Dwelling Held in a Family Trust

	Variable	Stats NZ Classification	Classification used in this project
20	population area (ha.)	population area (ha.)	population area (ha.)

9 Appendix 4: Model diagnostics

Tables 2 and 3 provide the analysis of variances for the models for the number of all fires and number of structural fires, respectively. The goodness of fit of the two models are acceptable having computed F-values greater than the tabulated F-values as shown with Prob > F to be equal to 0. The t-values of the different independent variables are all higher than the tabulated t-values as presented by the column on P > |t|.

The adjusted r-squared for the model is 0.56, for the all fires and 0.55 for the structural fires. This number (up to a maximum of 1), indicates the proportion of the changes in the number of fires that is explained by the factors listed. There are, clearly, other factors that affect fire outcomes, but these were not as significant as those above according to the findings of our regression analysis. These other factors could be, for example, education and awareness campaigns conducted by the NZFS; better responses by the NZFS resulting in fewer fire casualties.

Table 2 – Analysis of Variance for the Model for Number of All Fires

Source	SS	df	MS
Model	8054358.69	9	894928.744
Residual	6153456.31	1743	3530.382
Total	14207815.00	1752	8109.483

Number of observations = 1752

F (9, 1473) = 253.59

Prob > F = 0.000

Adj R-squared = 0.5647

Variables	Coefficient	t-values	P > |t|
YR91	110.27	6.58	0.000
YR96	88.36	4.85	0.000
YR01	82.98	4.56	0.000
YR06	101.50	5.54	0.000
Density	6.06	16.98	0.000
Gas	2.51	12.87	0.000
Separate	-1.12	-6.63	0.000
Adults	-2.09	-5.46	0.000
Educ	0.71	3.70	0.000

Table 3 – Analysis of Variance for the Model for Number of Structural Fires

Source	SS	df	MS
Model	853235.96	9	94803.995
Residual	690335.04	1743	396.061
Total	1543571.00	1752	881.034

Number of observations = 1752

F (9, 1473) = 239.37

Prob > F = 0.000

Adj R-squared = 0.5528

Variables	Coefficient	t-values	P > |t|
YR91	41.83	7.45	0.000
YR96	35.45	5.81	0.000
YR01	32.11	5.27	0.000
YR06	35.93	5.85	0.000
Density	2.10	17.59	0.000
Gas	0.67	10.31	0.000
Separate	-0.47	-8.27	0.000
Adults	-0.66	-5.13	0.000
Educ	0.30	4.62	0.000