Fire Research Report

A Pilot Study to Identify Strategies to Assess Vegetation Fire Hazards

Chilton Saint James School

February 2001

This project set out to establish the feasibilty and effectiveness of a method to determine the geographical distribution of vegetation fire hazard. This would provide a basis for planning more effective fire attack methods, identifcation of hazards to fire fighting staff and locations of greatest hazard to property and buildings.

The project was confined to the study of a small area in the Eastern Hutt Valley Hills. This area is considered to be a fire hazard as it is close to transport links and to residential areas. Fire hazard information data was obtained, including weather, vegetation type, slope and ignition hazard. The solar radiation was also calculated. The data was mapped using Geographic information Systems (GIS) technology, to allow for ease of analysis and future updating. The team set out to establish from studies on the ground the density of biomass, which required quantities of native bush and gorse to be measured. An investigation was conducted to see if the different types of vegetation cover could be identified from aerial photographs.

The first observation noted was that is areas of lower solar radiation the predominant vegetation type was native bush, which presents a lower fire hazard than gorse. It was also noted that the greater biomass, and therefore greater hazard was in the older gorse. However. it was noted that as the gorse ages it opens up and allows the regeneration of native bush. In other words if fires can be prevented in the medium term, the increasing proportion of native bush will lower the fire hazard in the long term.

The project concluded that they had identified a method for predicting fire hazard. This would rely on identifying areas of gorse form aerial photographs and then on the ground sampling of those areas to determine the age and biomass of the vegetation cover.

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Chilton Saint

James School

Estimating Vegetation Fire Hazard

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Candice Nel
Joanna Liu

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Chilton Saint James GIS Project 2000

INTRODUCING THE 2000 TEAM

From year 12: Candice Nel, Joanna Liu (members of the 1999 team)
From year 13: Irina Magoch (also a member of the 1999 team), Sarah Gazley and Mimi Song

BACKGROUND

The purpose of this research was to explore a method of predicting how prone to fire a gorse covered area is in relation to its aspect, slope and biomass. We also considered the age of the gorse, and the date of the last fire.

This project has been completed not only as an entry for the AURISA GIS School competition but as a contribution to our community. The potential contribution to the community of this research has been recognised by the NZ Fire Service and is part of their 2000 research programme.

Our research was based in an area bounded by the Wainuiomata Hill Road, and the ridge along the Eastern Hutt Valley Hills. This area is considered to be a fire hazard as it is close to transport links and residential areas. (Wellington Regional Council 1999 Wildfire Hazard map) The area was chosen as it is easily accessible and would provide us with data that could be compared to other gorse covered areas in both New Zealand and the world.

PURPOSE OF OUR STUDY

That a practical method can be developed to predict areas of greatest fire hazard.

We obtained data and a report from the Wellington Regional Council (Wellington Regional Council 1999) outlining their wildfire study. This study developed a GIS model using four categories of risk.

1) Vegetation type
2) Weather and drying variables
    - Aspect
    - Rainfall
3) Slope
4) Light up Hazard

We hoped to be able to obtain information to calculate biomass (a measure of how much fuel these is for the fire to burn) and the date of the last fire on the area. This information would be used to create additional layers to the Wellington Regional Council model. We hoped this information would allow a practical model to be developed that would give an indication of the current fire hazards. We also hoped such a computerised GIS model would be easily updated to give the model everyday relevance.

Criteria for testing the method

The method needs to:

1) Use data that is readily observed by non-experts.

2) To produce maps for analysis.

It is hoped that the method or its map results may offer practical suggestions to fire fighters.

General view of study area –see maps, air photo and photo analysis for detail

Maps of our study area (Figure 1 to Figure 5)

The following maps show the location of Lower Hutt and our study area on the Eastern Hills of Lower Hutt. (Figure 1 to Figure 2)

The area consists of 9 spurs, which are labelled along with our sample sites (Figure 3).

We also created a digital terrain model of the area, which shows the spurs, which tend to run in a SW-NE direction from the main ridge which is generally north –south (Figure 4).

This creates a series of slopes that face the sun at different angles. There are no permanent streams in our study area but each gully is drained by an empheral stream that flows once there has been sufficient run for runoff to occur (Figure 5) .

Figure 1

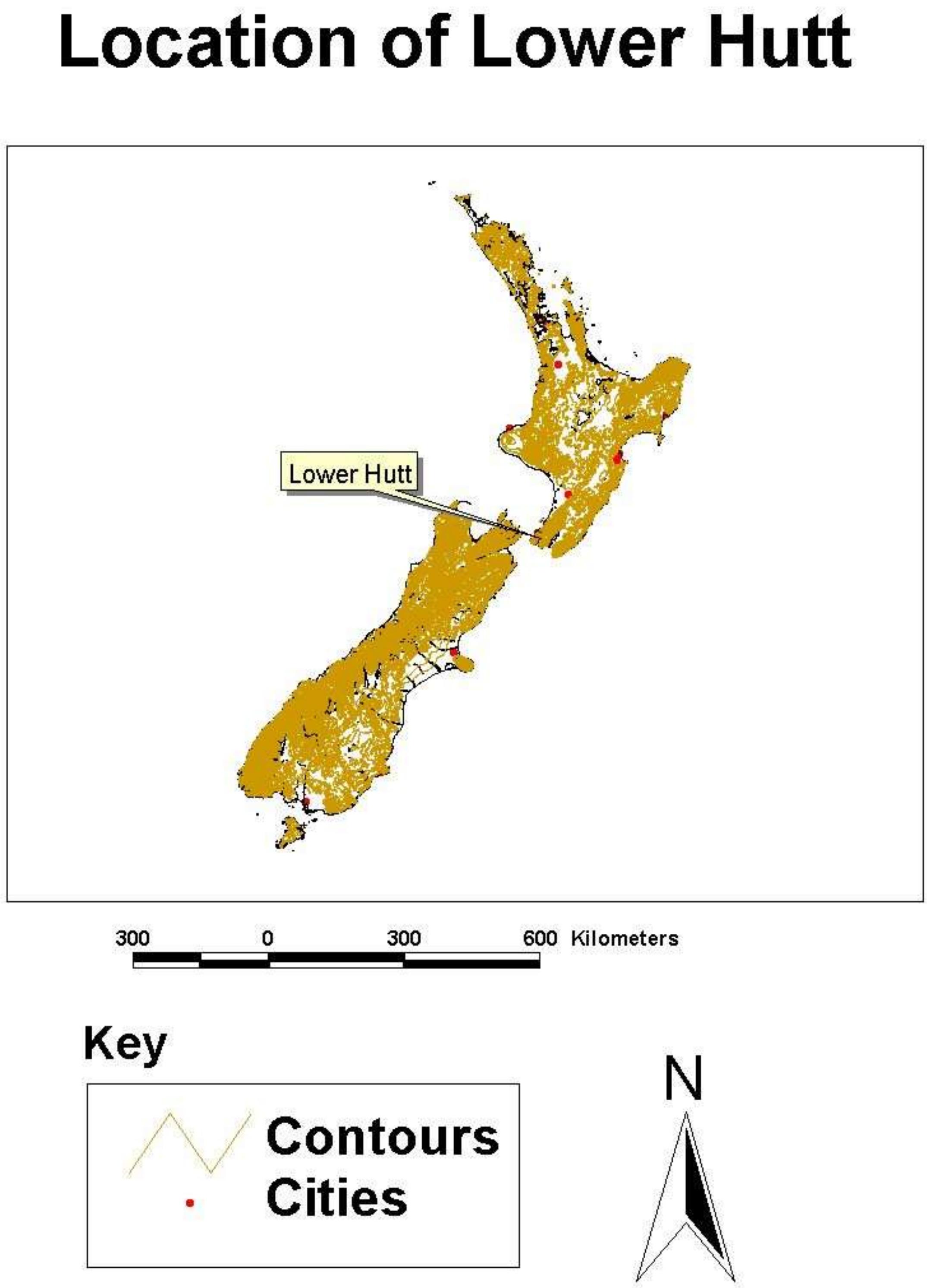

Location of Lower Hutt
Lower Hutt
300
0
300
600
Kilometers
Key
Contours
Cities
N

Figure 2:

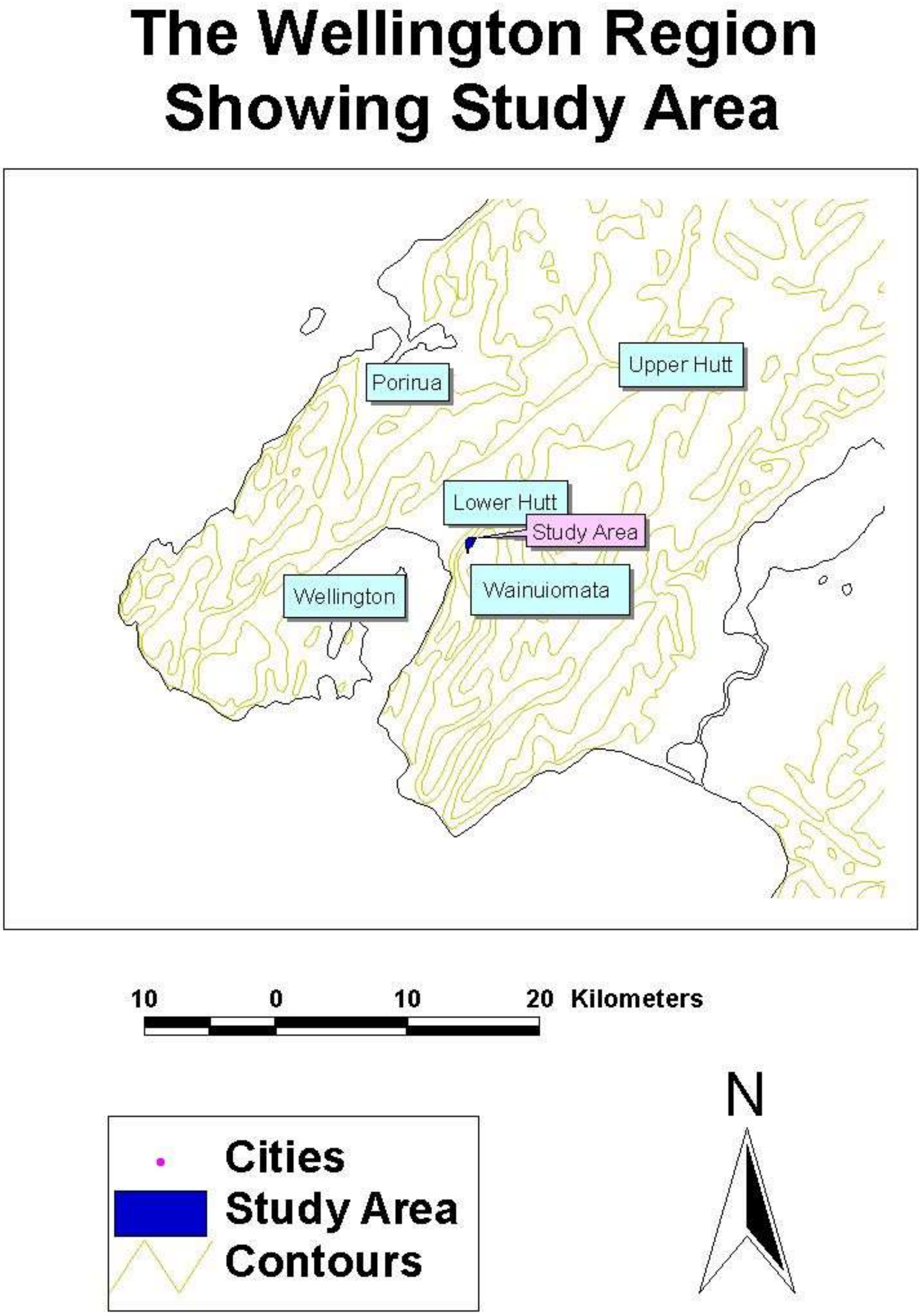

The Wellington Region
Showing Study Area
Porirua
Upper Hutt
Lower Hutt
Study Area
Wellington
Wainuiomata
10
0
10
20
Kilometers
Cities
Study Area
Contours
N

Figure 3

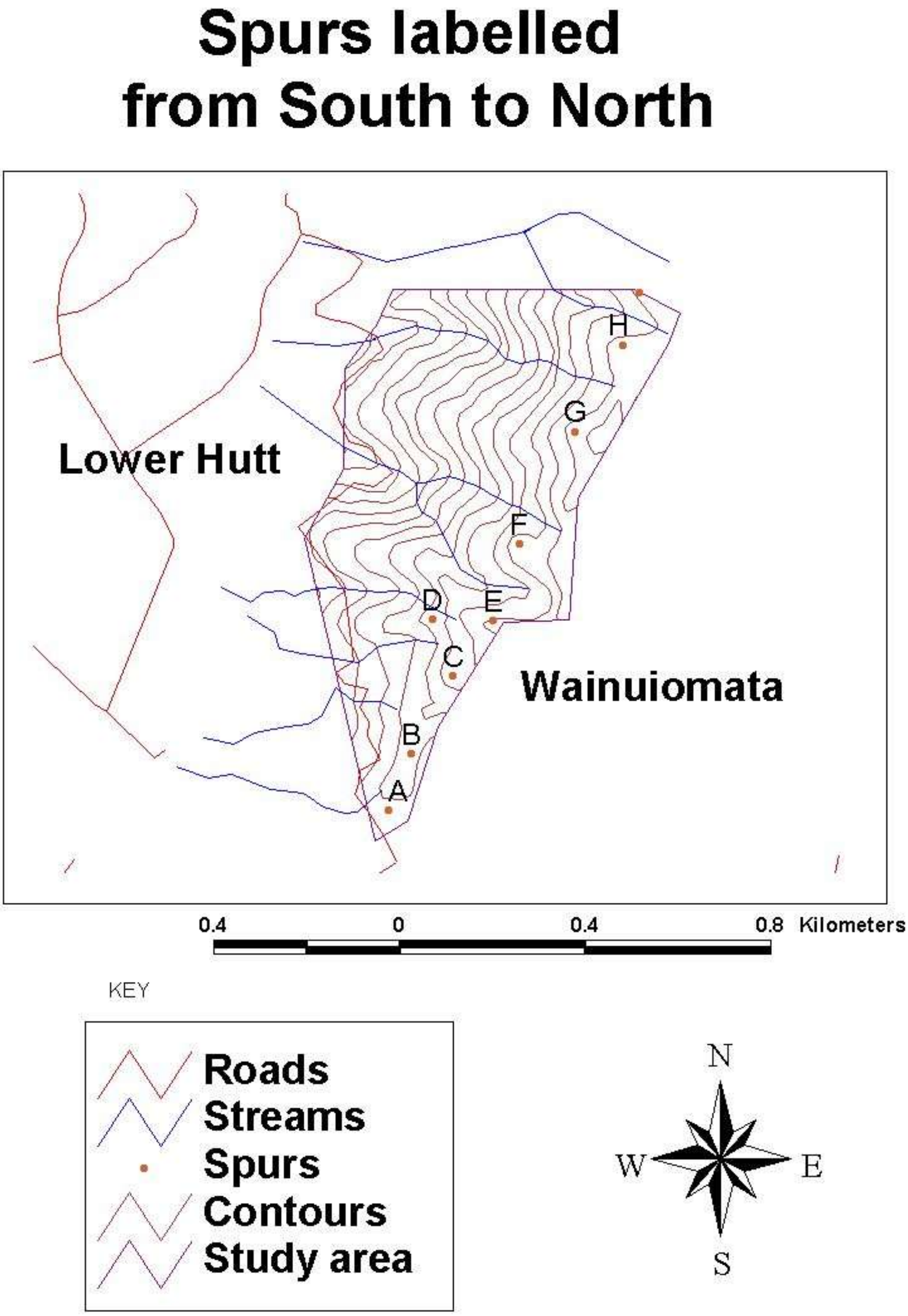

Spurs labelled
from South to North
Lower Hutt
Wainuiomata
A
B
C
D
E
F
G
H
0.4
0
0.4
0.8 Kilometers
KEY
Roads
Streams
Spurs
Contours
Study area
N
W
E
S

Figure 4

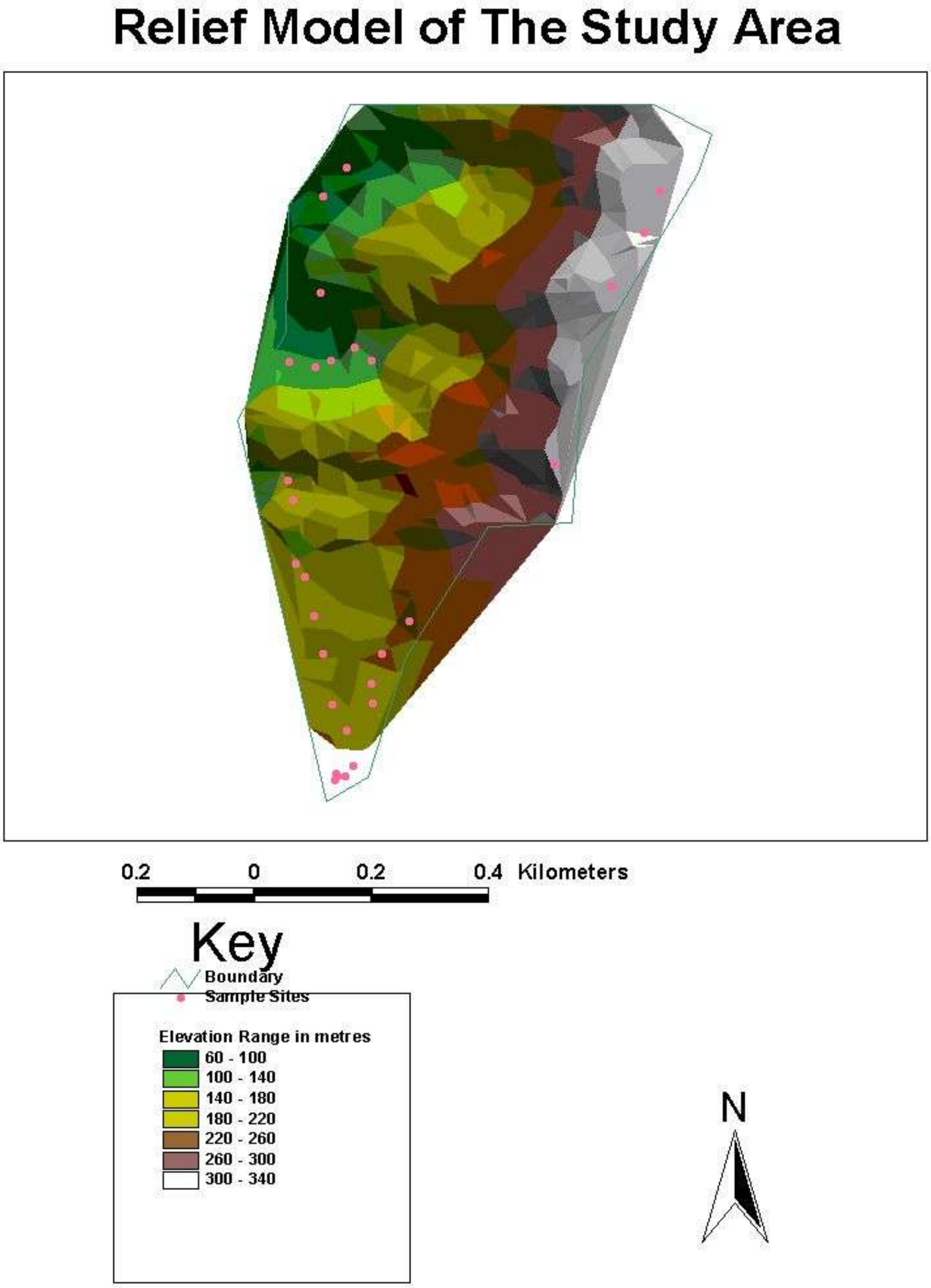
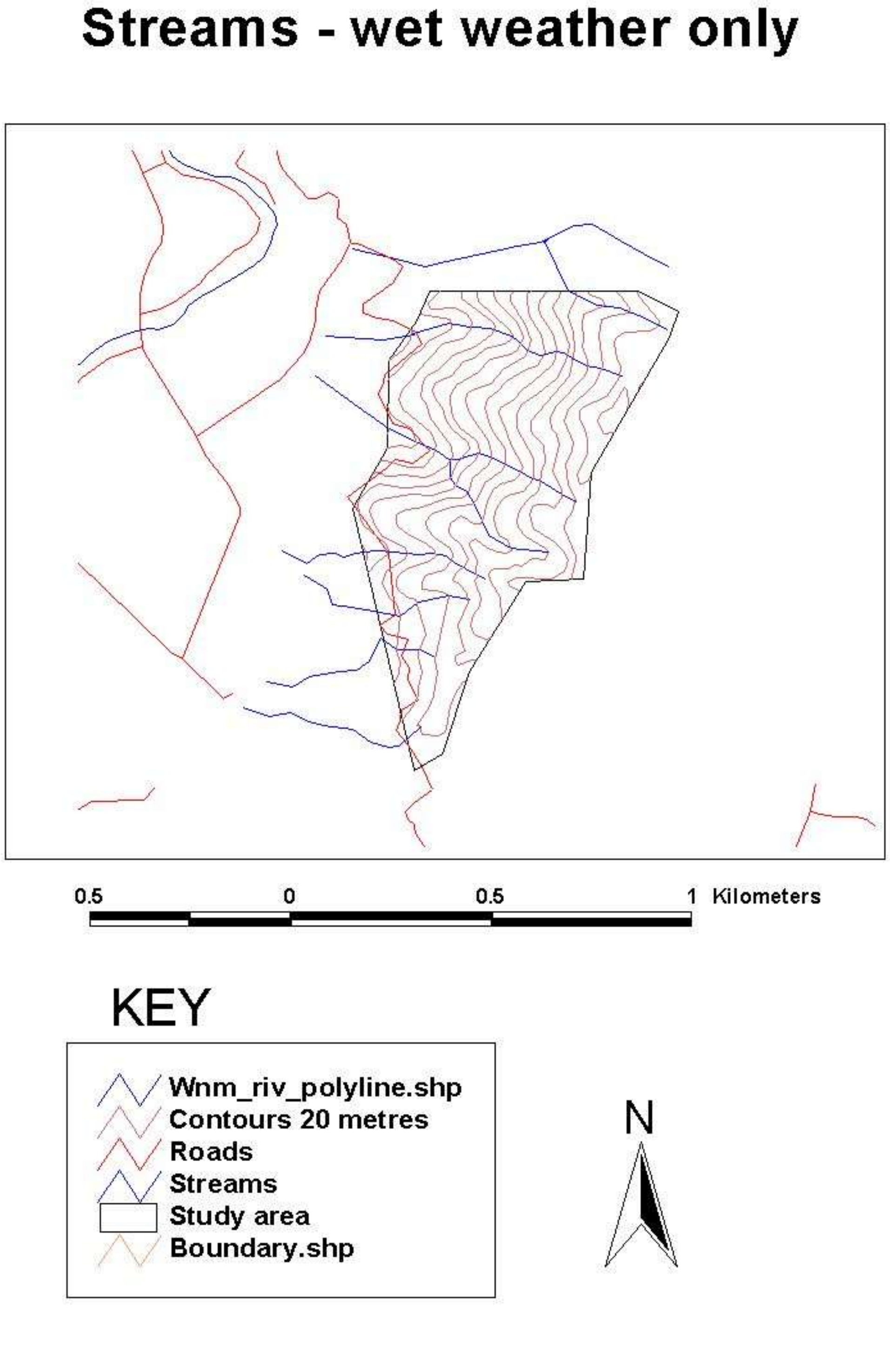

Relief Model of The Study Area
0.2 0 0.2 0.4 Kilometers
Key
Boundary
Sample Sites
Elevation Range in metres
60 - 100
100 - 140
140 - 180
180 - 220
220 - 260
260 - 300
300 - 340
N

Figure 5


Streams - wet weather only
0.5
0
0.5
1 Kilometers
KEY
Wnm_riv_polyline.shp
Contours 20 metres
Roads
Streams
Study area
Boundary.shp
N

METHOD

Data Collection

Our first step was to select a study area that was easily accessible to us. Once it was established that we were to take samples from the Wainuiomata Hill area we contacted the Wainuiomata Bush Fire Force, who sent us information on recent fires in the area. Information was also obtained from Mr Bert Borger.

The Wellington Regional Council provided us with the results and data from their wildfire study (Wellington Regional Council 1998). This data in digital form included the land cover database (LCDB) for Lower Hutt, slope, solar radiation and the risk of wildfire of the site. (see Figure 6, Figure 11 to Figure 14). From this we noted that our area is classified as being covered with gorse and scrub. We did some general research into the nature of gorse. (We were assisted by research done by year 11 students, as part of their School Certificate internal assessment on gorse as an environmental problem- (See Figure 7)

Topographic data on CD-ROM was obtained from Eagle Technology as part of their GIS in schools programme.

The Land Information section, Hutt City Council sent us aerial photos. (Figure 8 shows aerial photos of area.)

Mr Grant Pearce, Fire scientist, Forest Research Institute was contacted for information on research methods for determining biomass. (Fogarty L.G, Slijepcevic. A, Hawke A.E and Pearce, 1998)

A team member collects a gorse

We collected historical and current photos of the site. (Fire photo study) This included fully photographing all Spurs when we realised the aerial photo resolution was too low. (Photo analysis of the Spurs)

We used the photos to locate fire boundaries and areas of native bush and gorse. This was useful as it would allow us to find sites that we knew had or hadn't been effected by fire, and to ensure that we did not double up on sites i.e. so we did not take site readings from two sites within the boundaries of one fire.

Measuring height

After analysing this information we decided on a suitable method of collecting the necessary information from our sample area, i.e. the age and height of the gorse. For three Sunday afternoons our group travelled to our study area to collect data. To do this we broke into two groups, each with a GPS, a tape measure, a saw and a notebook. Each group went to several different sites within the study area and at each site took a GPS reading, a height recording of several gorse plants and at least two cuttings from the base of the gorse plants in that site. We recorded all the data in our notebooks so we could easily compare our information when we returned to school, and so we could enter our data into the computers.


Sanding a sample to count the rings

To calculate the age of the gorse we cut samples from a selection of gorse plants in each of the study areas. We would then count the rings for each of these samples and find the average age of the gorse at each site. To calculate the average height of the gorse at each site we measured the height of several gorse bushes (from base to foliage tip).

Before we could calculate the age of the cut gorse samples we had to sand one end of the sample in order to count the rings (see pictures). We also found the diameter for each sample and recorded it into the computers.


Samples

The biomass of the gorse was calculated by using tables based on a formula from research by Grant Pearce and others. (Fogerty et al 1998)

$$\text{Biomass} = 3.6621 + 0.9718 \times \text{height}$$

Biomass gives a measure of how much fuel a fire has to burn. The more fuel a fire has the greater the fire hazard especially as the fuel dries.
All the collected information was entered into our database and where appropriate mapped (Figure 14-15).

Summaries of the collected information

Item number		**Data**
1	Fire Risk	Fire risk of gorse (Figure 6 and Figure 7)
2	Table 1	Record of fires in Wainuiomata Hill Road area
3	Photo Study 1	Fire Photo Study
4	Photo Study 2	Photo analysis of study area.
5	Figure 8	Aerial photo showing the study area
6	Figure 9	The location of the photograph sites
7	Figure 10	The location of spurs and photograph sites
8	Table 2	Summary of field data and calculated data
9	Figure 11	Aspect of the study area
10	Figure 12	Solar energy received
11	Figure 13	The slope of the study area
12	Figure 14	The risk of wildfire

Fire risk

The vegetation cover

Our study area is classified as gorse and scrub on the land cover database for New Zealand. (Figure 6)

Gorse is a dense, spiny, dull greyish-green shrub that was first introduced to New Zealand by the early settlers. Originally it was used by farmers to contain livestock but New Zealand's sub Mediterranean climate has caused it to flourish and today it has spread to cover more than 3% of the total land area of New Zealand. Gorses' deep roots and small leaf area allow it to become established in even the driest areas. Once established gorse produces large amounts of litter, which accumulate on the soil surface causing an increase in the soils acidity. This prevents other plants that do not tolerate acidic conditions from growing in the area. However gorse does act as a nursery for the regeneration of native species (Figure 7).

In New Zealand gorse can live for up to 30 years and reach heights of several metres. Once established it is almost impossible to remove as its seeds are able to survive in the soil for up to 40 years before germinating.

Gorse has a high fire risk (Wellington Regional Council, 1998 p10). It also dries very quickly with a high proportion of light litter. Gorse can become dry enough for a fire in as little as three days. (Ellis R. 1994 p53). The recent fire behind Griffins at the foot of the Wainuiomata hills also shows that even September gorse can dry and burn (see fire photo study).

"Weddell had been sent up a steep gorse covered bank as part of a move to outflank the fire front. A northerly was gusting up to 70 knots. He was about 39 metres from the flames when the gale whipped the fire across the top of the gorse. 'It came at me in a fireball. The gorse was so thick round me I could hardly move one way or the other. I tried to get out of the way but I didn't really have a show'. He estimates he was in the fire for no more than 10 seconds, which was enough to burn the skin on 70 percentage of his body."

In his dissertation (1994 p56) Ellis described a test burn conducted by Mr L Foggerty and Mr G Pearce of the Forest Research Institute in the Wainuiomata River Valley in March 1994 The fire followed a period of rain, with a heavy down pour only two days previously. The Fire Weather Index (a measure used to predict the risk of fire based on weather conditions) was in its low range. As a result a rather quiet burn was expected. In the event the results were spectacular as the photo (right) shows with a rate of spread of 900 metres an hour and flame heights of 15-20 metres. The calculated fire intensity was 17,000 kilowatts per metre. The limit for

Test burn 1994 in Wainuiomata Valley showing the intensity of a gorse fire (unexpected by researchers) conventional fire control is considered to be 4,000 kilowatts per metre. The intensity was unexpected and considered exceptional. However the research by Ellis showed that the fine fuel moisture content was 15% lower than predicted by the Fire weather index. Clearly gorse dries very quickly and for longer than many other types of vegetation.

Figure 6

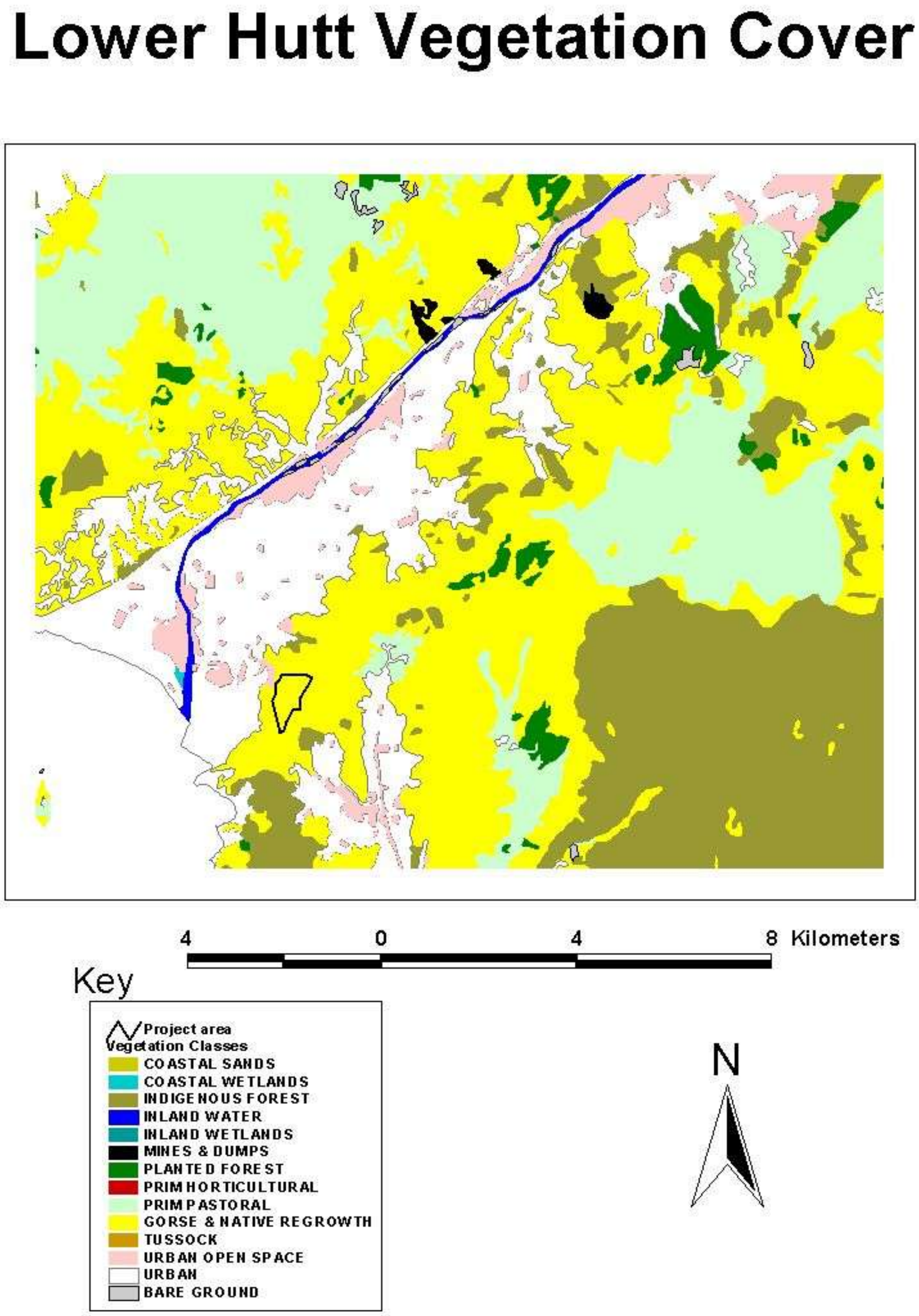

Lower Hutt Vegetation Cover
4
0
4
8 Kilometers
Key
Project area
Vegetation Classes
COASTAL SANDS
COASTAL WETLANDS
INDIGENOUS FOREST
INLAND WATER
INLAND WETLANDS
MINES & DUMPS
PLANTED FOREST
PRIM HORTICULTURAL
PRIM PASTORAL
GORSE & NATIVE REGROWTH
TUSSOCK
URBAN OPEN SPACE
URBAN
BARE GROUND
N

Figure 7

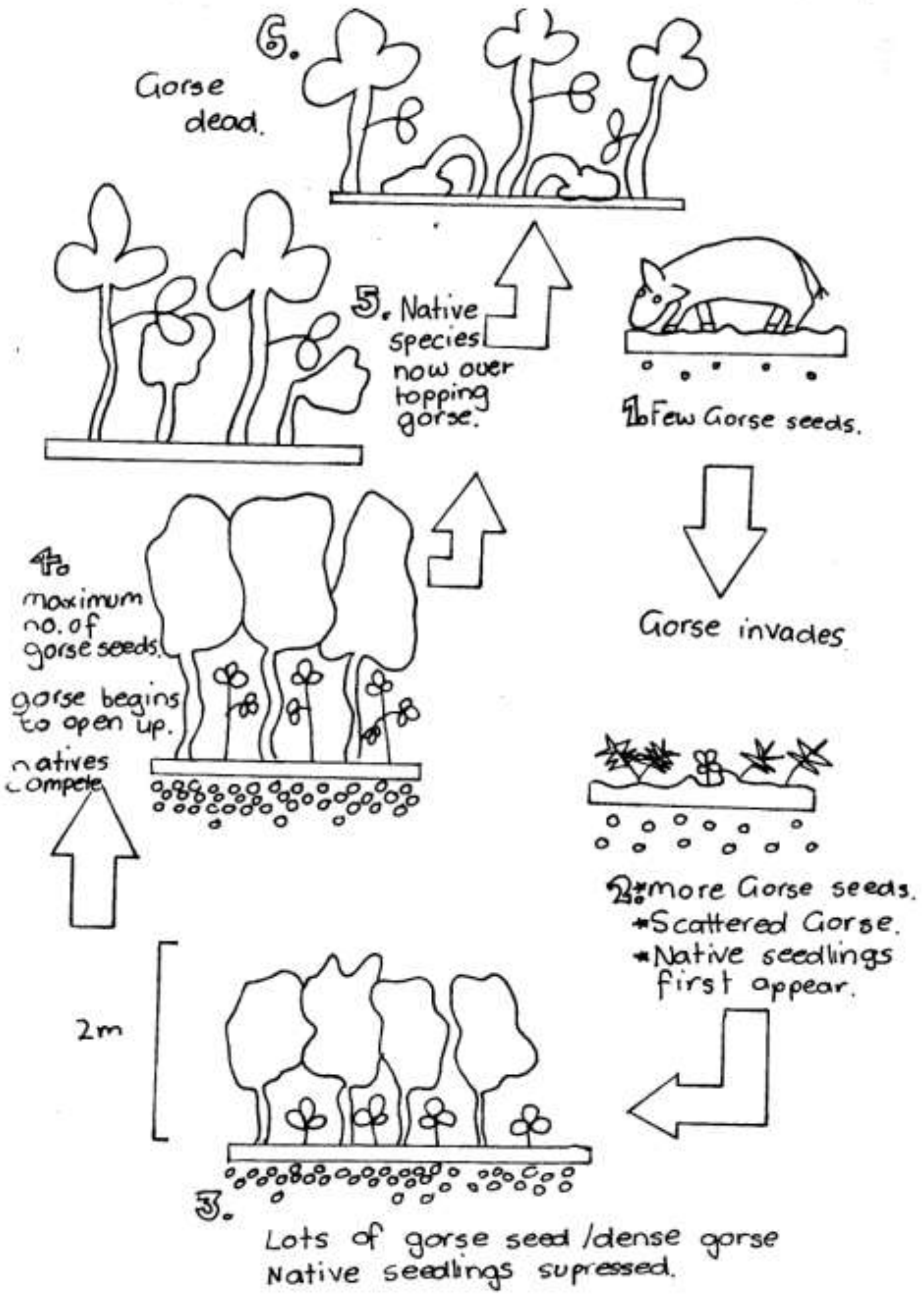

6. Gorse dead.
5. Native species now over topping gorse.
1. Few Gorse seeds.
Gorse invades
4. maximum no. of gorse seeds.
gorse begins to open up.
natives compete
2. more Gorse seeds.
*Scattered Gorse.
*Native seedlings first appear.
2m
3.
Lots of gorse seed /dense gorse
Native seedlings supressed.

Table 1 Fires Recorded in the Wainuiomata Hill Road Area

Date	year	Time	east	north	Size (ha)	Fuel	Cause	Comment (incl district)	study area
23.12.83	1983	1312						Wainui Hill	
9.4.89	1989	1100						Towai trig	yes
24/05/1991	1991	10:44				6	11	Wainuiomata Hill Road	
11/11/1993	1993	11:24				4		Water tower, Woa Hill Rd	no
18/02/1993	1993	13:08				4		Wainuiomata Hill Summit, SE Firebreak	no
5/11/1997	1997	22:56	26711	59941	0.1	4	12	Wainui Hill Rd Adj to Lookout	on other side of road ?
28/03/1991	1991	12:17				6	11	Wainui Hill Rd	

Key to codes for Cause, Vegetation/Fuel and Area

Code	Cause
1	Picnickers/campfires
2	Motor vehicles
3	Smoking/matches
4	Hunters
5	Railways
6	Burn breakaway/authorised
7	Burn breakaway/unauthorised
8	Chainsaws
9	Tractors/other machinery
10	Arson/incendiarism
11	Other
12	Unknown
13	Lightning
14	Powerlines

Code	Vegetation/Fuel
1	Beech
2	Podocarp
3	Manuka/kanuka
4	Gorse/broom
5	Bracken
6	Stubble/crops
7	Tussock
8	Miscellaneous
9	Grass
10	Exotic forest
11	Rubbish
12	Single tree, stump
13	Hayshed
14	Slash, logs

Extracted from Wainuiomata Bushfire Records. (Sourced from Allen, R and Borger, B)

Photo study 1

Fire Photo Study: Fires on the Eastern Hills

As well as the historic photos that we found, photos were taken of four sites outside our study area that have recently been burnt.
When the land was first cleared the soil was fertile. Over time the soil was eroded away, exposing the rock and clay. (We observed this ourselves and this was later confirmed by Murray Ellis).

In late 18^{th} and early 19^{th} century the Eastern Hills were cleared for farming. The land proved to be too steep with a heavy clay soil and was not economic. Gorse invaded the area. Until the 1970's wildfires that occurred either naturally or by human cause were left to burn. Over the last 20 years it has been realised that gorse provides a nursery for native species that will eventually come though the gorse and suppress it. For this to occur fires need to be prevented and fought when they occur. The old photos show how bare the hills were compared with today's cover of gorse and regrowth. (Kenneally l, 1983 p74)

Looking to our study area to the left of the Eastern Hills. The hill road can be seen. The hills are basically bare.
c.1900,s (Source: Kenneally l, 1983 p74)

Today the Hutt City Council is responsible for fire control. Now rather than leave the fire, fire fighters are used to fight the fires. The bush areas of the Hutt Valley are the responsibility of the Wainuiomata Bushfire Force. This is a volunteer force of about 40 members. The group has just celebrated 30 years of fire fighting. (Wallace,1980)

Work on the Wainuiomata Hill Road c 1911. Again the lack of vegetation is clear but stump shows it was recently forest

A fire on the Wainuiomata Hill Road 1971.

Observed fire patterns

1. Typical results –note the pattern of burning on the north facing slopes. 1979

(Source Wallace 1980 p32)

2. Gracefield   1996

Grid Reference 26706 59934

Note the distinct fire boundary as the fire moved over the ridge to the southern aspect of the spur.

3. Behind the Coal Research Association, corner of Gracefield Road and Parkside Drive. 1998

Grid reference 26707 59950

This fire was on a very steep slope. The regenerating gorse is now approx 0.5 metres.

4. Seaview 2000

Grid reference 00 59935

Fire on a cutting.
Note also evidence of earlier fire in the background on the north-facing slope with regeneration in the gully forming a clear fire edge

5. Behind Griffins   September 2000

Grid reference 26709 59957

Before the fire

After the fire

Burn on north facing aspect. Started alongside the hill road.

Result from fire photo analysis

All the fires all show clearly the influence of aspect on the fire extent.

All the recent fires started at the bottom of a Spur, probably intentionally. Slope was a factor in that fire travels quickly up a slope creating its own wind, and the prevailing northerly wind tends to fan fires up a slope. (Wellington Regional Council, 1998, p22) As well all these fires are on extremely steep slopes, and in two cases impossibly steep. This hazard for fire fighters is obvious, especially as typically fire occur at night.

Photo study 2

Vegetation patterns

The aerial photos we received had a low resolution. (Fig 8) This did not show enough vegetation detail for us to be able to map changes and create sample areas. However while in the field we discovered we could get good pictures using the digital camera so several photo trips were undertaken. The main problem was getting fine weather.

The spurs were labelled from south to north and the photo location was recorded using GPS. The map shows the location of the photos. (Fig 9 and Fig 10)

From these photos we could clearly see the pattern of gorse growing where fires have been more recently with the bush regenerating through older gorse area. The regenerating bush is clearly in the damper gullies and on the southern facing slopes. Aspect and thus the amount of solar radiation to dry the area would seem to underlie the greater fire hazard on these northern slopes.

Figure 8

Aerial Photo Showing the Study Area

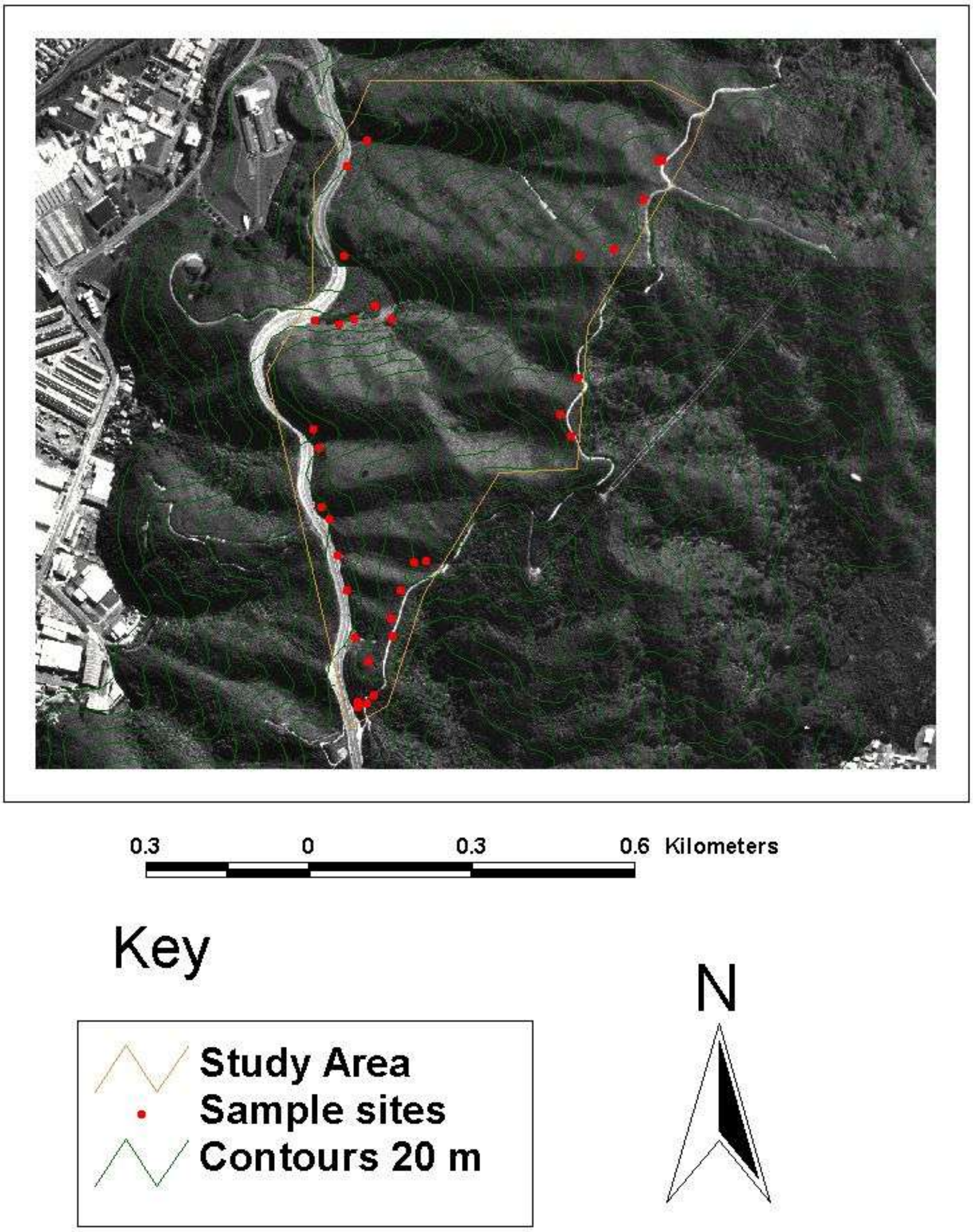


Figure 9

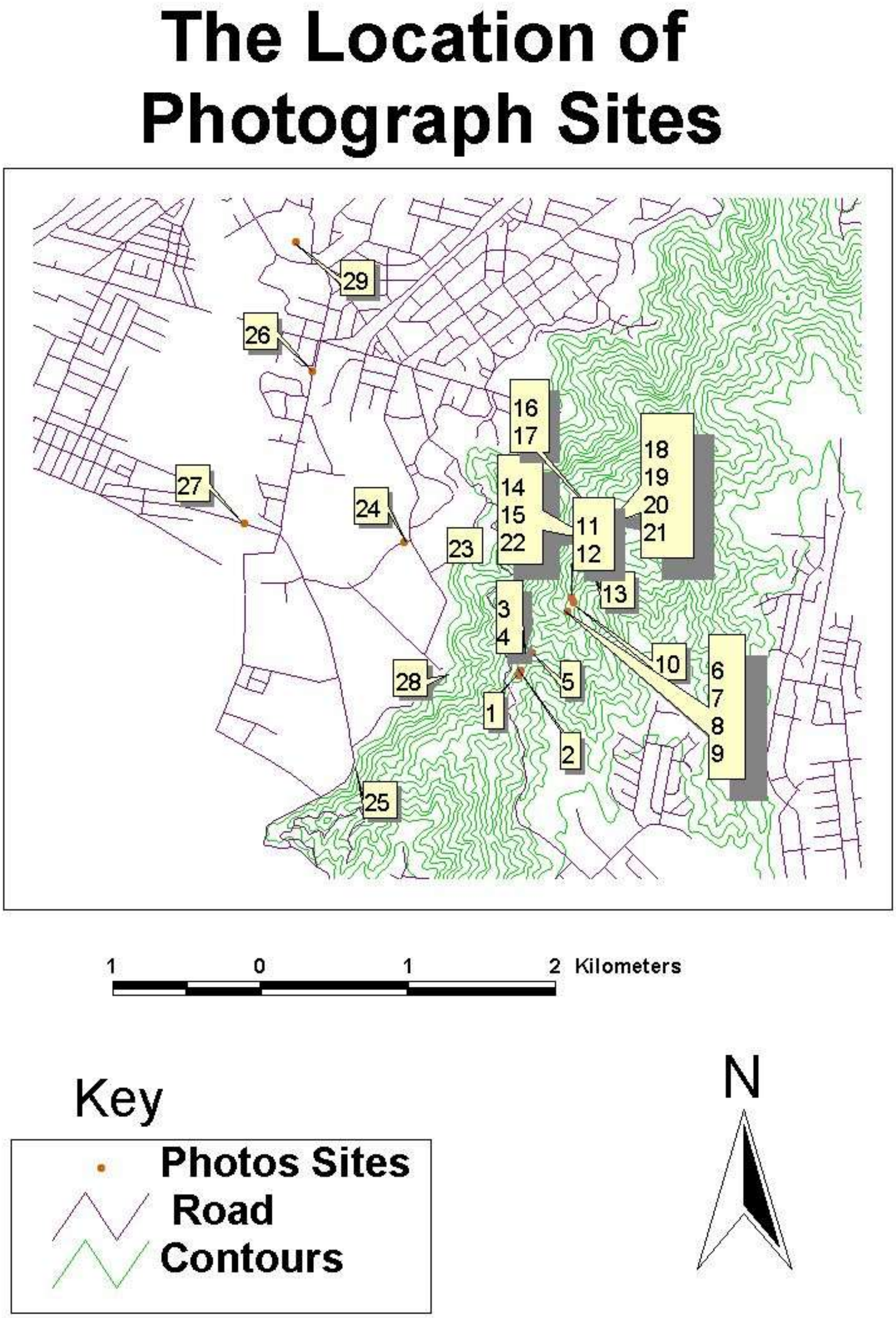
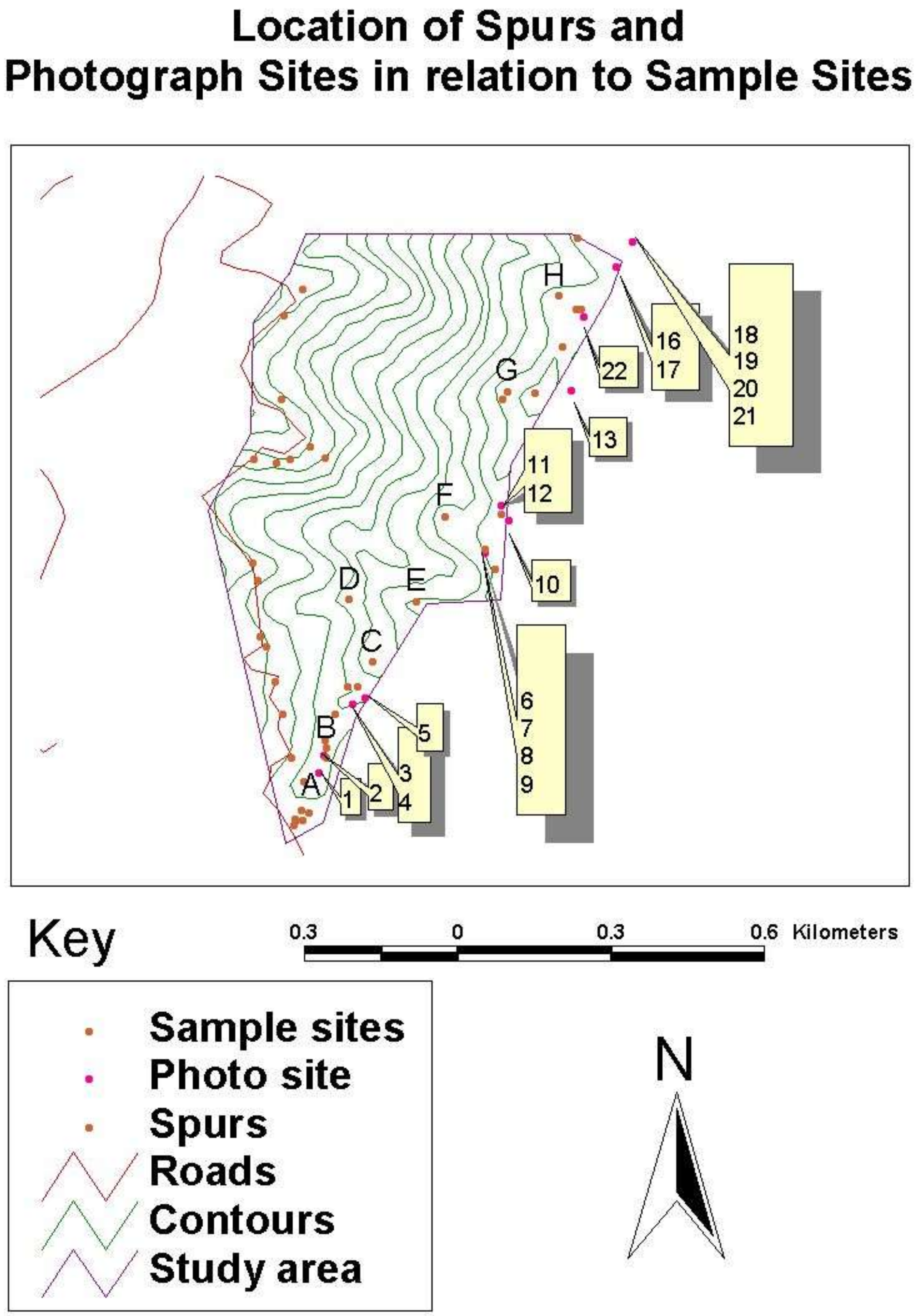

The Location of Photograph Sites
29
26
16
17
18
19
20
21
27
24
14
15
22
11
12
23
13
3
4
10
6
7
8
9
28
5
1
2
25
1
0
1
2 Kilometers
Key
Photos Sites
Road
Contours
N

Figure 10


Location of Spurs and
Photograph Sites in relation to Sample Sites
A
B
C
D
E
F
G
H
1
2
3
4
5
6
7
8
9
10
11
12
13
16
17
18
19
20
21
22
Key
0.3
0
0.3
0.6 Kilometers
Sample sites
Photo site
Spurs
Roads
Contours
Study area
N

North **South**

Looking East at the spurs from the Eastern Hills adjacent to the Wainuiomata Hill Road

Spur A

This site has evidence of at least two burns, with older gorse just over the ridge on the Wainuiomata (east) side

Southern aspect. However steep face and closeness to the road is hindering bush regrowth to the road has

Spur B

Northern aspect. Gorse with some manuka

Spur C

Southern aspect – bush regeneration beginning. Closeness to road has increased

Fires. It was noticeable that the gorse increased in age and there was more bush regeneration on the spurs further north along the ridge.

Northern aspect – Note gorse with fire edge along stream bed

Spur D

South aspect

North aspect

Bush is regenerating in the gully between spur C and D. A fire has burnt over the ridge onto the northern side but there is clear line where the bush is regenerating on the damper side. On the far right in the gully between D and E regenerating bush can be seen.

Spur E

Southern aspect

Note bush to south and gorse to north. Regeneration in gullies can also be seen.

Northern aspect

Spurs F,G and H could not be seen from the top

Spur H; Towai 348 metres

Top of Spur H

Gorse on west, bush on east

North aspect of spur H

Spur I

South aspect

North aspect

Northern limit of study

Table 2 Table of Site Data

Eastings	Northing	height	diameter (cm)	Age by ring numbers	Predicted biomass (t/ha)	Predicted date of last fire
2671128	5994894		0.9	3		1997
2671137	5995019	152.90	1.2	3	57.8	1997
2671178	5994195		2.1	3		1997
2671156	5994317	174.00	2.4	4	65.2	1996
2671267	5994456	140.00	2.5	4	54	1996
2671554	5994687		3	4		1996
2671634	5995031	110.00	4.5	4	42.7	1996
2671163	5994199	188.60	2.4	4.25	68.9	1996
2671128	5994894	158.00	2.2	5	57.8	1995
2671178	5994195	190.90	2.4	5	72.7	1995
2671142	5995184	190.90	3.3	5	72.7	1995
2671109	5994535		3.5	5		1995
2671126	5994467	169.00	3.7	5	65.2	1995
2671180	5995233	300.00	2.4	6	113.3	1994
2671083	5994901	207.00	4.3	6	83.8	1994
2671181	5994271	146.10	3.6	7	57.8	1993
2671567	5994795		4	7		1993
2671154	5994903	194.00	5	7	72.7	1993
2671567	5994795	190.00	5	7	72.7	1993
2671141	5994403	281.00	5.8	8	105.9	1992
2671161	5994187	291.60	5.8	8	109.6	1992
2671270	5991270	140.00	6	8	54	1992
2671192	5994211	282.90	6.4	8	105.9	1992
2671194	5994927	212.90	7.3	8	80.1	1992
2671554	5994687	225.00	8	8	87.5	1992
2671224	5994352	157.60	3.4	9	57.8	1991
2671081	5994700	209.00	3.9	9	80.1	1991
2671095	5994556	190.00	4.3	9	72.7	1991
2671180	5995233		6.8	9		1991
2671571	5995019	179.00	5	11	68.9	1989
2671226	5994318	224.30	5.8	11	83.8	1989
2671536	5994727	182.00	6	12	68.9	1988
2671165	5994194	196.90	6.4	13	76.4	1987
2671715	5995194	182.00	4	14	68.9	1986
2671688	5995122	204.60	6.5	14	76.4	1986
2671224	5994352		20.4	15		1985
2671109	5994535	220.00	8.2	5 from heart	83.8	1995
2671142	5995184		1			
2671156	5994317		2			
2671224	5994904	193.90	2		72.7	
2671224	5994904		2			
2671242	5994403		2.1			
2671137	5995019		2.2			
2671163	5994199		2.2			
2671083	5994901		2.3			
2671090	5994665	187.00	2.4		72.7	
2671267	5994456		2.5			
2671688	5995122		3.5			
2671242	5994403	188.40	3.6		68.9	
2671634	5995031		4.5			
2671226	5994318		6			
2671287	5994458	173.00	12		65.2	
2671181	5994271		13			
2671571	5995019					

Note: 1. Where there is more than one sample at a site the average canopy heught was measured.
2. Where ring count is missing the sample was not able to be counted.

Figure 11

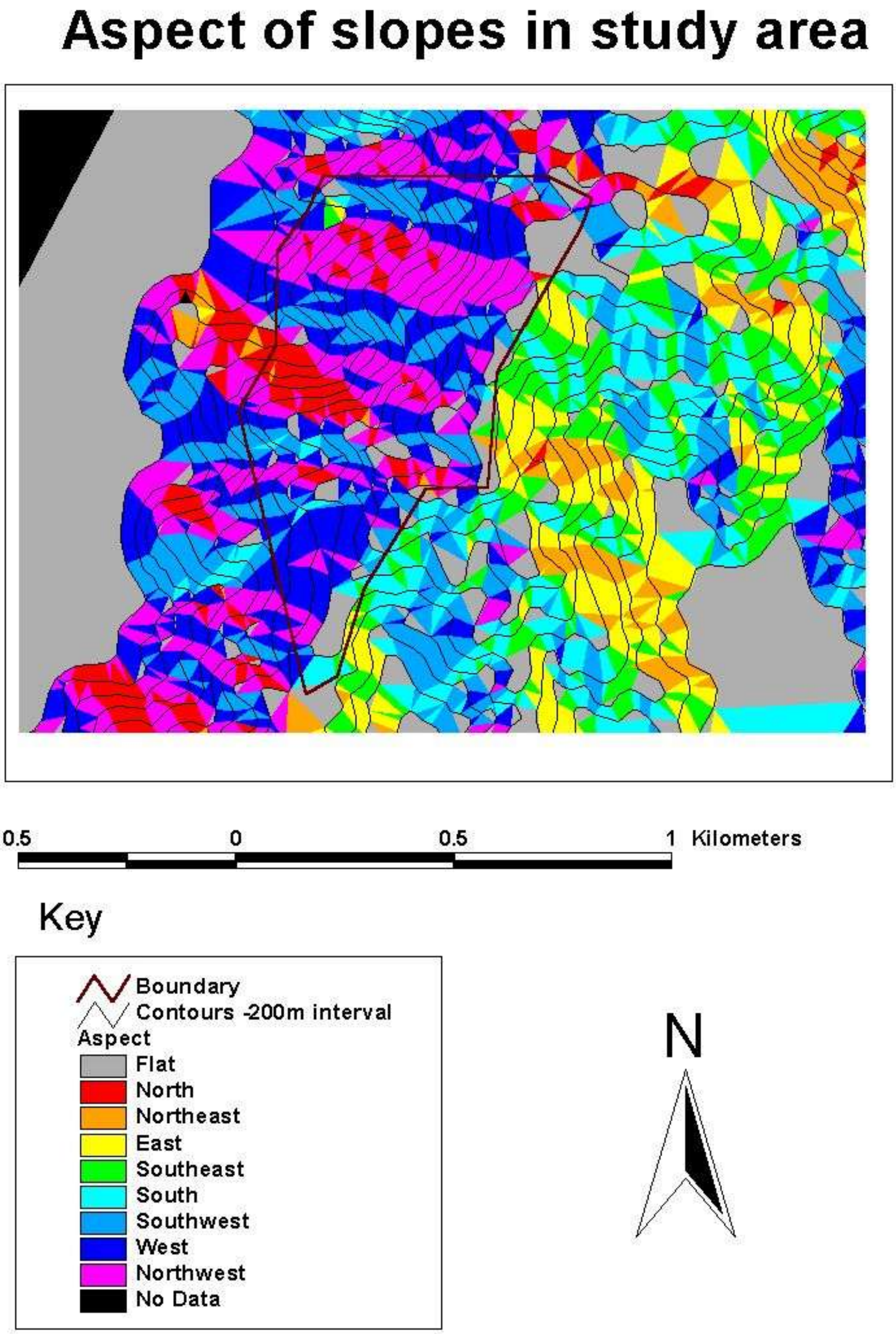

Aspect of slopes in study area
0.5
0
0.5
1 Kilometers
Key
Boundary
Contours -200m interval
Aspect
Flat
North
Northeast
East
Southeast
South
Southwest
West
Northwest
No Data
N

Figure 12

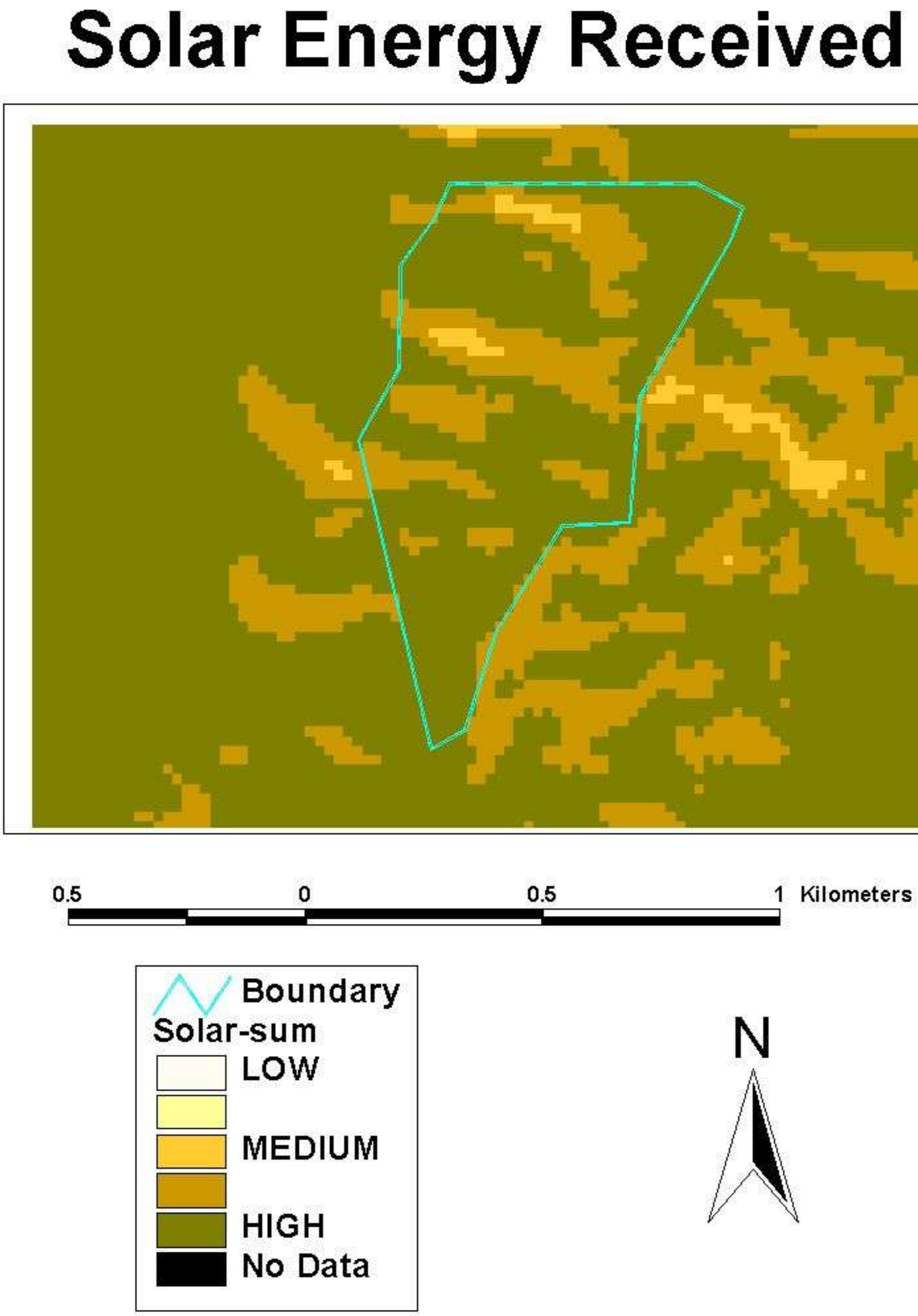
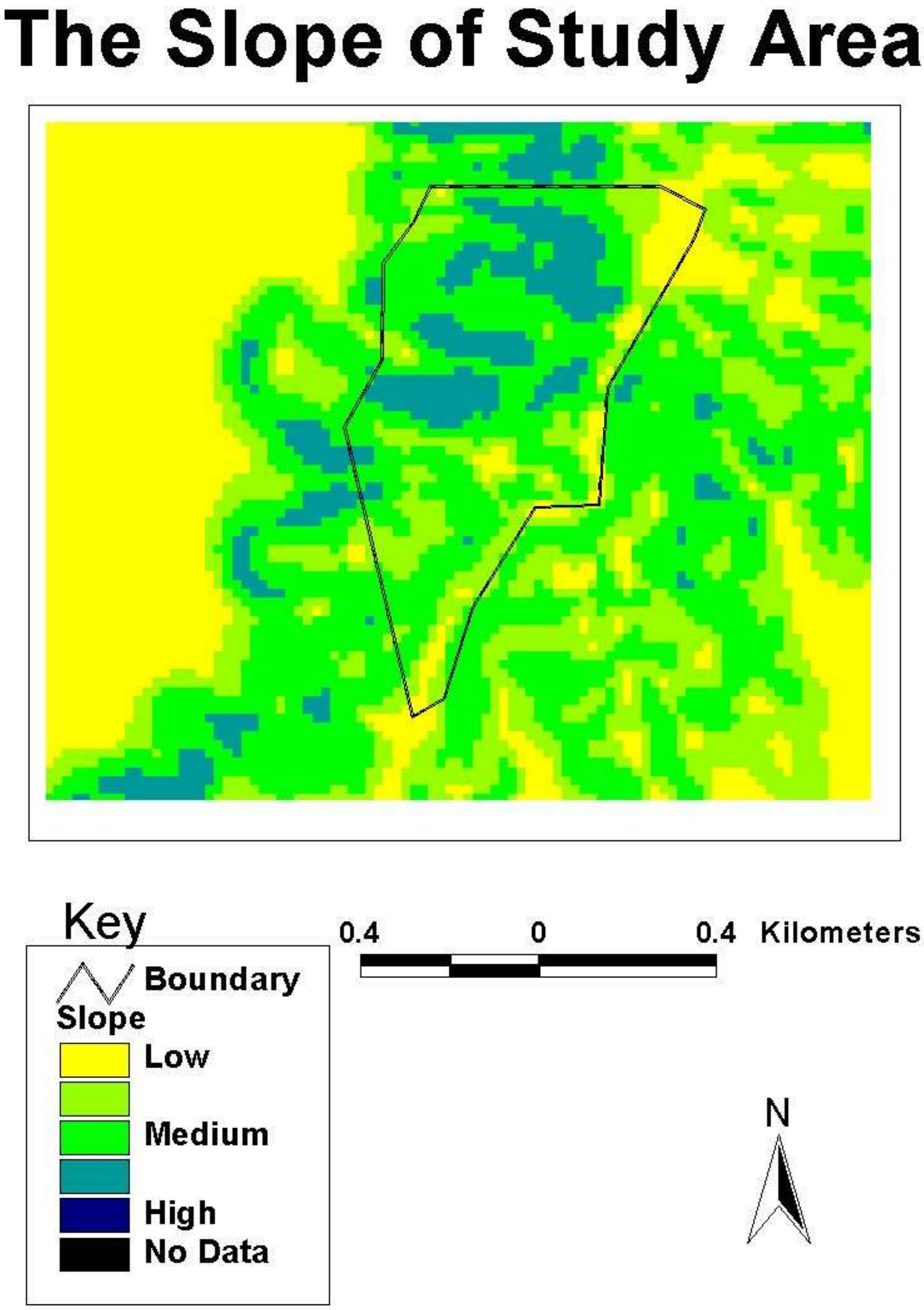
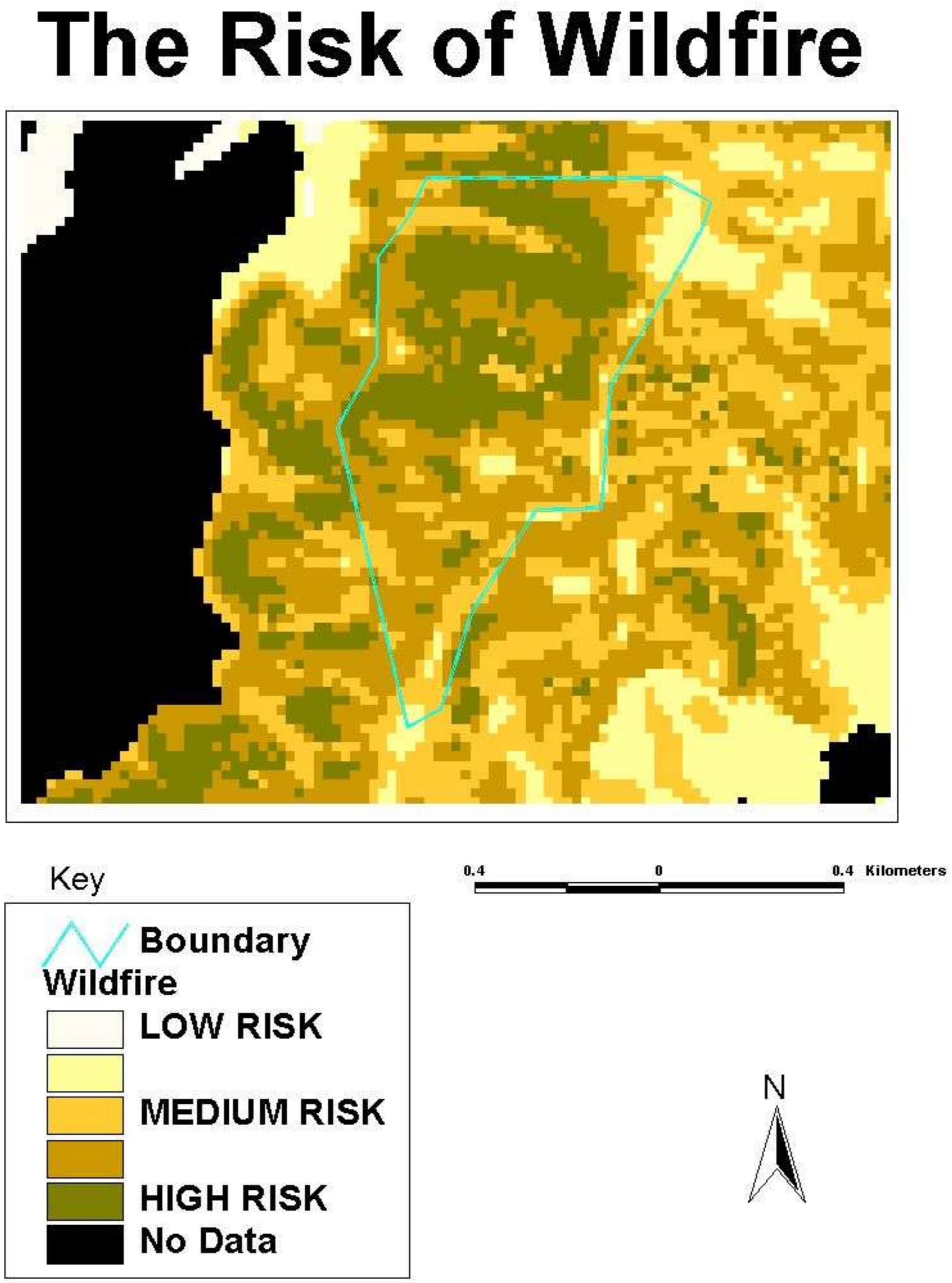

Solar Energy Received
0.5
0
0.5
1 Kilometers
Boundary
Solar-sum
LOW
MEDIUM
HIGH
No Data
N

Figure 13



The Slope of Study Area
Key
Boundary
Slope
Low
Medium
High
No Data
0.4
0
0.4
Kilometers
N

Figure 14


The Risk of Wildfire
Key
Boundary
Wildfire
LOW RISK
MEDIUM RISK
HIGH RISK
No Data
0.4
0
0.4 Kilometers
N

Analysis

The wildfire map produced by the Wellington Regional Council classifies all our study area as an extreme risk area. At the scale of this study this is clearly true. The area is predominately gorse, highly inflammable vegetation. However fire fighting is done literally at the gorse roots and at this scale a more varied and complex pattern of risk emerges

Our fieldwork, photo studies and mapping gave us several different types data.

We used visual observation of the photos and maps to observe patterns. On the computer we made several tables to compare the GPS position of the gorse to its height and diameter, and to compare the age of the gorse to its predicted biomass (see Table 2).

We used the digital topographic data to map the gullies and Spurs. We discovered that there are no permanent streams so created a layer to show the watercourses. (Figure 5) These were buffered at 20 metres to show the damper areas which are now all regenerating bush; species such as manuka, five finger, whitey wood, koromiko. (Figure 15) A layer was also created from our photo study to show the extent of the regenerating bush. (Figure 16). These two layers were combined to show our estimate of the area where bush is regenerating and the areas that still have gorse and therefore fire controlled. (Figure 17)The age and biomass at our sample sites were overlayed. (Figure 18 andFigure 19) The most obvious pattern is the mix of ages in some areas ie Spur A. From our estimate of when the last fires were in this area, along with observation and the fire record we know this area has had a number of burns. Its location at a parking area and the beginning of the ridge access track probably explains this. We also noted how some of the older samples are located close to regenerating bush.

Our estimate of fire ages was checked against the fire records from the Wainuiomata Bush Force. This data was obtained as pages photocopied from the minutes of the Annual meetings. We entered this data and then sorted it and extracted fires that mentioned the Wainuiomata Hill. (Table 1). While it was possible to eliminate two fires as being outside our area, only one fire (Towai) could be positively identified. The date of this fire matched our sample date 1996. The only fire with a grid reference was probably across the road from our first Spur. While other dates could not be matched our calculated dates and the record dates where in the same general range. We plan at a later date to map all the Wainuiomata Bush Force records for them as a thank you for their help and as a contribution to their work protecting our city.

Figure 15

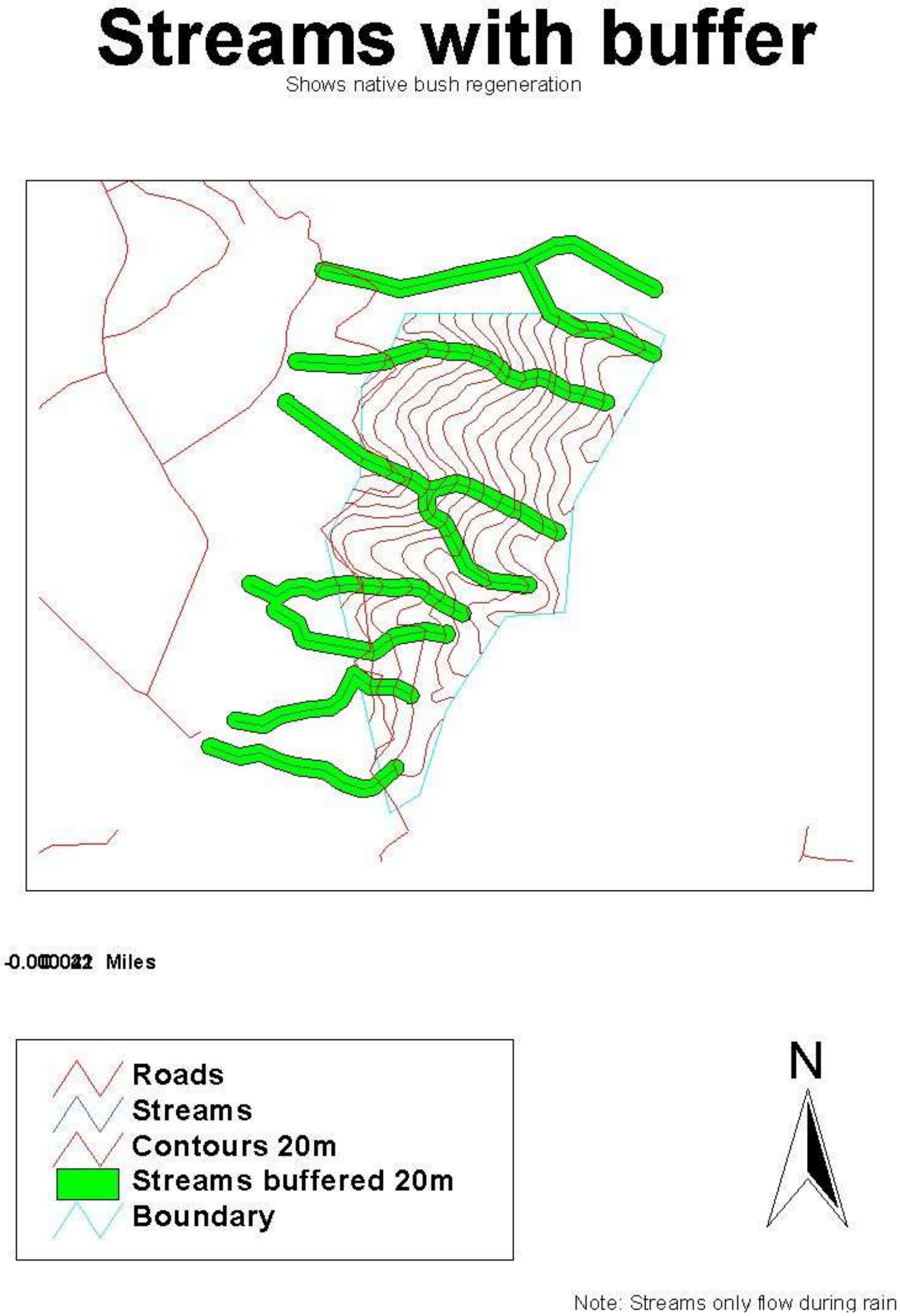

Streams with buffer
Shows native bush regeneration
Miles
Roads
Streams
Contours 20m
Streams buffered 20m
Boundary
N
Note: Streams only flow during rain

Figure 16

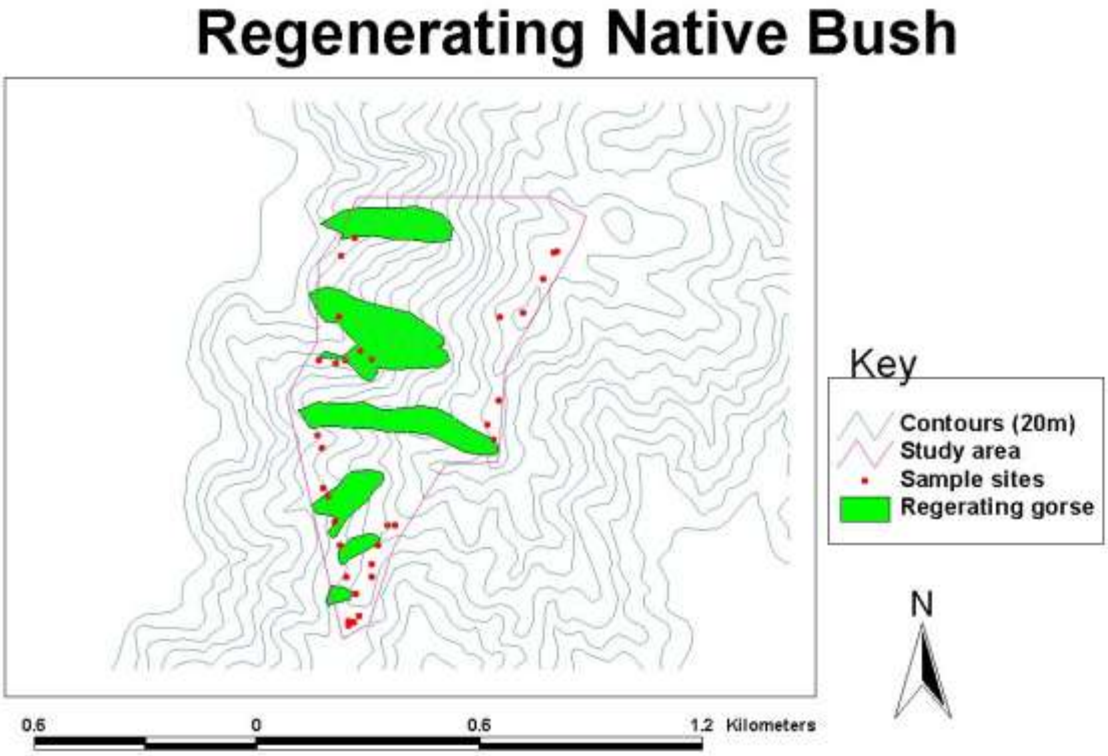

Regenerating Native Bush
Key
Contours (20m)
Study area
Sample sites
Regerating gorse
N
0.6
0
0.6
1.2 Kilometers

Figure 17

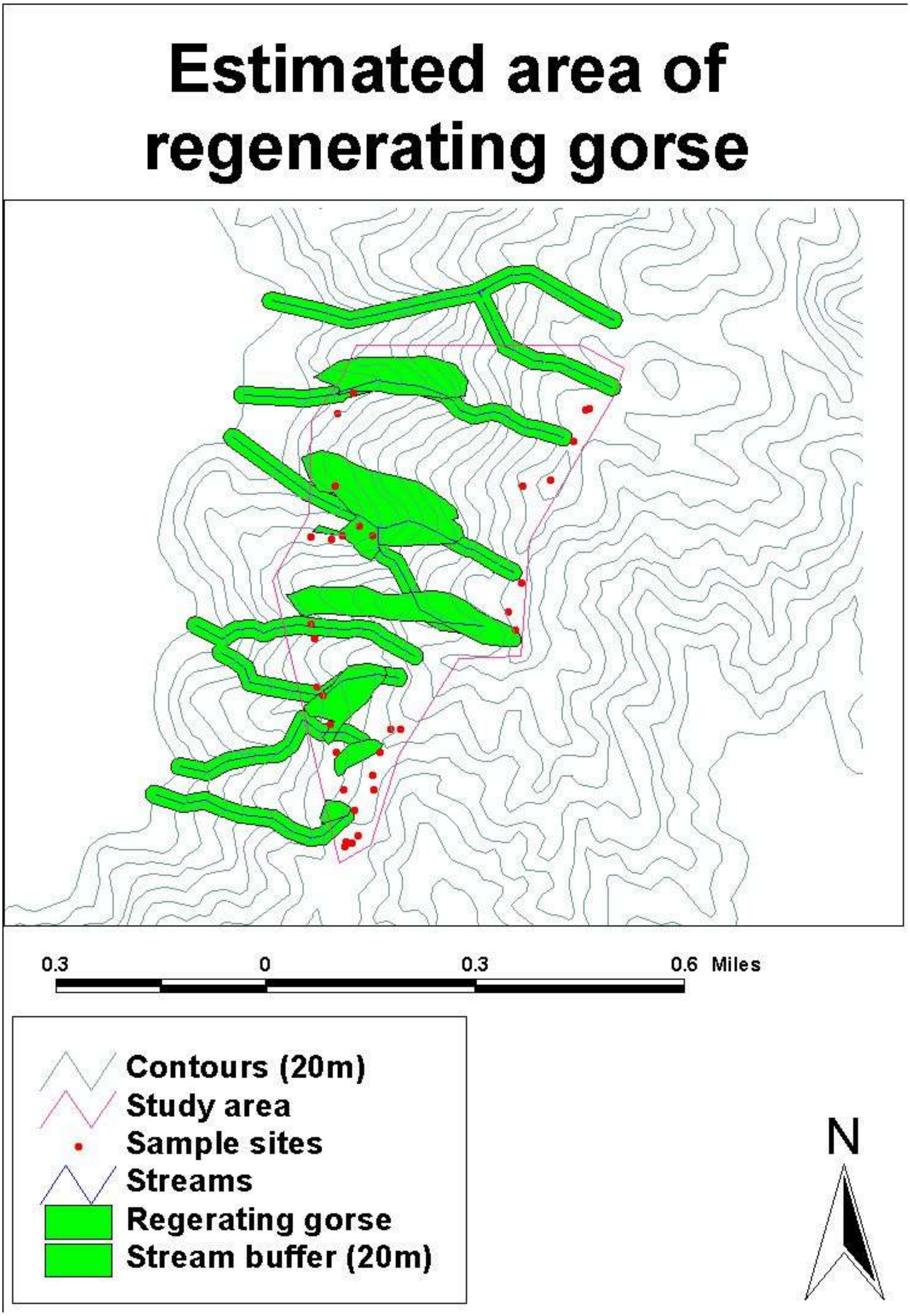

Estimated area of regenerating gorse
0.3
0
0.3
0.6 Miles
Contours (20m)
Study area
Sample sites
Streams
Regerating gorse
Stream buffer (20m)
N

Figure 18

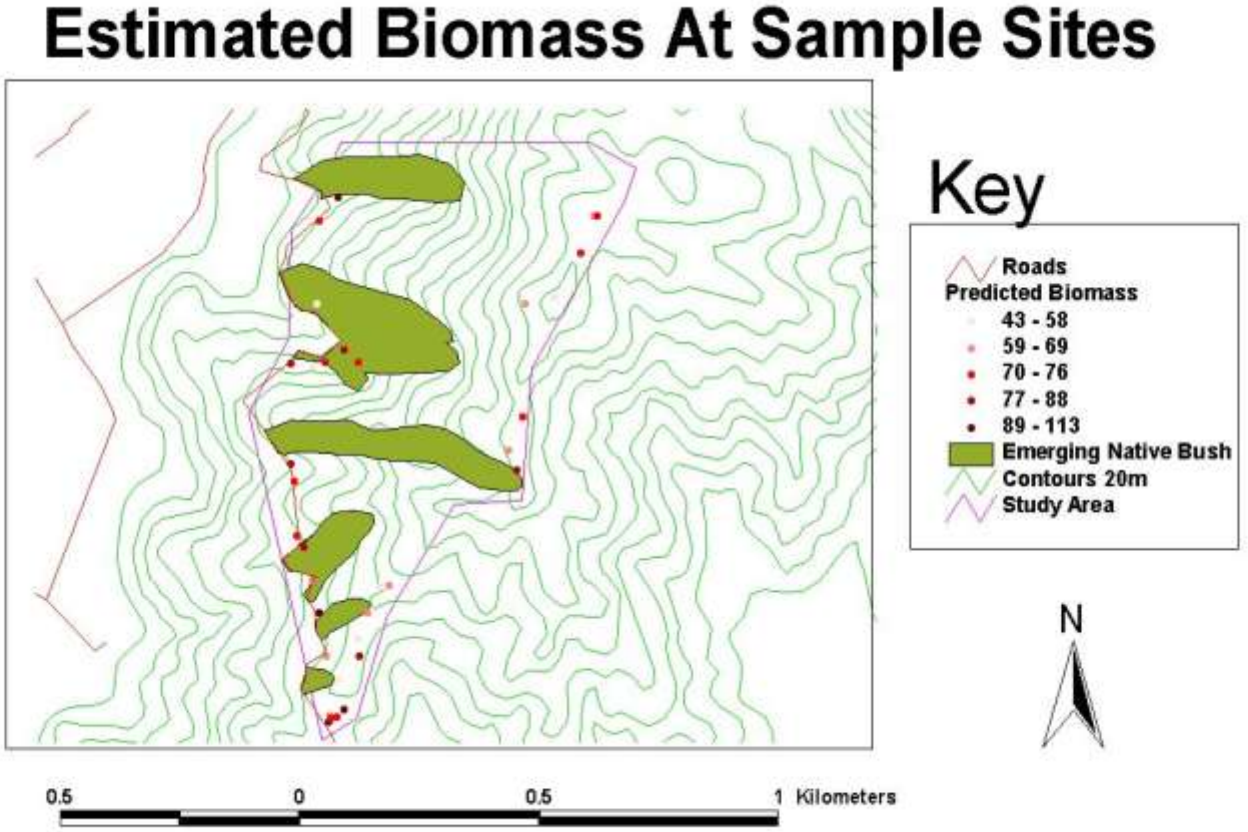
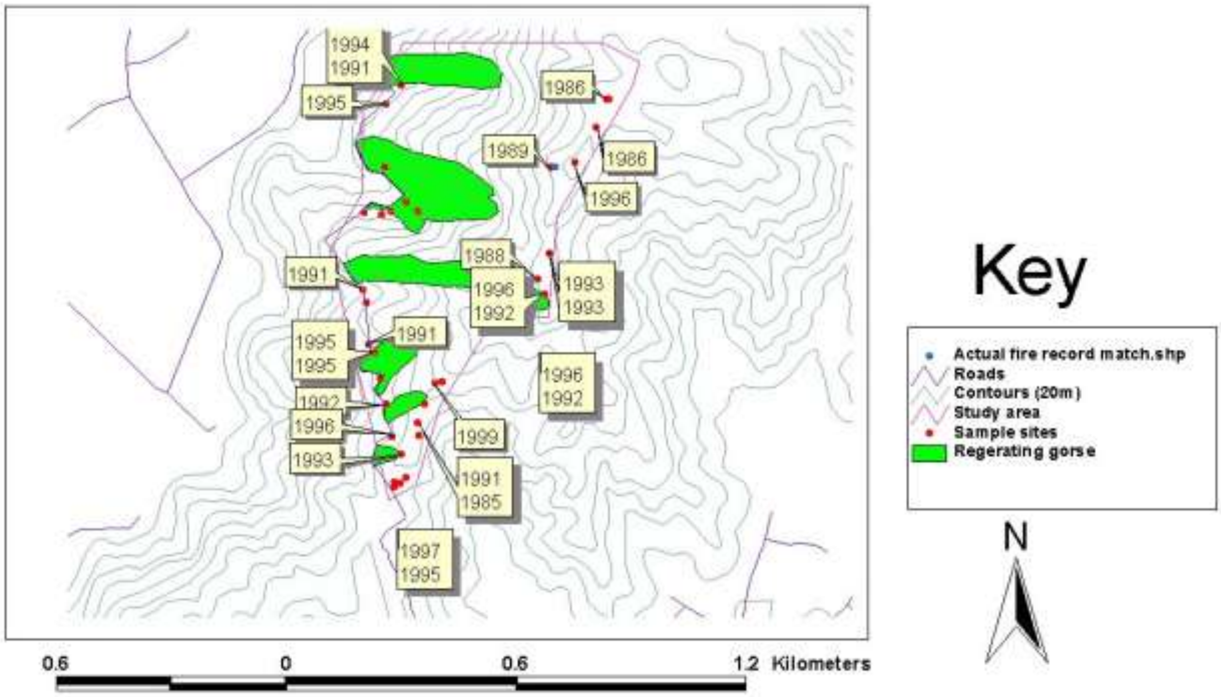

Estimated Biomass At Sample Sites
Key
Roads
Predicted Biomass
43 - 58
59 - 69
70 - 76
77 - 88
89 - 113
Emerging Native Bush
Contours 20m
Study Area
N
0.5
0
0.5
1 Kilometers

Figure 19

Estimated years of The Last Fire At Sample sites



To determine if there was a link between the biomass, slope, aspect and age of the gorse and its fire risk, we made a table (Table 2, p32) to compare these factors.

One method used to see if there was a relationship was to do simple correlation analysis using Excel to see if there was a relationship between the measured diameter and age (a check on our measuring) and between our estimated age and biomass. The biomass calculation is based on height and we thought there should be a correlation with our estimated age. These are graphed at Fig 20 and Fig 21.

Correlation results

Factors	**Correlation coefficient**
Relationship between measured diameter and ring count	**0.67**
Relationship between ring count and calculated biomass	**0.24**

The correlation between measured diameter and ring count showed a reasonable correlation, which showed that our measuring was reasonably accurate. However the relationship between ring count and calculated biomass was low. We are not sure whether this is a result of our measuring or that calculating biomass from height alone is inadequate.

Another comparison method was to use Model Builder (Fig 22) to create weighted grids which would compare slope and aspect. The basic grid data we used was from the Wellington Regional Council. For each factor ranking scores had been given to the lowest to highest hazard categories. For example slope was calculated from the contours areas with a slope of over 35° where scored as 5 while flat areas scored 0°. (Wellington Regional Council, 1998 p20) These ranks can then be added to create a map combining two factors such as slope and aspect. The ranks can also be weighted to see if one factors is more important than the other. We compared the two different factors on several different maps, each time changing the weighting of each factor. i.e. one of the maps we created was when slope was at 10% and aspect was at 90%. The aspect map is created with classes that cover the 360° of the compass. To explore our hypothesis that slope and a northerly aspect would be factors influencing fire risk we reclassified the data so that northerly and westerly facing slopes had a higher score (6-8). We also experimented with creating a weighted overlay using solar-radiation data (from Wellington Regional Council) and slope. (Fig 28 -30) The solar radiation data was developed using aspect and sunshine hours data. (see Wellington Regional Council. *Rural Fire Hazard in the Wellington Region*)

Ideally after making different versions of the same map, (each at various weightings of slope and aspect) we wanted to compare our results to the vegetation patterns from aerial photographs of our study site. However the aerial photos as mentioned were not of a high enough resolution so we used the photos we took from the site and draw in estimated boundaries showing the regenerating bush. This is far less accurate and if high resolution photos could be obtained actual fire boundaries could be drawn on as a theme and overlaid on the grid data.

The map that best matched our vegetation boundaries drawn from the photos would indicate which weighting was most appropriate and provide us with information about which factors caused the greatest fire risk. (Fig 23-Fig 27). We also overlaid the estimated vegetation data directly on the solar radiation and slope maps (Fig 31 and 31). Visually the vegetation pattern seems to relate to our observed patterns of areas of gorse. When we overlaid slope and our map of regenerating bush there was no clear pattern.

The most interesting grids are Fig 24 where aspect is 70% , slope 30% and Fig 25 where aspect and slope are each 50%. These give the best match with in the limitations of the data available. High resolution photos used with this method could improve the accuracy and the most appropriate mix of slope and aspect relating to fire hazard could be obtained.

Figure 20

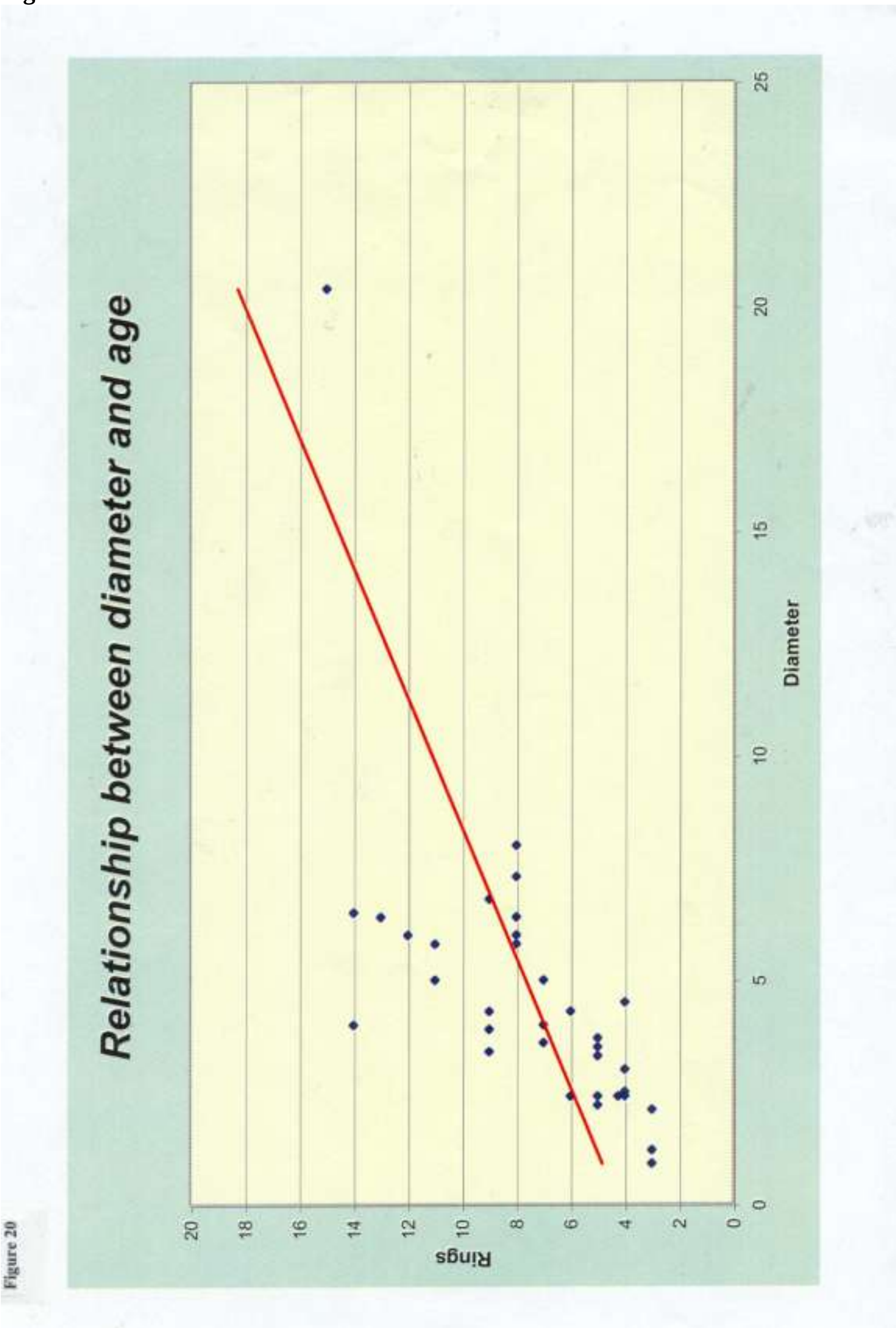
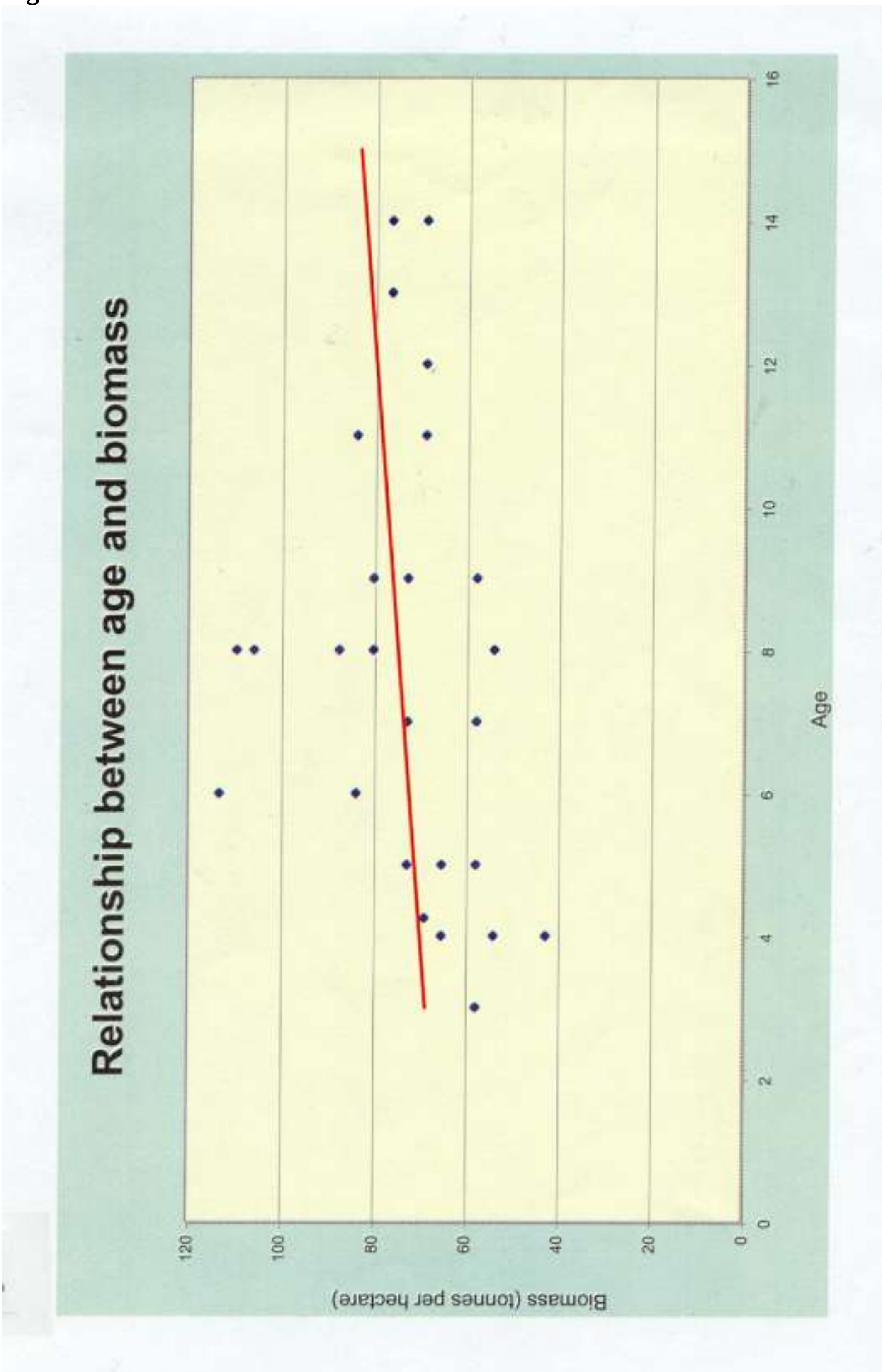


Figure 20
Relationship between diameter and age
Rings
Diameter
0
2
4
6
8
10
12
14
16
18
20
0
5
10
15
20
25

Figure 21



Relationship between age and biomass
Biomass (tonnes per hectare)
0
20
40
60
80
100
120
Age
0
2
4
6
8
10
12
14
16

Figure 22

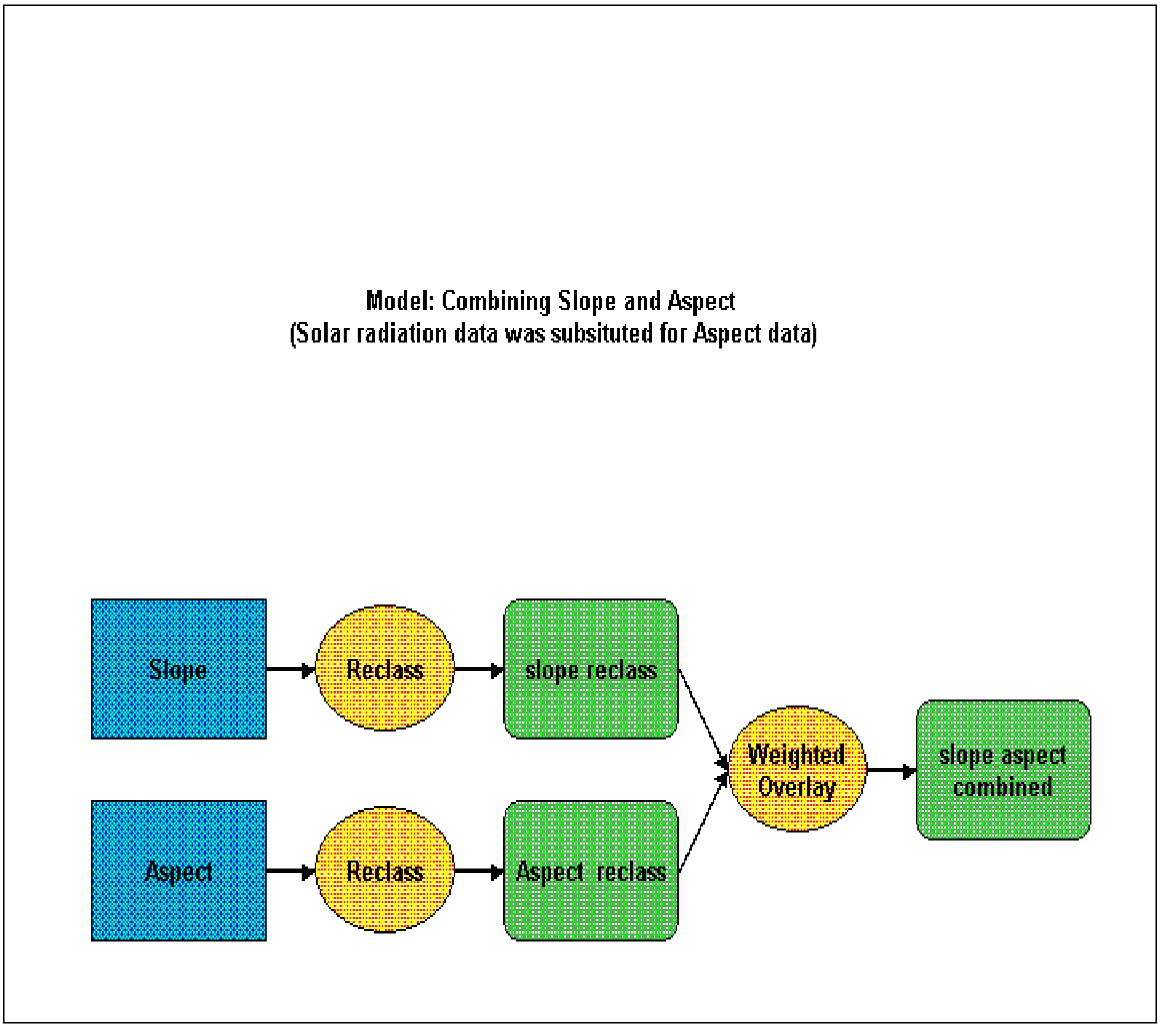
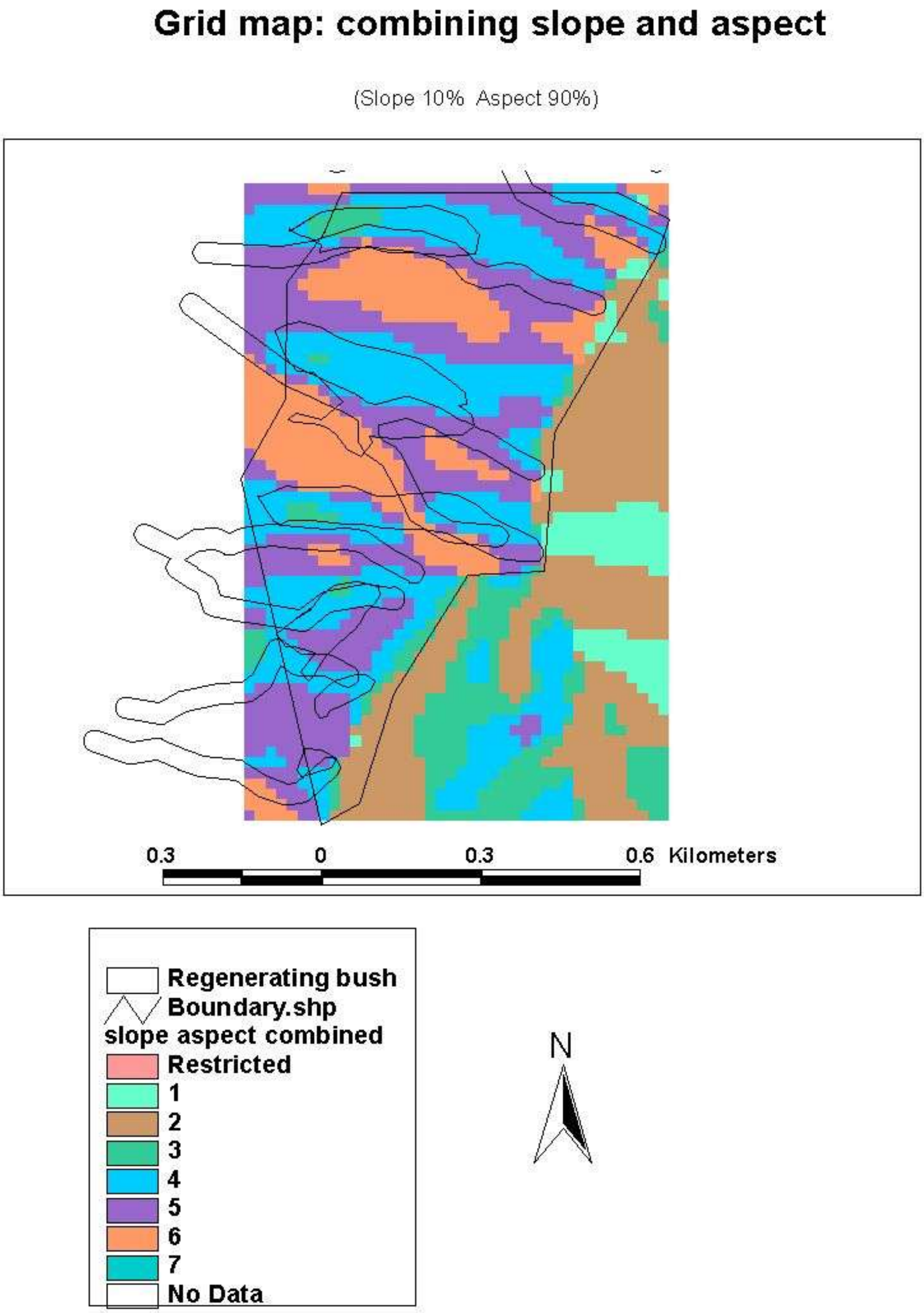

Model: Combining Slope and Aspect
(Solar radiation data was subsituted for Aspect data)
Slope
Reclass
slope reclass
Aspect
Reclass
Aspect reclass
Weighted Overlay
slope aspect combined

Figure 23



Grid map: combining slope and aspect
(Slope 10% Aspect 90%)
0.3 0 0.3 0.6 Kilometers
Regenerating bush
Boundary.shp
slope aspect combined
Restricted
1
2
3
4
5
6
7
No Data
N

Figure 24

Grid map: combining slope and aspect

(Slope 30% Aspect 70%)

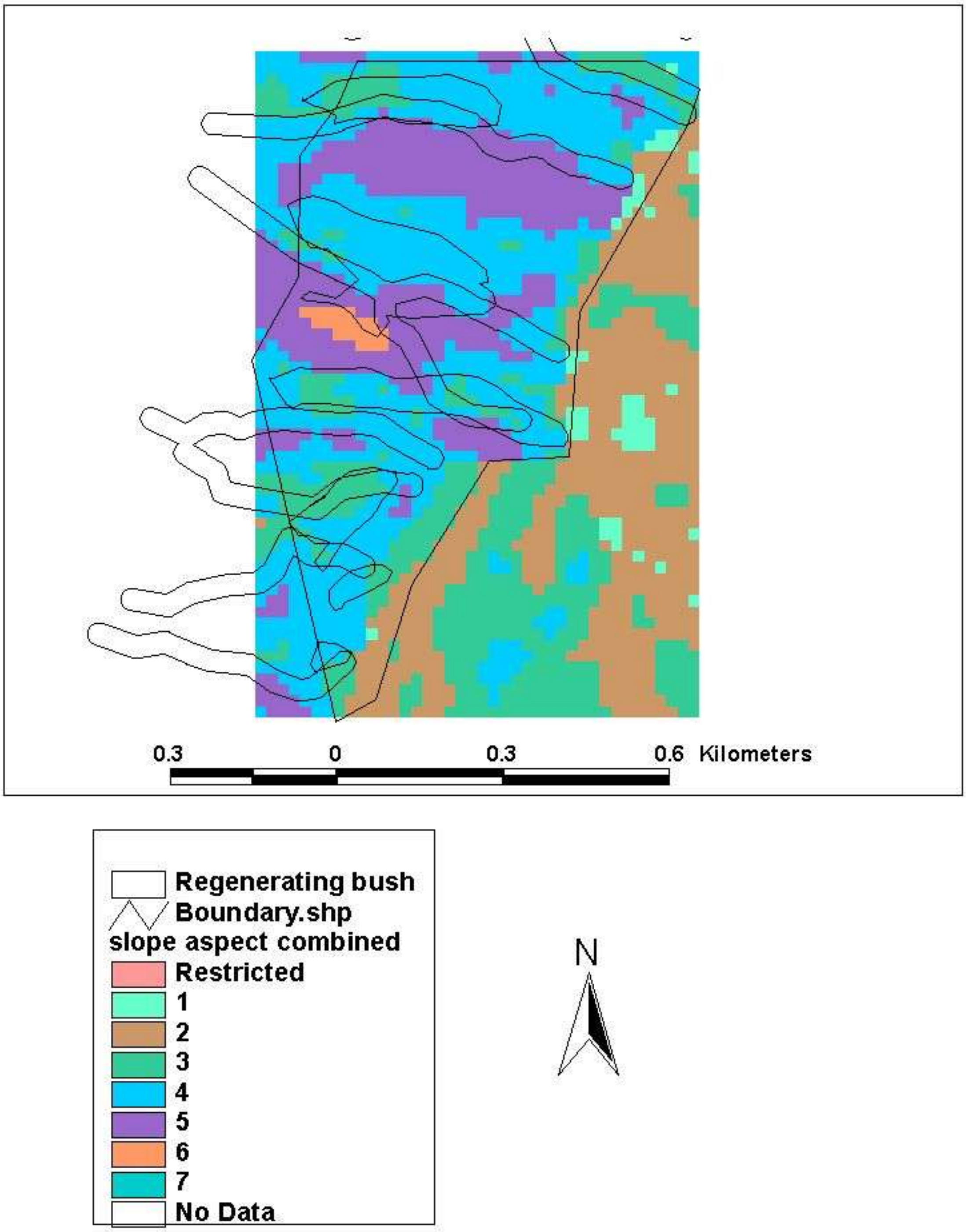


Figure 25

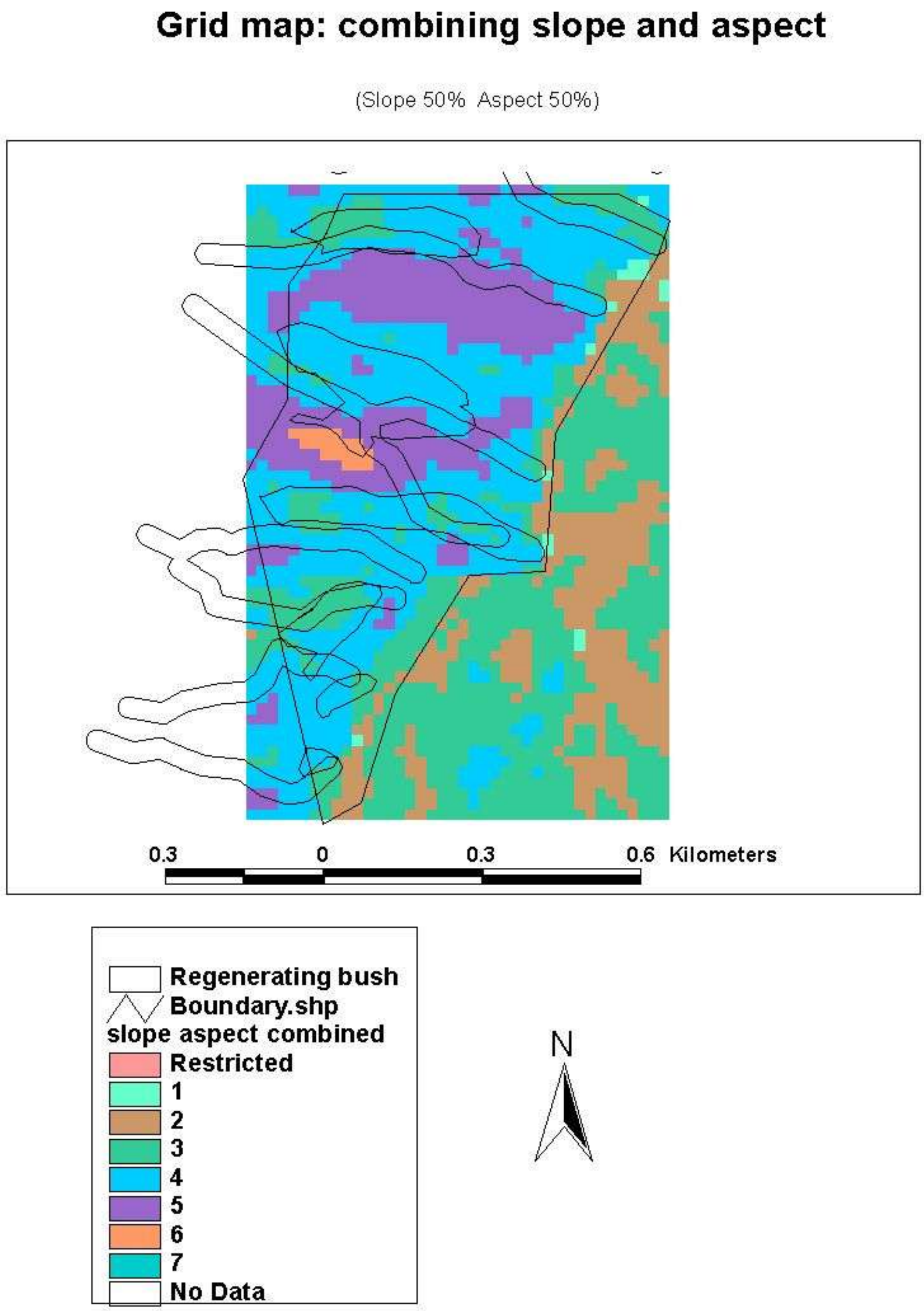

Grid map: combining slope and aspect
(Slope 50% Aspect 50%)
0.3
0
0.3
0.6 Kilometers
Regenerating bush
Boundary.shp
slope aspect combined
Restricted
1
2
3
4
5
6
7
No Data
N

Figure 26

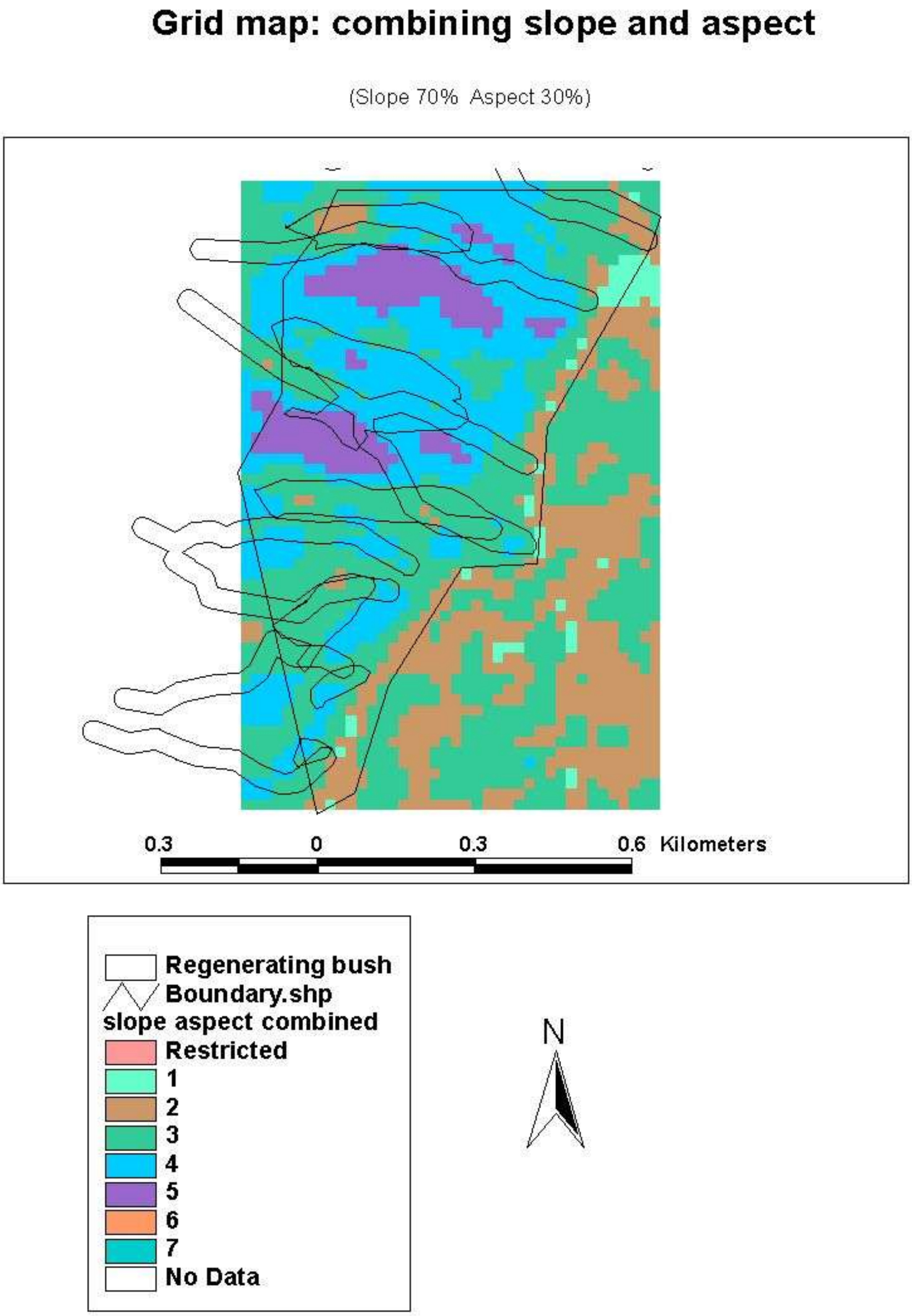

Grid map: combining slope and aspect
(Slope 70% Aspect 30%)
0.3
0
0.3
0.6 Kilometers
Regenerating bush
Boundary.shp
slope aspect combined
Restricted
1
2
3
4
5
6
7
No Data
N

Figure 27

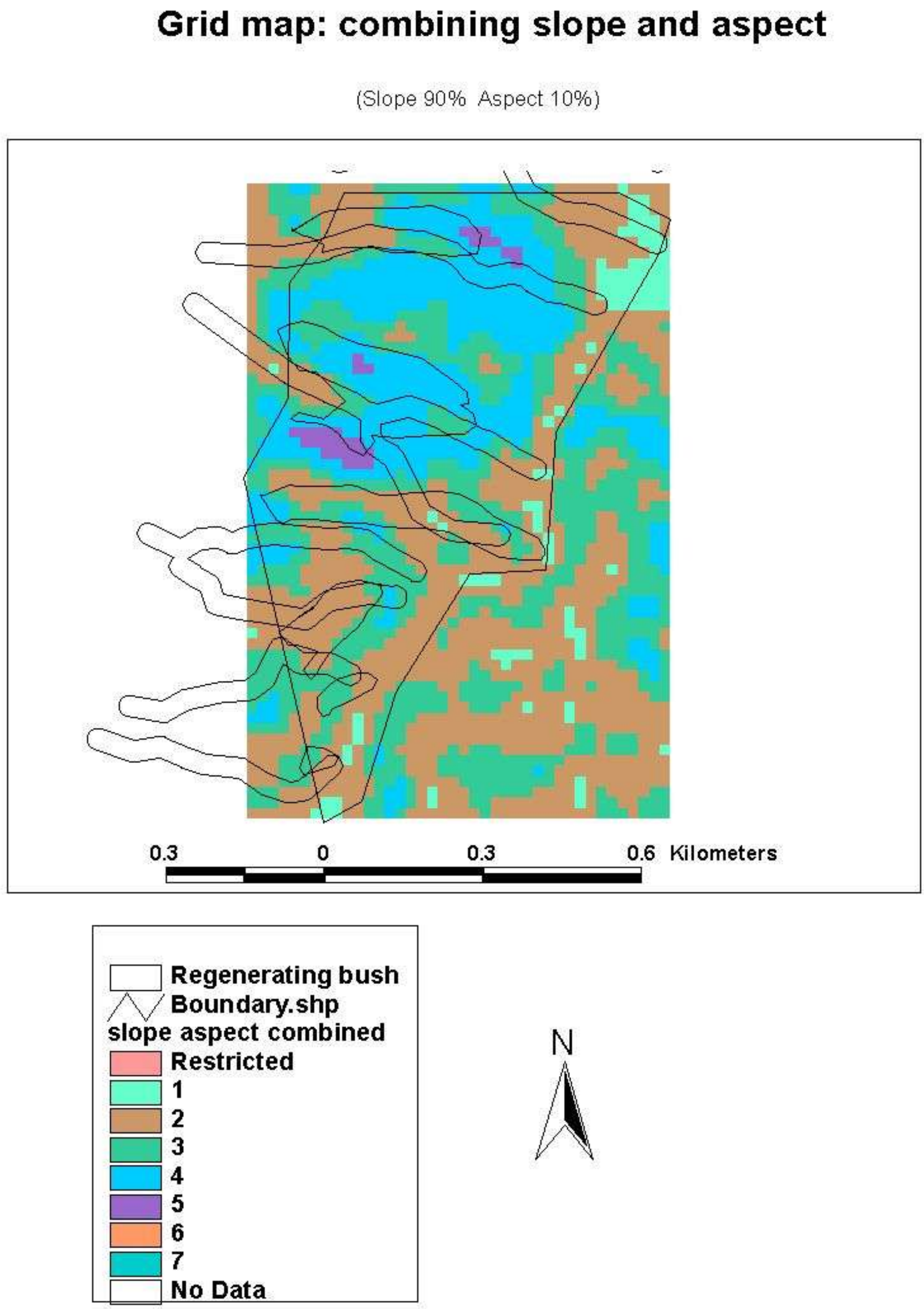

Grid map: combining slope and aspect
(Slope 90% Aspect 10%)
0.3
0
0.3
0.6 Kilometers
Regenerating bush
Boundary.shp
slope aspect combined
Restricted
1
2
3
4
5
6
7
No Data
N

Figure 28

Grid map: combining slope and solar energy

(Slope 10% Solar energy 90%)

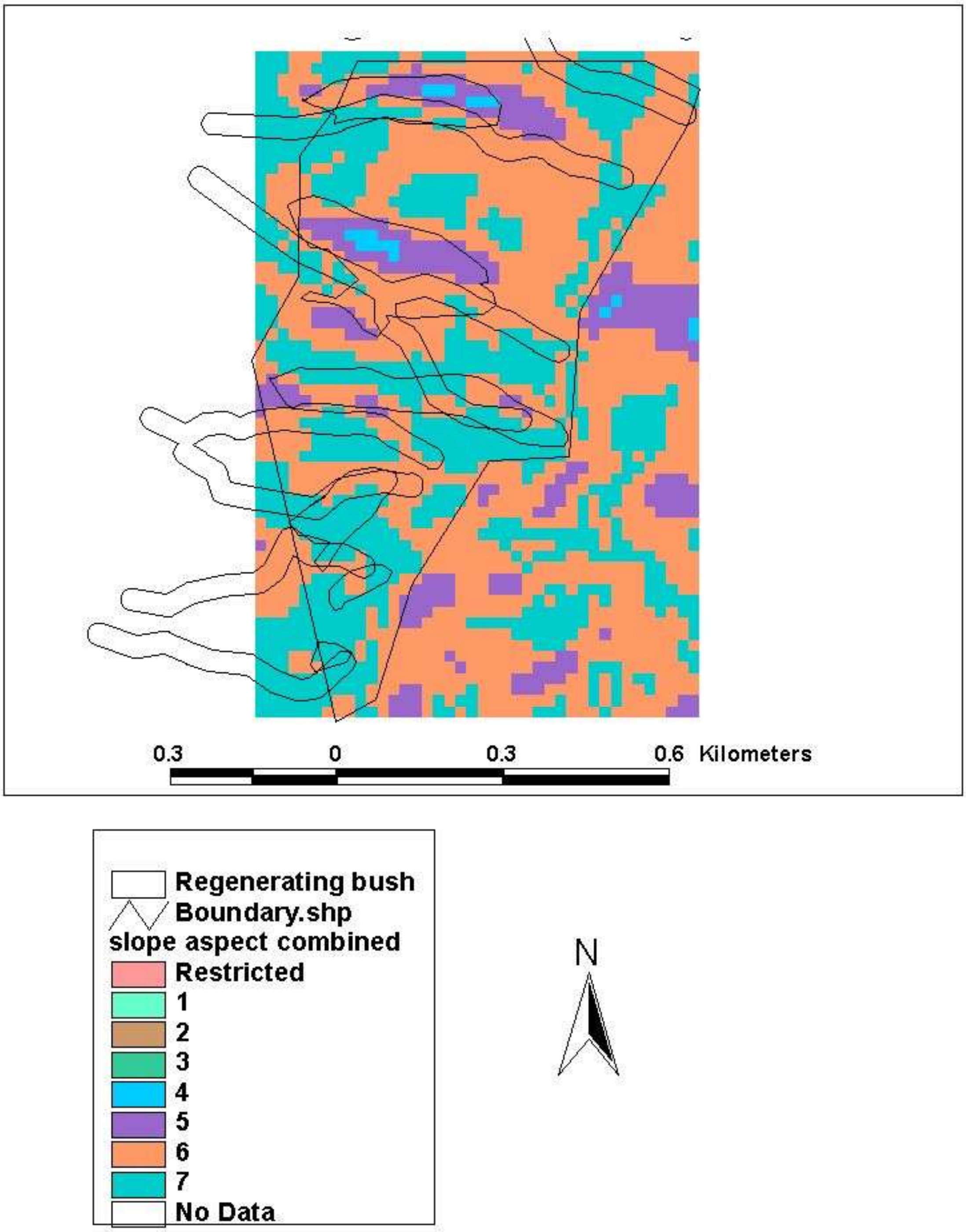


Figure 29

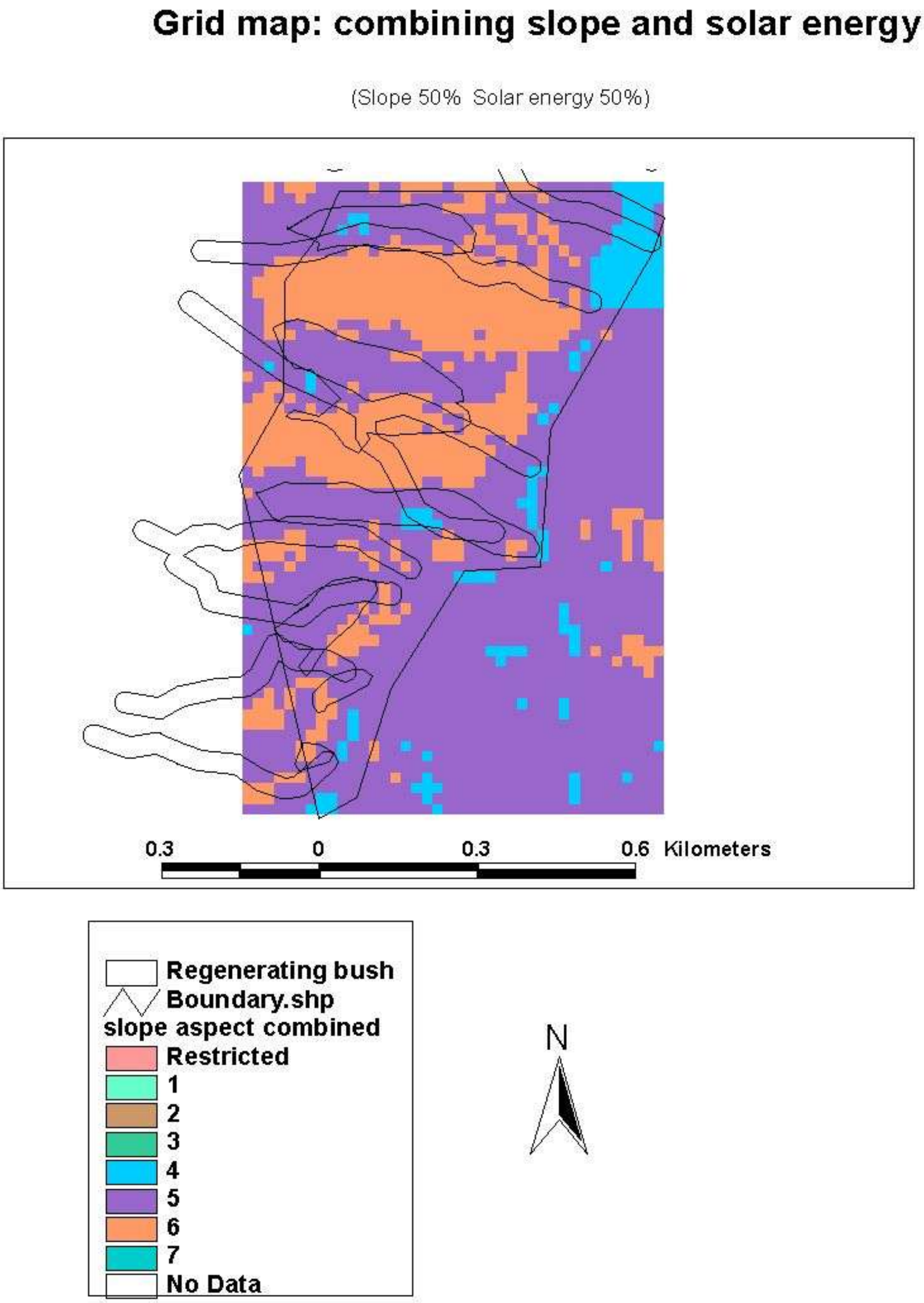
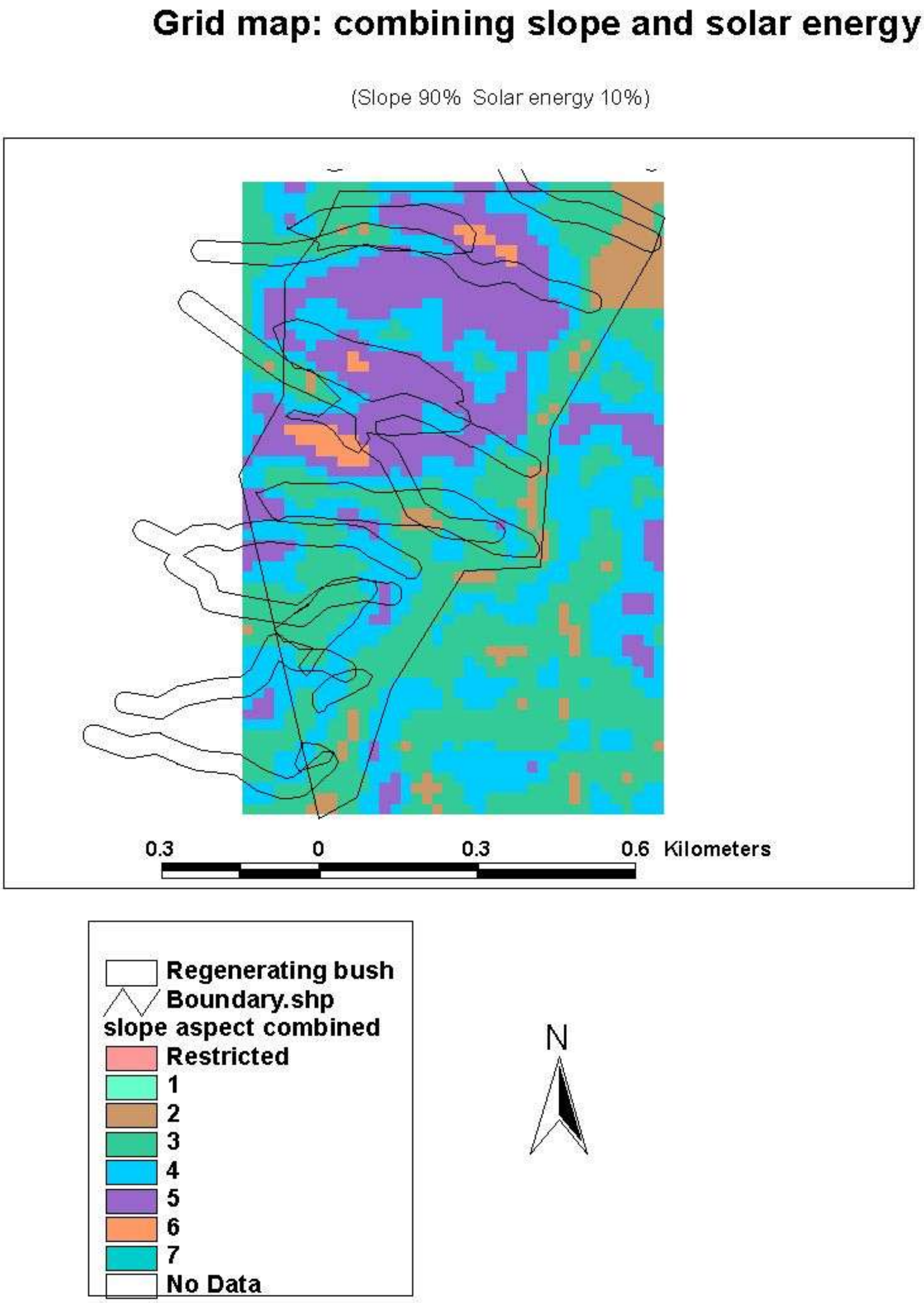

Grid map: combining slope and solar energy
(Slope 50% Solar energy 50%)
0.3 0 0.3 0.6 Kilometers
Regenerating bush
Boundary.shp
slope aspect combined
Restricted
1
2
3
4
5
6
7
No Data
N

Figure 30



Grid map: combining slope and solar energy
(Slope 90% Solar energy 10%)
0.3
0
0.3
0.6 Kilometers
Regenerating bush
Boundary.shp
slope aspect combined
Restricted
1
2
3
4
5
6
7
No Data
N

Figure 31

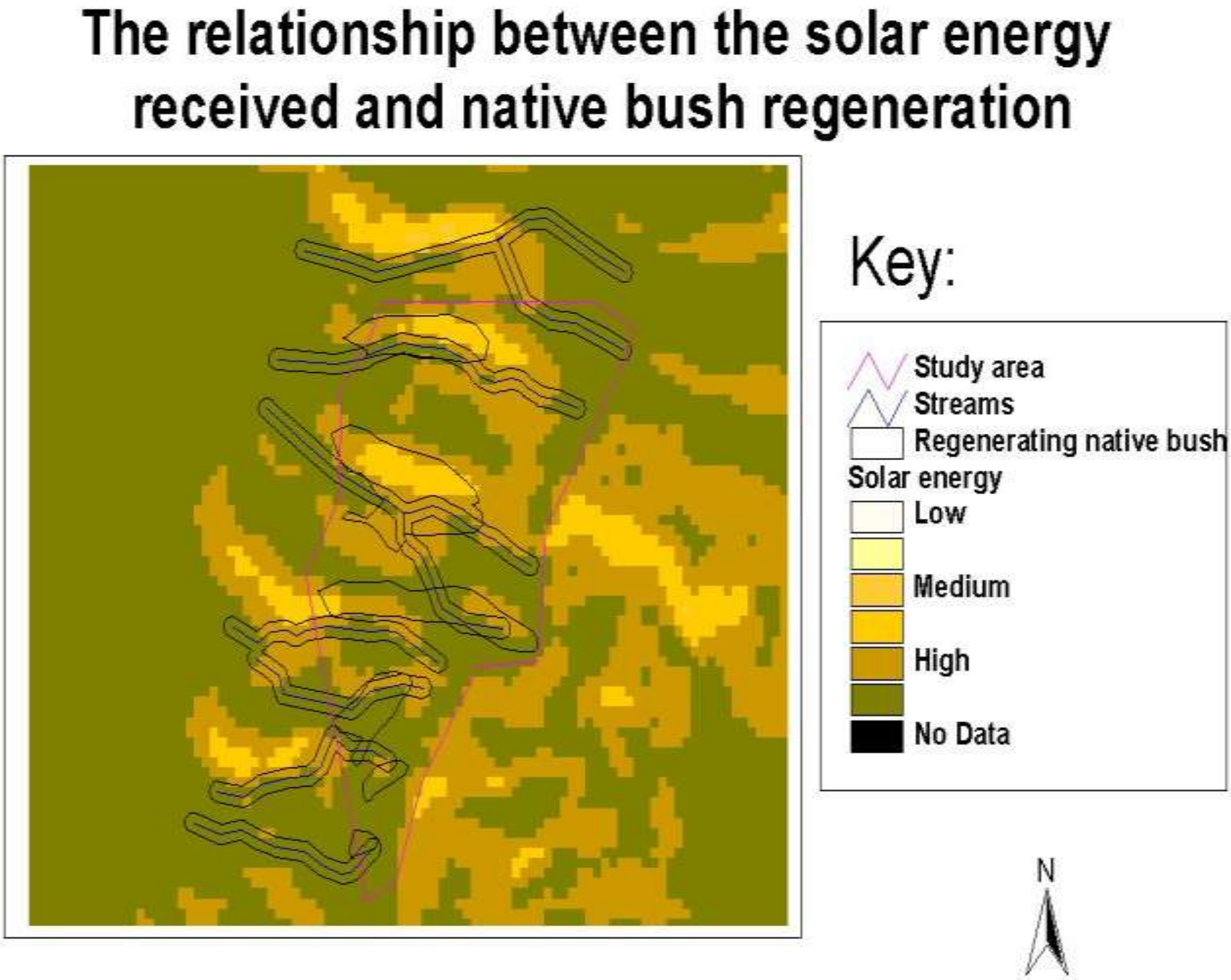
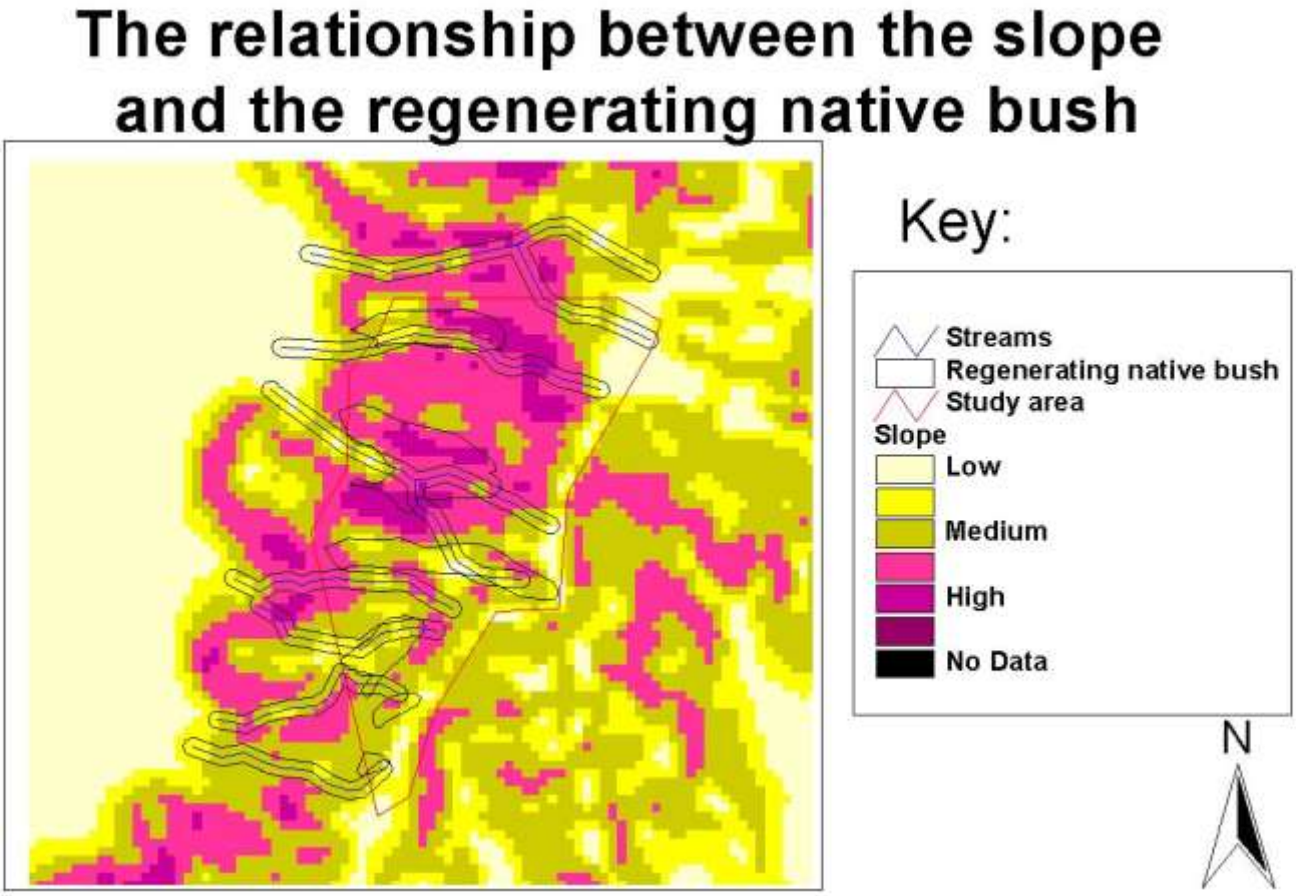

The relationship between the solar energy received and native bush regeneration
Key:
Study area
Streams
Regenerating native bush
Solar energy
Low
Medium
High
No Data
N

Figure 32


The relationship between the slope and the regenerating native bush
Key:
Streams
Regenerating native bush
Study area
Slope
Low
Medium
High
No Data
N

RESULTS

From our tables and maps we were able to observe several important things.

Field work observation, photos and maps

The most important of these being that even the slightest slope will dramatically change the aspect of the site. This is important because a change in aspect will also change the solar radiation and type of vegetation at a site and this will alter the fire hazard. We found that on slopes that were south facing there was less solar radiation and therefore these slopes were damper than the north facing slopes. On these slopes native bush was flourishing and this prevented the successful establishment of gorse. Fire risk in areas covered by native bush is far lower than the risk of fire in gorse covered areas, (Wellington Regional Council, p22) and from the photos we took at our sites it can be observed that there is a definite fire boundary between native bush and gorse. (see photo analysis).

Northern facing slopes however, receive far more solar radiation (Figure 31) and therefore dry more quickly to the south facing slopes. The native bush is regenerating on the damper southern slops and in the streambeds. (Figure 17) Gorse is considered to be dry after only 3 days of fine weather, so the risk of fire on these northern facing slopes is very high, especially in the summer. (Ellis, 1994, p45)

We thought that the angle at which a slope is tilted has little effect on the risk of a fire starting in an area as solar radiation which relates directly to aspect has more impact. (Wellington Regional Council, p 19) and therefore it is the aspect that increases or decreases the fire risk. Any angle with a southerly aspect will have a low fire risk while any angle with a northerly aspect will have a high fire risk. North facing slops dry quickly and where there is easy access these are areas of greatest risk. In our area all fires have started either from the road or the access route. While fires can be started by lightening strike this is not the major cause in our region (WBF data fires started by lightening)

While slope does not appear to influence vegetation directly it is an important factor in its own right Although we noted that even a small slope away from the north gives a more shaded aspect and in these areas the bush is regenerating more and so fire hazard is reduced. Slope does affect the severity of a fire once a fire has started. Fire spreads more rapidly up a hill (Wellington Regional Council, p22). Fire can create its own wind and in our region the prevailing northerly makes north-facing slope particularly hazardous during a fire. Steep slopes also increase the difficulties and dangers for fire fighters.

Fire edge on gentle slope change

Another important observation was that the greater the biomass the older the gorse was and the greater the fire hazard of the area. Because gorse dries quickly and keeps drying longer (Ellis, 1994, p45). Looking at the Eastern Hill we now see not only yellow flowers but also fuel drying ready to burn!

From the map that showed the estimated biomass at each of our sample sites (Figure 18) we found that the greatest biomass was located on the edges of the regenerating bush on the southern aspects. This is important to know as it shows that the areas of greatest fire risk are found right next to the areas of least fire risk (the native bush). As the gorse becomes older (25 years +) it “opens up” more and allows more light and moisture to reach the ground below it (Figure 7). This is an advantage to the native bush growing beside it as the older gorse provides protection.

Eventually, if there are no more fires in the areas that have the greatest biomass, the native bush will be able to spread into these areas and so increase the total area of low fire risk. If fires in our study area are confined to areas that have low biomass, or are totally eliminated all together, then the gorse that already has a reasonably high biomass will be able to “open up” more and this will allow even more bush to spread across our study area.

During our study we also found that our study area was located in a particularly high-risk area due to its close proximity to residential and industrial areas, and its easy access. Most of the fires in our region of study are caused by arson, with accidental fires caused by businesses and members of the public being the next largest group. (Borger, B analysis of 10 years of Wainuiomata Bush Fire Records).

CONCLUSION

Although we had some problems to solve we feel the method we used is an appropriate method for predicting fire hazard at a local scale for practical application. We where able to identify the areas predicted by other researchers as being the most hazardous and supported by our observation of gorse growth and bush regeneration; that is north facing slopes, as the most hazardous areas of our study area. This method could be applied to any other location as long as there are adequate aerial photographs to identify the edges of vegetation, particularly gorse and regenerating bush. Identified areas can then be sampled to obtain the height and diameter data. Age and biomass can be estimated using ring count or diameter alone (Table 2) and the formula produced by Fogherty et al. 1998.

Historical records can be used as a check on possible the age of the gorse. We found that existing records are very inaccurate with only vague locations and with no consistency of data entry. Hopefully with the availability of GPS and the availability of computer software to maintain databases this will be improved. Our study gives one small example of how this data can be used with GIS for research.

After talking with a member of the Wainuiomata Bushfire Force it was realised maps like ours that show the damper slopes with regenerating bush and the gorse areas **(**Figure 17 and Figure 30) are useful for practical fire fighting as they allow the probable direction of a fire to be predicted. This allows firemen to plan were to attack thee fire and to locate areas were it is easier to “choke” because the fire front is narrower in some areas and so prevent the fire spreading further. While firemen are interested in the biomass this is less important once the gorse is over 10 years. Though knowing areas of older gorse is important as this will include more native bush and be less of a fire hazard. For firemen biomass is of interest in three broad groups, new gorse (say under 10 year lower risk, mature gorse high risk and old gorse – a reducing risk). (Pers com Ellis, M)

USEFULNESS TO THE COMMUNITY

This project was chosen because it followed from our school 1999 AURISA project where the team studied the perception of risk in the Hutt Valley. They noticed that some people perceived bushfire as their greatest risk and one member of the1999 and 2000 teams has experienced this personally. Through our teacher's contacts we made contact with the Wainuiomata Bush Force and then a proposal was written for the project. Having the NZ Fire Serviced accept our proposal seemed like a good test of the project's potential usefulness.

PROBLEMS

During the course of our research we came across several problems that hindered our project.

The lack of aerial photographs of a sufficiently high resolution made it difficult for us to locate fire boundaries and this made it difficult to identify areas of gorse and native bush. However, we found that by using the school's digital camera we were able to take our own photographs of the sites and that these provided us with images we could use. We had to draw the boundaries as accuracy as we could by freehand on a new layer rather than being able to create the layer by tracing the edge. (data capture by on screen digitising).

We also had trouble accessing some of the more remote sites in our area as the gorse was very thick and some of the hillsides were very steep. We overcame this problem by wearing protective clothing and by trying to choose sites that were more readily accessible, or were nearer to the firebreak. We have first hand experience of the hazards faced by firemen, and we went during the day and there was no smoke to hinder us. (We also note the evidence of cannabis cultivation which must increase fire risk if people are careless. These sites are of course well away from the access track and road.)

Once we had reached our site we often found that the gorse plants could not be measured easily (heights) as they were often lying down the slope. While we tried to measure as many examples as we could we found that we had to leave some height recordings out, or estimate the heights we could not accurately measure. We later found that it was common for gorse that was over 15 years of age to grow in this way.

While not problems as such the group had to learn new skills ranging from using a saw, using a GPS, experiencing gorse (for the first time for our overseas student) to new GIS skills.

POSSIBLE FURTHER STUDY

If this method was to be used in the future then the relationship between the age and biomass of gorse could be further explored. Diameter is more easily measured than height in many instances. Ring counting is reasonably practical and would give greater accuracy.

Included in the material set to us by Mr Grant Pearce was information about software available on the internet called Biopak. This software computes plant biomass. We did not have an opportunity to explore this software. This software is developed in the USA and relates to shrubs in the Pacific North-West and the northern Rockies. This region also has a problem with gorse so it could be interesting to explore this software to see if it assists with the estimating of biomass.

If an accurate record of fires was kept then the age and potential biomass could be maintained and up dated for each when there was no further fire. This would allow accurate GIS maps to be created and maintained allowing the prediction of sites with the greatest fire risks and enable strategies to be in place to limit these risks. These maps would also be useful during a fire to help plan the attack on the fire.

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- Allen, Roger – searching Annual minutes for records
- Ellis, Murray – advice and coming out with us on our first sampling trip

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- Pearce, Grant – Fire Scientist, Forest Research Institute
- Borger, Bert – National Rural Fire Authority

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- Critchlow Associates (MapInfo)
- Eagle Technology (Arcview)
- Terralink NZ and Land Information NZ – use of topographic data

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