GIS and Possum Control on Mount Karioi

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ABSTRACT

Since their introduction into New Zealand, the Australian bush tail possum, *Trichosurus vulpecula*, has become a major animal pest. Possums are believed to number over 70 million, and are known to spread bovine tuberculosis, eat pasture and crops, kill young trees in forest plantations, cause severe damage to indigenous forests in conservation areas, and prey directly on insects and young birds. They have no natural predators (apart from humans) in New Zealand and range from the highlands to the coastal areas. Millions of dollars are spent each year by a number of government agencies in an attempt to curb the possum population. This paper explores a number of spatial data issues involved in possum control in an attempt to show how a GIS can assist with possum management on a conservation block. Examples are given using data obtained from a number of control operations on Mount Karioi and using the GIS packages ArcView and ARC/INFO. From the planning stage, through the operation and monitoring stages, GIS has an important role to play in pest management. The broader issues on spatial analysis explored here include remote sensing and image analysis, GPS, buffering, overlay and 3D analysis.

Keywords and phrases: possum control, GIS, Karioi, conservation, resource management, 1080, ARC/INFO, ArcView.

1.0 INTRODUCTION

Possums were introduced into New Zealand from Australia in 1837 to establish a fur trade. With no natural predators and a vast supply of food possums have spread throughout the country in the last 160 years. As can be seen from Figure 1, the spread of possums has been particularly dramatic in the last 50 years.

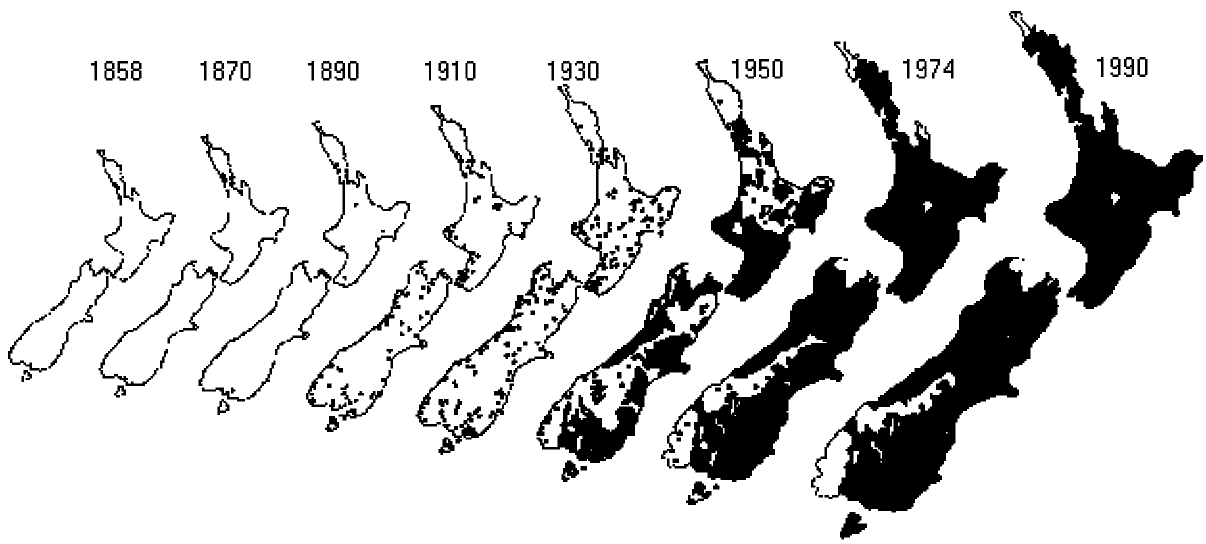
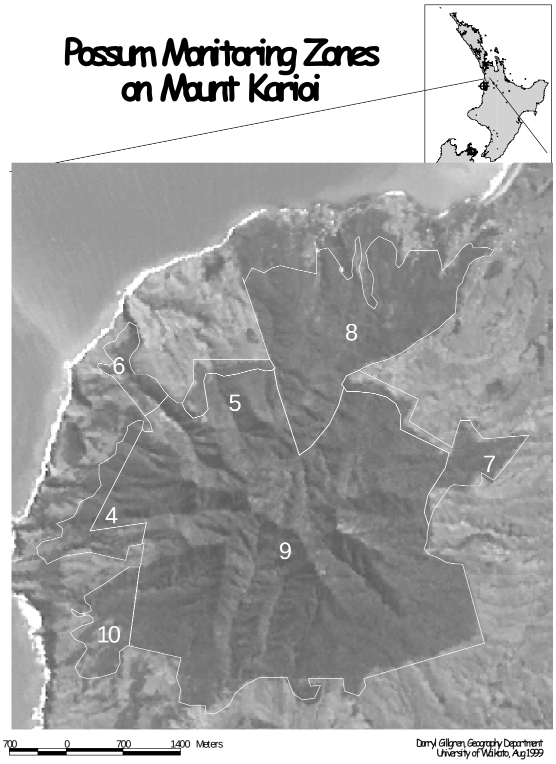


Figure 1: NZ Possum Spread 1858-1990 (from Coleman, 1998)

Known for their destruction of the upper canopy of forests, for their liking of green pasture, as a direct threat to the existence of our native birds, and as carriers of bovine TB, there is no argument that possum numbers need to be drastically reduced. The question is how? Hunting and trapping are expensive and seem unable to bring possum numbers down to a 'desired' level (except in the smaller self contained areas). Toxic baits dropped from the air seem to get the results, but does not have the social acceptance or employment benefits of hunting and trapping. A biological solution is still a few years away.

Mount Karioi is situated on the West Coast of the North Island near the coastal town of Raglan. It is the site of the second largest coastal forest between Taranaki and Auckland. The mountain rises from sea level to around 750m, and consists of approximately 1300 ha of native bush administered by DOC. Native species such as kohekohe, northern rata, puriri and karaka are prevalent on the mountain. Ninety percent of the land adjoining the Karioi block is farmland, the other ten percent is made up of small block holdings and Maori land (Gillgren, 1995). A spot image of Mount Karioi is shown in Figure 2.



There have been three possum control operations undertaken on Mount Karioi since the early 1990s. In 1993 a group of hunters were contracted to substantially reduce the possum population on the mountain, but were unable to meet their targets due to poor weather and some inaccessible country. This was followed in late 1994 by a very controversial aerial drop of 1080 baits on the mountain. In April 1999 another hunting and trapping operation was carried out. There have also been a number of pre- and post-operation monitoring exercises carried out, and it is from these monitoring exercises that data for this paper have been obtained.

The 1994 aerial drop of 1080 on Mount Karioi was discussed in Gillgren (1995). That paper focused on possums, 1080, some of the social implications of possum control, and an indication of how GIS may be used to improve the planning for a control operation. An attempt at analysing data from trap lines set to monitor the possums before and after the operation was also made. Buffering was used to establish a 'drop zone' for 1080 baits, and summary catch rates of the trap lines were shown spatially, rather than in a simple table, to determine 'where' on the mountain the possums were. At that stage the mountain was so highly infested with possums that the numbers were high for the most of the monitoring lines, and the variance in trap-catches could be explained by how the lines were placed rather than actual possum numbers.

Figure 2: Spot image of Mount Karioi with forest borders.

This paper looks at the different stages of possum control - namely: planning, operation and monitoring - and how a GIS may be used to:

- lower the costs,
- improve the results (i.e. kill rate of possums),
- make aerial drops more socially acceptable.

Many of the techniques illustrated use data that have been willingly provided by the Waikato Conservancy of DOC from their monitoring exercises on Mount Karioi, other techniques are merely outlined and tagged for further research.

2.0 PLANNING POSSUM CONTROL ACTIVITIES

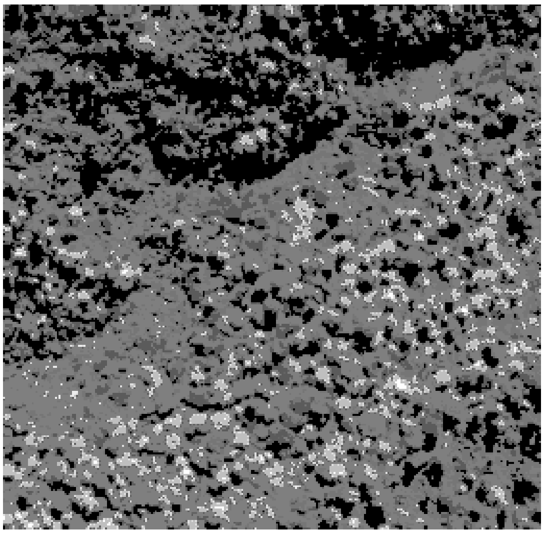
2.1 Aerial Photography

Most of the GIS work for planning a possum operation stems from manually tracing over aerial photographs to highlight possible possum habitats and bush/pasture margins. Likely sites are traced on to paper, and, given the appropriate scales, the areas and perimeters are then calculated using either a mapping wheel or a digitiser. Monitoring trap line locations are determined using grid overlays and random number generation (NPCA, 1999). Much of this work can be automated in a GIS, giving the planner more versatility in the design of the operation.

2.1.1 Area Measurement

By scanning aerial photographs directly into a GIS and using the image to digitise the desired areas, the task of calculating areas and perimeters becomes automated. The photo can also be used as a backdrop for showing other features of possum control, such as previous operation results, property boundaries, and the locations of bait traps and specimen trees.

2.1.2 Identification



Possums generally feed from the top of the forest canopy. Often they will keep feeding from the same tree until it is completely stripped. Possum-browsed trees, therefore, are easily identified from the air as they show up as light spots on the darker background of forest canopy. Using rectified aerial photography may be a way of easily identifying and locating regions in a forest (especially in remote areas) with a high infestation of possums. While remote sensing is not currently able to predict changes in biomass to an accuracy required by conservation agencies, it can show some changes that may directly relate to possum browsing - canopy death (Trotter *et al*., 1999). Figure 3 shows an example of how dead (possum-browsed?) trees stand out against the natural colour of an indigenous forest.

Figure 3: Possum 'hot spot' identification. The lighter grey areas depict dead vegetation (from Trotter et al., 1999)

2.2 Neighbourhood

Knowing who owns the area surrounding the operation site is important to the planners. Forested areas adjacent to the DOC estate need to be identified and included in the operation to hinder the re-infestation of possums, and owners of properties adjoining the operation site need to be advised of pending operations.

2.2.1 Consultation

Consultation is an important part of possum control operation planning, especially if an aerial drop of poison is planned. Finding the owners of adjoining properties to an operation site can be an arduous task. The aerial drop of 1080 on Mount Karioi in 1994 was delayed due to an underestimation, on DOC's part, of the need for public consultation. Local residents needed reassurance that the drop was absolutely necessary, and they also had a number of suggestions that made the drop safer for the community.

The lesson from Mount Karioi about public consultation was taken by DOC to the East Coast Conservancy where 'conservancy-managed lands of high ecological value' were felt to be 'under threat by severe possum infestation' (Para, 1999). The East Coast Conservancy of DOC undertook a full-scale consultation plan with the *tangata whenua* of adjacent lands as part of their Waitangi Tribunal obligations. It must be noted, however, that savings made by using aerial drops of 1080 were used up in the consultation process. Para (1999) observed that "the cost in staff time, in attending consultation hui as well as in helicopter time before operations began, made the whole possum programme far from cost-effective".

2.3 Trap Line Generation

For both pre- and post-operation monitoring exercises, the trap lines are randomly generated using a starting point and a compass bearing. For each monitoring operation, the lines are a set length with a fixed number of traps, and must follow a set of criteria laid down by the National Possum Control Agency (NPCA, 1999). These lines are then drawn to scale on a map. Planimetric distances only are taken into account, and individual trap locations are not noted.

Determining the location of a line using a starting point, compass bearing and distance can be simulated in ARC/INFO using the COGO command LAYOUT. Again this gives only the planimetric distance, whereas in reality the trap lines follow the surface contours (refer to Section 2.5 *3D-Modelling)*. In Arc/Info the approximate location of individual traps can also be determined using the COGO command STATIONING (refer to section *4.1 Trap Lines)*.

2.4 Buffering

2.4.1 Site Sensitivity

One of the concerns about the 1994 aerial drop of 1080 on Mount Karioi was poison filtering into the streams on the mountain. A number of local residents obtain their domestic water supply from the mountain, either from the streams or from the aquifer beneath the mountain. Despite the fact that 1080 appears to break down relatively quickly in water, concerns were raised about both short term and long term effects of covering the area with 1080. Because of the strong resistance of the local community, DOC agreed to a number of 'buffering' conditions prior to the aerial drop, including:

- 500m buffer zone upstream of any water intake,
- a 50m buffer around streams from which water was obtained,
- 250m 'no drop' zone adjacent to the borders of the conservation block.

These 'buffer' zones are outlined in Figure 4.

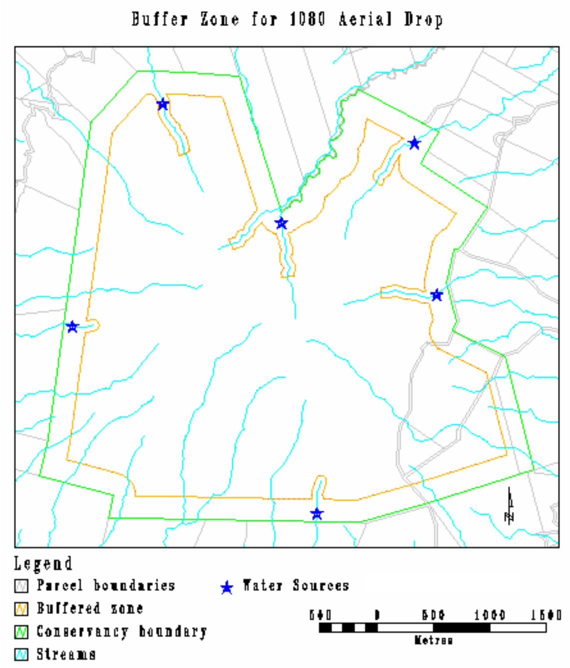
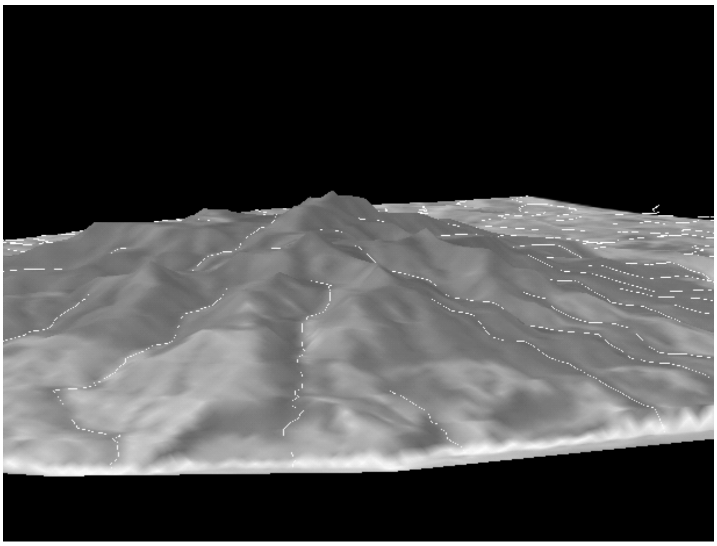


Figure 4. Buffer zones around sensitive sites. The outside line is the DOC boundary, the inside line is the buffer zone (from Gillgren, 1995).

2.4.2 Trap line placement

Part of the NPCA's criteria for possum monitoring involves the distribution of the trap lines. The NPCA stipulates that trap lines should not be within 200m of the monitoring area boundary or within 200m of another trap line. For Mount Karioi, no trap lines are located above the 500m contour, as there appears to be few possums on the higher slopes of Karioi, possibly due to the cooler climate or a change in vegetation. This is easily verified by buffering each trap line generated and checking for an intersection with other trap line buffers. If a trap line is found not to meet the criteria then a new line may be automatically generated and tested.

2.5 3D-Modelling



The ease with which 3D models can be developed using a contemporary GIS enables us to visualise real life landscapes quickly and efficiently. Figure 5 shows how a 3D view gives us a better visualisation of the Mount Karioi terrain. This section looks at two areas where 3D modelling could assist in the preparation of a possum control operation.

Figure 5 - 3D view of Mount Karioi generated by ArcView. The DTM has been draped with a spot image and highlighted with a stream coverage.

2.5.1 Accessibility

By building a 3D model of the operation area using contour and other topographical data, features of the area, such as elevation, slope and aspect can be quickly assessed. Likely inaccessible areas (steep, dense and elevated, for example) can be determined then checked out in the field. By relating data on possum habitats with topological data, an assumption of where possums are most likely to be found may be made and verified with monitoring.

2.5.2 Trap line placement

As previously mentioned, the method of generating the trap lines, outlined in section 2.3, gives only a planimetric representation of the trap line. In reality the line follows the contours of the surface and this needs to be taken into account when determining the extent of the trap line and the location of each individual trap.

By draping proposed monitoring trap lines over a 3D-Model, the terrain may be visualised and any hazards (such as cliffs or ravines) causing a trap line diversion may show, thus giving the planner an opportunity to try a different line. We need, however, a planimetric estimate of the distance the trap line covers when draped over the surface to be able to calculate the location of each trap (see section 4.1). The accumulated error in trap location is estimated to be up to 5m at the end of the trap line. The locational error increases with distance from the start of the trap line.

3.0 OPERATION IN POSSUM CONTROL

The main two methods of possum control are currently hunting/trapping and aerial drops of toxic baits (1080). Baits have been dropped in New Zealand by aircraft for over 30 years, in an attempt to control possums. This is an effective method of covering a wide area (especially if the terrain is inaccessible) in a relatively short space of time. One of the major objections to the aerial application of baits is the amount of bait required to ensure an effective distribution over the whole area.

3.1 GPS

3.1.1 Aerial Poison drops

In 1994 the amount of bait dropped on Mount Karioi was 4.7kg per hectare (a total of 6225 kg). Differential GPS was used in the helicopter during the operation and the swath width calibrated at 110m. The operation lasted one day (Giddy *et al*., 1995). By refining the use of GPS, DOC is now looking at application rates of around 2kg per hectare (Morgan, 1998), which is a huge saving in the cost of an operation. Flight plans can be predetermined shortening the amount of time an aircraft spends in the air, saving on fuel consumption. Once the plane has returned, flight data recorded by the GPS can be used as a check against the flight plan to ensure an efficient and effective drop.

3.1.2 Hunting, Trapping & Bait Stations

As described in section 2.3, a starting point, a direction and distance are used to determine the location of a trap line. To locate the starting point, the hunters are given an initial starting point on the edge of the bush (track entrance, fence post or some other identifiable position), a direction and a distance. GPS does have limitations under canopy, as it needs a clear sky to obtain the satellite signals, but could be used to more accurately locate the initial starting position on the forest edge, or in determining the location of bait stations in clearings within the forest.

4.0 MONITORING

Estimating possum numbers on Mount Karioi is not an easy task. Currently there are two main methods of determining possum numbers on Mt Karioi. Firstly, trap lines are set and a record kept of the possums caught in each trap. From this a percentage catch rate is calculated and possum numbers estimated. Results over the past 6 years have been difficult to compare, however, as different variations of the "trap-catch" methodology (section 4.1) have been used. The second method involves a number of trees known as "possum indicator species" (section 4.2). These are assessed annually and the extent of "possum browse" recorded. A third method of estimating possum numbers involving bait stations (section 4.3) is currently being investigated.

4.1 Trap Lines

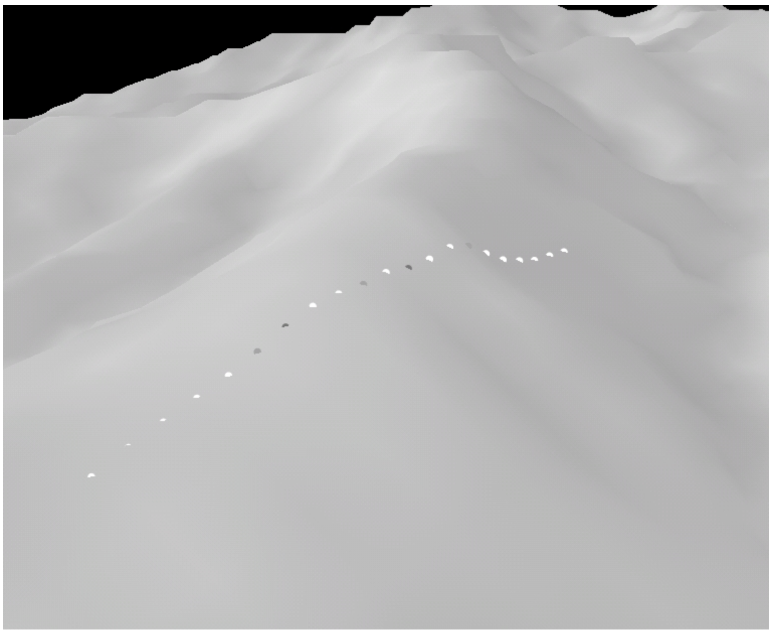
There have been several monitoring operations performed on Karioi over the past 7 years, and the methods used have been progressively refined making it difficult to compare the results from year to year. The methods for several monitoring operations are listed in the table below.

Table 1: Possum monitoring operations on Mount Karioi, 1993 - 1997.

Time	Objective	Traps/line	Trap Dist	No. of Lines
1993	Pre aerial drop	50	20m	12
1994	Post aerial drop	33/34	20m	3
1997	Control Determination	20	20m	10 set, 5 noted
1998	Pre Control Operation	20	20m	5
1998	Post Control Operation	20	20m	15

The earlier monitoring operations had a large number of traps in each line (up to 50). The later operations have fewer traps (about 20) in each line, compensated for by having a larger number of lines laid in the operation area. At present, analysing the data from the trap lines is restricted to simple statistics, charts and summary data for the operation area. Although this gives a general feel for how many possums exist on the mountain, it does not show their distribution over the mountain. Some anecdotal evidence of "less possums above 500m" and "this time round more possums were found in the gullies than on the ridges" have come out of the last two or three monitoring operations, so a small study using a GIS has been set up to try and investigate this.

By using a computerised GIS, a more detailed analysis can be performed, such as determining possum environment factors where possums are caught (ridges, gullies, vegetation preferences and so on), and the type of possum caught (male, female, with baby, young or old) in a particular type of location. If the individual traps can be modelled with some precision, then a better picture of possum habits may be drawn. Figure 6 shows individual traps in a trap line 'laid out' on a 3D image of Mount Karioi. The darkness of the traps indicates the number of possums caught in the trap over a 3-night period.



The majority of mapping measurements are calculated on a planar basis. By estimating the planar distance covered by a trap line over a surface, a better approximation of trap location could be made. The algorithm used to locate the traps on the surface is given in Appendix I.

Figure 6: Monitoring trap line laid over a DTM of Mount Karioi. The shading of the trap line indicates the number of possums caught, over a 3 day period. Jan 1997, trap line 2.

Legend:

○ 0 ○ 1 ● 2 ● 3

Number of possums caught over a 3 night period.

4.3 Possum Indicator Species

Nearly 150 native trees (96 kohekohe, 43 kamahi and 8 Hall's totara) have been tagged on Mount Karioi and are used as indicators of change in forest condition. These trees are assessed annually for change in foliage cover, possum browse and trunk use (Corson & de Monchy, 1998). By adding these data to a GIS, a better correlation between possum numbers and trap-catch rates may be formulated. This is an area that needs further investigation.

4.2 Bait Stations

Bait stations are proving an effective method of reducing possum numbers to low levels. Location of bait stations and numbers (and type) of possums caught could be added to a GIS and used to corroborate the trap-catch data. This is another area that needs further research.

5.0 CONCLUSION

Any environmental management effort, including possum control, involves spatial data. A computerised GIS system is an efficient means of handling the spatial data collected. From identification to monitoring, from hunting to spreading poison, and even in the consultation of the local people, GIS has a role to play in providing and storing possum control operation information.

Analysis of possum behaviour to date has mainly been statistical. Possum numbers in a given block are broadly estimated from trap-catch rates. As the methodology for using trap lines is still undergoing refinement, comparisons of previous results have proved difficult. By employing a GIS for possum control operation, a *spatial* component is added the analyses, which may lead to more definitive results and a better understanding of possum habits. By knowing about possum habits and movements, we can control their impact on our forests, pastures, wild life and domesticated animals more effectively. This paper has outlined some GIS techniques that could be useful in efforts to control possum numbers.

6.0 AFTERWORD

Finally I would like to leave you with this song written by the children in the Bilingual Unit of Raglan Area School about the legend of Karioi and the place she holds in the hearts of the local people. It is reproduced here with the kind permission of the Headmaster of the Raglan Area School.

I nga wa o mua,-Ko Karewa te tane a Karioi
I puremu ki a Pirongia

AUE TE MAMAE

Ka panangia e Karioi a Karewa ki te moana
Ka huri ia ki ana tamariki
E PIATA MAI RA!

A long time ago, Karewa was the husband of Karioi
But he flirted with her sister, Pirongia.
Oh, the pain!
Karewa was pushed out to the sea,
he turned to his children who were glistening.

Atawhaitia a Karioi, mana a ki tia
Whakamaramaha ki nga tohu o te taiao
Hei arahi i a matou e
Hei arahi i a matou e

Look after Karioi
Respect her
Understand thc signs of the environment,
as they will guide us

No Whaingaroa a Karioi te maunga o Te Taitamatane
Kei te taha o te moana
E TU ANA IA!
Ataahua tona ahua, he wahine whakahirahira
Ka rere ona makawe e heke ana
Ki TE MOANA!

Karioi is from Whaingaroa
She is the mountain of the western side
She stands by the side of the sea
She is beautiful and she is an important woman
Her hair flows, she descends down to the sea

Atawhaitia Karioi ...

Look after Karioi ...

E rere e nga waiora, hei rongoa mo te ao katoa
Whoatu ratou te oranga
Kl TE MANAWA!
Nga rakau kei runga i a Karioi
Nga manu e rere ana e, Te Kaitiaki a Karioi
MO TANE MAHUTA

The waters flow from her
which are medicines for the whole world
She gives us strength to breath
There are trees on Karioi and birds which fly around
Karioi is the guardian for Tane Mahuta!

Atawhaitia Karioi...

Look after Karioi ...

APPENDIX 1

This Appendix has been added for the people who enjoy working through algorithms.

Estimating individual trap locations by draping the trap lines over a 3D surface. This method gives a better (if not precise) approximation location of individual trap lines. Errors are accumulated over the length of the line, but should be within 5m of their real world location. Note also that a trap may be shifted up to 5m from it's proper location if an obstacle is in the way.

1) Length of trap line = num_traps * distance_between_traps
2) Generate trap lines using initial values from 1)
   i.e LAYOUT <bearing> <distance> <start_x,start_y>
3) Determine surface distance covered by the trap line using SURFACELENGTH.
   Creates attribute in AAT table - need to give interval parameter - in this case 20m were used as the contour lines are 20m apart, and the traps are set at 20m intervals.
4) Calculate new planimetric distance using SLENGTH from aat as well as original distances
   (orig_length/surface_length) * orig_length
5) Regenerate trap lines with new planimetric distance (new_length)
6) Calculate approximate planimetric distance between traps
   new_length / num_traps
7) Use STATIONING to generate point coverage of trap locations.
8) Check errors

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