POWELLIPHANTA LAND SNAIL:

A PREDICTIVE MODEL FOR IDENTIFYING THE POTENTIAL LOCATION OF *POWELLIPHANTA* LAND SNAILS IN THE SOUTH ISLAND OF NEW ZEALAND

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ABSTRACT

The weights of evidence spatial data modelling technique has been used to create a predictive map that identifies possible locations of alpine *Powelliphanta* land snails in the South Island of New Zealand. This technique is commonly used in the mineral exploration industry and is becoming more widely used in environmental fields as data becomes available in a digital form. Climatic, soil, topographic, and botanical data used in the model came from various organisations including NIWA and Landcare Research. The model uses the known locations of five *Powelliphanta* "taxa" that occur in high elevation, isolated alpine habitats to find other areas that may support similar *Powelliphanta* populations. The weights of evidence technique allows data to be assessed and weighted according to how great its influence is in relation to the current known locations of *Powelliphanta* snails. The most important variables identified from this spatial analysis were combined to produce a map showing the most likely places for *Powelliphanta* snails to be found. The resulting predictive model for snail habitat locations shows that mountain ranges in north-western part of the South Island have the highest probability of finding *Powelliphanta* land snails. It also shows that high altitude, low temperature and high rainfall condition are favoured by the snails. The model has been validated in the field and some areas not covered by the training points that were classified as highly probable by the model have recorded sightings of snails.

Keywords: South Island – *Powelliphanta* Land Snails – Weights of evidence modelling

1.0 INTRODUCTION

The aim of this modelling study was to identify possible locations of the rare *Powelliphanta* land snail in the South Island of New Zealand. The project used available climate, soil, and vegetation data and modern spatial modelling techniques in a GIS to develop a predictive map of *Powelliphanta* land snail habitats. This modelling allows conservationists to identify areas where these snails might occur and enable them to proactively organise environmental surveys and protect land areas.

Identifying new locations where *Powelliphanta* land snails could be found is complex as there are many environmental factors to be considered (e.g. climatic, topographic, soil properties etc.) and each separate factor be it rainfall, elevation or soil pH will have a varying degree of importance. The use of spatial modelling to combine these factors gives the conservationist a way of viewing all the data together in the context of each variable's relative importance, which would not be possible using traditional paper maps and historical reports.

2.0 PROBABILITY MAPPING IN THE SOUTH ISLAND

The weights of evidence method of spatial modelling has been highly effective in mineral exploration and geo-hazard identification and is used by many geological surveys and regional councils throughout the world (e.g. Crown Minerals, United States Geological Survey and the Canadian Geological Survey for resource assessment). Its application to other spatially based activites such as environmental management and horticulture is also becoming possible as more information is available to organisations in a digital format. The weights of evidence technique has been used in this study to integrate and interpret the available data over the South Island of New Zealand as an example of the use of spatial modelling in *Powelliphanta* land snail habitat location.

A number of features important for *Powelliphanta* snail habitat (e.g. a moist environment) were identified using documentation from The Department of Conservation (DOC) (Walker 2003) and Sustainability Solutions. The relevant digital data was obtained from the Land Environments New Zealand (LENZ) dataset, National Institute of Water and Atmospheric research (NIWA), Landcare Research, Department of Botany – Otago University and GNS Science. ArcView, Spatial Analyst, MapInfo and ArcSDM were all used for GIS analysis. The data was converted into a common projection and clipped to the study region. Grids were then reclassified in order to maximise the correlation between the data themes and the known occurrences of *Powelliphanta* snails.

The South Island *Powelliphanta* land snail model was generated using coarse scale data and does not allow for detailed habitat differences. Therefore the results should be interpreted appropriately for this scale. Later versions of this model are planned that will integrate more detailed datasets and will allow for the modelling of specific taxa. As we have not modelled for particular taxa, rather a group of taxon, which have similar habitats, it is again important to interpret the results as a generic and preliminary study.

3.0 SPATIAL CORRELATION ANALYSIS AND RESULTS

Spatial modelling, in particular the weights of evidence method, requires training data to test the correlation between known occurrences of snails and the map data sets. The 22 point training data set for this study is based on the locations of snails from five taxa namely: *Powelliphanta* "Kirwans", *Powelliphanta* Victoria/Brunner Ranges, *Powelliphanta* "patrickensis", *Powelliphanta* gagei and *Powelliphanta* rossiana rossiana that have been recorded by DOC. The locations of the training data points are shown in Figure 1.

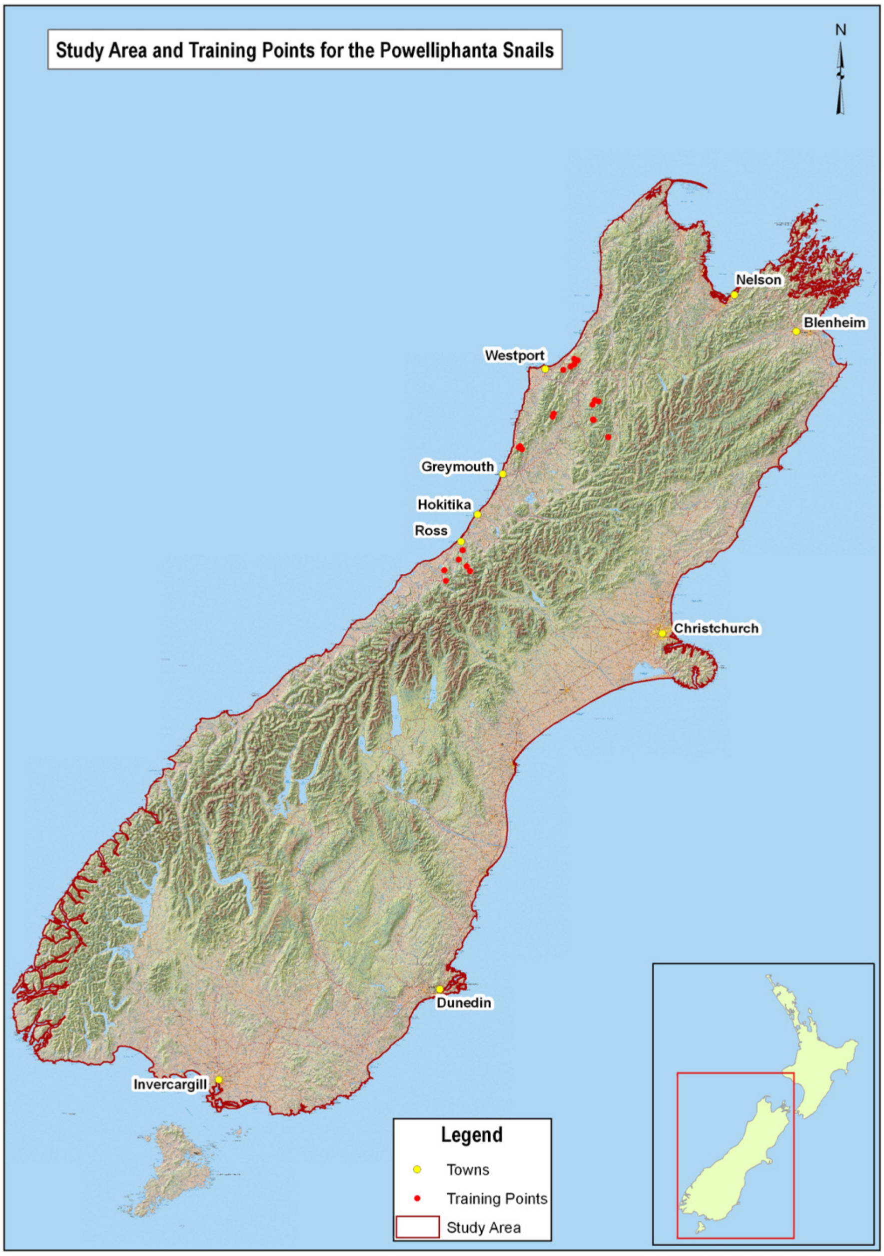

Figure 1. Study area outline of South Island with distribution of training points (orange circles).

The study area for this modelling project consists of the entire South Island (Figure 1). A large area that encompasses known snail locations and areas without any known snail occurrences has been chosen so that a wide range of climate and topographic variables can be

tested in this preliminary study. For the modelling a 200 m by 200 m resolution grid was generated over the South Island. Themes developed for testing in the modelling have the same area and resolution as the study area grid. The resolution of the grid was chosen to represent the minimum scale that the data should be viewed at. The area was then subdivided into a unit cell grid of 25 km2. The unit cell represents the size of the habitat being modelled. The probability of a snails occurring by chance (prior probability) is 0.00364 in this area based on the training dataset and the study area, i.e. there is a 0.00364 chance of finding snails in any 25 km2 block in the study area before any knowledge about the climate, soil, or topography is applied.

Spatial correlations were calculated using the weights of evidence technique developed by Bonham-Carter of the Canadian Geological Survey (Bonham-Carter, 1994). This was done using the Spatial Data Modeller extension (ArcSDM) (Sawatzky et al. 2004) developed for ESRI's ArcGIS software and could also have been performed using the MI-SDM extension for MapInfo by Avantra Geosystems Ltd. The modelling technique is a Bayesian statistical approach that allows the analysis and combination of data to predict the occurrence of events. It is based on the presence or absence of a characteristic or pattern and the occurrence of an event. The spatial correlation of a theme in the model can be calculated by using the relationship of the area covered by the theme being tested and the number of training data points that fall onto it. This produces a W+ result based on training points falling on the theme and a W- result based on training points falling where the theme is absent. A W+ value greater than 0 indicates a positive correlation with the theme, whereas a W- less than 0 indicates a negative association with the non-theme area. The contrast, which is the difference between W+ and W-, gets higher with an increase in the correlation between the theme and the training data (i.e. a theme that correlates well with known snail locations will have a high contrast value).

The best themes for the models are selected based on their correlation (C) and their level of uncertainty (studentised contrast). The uncertainty is calculated from the standard deviations of W and C (Ws and Cs), from which the Studentised value of the contrast (StudC) can then be calculated (the ratio of the standard deviation of the contrast (Cs) to the contrast (C)). StudC gives an informal test of the hypothesis that C=0 and as long as the ratio is relatively large, implying the contrast is large compared with the standard deviation, then the contrast is more likely to be real. Ideally, a StudC value larger than (-) 1.5 can be considered as a positive or negative correlation. This ratio is best used as a relative indicator of spatial correlation, rather than an absolute sense. In this study a strong correlation is inferred from C values > 3.0, StudC values >1.5, moderate correlations inferred from C values between 1.0 and 2.0, StudC values >1.5, weak correlations inferred from C values between 0.5 and 1.0, StudC values between 1.0 and 1.5, and poor correlations inferred from C values < 0.5 or StudC values <1.5.

In this study forty-two different maps were tested for spatial correlation with the selected training points (snail occurrences). The results from the spatial correlation analysis highlight the environmental variables that are most important for snail habitats. In the South Island the modelling shows the habitat of Powelliphanta snails is spatially associated with climate, soil and geographic themes. The eight layers that produced the best correlations based on contrast and confidence statistics were used in the final model. These themes, their correlation, and spatial weights are listed in Table 1.

There are additional variables which may affect the locations of *Powelliphanta* snails and these include, among others, predator populations, historical fire locations and historical climate variations. Unfortunately these could not be included in this model as they are not readily available digital datasets at this time. As a result some of the predicted occurrence sites from this study may not actually contain *Powelliphanta* snails due to not having this data to use in the modelling. Follow-up investigation at all the predicted occurrence sites should include analysis of these types of data if possible.

Spatial Variable	Best Spatial Correlation	W+	W-	C	Stud C
October 9 am vapour pressure deficit (kPa)	Vapour Pressure Deficit between 0 and 0.14	1.9350	-2.9427	4.8778	4.7617
Mean Annual Rainfall	Mean annual rainfall of between 191 and 650 mm	1.3657	-2.8118	4.1775	4.0797
Annual mean of the monthly average daily temperatures (°C)	Mean annual temperature between 5.0 and 9.0 °C	0.7982	-2.5295	3.3277	3.2502
DEM	Elevation between 740 and 1300 m	1.1584	-1.2037	2.3621	4.6348
SIFSL - Soil Type	Steepland soil type	1.1542	-1.2024	2.3565	4.6240
Acid Soluble Phosphorus	Acid soluble phosphorus of between 0 and 7 mg per 100 g soil	1.3816	-0.7331	2.1147	4.8556
Types of Tussock	Types of tussock either, alpine snow, sub alpine snow or tall red	1.2523	-0.7088	1.9611	4.5084
SIFSL - pH Class	Soil pH between 4.5 and 5.7	0.4462	-0.7992	1.2454	2.4448

Table 1. Weights of evidence results for predictive themes included in the final model. Note the higher the Stud(C) value, as defined by Bonham-Carter 1994, the better the correlation the variable has with known snail locations.

4.0 PREDICTIVE MODELLING

The model consists of a grid response theme containing the intersection of all of the input themes in a single integer theme. Each row of the attribute table contains a unique row of input theme values, the number of training points, area in unit cells, sum of weights, posterior logic, posterior probability, and the measures of uncertainty. The variances of the weights and variance due to missing data are summed to give the total variance of the posterior probability. The response theme can be mapped by any of the fields in the attribute table. The calculation of weights of evidence assumes conditional independence among the evidential themes input into the model. Various measures to test the conditional independence have shown that conditional independence is not a problem in this model. The results have been normalised to produce a post probability map (predictive map), which should be viewed as a relative measure of favourability for the tested factors that influence the habitat of *Powelliphanta* land snails. The predictive map could be used to focus further modelling work or to plan snail field surveys in areas of interest throughout the South Island.

5.0 POWELLIPHANTA SNAIL MODEL –REVIEW

The predictive map (Figure 2) clearly highlights the most favourable areas for *Powelliphanta* snail habitation. Areas that are identified as having the highest likelihood of finding snails are shown in red or orange. The following areas are of particular interest and in-

cluded as inset maps in Figure 2. Inset 1 shows that the Haupiri Range northwest of Nelson, the Tasman Mountains, the mountain ranges west of Karamea, and the Glasgow range to the west of Hector are probably all good snail habitats. Inset 2 shows the Paparoa and Victoria Ranges to the west and east of Reefton and Hohomu Range to the south-west of Lake Brunner as potential snail habitats. Inset 3 shows the Hunter Mountains to the south-west of Manapouri as possible *Powelliphanta* habitats. Similar taxa to those used as training data have been found in locations identified as highly probable by this modelling. This suggests that the modelling could be used to identify habitats of more than just the five taxa used in this model.

The high probability areas in the model are a result of the occurrence of high altitude, low temperature and high rainfall conditions. The presence of tussock in these areas also contributes to a high probability as the snails often live under the skirts of the tussock plants. The high October pressure deficit of the area (high humidity) is an important factor as the snails prefer moist conditions.

This preliminary model is successful as it has highlighted known snail occurrences in the South Island that were not included as training points; e.g. Seven Mile Creek, Rewanui and Sullivan Mine near Mount William where snails have been found in the past. It has also clearly shown low probability areas where it is highly unlikely that snails will be found; such as areas with dry but high altitude conditions like the Studleigh Range south-west of Lake Summer and the low altitude, warm conditions of Canterbury. These results support the validity of this model as a predictor for *Powelliphanta* snails.

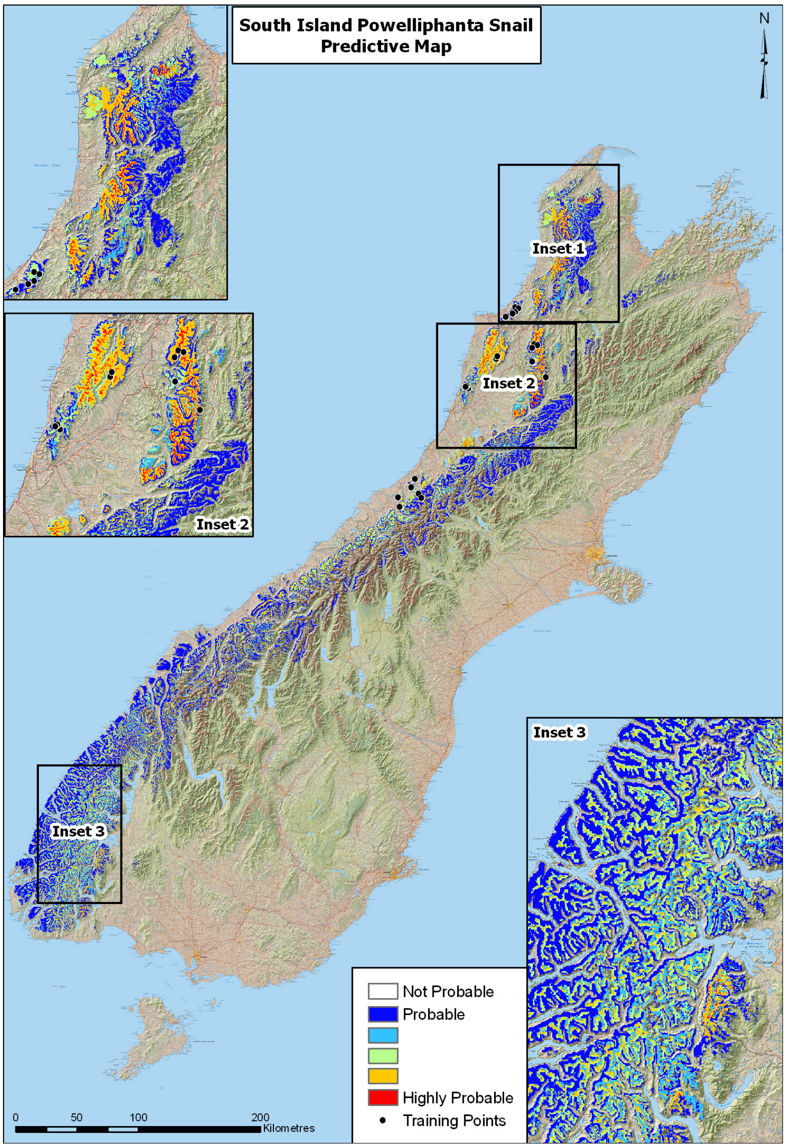

Figure 2. Predictive map showing the most probable locations of tested *Powelliphanta* Snail habitats

6.0 FUTURE WORK TO IMPROVE THE POWELLIPHANTA SNAIL MODEL

Future work to improve the model would include re-running the model using grid data for all the variables with a resolution of at least 50 metres over smaller study areas. This would provide better targeting of the snail habitats. Modelling individual taxa could be undertaken to create specific models for habitat analysis that take into account the subtle differences between the *Powelliphanta* species and subspecies. As alpine *Powelliphanta* snail species are geographically isolated any detailed modelling should be done with a much smaller study area than the whole South Island. In addition to using the existing digital data at a more detailed scale, new data should be acquired where possible that accounts for other factors that influence snail habitats such as predators and food sources. Field surveys could also be carried out in the highly probable areas identified by the model

to gather new data, check the accuracy of the results, and to potentially identify new snail populations.

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REFERENCES

Bonham-Carter GF, 1994, *Geographic Information Systems for geoscientists: Modelling with GIS*, Pergamon, London.

Sawatzky DL, Raines GL, Bonham-Carter GF and Looney CG, 2004, *ARCSDM3.1: ArcMAP extension for spatial data modelling using weights of evidence, logistic regression, fuzzy logic and neural network analysis,* Web site: ige.unicamp.br/sdm/ArcSDM31 (accessed 06 June 2008)

Walker K, 2003, *Recovery plans for Powelliphanta land snails 2003-2013. Threatened Species Recovery Plan 49*, Department of Conservation, Wellington

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