University of Southern Queensland

Faculty of Engineering and Surveying

Spatial Analysis of Tasmanian Devil Facial Tumour Disease

A dissertation submitted by

Mark McGovern

in fulfilment of the requirements of

Courses ENG4111/4112 Research Project

towards the degree of

Bachelor of Spatial Science Technology (Geographic Information Systems)

Submitted: October 2005

<u>Abstract</u>

The analytical capabilities of a Geographic Information System (GIS) are increasingly being used to map the spread of disease and subsequent disease control. This project uses the spatial analysis techniques of a GIS to model habitat suitability of the Tasmanian devil and compare with available data on a disease affecting the devil.

The Tasmanian devil (*Sarcophilus harrisii*) is the world's largest surviving carnivorous marsupial, and is only found in Tasmania. Approximately 10 years ago the devils began showing signs of a fatal disease that has now claimed between 33 - 50 percent of the native population. Devil Facial Tumour Disease (referred to as DFTD) has been recorded in over 65 percent of the state but is feared to be present over a larger area. Research conducted so far has failed to identify the cause of the disease or provide a cure. There is evidence to suggest that the spread of DFTD is dependent on devil population density (Jones M, pers comm).

Available data was used to determine factors associated with devil habitat and perform spatial analysis to map areas of devil habitat suitability which can be used to determine where higher densities of devil populations could be expected. The results of the habitat suitability model were then compared to locations where devils have been trapped and incidents of DFTD have been recorded, and examined for the existence of any relationships.

The existence of strong relationships may then be used to predict DFTD occurrence in inaccessible areas or where devil populations may be at a higher risk of infection.

University of Southern Queensland

Faculty of Engineering and Surveying

ENG4111 & ENG4112 *Research Project*

Limitations of Use

The Council of the University of Southern Queensland, its Faculty of Engineering and Surveying, and the staff of the University of Southern Queensland, do not accept any responsibility for the truth, accuracy or completeness of material contained within or associated with this dissertation.

Persons using all or any part of this material do so at their own risk, and not at the risk of the Council of the University of Southern Queensland, its Faculty of Engineering and Surveying or the staff of the University of Southern Queensland.

This dissertation reports an educational exercise and has no purpose or validity beyond this exercise. The sole purpose of the course pair entitled "Research Project" is to contribute to the overall education within the student's chosen degree program. This document, the associated hardware, software, drawings, and other material set out in the associated appendices should not be used for any other purpose: if they are so used, it is entirely at the risk of the user.

Prof G Baker
Dean
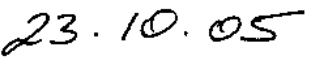Faculty of Engineering and Surveying

Certification

I certify that the ideas, designs and experimental work, results, analyses and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

Mark Andrew McGovern

Student Number: 0019320457

_____
Signature

_____
Date

<u>Acknowledgements</u>

I would to acknowledge the assistance of the following people during the completion of this project:

My Project Supervisor, Dr Yan Liu, of the Faculty of Engineering and Surveying of the University of Southern Queensland for her assistance, guidance and encouragement.

Dr Clare Hawkins of the Nature Conservation Branch of the Department of Primary Industry, Water and Environment (DPIWE) for her assistance with information on the Tasmanian devil, provision of data from the trapping and monitoring program, general guidance and encouragement.

Roger Ling, Kristy Goddard and Greg Hocking of DPIWE for their assistance with provision of spatial data used during this project.

Lastly I would like to thank my wife and children for their support and patience over the last 12 months.

<div align="right">

Mark McGovern

October 2005

</div>

<u>Table of Contents</u>

List of Figures

List of Tables

Glossary

ArcGIS
Desktop GIS software developed by ESRI

ArcToolbox
Tools available within ArcGIS

DEM
Digital Elevation Model

DFTD
Devil Facial Tumour Disease

DPIWE
Department of Primary Industry Water and Environment

ESRI
Environmental Science Research Institute – developers of ArcGIS

Euclidean Distance
Straight line distance to source

GIS
Geographic Information System

IDW
Inverse Distance Weighted – interpolation method

ModelBuilder
Analysis tool within ArcGIS

Raster
Grid structure to store geographic information

Shapefile
Vector data format supported by ArcGIS

AGD66
Australian Geodetic Datum 1966

GDA94
Geocentric Datum of Australia 1994

Chapter 1

Introduction

The Tasmanian devil (*Sarcophilus harrisii*) is the world's largest surviving carnivorous marsupial, and is only found in Tasmania. Approximately 10 years ago the devils began showing signs of a fatal disease that is thought to have claimed between 33 and 50 percent of the native population. The disease has been recorded in over 65 per cent of the state but is feared to be present over a larger area. Research conducted so far has failed to identify the cause of the disease although recent research has raised the possibility of the disease being genetic in origin and passed from animal to animal as a result of biting from fights between two males, or males and females during mating season, and during communal feeding at carcasses.

Much of the research currently being carried out has concentrated on understanding the genetic structure of the devil and the disease, defining the disease and finding a cause. State-wide monitoring and mapping of the disease has also been undertaken, but spatial analysis of this data has been limited.

The aim of this project is to perform spatial analysis techniques using data collected on devil populations, habitat and land use, to help predict density levels of devils and compare with data collected on disease presence and absence.

1.1 The Tasmanian Devil

1.1.1 Description

The Tasmanian devil (*Sarcophilus harrisii*) or simply devil, is a nocturnal, carnivorous marsupial with a thick-set, squat build, with a relatively large head and short, thick tail. The fur is mostly or wholly black, but white markings often occur on the rump and chest. Body size also varies greatly, depending on the diet and habitat. Adult males are usually larger than adult females, weighing up to 12kg and standing about 30cm high at the shoulder. They have a lifespan of approximately five to six years (DPIWE 2004a). They generally live a solitary life except for mating season and at feeding times. While not considered territorial they do have a home range of approximately 10-20km^2, which can overlap with other devils, before returning to a primary den during the day (Pemberton 1990).

Figure 1.1 - Tasmanian Devil (*Sarcophilus harrisii*)
(Source: http://www.boxerrescue.com/rudys_page.html, accessed 23/9/05)

1.1.2 Disappearance from Mainland Australia

The widespread discovery of fossils show that the devils once existed on mainland Australia, but today is only found in Tasmania. They are believed

to have become extinct on the mainland between 430±160 and 5000 years ago (Gill 1971; Archer & Baynes 1972; cited Jones et al 2004), prior to European settlement. Guiler (1982, p. 160) in reference to its disappearance from the mainland said the devil:

> 'has been extinct for a sufficiently long period of time in Australia for its religious, legendary and food significance to have disappeared from Australian tribes. Such a vociferous and flamboyant species as Sarcophilus would be expected to be handed down for many years in native song, dance and legend. There is no evidence of this and presumably therefore the species was not known to the natives in the near past'.

Reasons for the disappearance of the devil from mainland Australia include competition with the dingo and climatic change, although Guiler (1982, p. 159) is of the opinion that some of the terrain of New South Wales and Victoria would offer a habitat for devils little different to that of north-eastern Tasmania and it is difficult to believe that climatic changes are responsible for their extinction on Australia. He feels that some other presently unknown factor or factors may have contributed (Guiler 1982, p. 160).

1.1.3 Tasmanian Distribution and Habitat

Today the devils are widespread in Tasmania, from coastal regions to mountain areas, and are particularly common in north, eastern and central districts. Devils are more abundant in habitats (open eucalypt forests and woodlands, coastal scrub) that support dense populations of their prey (macropods, wombats, possums; Jones & Barmuta 1998; cited Jones et al 2004). Population densities are low in dense wet forests, low heathlands, alpine areas, open grasslands and extensively cleared farmland (Jones, unpublished data; cited Jones et al 2004). There is a broad trend for a decrease in densities from the drier warmer areas of the sclerophyll habitat through the wet sclerophyll forests to the wetter rain forests and sedge lands and the colder alpine moorland (Dept. Parks Wildlife & Heritage TASPAWS records, cited Pemberton 1990).

The highest devil population densities appear to occur from late summer until early autumn, largely as a result of the appearance of weaned young and juveniles into the population (Pemberton 1990). Pemberton (1990, p.215) in a study of devils in Mt. William National Park, suggested that the availability of food was the major influence on the population density of devils.
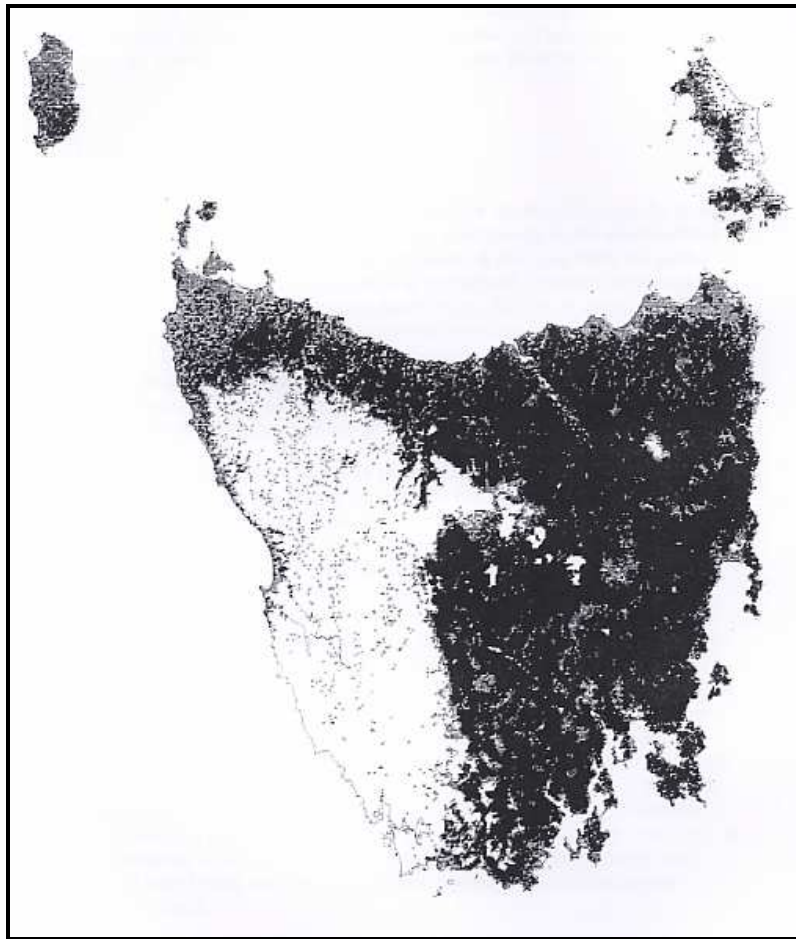
Figure 1.2 - Tasmanian Devil Distribution 1996
(Source: Report to the RFA Environment & Heritage Technical Committee 1996)

1.1.4 Diet

The Department of Primary Industries, Water and Environment (DPIWE) provided the following information on the diet of the devil:

The devil is mainly a scavenger and feeds on whatever is available. Powerful jaws and teeth enable it to completely devour its prey, including bones and

skin. Wallabies, and various small mammals and birds, are eaten, either as carrion or prey. Reptiles, amphibians, insects and even sea squirts have been found in the stomachs of wild devils. Carcasses of sheep and cattle provide food in farming areas. Devils maintain bush and farm hygiene by cleaning up carcasses. This can help reduce the risk of blowfly strike to sheep by removing food for maggots.

While the devil appears to survive predominately on carrion, there is evidence to suggest that they will hunt down live prey. Buchman and Guiler (1977, cited Pemberton 1990) state that devils are inept at killing and Pemberton (1990) suggests predation 'would only occur in the absence of available carcasses of large animals, such as macropods'.

1.1.5 Breeding

Mating season usually occurs in March with the young born in April after a gestation period of 21 days. The mother's pouch can accommodate four young, although on average two or three will survive. The young remain attached to a teat in the pouch and are carried for about four months before venturing out. After leaving the pouch they remain in a simple den prior to weaning at five or six months. By late December they have left their mother and are living alone in the bush. Females are ready to breed by the end of their second year (DPIWE 2004a).

1.1.6 Current Status

For over a century they were hunted and poisoned and numbers dwindled to a level where extinction was a possibility. They were not protected by law until 1941 and numbers increased to a point where their survival was apparently safe. By the mid 1990's their numbers were widespread and numerous which Pemberton (1990) attributes partly to their ability to exploit food sources associated with farming practices.

1.2 Devil Facial Tumour Disease

1.2.1 Disease Description

Devil Facial Tumour Disease (referred to as DFTD) is the name given to a fatal condition that is afflicting a significant portion of the native population of Tasmanian devils. The condition first becomes noticed as small lesions or lumps around the mouth that develops into large tumours predominantly around the face and neck, but sometimes in other parts of the body as well (DPIWE 2004b).

Figure 1.3 - Healthy Devil
(Source:http://www.worksandwords.com/coins/ecc/ecc9801.htm, accessed 23/9/05)

Figure 1.4 - Diseased Devil
(http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/LBUN-5QF86G?open accessed 18/1/05)

DFTD was first reported in the mid 1990's (DPIWE 2005a) and has now been confirmed in most areas throughout Tasmania except for north-west and west coast devil populations (See Figure 1.5). It is having a major impact in areas with high-density populations, and is predominantly affecting the adult populations. The disease does not usually become apparent in devils until they are at least two years old. The cancers affect the capability of the devil to ingest food thereby weakening the animal and making it more difficult for it to compete with other animals for food. Evidence suggests that animals appear to die within three to five months of the lesions first appearing, from starvation and the breakdown of body functions (DPIWE 2005a).
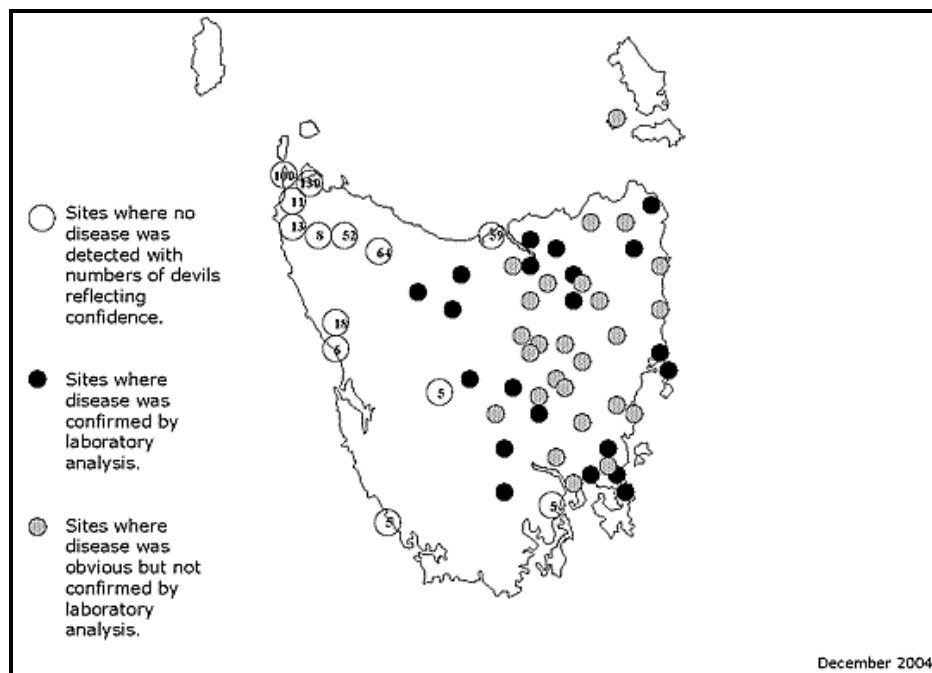
Figure 1.5 - Distribution of DFTD and apparently disease free areas where 5 or more devils have been sampled (1999-2004)
(http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/JCOK-65X2Y6?open, accessed 18/1/05)

1.2.2 Disease Management Strategy

The Tasmanian Government has nominated the devil for listing as vulnerable under the State's Threatened Species Act in response to field

data indicating the devil population had dropped between 33 and 50 per cent from a 1990 peak of 130000 (Examiner, p2, May 12 2005).

DFTD appears to be an entirely new wildlife disease (DPIWE 2005b) and in response, DPIWE has developed a Disease Management Strategy. The five key elements of the strategy are:

1) Ongoing field mapping and monitoring of the disease and diagnostic research and investigations;

2) The isolation of devils in quarantined insurance populations;

3) Field trials to test the effectiveness of isolation and disease suppression techniques in maintaining and restoring devil populations and limiting the apparent spread of the disease;

4) Ongoing work to maintain the biosecurity and genetic diversity of captive devils held by wildlife parks in Tasmania; and

5) Improved management of captive devils held by interstate wildlife parks to maximise breeding.

1.2.3 Disease Consequences

If devil numbers continue to fall at the large rate indicated above, there is a concern it may lead to increased numbers of other non-native species such as feral cats and the fox, recently thought to be introduced to Tasmania. Mooney (2004, p34) says devils would normally act as a buffer against foxes through competition for carrion and predation on fox cubs.

However Mooney (2004, p34) also suggests that other native species such as spotted-tailed quolls, eagles and harriers may increase in numbers.

The devil plays a vital ecological role in disposing of carcasses in the wild and on farms (DPIWE, 2005a) and its loss may have detrimental affect on agricultural activities.

Tasmania has been lamenting the loss of the Tasmanian Tiger and there are grave concerns that the devil may follow its path to extinction.

1.3   Project Rationale

The use of Geographic Information Systems (GIS) is increasingly becoming a useful tool in the analysis of animal populations and spread of disease. The United States Department of Agriculture (USDA) has used GIS to demonstrate where a disease does or does not occur (Ramirez 2004).

Also in the United States, GIS was used to model potential habitat for wolves in Jasper National Park. The primary objective of the modelling exercise was to quantify the observed effects of human developments on wolf habitat and wolf movement patterns (Purves & Doering,). Four components; prey availability, slope, aspect and elevation; were assigned weightings and used to calculate potential habitat. Wolf population dynamics are also believed to be largely dictated by the available prey, vulnerability of prey and degree of human exploitation (Keith, Fuller cited in Paquet, Strittholt, Staus 1999). Whereas the wolf may have suffered due to human intervention, devils have learned to take advantage of the farming activities of man and flourish.

Previously GIS modelling was devised by the Tasmanian Parks and Wildlife Service to determine the best sites to place traps for devil monitoring. While similar factors were used in that model were also used in this project, there was a different objective for each model. The trapping model had to consider increased chance of capturing devils as well as access to the trap site. This project is mainly concerned with predicting areas of higher devil populations.

Statistics have been gathered on devil numbers by different methods including spotlighting and capture-mark-recapture (CMR) programs. There

is evidence to suggest that the spread of DFTD is dependent on devil population density (Jones M, pers comm). By using available data on devil populations and factors relating to devil habitat, it is intended to use spatial analysis to predict areas where high density of devil populations can be expected. Areas where DFTD has been recorded can then be compared to examine the existence of any relationships. If strong relationships exist, the modelling may be used to predict areas where the disease may exist or where devil populations may be at a higher risk. This may serve to assist in the management strategies of the preservation of devil populations.

1.4   GIS Software

Due to isolation from the Toowoomba Campus and lack of suitable GIS software available through the student's place of work, a major problem to be overcome was access to GIS software suitable for the spatial analysis required for the project.

Enquiries were made to suppliers of MapInfo and ESRI GIS software on the availability of student licences and associated costs. Responses were received on both products and a decision was made to purchase an ESRI ArcGIS licence. This decision was based on cost, familiarity with the product through use on campus, and the inclusion of three extensions: ArcGIS Spatial Analyst, ArcGIS 3D Analyst, and ArcGIS Geostatistical Analyst, that may be required for the analysis during the project.

A period of the project was dedicated to reviewing skills with the software and training in areas required to complete the analysis and mapping tasks. These were completed using the documentation and tutorials provided with the software; and seeking advice from experienced users where required.

In general, spatial analysis and mapping tasks associated required by the project were able to be achieved with the software. Where difficulties were encountered, it was due to the inexperience of the operator. This resulted in several attempts at some tasks and repetition of other tasks that could have been avoided with greater knowledge of the software. One example was the use of a map template, to ensure the maps produced had the same appearance.

1.5 Risk Assessment

The majority of the tasks associated with the project were computer based and no field based activities were planned or undertaken. An invitation was made to participate in a devil trapping field visit but this offer was not taken up during the project. Strict guidelines are set out by DPIWE for these types of activities and require assessment of all participants and formal approval. Participants in these exercises are required to read and understand the Tasmanian Devil Handling Safe Working Practices and Nature Conservation Branch Safe Work Practices for On-Ground Fieldwork in Remote and Isolated Areas.

Standard work practices involving prolonged use of computers were adhered to at all times.

Chapter 2

Devil Habitat Modelling

2.1 Data

It was the availability of the data required for the project that was to be the most critical component. Datasets that were identified to be used in the creation of a devil habitat suitability model for the project included:

- vegetation types and coverage
- elevation/slope data
- climate data (particularly rainfall)
- land use data (forestry/agriculture/grazing etc)
- Devil population data
- Fauna data (food supply)

The majority of the data was available from government departments and was made available for the project subject to fulfilment of a data share agreement (Refer Appendix B1 for Conditions of Use).

Various forms of data existed for devil populations and these were evaluated to determine fit for purpose. Data on presence of other fauna that are part of the devil food supply was more difficult to obtain which threatened the effectiveness of the analysis. Land use data availability was also of some concern as it did not exist on a detailed level i.e. sheep grazing separate from cattle grazing.

Spatial data was supplied in various formats and on different projections and coordinate systems. Prior to any analysis the data required conversion to formats and coordinates systems suitable for analysis.

The size and location of the area to be subject to the analysis was determined in consultation with Dr Clare Hawkins of DPIWE and was based on:

- availability of data
- practicality for completion of project within timeframe
- area of most need
- capabilities of software/hardware

The project relied on most data being either made at no or minimal cost to the student. As the project was being supported by DPIWE, access to data was also made available through government agencies.

One of the aims of the literature review carried out in the early stages of the project was to determine the leading factors associated with devil habitat. As population density was thought to be a primary agent in the spread of DFTD it was important to determine what conditions would provide optimum habitat for a devil population. As previously stated, food supply is a major influence on devil populations. Three datasets were identified as important to contributing to available food supply. They were vegetation coverage, land use types and existence of other mammals considered part of devil diet.

In partnership with food supply, availability of a reliable water supply was also considered important. As previously stated, devil numbers appear to decrease from the drier areas to wetter, colder areas. Spatial data relating to climate including rainfall and temperature were sought from the Bureau of Meteorology to use in the analysis. This data was only able to be obtained on a nationwide coverage and at a resolution not considered useful for modelling over small areas. Attempts to clip the datasets to Tasmanian extents, and then reproject to the common datum used for the analysis, also provided unsatisfactory results. As the type of vegetation at any location is greatly influenced by the climate, it was considered that the

provision of climate data would not greatly alter the results of the final analysis.

Altitude was also considered as an influencing factor on devil presence. A digital elevation model (DEM) was made available for the project. Just as vegetation type was considered as influenced by climate it was also considered as influenced by altitude. As altitude increased or decreased this would influence the type of vegetation present. For this reason altitude was not considered as a dataset to be used in the modelling of devil habitat. It was decided to use slope as an indicator of devil presence, because as slope increased, devil density was considered likely to decrease.

Other factors that were initially considered but not included in the final analysis were aerial spraying activities, specific forestry activities, water quality and presence of roads. Spatial data for the first three items was not available or in formats that would have been difficult to convert to a usable form within the time constraints of the project.

The affect of roads on devil populations was not made clear in any of the research carried out. It could be suggested that the presence of a road may have positive and negative influences on devil populations. A major traffic route may provide a barrier to devils accessing an area of suitable habitat, but a secondary road is unlikely to prevent devil movements. A road also provides a ready supply of carrion in the form of road kill, an all too common site on Tasmanian roads. The attraction of a ready food supply, and an easy path for long distance travelling, makes devils highly susceptible to road mortality (Jones 2000). As other natural environmental factors were considered more critical to devil presence, it was decided not to include roads in the final analysis.

The five factors chosen to model devil habitat suitability were:

1. Vegetation coverage
2. Land use
3. Fauna distribution
4. Proximity to water
5. Land slope

2.1.1 Vegetation Coverage

As stated in 1.1.3 there is a broad trend for a decrease in devil densities from the drier warmer areas of the sclerophyll habitat through the wet sclerophyll forests to the wetter rain forests and sedge lands and the colder alpine moorland (Dept. Parks Wildlife & Heritage TASPAWS records, cited Pemberton 1990).

The type of vegetation influences devil habitat on two fronts. It will determine what other animals are present and therefore influence food supply available to the devil, and it will also determine den suitability for devils during the day and at breeding times. Devils prefer areas that provide good vegetation coverage rather than open areas.

A dataset called TASVEG Version 1 was made available by DPIWE for use in the project. TASVEG is produced by the Tasmanian Vegetation Mapping Program (TVMP) and uses 154 distinct vegetation communities to produce a Tasmania-wide vegetation map at a scale of 1:25,000. The dataset was supplied in ESRI shapefile format with a GDA94 projection.
Full metadata details are provided in Appendix B-2 and a list of the vegetation communities in Appendix B-3. The 154 vegetation communities can be generalised into 11 vegetation groups. For the spatial modelling of devil habitat suitability, each vegetation group was assigned a value according to its suitability for devil habitat. These values will be discussed in 2.2.5.1.

2.1.2 Land Use

As stated above land use will have an influence on food supply for devils. Types of land use that will provide a food supply for devils are grazing activities, forestry activities, some cropping activities and rural residential.

Grazing areas provide a food supply to devils through carcasses of animals that have died of old age, disease, orphaned/lost lambs and in rarer instances predation on weak or young animals.

It is common for poisons to be used in plantation forests and cropping areas to eradicate wallabies, possums, and other animals that like to feed on the available plants. The carcasses of these animals then provide a food source for devils. Forests also provide good coverage and den conditions for devils.

Chicken runs in rural residential backyards also provide a ready food source for devils.

The land use data set used in the modelling is a database that contains a land use code for land parcels in Tasmania. The codes are recorded in the VISTAS system as part of the property valuation system utilised in Tasmania. A full listing of land use codes is included in Appendix B-3. The land use code was linked to a property parcel via a property identification number (PID). The property parcels were supplied in an ESRI shapefile with a GDA94 projection. Full metadata details for the parcel coverage are provided in Appendix B-4.

A deficiency in this data was the existence of property parcels that didn't have a PID. This is a common occurrence in the property cadastre in Tasmania and usually relates to crown or unidentified land. As a result not all parcels would have a land use code assigned. The consequences of this will be discussed in the spatial analysis process.

For the spatial modelling of devil habitat suitability, each land use type was assigned a value according to its suitability for devil habitat. The values will be discussed in 2.2.5.2.

2.1.3 Fauna Distribution

The devil predominately feeds on the carrion of other dead mammals, such as possums, wallabies, pademelons, wombats and quolls. Fauna surveys have been carried out annually at numerous sites throughout Tasmania since 1975. The locations are shown in Figure 2.1. Each site represents a section of road where a spotlight survey was carried out. At each site a count was performed on numbers of a specific animal sighted. The animals counted were: Bennett's Wallaby, Pademelon, Brushtail Possum, Eastern Quoll, Wombat and Tasmanian devil. With the exception of the devil, they are all considered as a potential food source for the devil. The most recent survey conducted state-wide, 2003, was used as an indication of available food for the devil.

The data was supplied in an excel spreadsheet format, which included a site identifier with an approximate AMG co-ordinate, as well as the animal counts. Using the co-ordinates, point features for each site were created in a shapefile and the respective counts were attached as attribute data. The total number of animals counted, excluding devils, was used as the point value for each site. As the co-ordinates were AMG co-ordinates, the point features were then projected to GDA MGA. How this data was used will be discussed further in 2.2.3.
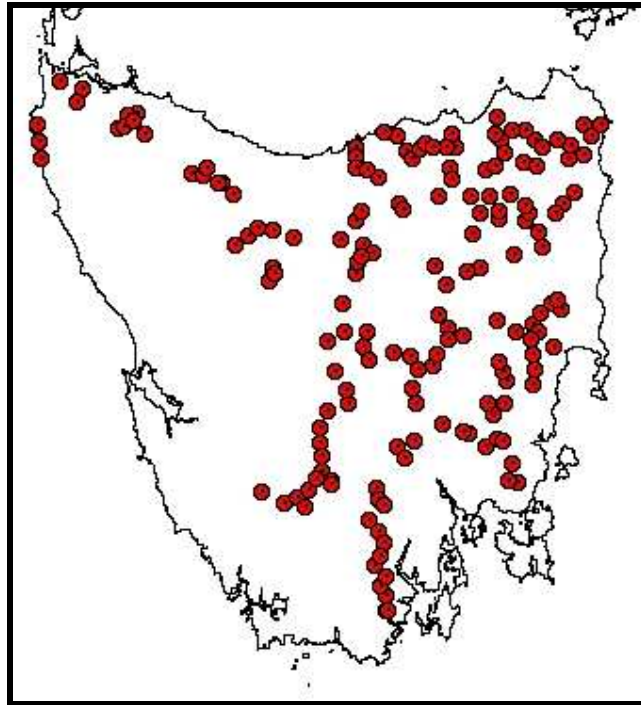
Figure 2.1 - Fauna Spotlight Survey Locations

2.1.4 Water Proximity

Tasmania has an extensive drainage network with over 166,000km of natural watercourses, nearly 7,450km of artificial watercourses and nearly 94000 water bodies (RPDC 2003). During Tasmania's wet season, May to September, there is a plentiful supply of drinking water available to the states fauna.

A dataset of the drainage system in Tasmania was obtained from DPIWE for use in the habitat suitability modelling. The dataset was in an ESRI shapefile format with a GDA94 projection. Full metadata details are provided in Appendix B-5.

This dataset was used to provide an indication of proximity to water supply for the habitat suitability model.

2.1.5 Land Slope

As stated above, devil population density decreases with an increase in slope of the terrain. A state-wide DEM was provided by DPIWE in an ASCII format. This was able to be converted into a raster file in ArcGIS. The data was supplied with a cell size of 25m and an AGD66 projection. This was reprojected in ArcGIS to a GDA94 projection. From this DEM, slope was extracted using Spatial Analyst Tools in ArcToolbox, an extension to ArcGIS.

2.2 Model Design

2.2.1 Introduction

To achieve the project objective of predicting devil density, a habitat suitability model would need to be created, based on factors affecting devil habitat. Habitat suitability can be determined by summing the values associated with the various influencing factors. This technique is called overlay analysis or map overlay and is frequently used in spatial analysis. Two types of map overlay can be performed; vector overlay and raster overlay. For this project it was decided to perform raster overlay for reasons of simplicity and efficiency.

Once the required layers had been supplied, a common format and projection needed to be determined prior to the commencement of any habitat modelling. As three of the five layers (parcels, vegetation and hydrology) had a projection of GDA94 it was logical that this projection be used for the analysis. This required the other two layers, the DEM and fauna survey to be reprojected from AGD66 to GDA94. This was achieved using Data Management Tools in the ArcToolbox extension of ArcGIS.

2.2.2 ModelBuilder

The five layers to be used for the habitat suitability model were now ready to undergo a series of transformation and spatial analysis tasks. These tasks could be carried out individually by applying the appropriate tools in sequence one after the other. For this type of project, a feature of ArcGIS called ModelBuilder, provided a more efficient way of completing the tasks.
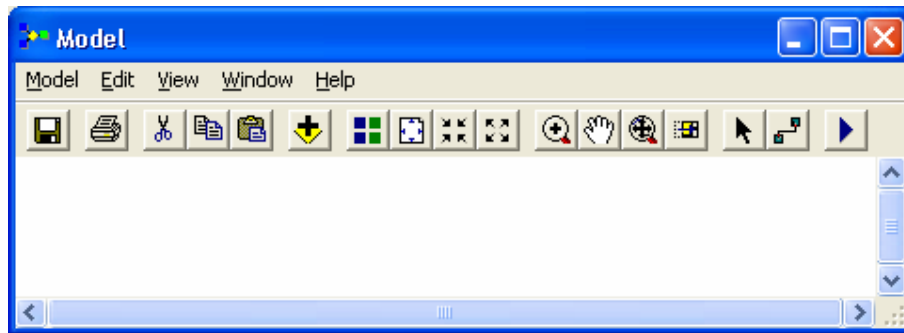
Figure 2.2 - ModelBuilder Window

ModelBuilder provides a window where tools can be combined into one model. Environment settings applying to all the operations to be carried out can be set once and input values changed as required. This allows the entire model to be run over again to achieve the desired results. If a different setting is required for any of the individual tools, they can be applied to the tool and will override the environment settings for the model. A summary of the tasks to be performed on each layer in the model prior to the final weighted spatial analysis is shown in Table 2.1.

Each task performed in habitat modelling was placed into the ModelBuilder window which displayed the task graphically. At the completion of the model, a schematic indicating all the tasks completed and the relevant inputs and outputs are shown graphically, similar to a flowchart. The completed schematic is included in Appendix C.

Table 2.1 - Layer Operations

Layer	Operations	
Vegetation	Vector to Raster	Assign Scale Value (1 to 10)
Land Use	Vector to Raster	Assign Scale Value (1 to 10)
Fauna Surveys	Create Surface	Reclassify (1 to 10)
Watercourses	Distance to Source	Reclassify (1 to 10)
DEM	Slope Extraction	Reclassify (1 to 10)

The intention was to create a spatial analysis model that would be able to be applied to any location within Tasmania, but at the time the model was ready to be tested, state-wide coverage of all layers was not available. Land use coverage was limited to one municipal area in Tasmania, the Northern Midlands Council, while all other layers were available on a state-wide coverage. Until the remaining land use data was made available, preliminary testing of the spatial model would be carried out within this area only (Refer Figure 2.3). Final modelling would be carried out on areas determined by a selection of devil trapping sites.

As stated above, ModelBuilder would allow certain values to be set prior to performing any analysis. For this model four values would be set:

1. A pathname representing the location of spatial data;
2. A pathname representing the location of a results folder;
3. The area to be used for the analysis, in this case a polygon representing the boundary of the Northern Midlands Council; and
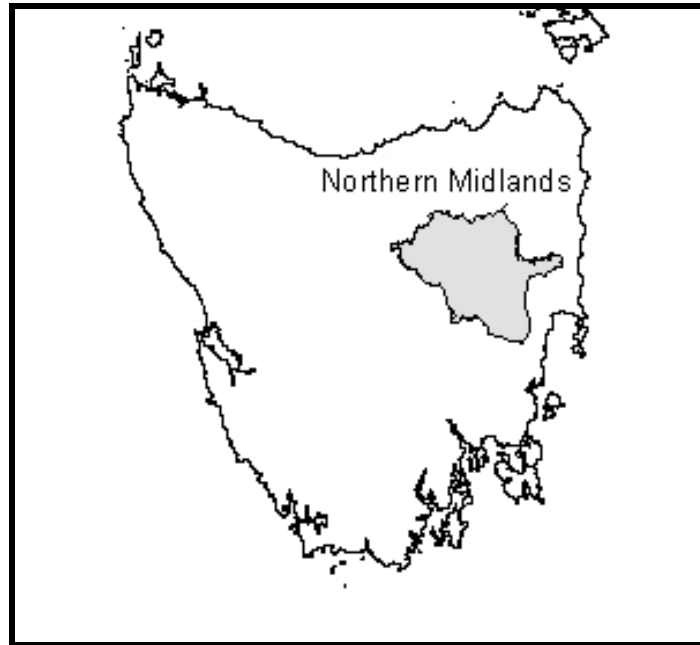4. The cell size for all raster outputs. For this model the cell size was set to 50m.

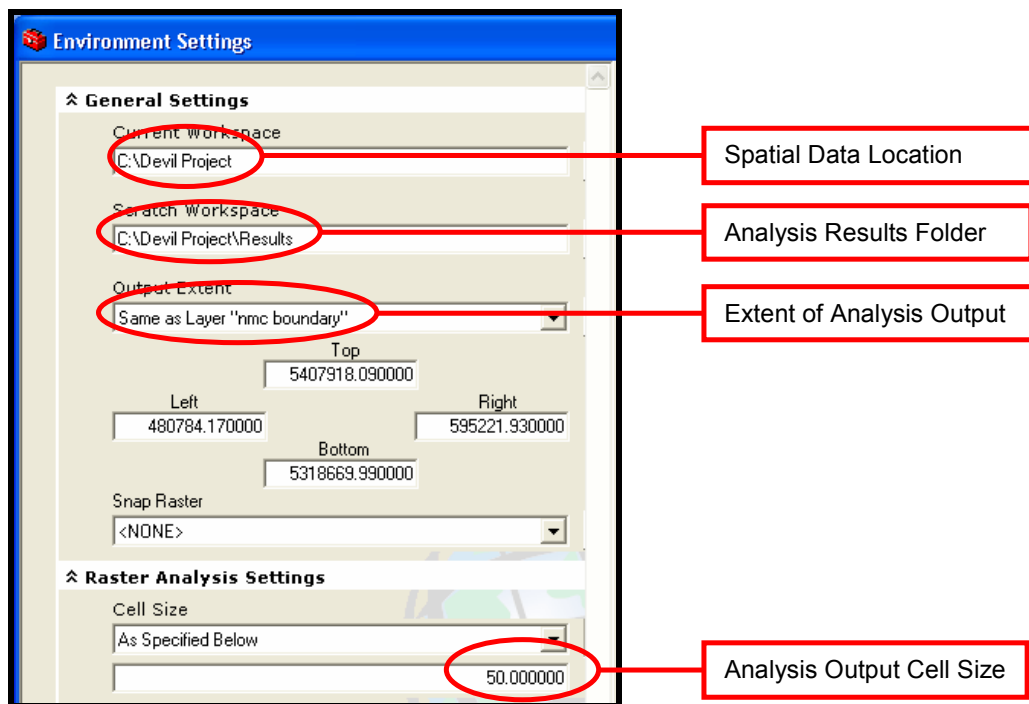**Figure 2.3 - Preliminary Modelling Area**

Figure 2.4 - ModelBuilder Environment Settings

The DEM to be used in the analysis had a cell size of 25m, but this was considered to be too small for the analysis as it may have required long processing times for large analysis areas. Many of the layers had also been derived from 1:25000 mapping, therefore a cell size of 25m would not have been appropriate for the accuracy able to be obtained. To reduce the time required, but maintain an acceptable resolution, a cell size of 50m was chosen for all raster outputs.

2.2.3 Creation of Raster Datasets

The first step in the analysis was to perform a series of tasks that would result in the creation of a raster layer for each of the five input layers.

For the vegetation and land use layers this was a straight conversion of the feature data of the shapefiles to raster layer, also known as rasterisation. This was achieved using a conversion tool in ArcToolbox. Each cell in the raster was given a value which related to a particular vegetation type or land use type.

The point data of the fauna surveys required conversion to a fauna distribution layer. This was achieved by interpolating the data using an inverse distance weighted (IDW) technique and resulted in a raster distribution of the point values over the analysis area. Each cell of the raster would have a value that represented an approximation of the number of animals within the area of the cell.

The ArcGIS documentation states that the output value for a cell using IDW is limited to the range of the values used to interpolate. The best results from IDW are obtained when the point values are sufficiently dense with regard to the local variation that is attempted to simulate. If the sampling of input points is sparse or very uneven, the results may not sufficiently represent the desired surface (Watson and Philip cited in ArcGIS Desktop Help). With this in mind, the fauna coverage created can

only be taken as an approximation only and this was reflected in the weighting used for this layer in the final analysis.

To obtain a measurement of proximity to a water supply, a Euclidean Distance tool was applied to the hydrology layer. This provided a raster layer with each cell representing a Euclidean or shortest distance to a source, in this case the feature representing a watercourse. The hydrology layer included all watercourses from rivers and major creeks to any topographical feature capable of carrying water. If the Euclidean distance tool had been applied to the layer in its original form, the output raster would have had a small range of values and not have contributed much to the final analysis. As many of the watercourses were likely only to carry water in the wet season, it was decided to only use the watercourses that would provide year round water. This was achieved by making a selection based on an attribute stored with the data shapefile. The result was a layer that provided a greater range of values for the final analysis.

While the DEM was already in a raster format, the slope needed to be extracted for use in the analysis. This was achieved by using a surface analysis tool in ArcToolbox. The result was a raster layer where each cell had a value representing a slope in degrees for area represented by the cell.

After completion of Stage 1, there were five new layers created. These are indicated in Table 2.2 with their associated cell values. As stated previously, the environment settings that were set prior to performing analysis tasks would produce output rasters with a cell size of 50m and restrict the extent of the outputs to the area of the Northern Midlands Municipality. A map showing each layer is included in Appendix D.

Table 2.2 - Raster Layers

Layer	Value	Value Range	Map No.
Vegetation	Vegetation Code	1 to 93	D-01
Land Use	Land Use Code	1 to 122	D-02
Fauna Surveys	Count	1 to 84	D-03
Watercourse	Distance	0 to 12000	D-04
Slope	Degrees	0 to 57	D-05

2.2.4 Reclassification

For the five layers to be used in a raster overlay analysis, each cell would need to have values on a common measurement scale. That is values on a scale of 1 to 10 could not be combined with values on a scale 1 to 93. Previous analysis tasks have produced layers with various ranges of values. These layers need to be reclassified where each range of values is assigned one discrete integer value. For this exercise the measurement scale used was 1 to 10 with attributes associated with favourable habitat for devils given a higher value.

For the layers associated with the fauna surveys, watercourses and slope, this would involve using a tool to reclassify the results of the previous analysis into 10 ranges. The reclassified layers and the assigned value are shown in Table 2.3.

For the vegetation and land use layers, values were set for each code in the final step of the analysis, the weighted overlay analysis.

Table 2.3 - Reclassification Values

Fauna Survey	Distance to Water	Slope	
Old Values	Old Values	Old Values	New Values
1 to 10	10800 to 12000		1
10 to 18	9600 to 10800	Over 45	2
18 to 26	8400 to 9600		3
26 to 34	7200 to 8400	30 to 45	4
34 to 42	6000 to 7200		5
42 to 50	4800 to 6000	15 to 30	6
50 to 60	3600 to 4800		7
60 to 68	2400 to 3600	5 to 15	8
68 to 76	1200 to 2400		9
76 to 84	0 to 1200	0 to 5	10

2.2.5 Weighted Overlay Analysis

The final stage of the analysis would be to weight and combine the five layers to produce a map showing the most suitable habitat for devils. The layers for fauna surveys, distance to water and slope, have all been reclassified to a common measurement scale. The vegetation and land use layers will be assigned a value on the common measurement scale as part of the weighted overlay process.

As weighted overlay analysis suggests, a weight or degree of influence needed to be assigned to each of the layers. This is achieved by assigning a percentage value to each layer, with a higher percentage representing a high degree of influence. As stated previously, food supply is a major influence on the presence of devils and three layers were identified as contributing to the presence of a food supply: vegetation, land use and fauna surveys. It was therefore logical that these layers were assigned a

significant majority of the weighting. The weighting for each layer was assigned as follows:

Vegetation	=	30%
Land Use	=	25%
Fauna Surveys	=	15%
Distance to Water	=	20%
Land Slope	=	10%

These values were derived from the background research carried out and from previous modelling used to select sites for the trapping program carried out as part of the strategic management plan. Initial modelling had placed a higher weighting on the fauna surveys, but as the data used to create this layer was relatively sparse, and therefore an approximation, the weighting was reduced and redistributed between the vegetation and land use layers.

2.2.5.1 Vegetation Cell Values

The TASVEG layer represents 11 vegetation groups, with each group made up of varying numbers of vegetation communities. For the weighted overlay analysis each vegetation type was assigned an integer value between 1 and 10, depending on the suitability for devil habitat. The vegetation groups and assigned values are shown in Table 2.4.

Vegetation groups representing good cover and warmer drier climates were assigned higher values than those representing poor cover and wetter, colder climates. Other natural environments were given a restricted value, as these values would not be included in the analysis. Vegetation types in this group represented sand, mud, water and sea; not likely to be considered as habitat for devils.

Table 2.4 - Vegetation Group Cell Values

Vegetation Group	Cell Value
Moorland, Sedgeland, Rushland and Peatland	1
Saltmarsh and Wetland	1
Highland, Treeless Vegetation	2
Wet Eucalypt Forest and Woodland	4
Rainforest and Related Scrub	4
Non-Eucalypt Forest and Woodland	5
Native Grassland	6
Agricultural, Urban and Exotic Vegetation	8
Scrub Heathland and Coastal Complexes	8
Dry Eucalypt Forest and Woodland	10
Other Natural Environments	Restricted

2.2.5.2 Land Use Cell Values

The land use codes contain 251 values representing eight main land use groups. The land use groups are Commercial, Industrial, Primary Production, Public Service/Institution/Utility, Quarrying and Mining, Residential, Sporting Facility/Recreation, and Vacant Land. Each land use code was assigned an integer value between 1 and 10 depending on suitability for devil habitat. The integer value could not be assigned generically for each land use group, as some land uses may be more or less suitable than others within a group. As an example, the Primary Production group includes grazing activities and vineyards. Grazing activities such as sheep grazing is likely to be more attractive than vineyards for devils. Another example is the Residential group. Urban residential areas are not likely to be suitable for devil habitat whereas rural residential areas are known to have visits from devils, particularly if a chicken run is present. As a result each individual land use code needed

to be provided with an integer value depending on the influence on habitat suitability. Examples of some of the values are shown in Table 2.5, with a complete listing provided in Appendix B-4.

Table 2.5 - Examples of Land Use Cell Values

Land Use Group	Land Use	Land Use Code	Cell Value
Commercial	Supermarket	C15	Restricted
Industrial	Warehouse	I0	Restricted
Primary Production	Farming–Mixed	L10	2
Primary Production	Farming-Grazing/Pastoral	L15	10
Primary Production	Forestry-Natural Bush	L33	8
Residential	House or Cottage	R1	Restricted
Residential	Rural Residential	R5	2

A problem arose in how to treat land parcels that were not linked to a land use code as mentioned in 2.1.3. The spatial analysis tool would read this as no data, and would assign a no data value to the output cell, even if other layers contained information. To avoid this, a value of 5 was assigned to cells containing no data. This would ensure a result would be provided for all cells. This value was chosen because it was in the middle of the scale and would not skew the result in either direction. The majority of cases where this occurs tend to be in rural areas, where other factors would assist in determination of the habitat suitability.

An alternative would have been to investigate each parcel on a case by case basis and determine an appropriate value based on surrounding uses.

2.3 Model Results

All five layers now contained integer values on the same measurement scale and were assigned a weighting percentage. The weighted overlay analysis was run and produced a map indicating devil habitat suitability with values ranging from 1 to 10. This map (D-06) is included in Appendix D6.

As one last step, the values were reclassified into five values which would indicate low, medium/low, medium, medium/high and high devil habitat suitability. The map (D-07) showing the revised classifications is also included in Appendix D7.

The map indicates that the Northern Midlands region consists of predominately medium/high to high habitat suitability. This is consistent with the area as it contains pastoral/grazing activities, forestry activities, and dry forested areas. These are factors identified as supportive of devil presence.

Chapter 3

Trap Site Modelling

3.1 Trap Site Locations

The next stage of the project involved selecting a number of sites that had been used to trap devils as part of a monitoring program under the management strategy. Five sites were chosen, three where DFTD has been confirmed and two in areas that were DFTD free. The five locations are shown in Figure 3.1. Data was received from Dr Clare Hawkins of DPIWE in a spreadsheet format.
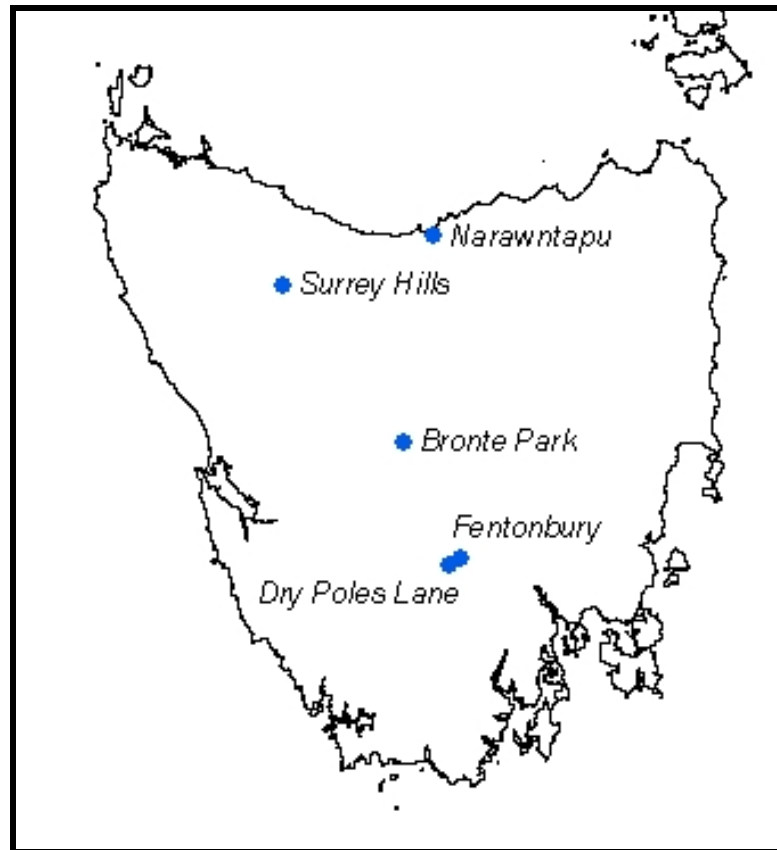
Figure 3.1 - Trap Site Locations

At each location trap sites were set for ten days, with each trap capable of catching one devil per night. Each devil caught was micro-chipped for future reference. Data was also collected for each devil trapped including sex, estimated age, weight, general condition and a DFTD score from 1 to 5. A score of 4 or 5 was considered to be diseased with 1 to 3 considered healthy.

Each trap site was also mapped with a set of co-ordinates, either AGD66 or GDA94. The data provided in the spreadsheet format was saved to a comma separated file. This allowed the locations to be mapped in ArcGIS as x and y co-ordinates.

Following receipt of the data it was noted two sites contained insufficient trap data to complete an analysis. These sites were Dry Poles Lane and Surrey Hills. While habitat suitability modelling was carried out at all five sites, further analysis was only carried out on the three remaining sites of Fentonbury, Bronte Park and Narawntapu. Summaries of the data collected from the three trap sites including trap site locations, are shown in Appendix E.

3.2 Trap Site Habitat Modelling

At each trap site location the trap site locations were buffered by 25km to provide an area that the habitat suitability model would be limited to. By dissolving the boundaries of all the buffers, a single shape was produced which formed the extent of the output for the modelling. The vegetation and land use layers were also clipped to this extent. This operation was included in the ModelBuilder window as part of the model. As the areas were considerably smaller than the original modelled area, it was decided to use the minimum raster cell size of 25m for the analysis.

The habitat suitability model was run at each of the trap site locations. A revised model schematic used for the trap sites is included in Appendix F.

A map for each of the trap site locations showing modelled habitat suitability, trap locations, trap success rates and devil status, is included in Appendix G.
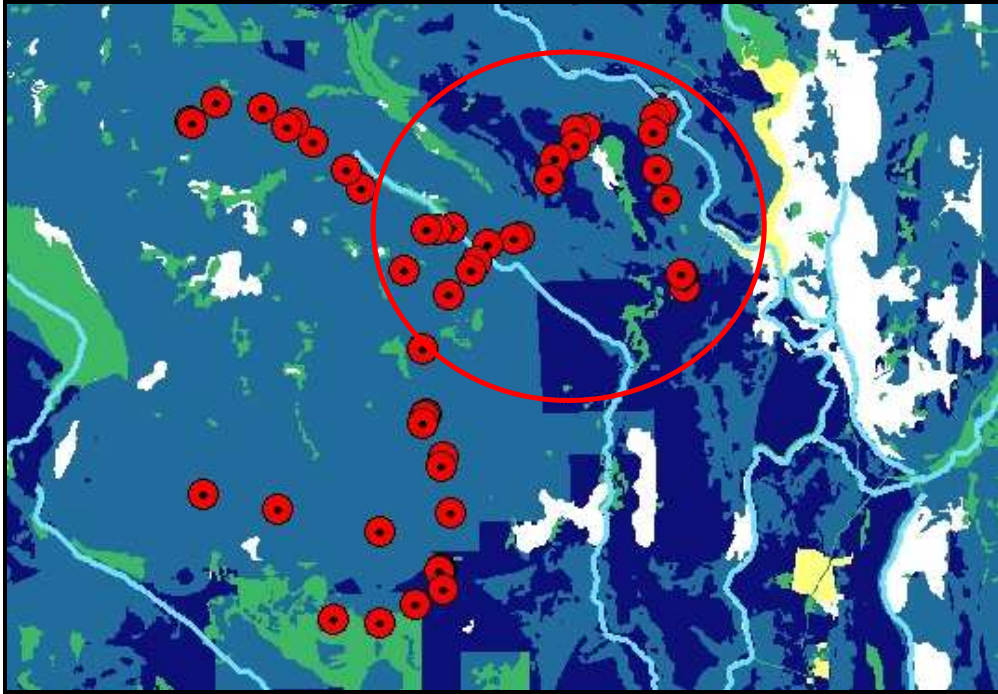
3.2.1 Bronte Park

The habitat suitability model when applied to the Bronte Park trapping area produced areas of mostly medium to high suitability (Refer Appendix G1 and G2). There were also a few small areas of no data indicated by the white areas of the map which indicated the location of water bodies.

An inspection of the individual layers used in the model support this area having a high suitability for devils. The vegetation is predominately Dry Eucalypt Forest and Woodland with some regenerating cleared land ranking next highest. Land use is predominately forestry and grazing, and the spotlight survey score for the area was 32, which equates to a value of 4 on the 1 to 10 scale in the model. This area was not located in close proximity to many of the spotlight survey sites, which were mostly to the east; therefore it was not well placed in the IDW process. The sites were mostly in an area of gently sloping terrain, as dictated by the model used to locate them, with the slope mainly from 0 to 15 degrees. There was also several watercourses running through the area plus the water bodies mentioned above.

The results of trapping in this area are shown in Appendix E1 and E2. Of 47 individual devils trapped in this area, 19 showed signs of DFTD. The majority of these appear to be on the eastern side of the trapping area, traps 1 to 20 (Refer Figure 3.2). This area is closer to the larger watercourses as well as a lagoon. It is mostly in an area where forestry is the major land use, as are many of the other sites that trapped significant numbers of healthy devils.

Of the 47 devils trapped, 23 were first captured in this eastern section and of these 14 were found to have DFTD. This represents a significant portion

of total devils trapped and devils with DFTD. For traps 21 to 34 (north western area), the ratio was 12 trapped and 2 with DFTD, and traps 35 to 50 (southern area) the figures are 12 trapped and 3 with DFTD.


Figure 3.2 – Bronte Park Trap Sites
Eastern sites, shown circled, trapped nearly half of devils caught and 14 of the 19 considered as having DFTD.

The eastern trap sites did contain more areas of high habitat suitability than other sites within the trapping area. These figures provide some support to the habitat modelling, in that it provides a reasonable indication of higher devil populations. Devils have a home range of up to 20km^2, and the trap sites are located within a radius of approximately 4km, so it can be assumed that there will be a degree of overlap among devils in the area.

The figures also provide an indication that prevalence of DFTD may have a strong relationship with higher devil population densities, as stated in 1.3.

3.2.2 Fentonbury

The habitat suitability model when applied to the Fentonbury trapping area produced areas of mostly medium/high suitability (Refer Appendix G3 and G4). There were also approximately equal areas of medium and high suitability areas. Of major significance was the occurrence of a large area of no data as indicated by white areas on the map (Refer Figure 3.3). On further investigation it was noted that these areas corresponded with areas within the Dry Eucalypt Forest and Woodland group, which should have received a high value under the weighted overlay analysis. When the values in the ModelBuilder were checked it was noted that a code for the specific vegetation community didn't exist, and therefore no data was output in the result.
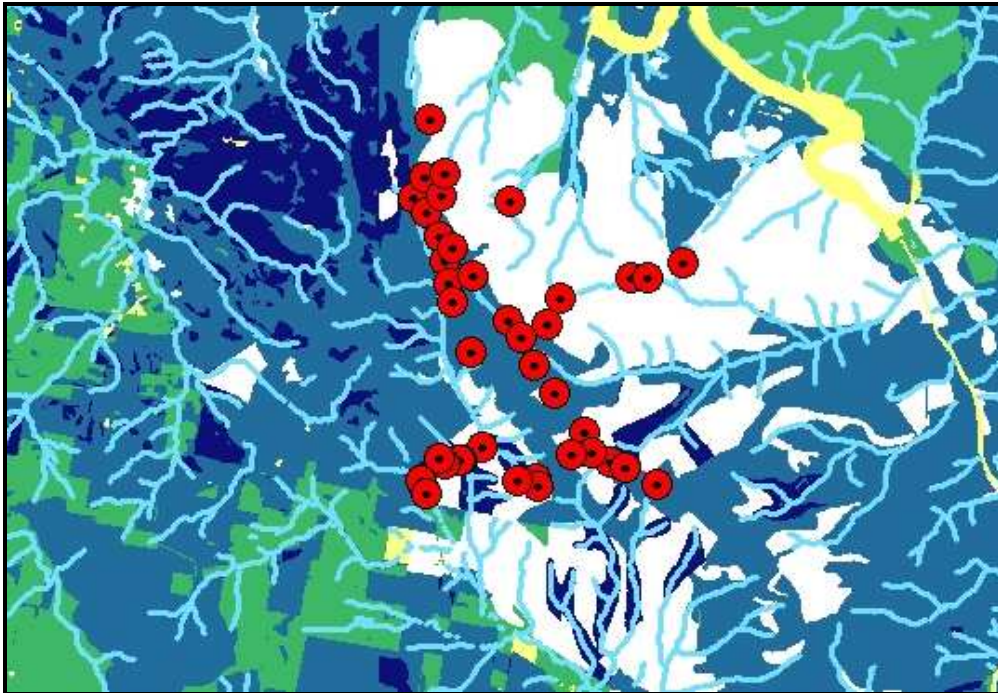
Figure 3.3 – Fentonbury Trap Sites
White areas indicate no data where relevant vegetation code was omitted from weighted overlay analysis.

When the original model was created for the Northern Midlands, only those vegetation polygons that appeared within the bounding polygon were selected and therefore only those respective codes appeared in the weighted analysis toolbox and assigned a value. After successful completion of the model, it was then copied for use at the selected trap site areas. Any vegetation codes that had not previously occurred, would not have received a value in the final weighted overlay analysis. This was a serious oversight that was not picked up until the end of the project, and therefore could not be remedied. To ensure all vegetation codes were included for subsequent modelling, a selection should have been completed on the state-wide vegetation dataset.

On inspection of the layers used in the modelling, there appears to be support for the area to have medium/high suitability. Vegetation in the area includes dry eucalypt forest and woodland, regenerating cleared land, scrub and coastal heath, and agricultural. These groups have a high value assigned in the weighted overlay analysis. Land use is mainly grazing/pastoral and forestry with some rural residential and cropping. The fauna coverage value was again low at only 3. There is adequate access to water and slope varies between 0 and 30 degrees, but is predominately below 15.

Taking this into account, if the model had functioned correctly, it could be estimated that the no data areas would have appeared as medium/high suitability.

The results of trapping in the area are shown in Appendix E3 and E4. Of 62 individual devils captured in this area, only 3 showed signs of DFTD. Only 2 trap sites did not catch at least one devil over the 10 day trapping period. The spread of devils over the trapping area appears to be reasonably uniform with no obvious areas of higher population density. The suitability modelling, assuming medium/high values in place of the no data values, appears to be fairly uniform over the trapping area. This may

account for the more uniform results in the trapping program. The overall trapping success rate was higher than for Bronte Park, 29.25% against 16.2%.

3.2.3 Narawntapu National Park

The habitat suitability model when applied to the Narawntapu National Park trapping area produced areas ranging from low to high (Refer Appendix G5 and G6). The significant portion of low suitability actually represents Port Sorrel at the mouth of the Rubicon River. The land portion of the area is mostly medium/high suitability, with areas of medium suitability and some smaller areas of high suitability.

Once again there were some areas that appeared as no data, but not to the extent of the Fentonbury trapping area. The cause for this was assumed to be another missing vegetation type code in the weighted overlay analysis, but this was not fully investigated due to time constraints. On inspection of the vegetation codes they were found to be of a type that would score highly for devil habitat.

The Narawntapu trapping area is a coastal site, unlike the previous sites that are situated in central Tasmania. There is greater variation in the vegetation types, but predominantly of a type suitable for devil habitat. Land use is predominantly forestry and pastoral grazing. Fauna coverage was once again low with values of between 2 and 3 over most of the area.

There is an extensive network of watercourses providing good access to water. The slope varies from 0 to 5 degrees near the coast, but increases inland up to 30 degrees. The variation in the input layers is reflected in the variation in the habitat suitability map.

The trap sites followed a section of the coastline in an east-west direction, and inland in a north-south direction (Refer Figure 3.4). The results of the trapping program in this area are shown in Appendix E5 and E6. To date,

no devils with DFTD have been recorded in this area and therefore only population density can be discussed for this site.
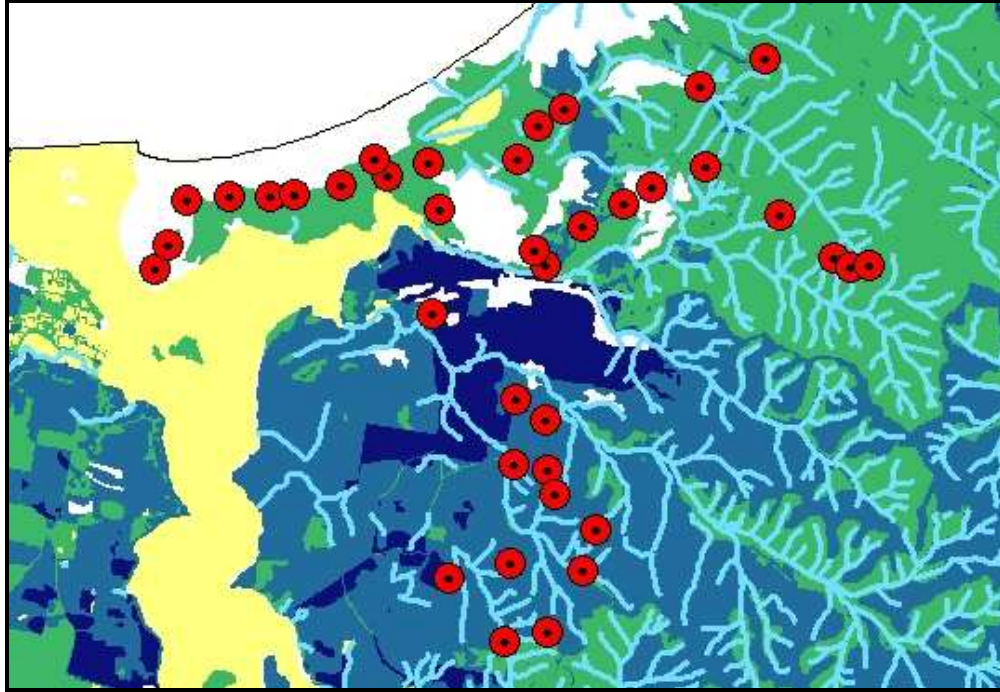
Figure 3.4 - Narawntapu National Park Trap Sites
Yellow area represents Port Sorell

Although in a medium suitability area, of the 60 individual devils trapped, 24 were first trapped in this area, and 58 out of the total of 116 devils captured. This suggests that a factor relating to coastal conditions needed to be included in the modelling, or that one of the datasets used may have had a particular cell value under weighted. On inspection of the land use data, there was a large parcel of land that did not have a land use associated with it. As this is a National Park it could be assumed, that the land is in a natural state and should have received a higher value in the analysis. Tasmanian devils are also known to include some sea life in their diet.

The area to the south of the coastal strip, including traps 27 to 37, accounted for 23 of the initial devil captures and 38 of the overall numbers

trapped. This is an area of medium/high to high devil suitability and therefore the results support the modelling.

The remaining trap sites, traps 15 to 26, were in an area of predominantly medium suitability in the east, and medium/high suitability in the west. The western area achieved similar trap success rates as those in other areas of medium/high suitability. The eastern area achieved the lowest trap success rates for this trapping area and also had the lowest habitat suitability score.

In general there appeared to be some good correlation between habitat suitability and trap success rates for this area. This could suggest that the modelling may be a good predictor of devil density.

The reason for the absence of DFTD in this area is of interest to the researchers, as it has significant devil populations, similar to other areas.

Chapter 4

Conclusions and Further Work

4.1   Achievement of Objectives

This project has demonstrated how spatial and non-spatial data in various forms, can be transformed, combined, weighted and overlaid to model the habitat of the Tasmanian devil. By comparing the results of the spatial analysis with data collected in the field, a measure of the effectiveness of the modelling could be performed. Despite some errors made in the completion of the modelling, some positive results were obtained. The project highlighted the importance of ensuring the data input into the process is correct and processes are routinely audited to ensure useful results.

The habitat modelling was only compared with one area that contained significant numbers of devils with DFTD. There was a small indication that areas modelled as more suitable for devils, contained higher numbers of devils and also a higher incidence of DFTD. This might prove useful in the siting of traps for future monitoring programs.

The success of the project was somewhat limited by the level of skills with the chosen spatial analysis software. In general, the software used performed well, but a better understanding and knowledge of the software would have benefited the project. More effort in this area was needed in the early stages of the project.

4.2   Further Work

The datasets used in the habitat model were of differing accuracy and reliability. For a project of this type to be effective, the quality of the data

needs to be at a higher level and with fewer margins for error. The time constraints of the project meant that time for data collection was restricted and data used needed to be in a form that required minimal preparation. If further work was to be performed in this area, other datasets should be researched to provide more accurate results. The model should be further refined, with the addition of other data layers if available. An example of this would be to include accurate climate data as a layer in the model.

Only three trap site areas were examined in this project, so further work on all other trap sites should be performed to further investigate relationships between habitat suitability, devil populations and presence of DFTD. This should only be done after further refinement of the model and ground proofing with field data to determine the accuracy of the model.

Comparison of the habitat modelling results with the data collected from trap sites was on a basic level only. More detailed statistical analysis should be used to further examine the existence, absence or strength of any relationships.

Other environmental factors that could be assisting in either the cause or the spread of the disease should also be investigated and subjected to spatial analysis techniques. This might include the use of chemicals in farming and forestry activities, sources of pollution, river water quality and distribution of other fauna and flora.

This project has only examined one aspect where spatial analysis can be used as a support tool to management strategies of disease control and native animals. Further projects may assist in ensuring that the Tasmanian devil remains a vital part of the Tasmanian environment.

__References__

DPIWE 2004a, *Tasmanian Devil,* Department of Primary Industries, Water & Environment, viewed 17/1/05
< http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/BHAN-5358KH?open>

DPIWE 2004b, *Information on Devil Facial Tumour Disease,* Information Sheet, Department of Primary Industries, Water & Environment, viewed 7/1/05
<http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/LBUN-5QF86G?open>

DPIWE 2005a, *Research into the Tasmanian Devil Facial Tumour Disease (DFTD),* Progress Report, Department of Primary Industries, Water & Environment, viewed 30/1/05
<http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/JCOK-65X2Y6?open# ResearchintotheTasma>

DPIWE 2005b, *Tasmanian Devil Facial Tumour Disease (DFTD), Disease Management Strategy,* Department of Primary Industries, Water & Environment, viewed 20/2/05
< http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/JCOK-65X2Y6?open# DiseaseManagementStr>

ArcGIS Desktop Help, ESRI ArcMap 9.0

Guiler, E. R. 1982, 'Temporal and spatial distribution of the Tasmanian devil, Sarcophilus harrisii (Dasyuridae: Marsupialia)' , *Royal Society of Tasmania Papers*, Vol. 116 (1982), p153-163

Jones, M , Paetkau, D, Geffen, E, Moritz, C, 2004, 'Genetic diversity and population structure of Tasmanian devils, the largest marsupial carnivore' *Molecular Ecology,* Vol. 13, pp 2197-2209

Mooney, N 2004, 'The Devil's New Hell', *Nature Australia,* Vol. 28 Issue 3, p34, 8p, viewed 17 May 2005, EDSCOhost database, Item:15624509.

Paquet, P, Strittholt, J & Staus, N 1999, *'Wolf Reintroduction Feasibility in the Adirondack Park'* Conservation Biology Institute, Corvallis OR

Pemberton, D 1990, *Social Organisation and Behaviour of the Tasmanian Devil, Sarcophilus harrisii,* PhD Thesis, University of Tasmania

Purves, H & Doering C, *Wolves and People: Assessing cumulative impacts of human disturbance on wolves in Jasper National Park,* viewed 14/4/05
<http://gis.esri.com/library/userconf/proc99/proceed/papers/pap317/p317.htm>

Ramirez, A 2004, *Geographic Information Systems and its Role in Biological Risk Management,* Centre for Food Security and Public Health, Iowa State University, viewed 12/4/05
<http://www.cfsph.iastate.edu/BRM/resources/General/GeographicInformationSystesRoleBRM_Sept2004.pdf>

Resource Planning and Development Commission 2003, *State of the Environment Tasmania 2003,* last modified 2 May 2005, viewed 17 October 2005, *<http//www.rpdc.tas.gov.au/soer>*

Appendix A: Project Specification

University of Southern Queensland
Faculty of Engineering and Surveying

ENG4111/4112 Research Project
PROJECT SPECIFICATION

FOR: **Mark Andrew McGOVERN**

TOPIC: SPATIAL ANALYSIS OF TASMANIAN
DEVIL FACIAL TUMOUR DISEASE

SUPERVISORS: Dr Yan Liu

ASSOCIATE SUPERVISOR: Dr Clare Hawkins
Department of Primary Industry, Water and
Environment, Tasmania

PROJECT AIM: The project will use spatial analysis techniques to examine relationships between Tasmania Devil populations inflicted with a facial tumour disease, and environmental and population factors.

PROGRAMME: **Issue B, 6 October 2005**

1. Research background on origins, characteristics and spread of disease.

2. Obtain spatial data on devil population densities for diseased and disease free populations.

3. Obtain spatial data on various environmental factors including land uses, vegetation type and coverage, agricultural practices including aerial spraying and other chemical use, forestry practices, and water quality.

4. Determine areas to be used for spatial analysis.

5. Use GIS software to perform spatial analysis on the available datasets to identify areas where Tasmanian Devils are at a higher risk of contracting the disease.

6. Compare areas of diseased and disease free devil populations to assist in the identification of areas that may be set aside as quarantine zones for healthy animals.

AGREED:

_____ (Student)

_____ (Supervisor)   Dated: _14_/_10_/_2005_

Appendix B: Metadata

Appendix B1: LIST Data Conditions of Use

Appendix B2: TASVEG Version 1 Metadata

Appendix B3: TASVEG Vegetation Communities

Appendix B4: Land Use Codes

Appendix B5: LIST Parcel Metadata

Appendix B6: LIST Hydroline Metadata

Appendix C: Habitat Suitability Model Schematic

This a graphic representation of the datasets, tools and processes used to complete the devil habitat suitability model.

Appendix D: Habitat Suitability Modelling

Northern Midlands – Input Layers and Model Results

Appendix D1: Map D-01: Vegetation Coverage

Appendix D2: Map No. D-02: Land Use Coverage

Appendix D3: Map No. D-03: Fauna Survey Coverage

Appendix D4: Map No. D-04: Watercourse Proximity

Appendix D5: Map No. D-05: Land Slope

Appendix D6: Map No. D-06: Habitat Suitability

Appendix D7: Map No. D-07: Reclassified Habitat Suitability

Appendix E:TRAP SITE DETAILS

E1 - Bronte Park Trap Sites

E2 - Bronte Park Tasmanian Devil Data

E3 - Fentonbury Trap Sites

E4 - Fentonbury Tasmanian Devil Data

E5 - Narawntapu National Park Trap Sites

E6 - Narawntapu National Park Tasmanian Devil Data

NOTES:

1. Tasmanian devil data covers the data collected the first time an individual devil is trapped.
   Some devils are caught more than once. The trap sites page gives total devils trapped and the devil data page gives the number of individual devils trapped.

2. DFTD Score:
   4 or 5 is considered as a diseased animal.
   3 or less is considered healthy.

3. General Condition Score:
   2 = skinny
   3 = average
   4 = fat

4. Age:
   Four age classes estimated unless there is prior knowledge.
   Oldest animals are '4 years or older'.
   Age is in terms of estimated year of birth.
   Assumed devils are born in March, though this can be between February and August.

Appendix F: Habitat Suitability Model Schematic (Trap Sites)

This a graphic representation of the datasets, tools and processes used to complete the devil habitat suitability model for the devil trap sites.

Appendix G: Trap Site Modelling