Urban Ecological Mapping

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ABSTRACT

At present there is no ecologically based mapping system designed for urban areas in New Zealand. The focus to date has been on developing vegetation mapping techniques for application to native habitats in primarily rural areas. Urban areas differ substantially in both their vegetation and habitat types from these areas. This paper describes the development of an ecological mapping methodology applicable to urban areas in New Zealand. It focuses on a project established in conjunction with Dunedin City Council to map all Dunedin's natural areas including formal open space such as nature reserves, parks, sports pitches and informal open space such as scrub, gardens, vegetated gullies and wasteland. A Geographic Information System (ArcView GIS) has been used to map the urban ecology and to assist in the development of an open space strategy for Dunedin that incorporates all types of natural open space present in the city.

Keywords and phrases: urban habitats, GIS, ecological mapping

1.0 INTRODUCTION

Dunedin City Council wants to develop a comprehensive open space strategy for the city that complements its existing reserves management strategy and places this strategy within the wider context of managing the total open space resource. The development of such a strategy is only possible once all open spaces are identified, classified and mapped at the micro-scale, i.e. at site based level. A comprehensive data base containing all open space types is important for the following reasons:

- To facilitate identification and comparison of the range of urban habitat types and the relationship between natural, indigenous and modified habitats.

- To facilitate the identification of ecological corridors, linkages and gaps in open space networks
- To inform decision making regarding development proposals
- To identify both short term and longer term changes in the open space network
- To identify areas of natural deprivation
- To develop urban amenity indicators to assess open space accessibility and other factors
- To guide the future development of open space and natural habitats, in particular the allocation of scarce conservation resources and the identification of focus areas.

This paper describes the ongoing development of the Dunedin ecological mapping project, focusing on the development of the GIS data base system. Whilst the intention is to trial the mapping system in Dunedin, it is intended that the system developed will have wider applicability for New Zealand's urban areas.

2.0 THE PROBLEM

Urban ecological mapping systems have been developed and applied overseas (e.g. Sukopp & Weiler 1989, NCC, 1993) but there is at present no ecologically based habitat mapping system designed for urban areas in New Zealand where modified habitats predominate. The focus to date has been on developing vegetation classifications for application to natural and indigenous areas, primarily in rural settings. Newsome's 'Vegetation cover of New Zealand' (1987) and Atkinsons vegetation structural classes (1985) are such examples. Although urban plants and vegetation are found to occupy analogues to their natural or original habitats (Meurk and Hall, 2000), urban areas differ substantially from rural areas in their development history and their exposure to stress. The existing New Zealand ecological classification systems generally omit habitats that are important contributors to the urban open resource, habitats such as cliff faces, disused quarries, private gardens and grounds, river and rail corridors. Therefore, the need is for an ecological mapping system that incorporates all types of urban open space ranging from indigenous natural forest and bush remnants to modified open space such as recreation grounds and derelict land and which enables these to be incorporated into the open space planning process.

The modified nature of habitat types in urban areas means that some elements of the ecological mapping process will necessarily incorporate elements of subjectivity. Every effort has been made to reduce subjectivity in the Dunedin project, through clear exposition of criteria, standardization of categories as far as possible and incorporation of methods from established ecological classification methodologies. Successful ecological mapping will nonetheless depend on a combination of an effective and clearly understood methodology and the use of trained field researchers.

3.0 THE MAPPING PROCESS

The software package ArcView was chosen as the Geographic Information System to be used for this project. The pragmatic reason for this was that the Dunedin City Council already uses this software system as its GIS data base for its land use and planning data and thus use of ArcView was necessary to ensure compatibility of data. The mapping process was based on combining the use of coloured aerial photographs and field work to identify and classify all vegetated open space in Dunedin. During the course of the habitat data acquisition it became clear that within the time frame of the project, i.e. one year, comprehensive mapping of all habitat parcels would not be feasible. Therefore, a decision had to be made regarding the level of detail that could be incorporated into the project whilst still achieving the project aims as shown in table 1.

Table 1. Alternative methods for mapping urban habitats in Dunedin

	Method 1 **Selective mapping (natural areas only)**	**Method 2** **Comprehensive mapping (detailed level)**	**Method 3** **Comprehensive mapping (strategic level)**
Focus	Natural areas	All open space	All open space
Extent	City-wide	Selected areas	City-wide
Methods	Identified on aerial photos and ground-truth in field (incl. dominant species, vegetation structure and notable site features)	All open space identified and mapped using aerial photos and extensive fieldwork. Classification needed to detailed level.	All open space identified and mapped using aerial photos. Limited fieldwork for most ambiguous categories. Classification to broad categories.
Outcome	City-wide coverage of selected natural areas incl. broad descriptions	Detailed habitat maps for all areas.	City-wide coverage of urban habitats classified to broad categories
Advantages	Field assessment of areas incl. target notes (e.g. main canopy species, under-growth structure, notable site features for forested areas)	Coverage of all open vegetated space in Dunedin. Additional ecological information for visited areas	Fastest method to give important strategic planning information and focus future studies
Disadvantages	"Focus on the obvious" so potential sites for re-vegetation are missed, comparative analysis of all open space not possible	Resource intensive. More complex classification system (i.e. more categories)	Limited information on site features Information loss through application of broad categories

Different mapping methodologies and alternative levels of detail were considered and discussed with the City Council to ascertain how best to progress the mapping (see Table 1 and Figure 1). Selectively mapping only open areas which showed a higher degree of naturalness (e.g. bush remnants) would not provide the information needed for successful strategic planning of urban open space. A decision was made to map habitat data at two levels:

- Comprehensive mapping at a detailed level would be made for sample areas identified as experiencing significant development pressure (Method 2).
- Comprehensive mapping at a strategic level would be made for the whole city of Dunedin (Method 3)

On the one hand the use of these different levels was a pragmatic response to time constraints, but on the other it also allowed for the assessment of the comparative benefits and problems associated with different data scales. This approach also enables for the evaluation of alternative approaches to habitat mapping. In mapping habitats the focus was on key habitat types and key species, it was not intended that the project should provide a detailed ecological record for each site. For Dunedin city the following data was recorded for each habitat parcel:

- Location
- Size
- Site age (estimated)
- Urban land use type for the site and surrounding parcels, e.g. private garden, transportation space

- Habitat type e.g. improved pasture, gorse scrub
- Key plant species, e.g. mahoe, kanuka, gorse, fuchsia

A hierarchical habitat classification was used which allowed for habitat mapping at the two different levels, with defined mapping scales at each level. Broad habitat categories were applied at the strategic level (Method 3). These habitats could then be further refined in more a detailed habitat mapping (Method 2). An example of the strategic habitat maps is shown in Figure 1.

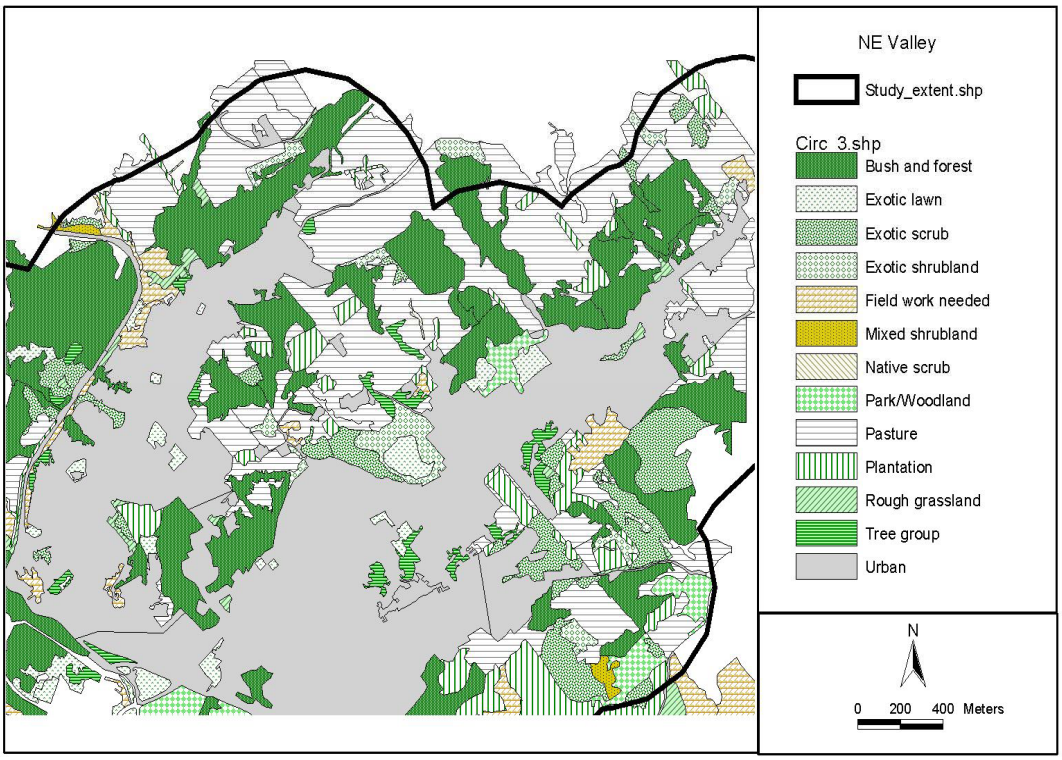

Figure 1. Sample area showing aerial photo and urban open space classified to a strategic planning level

4.0 EVALUATION OF THE MAPPING SYSTEM

In developing and testing the mapping methodology the following were identified as key issues and problem areas that needed to be addressed

- Subjectivity of the mapping process
- Lack of rapid mapping techniques for regenerating urban bush
- Cost-benefit analysis of different methodologies
- Time consumption of GIS work
- Conflict between information detail and time constraints
- Scale problems

Subjectivity is always of concern for every ecological mapping process. However, establishing clear criteria that define the different steps in the mapping process can reduce it. Digitization rules can assist in the spatial GIS work. One area in which digitizing rules for example, were made explicit was in relation to the size of habitat areas digitized. The rule used to guide the digitizing of habitat areas was as follows:

Habitats larger than 0.5 hectares
Adjacent polygons with a different vegetation structure and larger than 0.5ha are digitised and classed as separate habitats
Habitats smaller than 0.5 hectares
Habitats and land use types smaller than 0.5ha will not be mapped at the strategic mapping level. These areas will be included into the neighbouring and/or surrounding habitats and land use types. Thus areas surrounded by the same habitat type are included into the surrounding habitat. For example- a residential building with lawns totaling less than 0.5ha and surrounded by native bush would be classified as native bush

Standardized survey field sheets were used to ensure a consistent information level of field data. Habitats were grouped according to pre-defined criteria. When undertaking the fieldwork it became apparent that the existing vegetation classifications were not suitable to allow a rapid assessment of especially regenerating urban bush. They were either too detailed to be used during our project or their categories applied more to mature native forest communities. Further, during the course of the mapping process it was evident that compromises were constantly needed between the spatial accuracy of the data set and the time constraints of the project. The creation of the habitat data set, notably the digitizing work within the GIS proved to be the most time consuming aspect of the project. Many of these problems were clearly related to the problem of scale in ecological applications (see Wiens 1989, discussion on ecological scaling). Plant communities are neither discrete units nor homogeneous. Hence there is a problem of boundary detection, which is scale dependent. Boundary types can range from sharp, clearly defined boundaries between highly modified plant communities and anthropogenic created land-use types at one extreme, to more gradual and diffuse boundaries between natural and semi-natural plant communities at the other (Kent et al. 1997). Ecological mapping units are therefore defined at a specific scale depending on management needs. Employing defined mapping scales at two habitat levels with defined digitizing rules was considered to provide the best compromise solution for achieving a sound database for the mapping and strategic evaluation of Dunedin's urban open space.

5.0 APPLICATIONS

The Dunedin City Council was mainly concerned with the construction of a habitat map which showed key habitat types, their relative quantities, quality and which would act as a base on which they could develop an overall open space strategy for the city. However, once construction of the habitat map has been completed the potential for more advanced modeling capabilities and applications can be realized. The final phase of the project then is to illustrate the modeling capabilities and applications of the database (Figure 2). These include:

- Comparative analysis of habitat types through application of simple query functions
- Identification of relative proportions of different habitat types e.g. comparison of areas of different forest types, native, semi-natural and exotic.
- Identification of potential corridor links by calculating distances between habitats and identifying all open space within a given area
- Identification of areas of natural deprivation through creating a buffer zones around all natural areas, areas with the urban falling outside are classed as areas of natural deprivation
- Mapping possible scenarios, e.g. deforestation of bush gullies by changing these sites to urban built-up areas
- Ecological habitat analysis for animal species (e.g. animal movement, number of suitable habitats)

6.0 CONCLUSION

The system under development became far more time consuming as regards creation of the habitat database than was anticipated. This means that compromises are being made on the comprehensiveness of the data. Nonetheless this is the first time an attempt has been made to develop and apply a rapid ecological mapping

system of the sort developed and used in Germany and the UK for application to New Zealand urban areas. The development of intelligent digitizing techniques that could undertake the bulk of the manual digitizing would be a huge step forward. Until such systems become available it is likely that the compromise approach adopted for Dunedin with most areas mapped at broad scale with finer scale being used for natural areas and areas of particular concern will need to be followed. Nonetheless, the substantial capabilities and applications that can be derived from a comprehensive urban ecological map are clearly evident and an exciting step forward in urban green-space and urban ecological planning. Particularly exciting are the modeling applications related to urban amenity indicator development, green corridor development and identification of areas of natural deprivation.

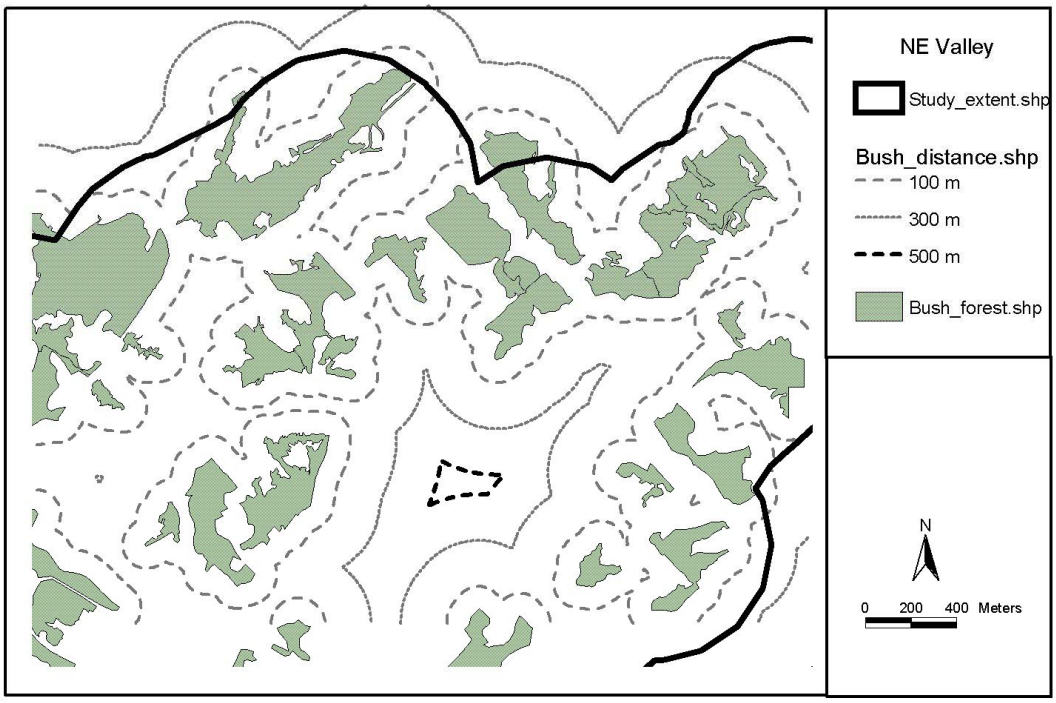

Figure 2. A simple method of habitat analysis by expressing distance from bush and forest habitats through contour lines.

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