Spatial implications of perceptions and interpretations of "natural character" and indicators of biodiversity

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ABSTRACT

New Zealand's Resource Management Act 1991 calls for the preservation of "natural character" without defining this term. A study looked at the interpretations of this Act in resource management plans, at public perceptions of natural and modified landscapes, and biodiversity as an ecological indicator of naturalness. A component of this study investigated the use of GIS to create maps illustrating some of the issues raised by the other components of the research. This helps to clarify and make more explicit the localities and the extent of the areas affected by resource management decisions.

***Keywords and phrases*:** GIS, mapping, legislation, public perceptions, indicators

1.0 INTRODUCTION

New Zealand's Resource Management Act 1991 (RMA) replaced previous legislation on the management of the natural and physical resources in New Zealand. Integral to the implementation of the Act are the terms "natural features", "natural landscapes" and "natural character", which are referred to as "matters of national importance" in:

- Section 6(a) which requires "the preservation of the natural character of the coastal environment (including the coastal marine area), wetlands, and lakes and rivers and their margins, and the protection of them from inappropriate subdivision, use, and development"; and

- Section 6(b) which requires "the protection of outstanding natural features and landscapes from inappropriate subdivision, use, and development".

These terms are, however, not defined in the legislation. As a consequence, disagreement as to their interpretation and meaning with regard to the implementation of the RMA resulted (for example, Maplesden, 1995). In 1997, Forest Research commenced a research programme to identify how resource managers and the general public perceive "natural features", "natural landscapes" and "natural character", as well as the usefulness of ecological indicators for characterising naturalness in landscapes.

The site for this research was in the Coromandel Peninsula, on the east coast of the north island of New Zealand. This is a relatively unpopulated area that is a popular tourist and holiday destination, and is known for its scenery, rural settings, small settlements, indigenous bush and beaches. The study site boundary was the watershed which includes the towns Whangamata in the south to Tairua in the north, encompassing an area of approximately 53,000 hectares. Included in this area is approximately 13,000ha of *Pinus radiata* plantations.

One component of this research programme was the investigation of the usefulness of GIS for demonstrating issues raised by the other research components. The use of GIS and the availability of GIS data for natural resource planning has increased significantly in New Zealand over recent years. Maps can be used, for example, to indicate the localities and extent of areas under discussion (for example, Hock *et al*, 1995) and for the support of 'what-if' scenario modelling (eg Lemberg and Church, 1996, Densham, 1994).

This paper describes the components of the research programme in more detail, lists the GIS data available to this study and describes how they were used to create maps relating to these components, shows the resulting maps, and concludes with some overall comments.

2.0 DEFINITIONS AND PERCEPTIONS OF NATURAL LANDSCAPES

Sustainable resource management requires the understanding of not only ecology, but also of the attitudes and cultural aspirations of people towards the environment. The programme investigated

- the planning literature of New Zealand's statutory bodies
- public perceptions of natural and modified landscapes
- the quantification of associated ecological variables

The specific ecological indicator chosen to measure the health of the natural and modified habitats was an indicator of biodiversity.

2.1 Interpretations by statutory bodies

Descriptions and definitions of 'natural character' in a number of regional and district plans and policy statements were analysed (Boffa Miskell, 1998). There is a mixture of values that reflect, on the one hand, a human relationship with, or perceptions of, the environment - "spiritual, cultural, aesthetic"[1] - and, on the other, values generally held to describe nature on its own - "physical"[2], "ecological"[3]. Both of these views contain components that can be mapped, as in the examples given in Table 1, and it was these that the work concentrated on.

'Nature' without humans	Human viewpoint or influence
Landforms	Cultural values (eg historic sites)
Indigenous vegetation or flora	Archaeological values
Undeveloped	Scenic values (and scenic sites)

Table 1. Examples of human viewpoints and describing 'nature' on its own (after Boffa Miskell, 1998)

Certain broad habitat types or landscape features were seen as key examples of the meaning of natural character or as the subject of specific policies where natural character was relevant. These included beaches, headlands, harbours, estuaries, and riparian margins.

Indicators of a lack of natural character were those identified as potentially having adverse effects on the environment, such as structures and buildings, public access (potentially compromising natural character because of damage, noise or disturbance), and industry and development generally.

2.2 Public perceptions

In a survey of locals and visitors to the Coromandel case study site, subjects were asked to sort a number of carefully selected and edited photographs and provide comments to illustrate their thought processes (Fairweather and Swaffield, 1999). The photographs deliberately depicted key natural and modified features against a backdrop of different landscape types in the study area. Q method (Fairweather *et al*, 1994) was used for the analysis of the survey responses in order to determine if there were commonly held views amongst the people interviewed; these are known as factors. A detailed description of the results is given by Fairweather and Swaffield (1999); the emphasis below is on those findings that relate to this paper.

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[1] Bay of Plenty Proposed Regional Coastal Environmental Plan, Glossary, p512
[2] Southland Proposed Regional Policy Statement 1993, Appendix 3: Glossary.
[3] in [1,2] and in Manawatu - Wanganui Proposed Regional Policy Statement 1995, p134, and Waikato Proposed Regional Policy Statement 1993, p166

There was a general similarity in the perceptions on what constitutes naturalness, with images of relatively unmodified coastal, estuarine and upland settings placed at the most natural end of the scale. However, there was a notable divergence of views in the evaluation of what is least natural, with the key difference being the perceptions of plantation forests (Table 2). Of the two factors identified, Factor 1 regarded the presence of human construction or artifacts as the essential of test of what is unnatural, with natural character being based on biological function and processes. Factor 2, by comparison, viewed the visible effects of large-scale commercial plantation management as highly unnatural, including with it the prospect of clear felling, although large tracts of open, unimproved pasture with no trees visible was also viewed as highly unnatural.

Photographs	Factor 1	Factor 2
• young plantations • clear cuts • visibly managed plantations	largely neutral	least natural
• settings with distant views of mature pine plantations across less modified environments such as mangroves	more natural side of the range	toward least natural side of range
• treeless pasture	largely neutral	among least natural
• buildings and urban settings (except view of main street in a local town)	least natural	displaced from least natural end of range

Table 2. Key distinguishing features between the two factors identified in the public perceptions survey responses. (after Fairweather and Swaffield, 1999)

2.3 Indicators of Biodiversity

Of the possible indicators of biodiversity, this programme focused on the diversity of insects as these represent about 70-85% of the world's genetic variation (Hammond, 1992). In New Zealand, estimates of insect endemicity are extremely high at approximately 80%, with all New Zealand insects providing most of the genetic resource of the country as well as being the primary contributors to the biodiversity of the country (John Hutcheson, pers comm). The degree of endemicity of insect communities can provide a quantifiable measure against which to compare human perceptions of naturalness. Coleoptera (the beetles) have been estimated to comprise nearly 50% of the New Zealand insect species (Watt, 1982) and their intimate association with their habitats make them ideal ecological indicators (White, 1993). The objective of this study was to evaluate this indicator across various habitat types in the Coromandel study site (Hutcheson, 1990, McLean et al, 1999).

Site	Habitat types	Location	Comments
1	sand dunes	Wharekawa Harbour Reserve	protected breeding grounds, low access
2	sand dunes	Otahu River Estuary sand dunes	heavily used area
3	grass/pasture	grassed access to Whangamata beach front	adjacent to houses
4	grass/pasture	pasture in Wentworth Valley	locked up for hay production
5	plantation forest	east facing slope near Pa Road look-out	young radiata pine trees (6 years old)
6	plantation forest	ridge south of Pa Road look-out	mature radiata pine trees (24 years old)
7	indigenous bush /forest	near end of Wentworth Valley Road	fern dominated bush
8	indigenous bush /forest	Wentworth Valley Reserve	kanuka (Kunzea ericoides) dominated

Table 3. Sites selected for the biodiversity indicator study. (after McLean et al, 1999)

Malaise traps (Townes, 1972) were set out at a number of sites selected as representative examples of key habitat types in the (Table 3). Analysis of the samples from these traps showed that the highest biodiversity in insect fauna was found in the mature pine plantation and the two indigenous bush sites. The sand dunes showed the least diversity, as could be expected. An unexpected finding was that indigenous beetle (Coleoptera) abundance was highest in the mature radiata pine plantation, significantly higher than in all other habitat types. While the pine forest trap sites were representative examples of the plantation in the study site, the mature forest was not, however, a typical example of all New Zealand plantation forests with its combination of low stocking and open canopy.

3.0 GIS DATA

The regional council, Environment Waikato, within whose jurisdiction the study site falls, allowed access to some of their GIS data for the purpose of this study. This was supplemented with digitised data and other commonly available databases such as the Land Resource Inventory (LRI) data set (Water and Soil Division, 1979). Digitisation used the New Zealand Map Sheet (NZMS) 260 series, a topographical series at the 1:50 000 scale. Table 4 lists the GIS data collected.

3.1 Landforms

Elevation provided a rough but reasonably representative estimate of the transition between the various landforms in the relatively small study site. A narrower definition for the foothills of between 40m to 80m was also investigated at a later stage but while it varied the extent of the foothills, it did not change the overall concept. A more accurate approach to deriving macro morphological landforms based on the detailed analysis of changes in slopes and digital elevation data (eg. Brabyn, 1998) was considered as a possible option, but time did not permit the full implementation of this particular method.

3.2 Cadastral and valuation data

The cadastral and valuation data sets were linked. The valuation data set contains information that was considered to be of use to this research but is in the form of a textual database with individual properties as key. The cadastral data set, while GIS-based, contains all legal boundaries of which property boundaries is only one subset. Thus additional work is required in order to link them and ultimately produce maps of the valuation information. The cost of the data sets and the work required to link them together meant that, although this was a very valuable source on information, only a subset of the full study site could be covered. This sub-area included all of the northern part of the study area, as far south as Onemana.

3.3 Data for human constructions

Of particular interest in the valuation data set was:

- the value of the improvements on the land, which was calculated by subtracting land value from capital value; and
- the building ages, which ranged from 1800's to the present time.

3.4 Population density - rural areas

The boundary of the study site was catchment-based, which did not always coincide with the meshblock boundaries. Clipping the meshblocks relevant to the study site resulted in some anomalies along the study boundary with relatively high population densities shown on what was known to be unpopulated conservation land. For example, the meshblock that includes Whiritoa, a town outside the study site, overlaps the study site. Thus the part of this meshblock that is inside the site showed a population of 200 while it was known that this part of the meshblock had no formal human habitation or settlement. These border anomalies were edited on the basis of land ownership, land use, and local knowledge.

Meshblocks in the rural areas are relatively large. In order to avoid showing misleadingly low population rates in the study site, it was felt that a more appropriate population density map would be achieved by excluding unpopulated areas from the meshblocks data. For example, large areas of plantation forest and conservation lands in the Coromandel study site were known to have no form of habitation.

Data	Source	Modifications, if any
rivers	digitised	labelled as major or minor
coastline including off-shore islands	Environment Waikato derived from 1:250,000	
estuaries	extract from coastline, otherwise digitised	line added to form closed areas (polygons)
beaches	digitised areas indicated as sandy beaches	
headlands	coastline that isn't beach or estuary	
steep relief	LRI slope groups: • steep (F, 26°-35°) • very steep (G, >35°)	to simplify the analysis, composite slopes(*1) were grouped as: • E/F, F and F+G were classed as steep slopes (F) • F/G and G were classed extremely steep slopes (G)
contours	20m contours	
landforms	from the contour data: • ranges (> 100m) • foothills (20m - 100m) • flats (0 - 20m)	see also 3.1
roads	Environment Waikato derived from 1:250,000	
human constructions	cadastral data (Terralink) linked to valuation data (Valuation NZ)	The two data sets were linked as described in 3.2. The data used is described in 3.3.
land use	cadastral data (Terralink) linked to valuation data (Valuation NZ)	grouped into residential, industrial, commercial, multi use, utilities, community services, recreational, reserve forest, hydrology, production forestry, horticulture, agriculture and vacant land
population density	1996 census data (Environment Waikato) LCDB (MAF) cadastral data (Terralink) linked to valuation data (Valuation NZ)	details given in 3.4 and 3.5

(*1) The symbol '+' in F+G indicates that the slopes are mainly steep with pockets of very steep slopes. The symbol '/' indicates slopes that are borderline between two slope classes.

Table 4. GIS data for the Tairua/Whangamata study site

Land-ownership data, which would have depicted in particular the plantation forest and conservation lands most accurately, was not available to this study. Instead, the Land Cover Database (LCDB) map (supplied by the then Ministry of Forestry and based on 1990 satellite image) was available with four different land covers: indigenous forest, exotic forest, shrub and other. Conservation land is almost exclusively indigenous forest and shrub, but as there are also a number of life-style blocks in the study area with these vegetation types, it was decided that these land cover classes could not be used to show areas of zero population. The exotic forest class, however, could be used. Using the cadastral dataset, road segments, road intersections, utility reserves, road reserves, recreation reserves, forest reserves, esplanade reserves and hydrology segments were set to zero population.

Setting a component of a meshblock to zero population created difficulties when the process fragmented the block into separate areas. The population for the total meshblock was then apportioned relative to the size of each fragment. A more representative population density could then be calculated.

3.5 Population density - urban areas

Unmodified meshblocks with a density of greater than one person per hectare were selected as giving the best representation of urban areas, based on topographic maps and local knowledge. This resulted in the identification of four main urban centres, Tairua, Pauanui, Opoutere and Whangamata. The meshblock that includes Onemana was excluded from the urban set as this block covers a much wider area than the size of the main settlement, making the per-hectare density very low. Other potential sources of information that could be used to define urban extent are cadastral data and ownership data, which were not available for the total study area.

4.0 METHOD AND RESULTS

GIS data manipulation used Arc/Info and ArcView, while map-production used only the latter software.

4.1 Interpretations by statutory bodies

The locations of geo-physical features such as beaches and estuaries and bio-physical features such as indigenous vegetation are relatively straightforward to map as their definition is reasonably clear (Figure 1a). Landforms, however, require interpretation and translation before they can be mapped. Field visits for the public perception survey had identified three separate, visually distinct landforms - the flat, lower lying land surrounding the estuaries and of the valleys up-river of them; the lower hills and the toe slopes of the main divide; and the hills forming the backdrop to the views (Figure 1b). Further refinements might be possible given details of what specific features of the landforms are of importance.

Riparian zones can be found by buffering rivers and overlaying this with landcover data such as the LCDB. In this study, the proximity to water was calculated by creating a 250m buffer around the major rivers and 1km buffer around the estuaries, and overlaying the result with the LCDB to list the types and show the localities of different vegetation types surrounding these water features (Figure 1c).

With the emphasis on undeveloped areas representing natural character, the proximity to developed areas was used as another way of indicating distance from developments. For example, all publicly accessible roads were buffered by 500m, 1km and 1.5km (Figure 1d). These buffers could then be overlaid on any of the other GIS data layers.

4.2 Public perceptions

Mapping the presence of human constructions is straightforward when these are grouped and appear on smaller scale maps. Capturing digitally the locations of structures in rural areas is possible but has not been done for the Coromandel. As a surrogate, population density was used to indicate the likelihood of encountering a related density of human constructions (Figure1e).

The extent of the large-scale plantation forest was available, but the locations of key signs of the commercial nature of the forest (clear-felled land, young symmetrically planted trees) move through the forest over time. An approximate figure of a third of the forest falling into this category was used to produce a map of typical forest operations (Figure 1f).

Other factors mapped were the presence of large expanse of treeless pasture (Figure 1f), and the presence of costly infrastructure on the land (Figure 1g). The latter was as a surrogate for age and size of human structures, on the assumption that newer and larger structures have a higher value.

The visibility of constructions and forestry was attempted, taking some locations along the major road through the study area.

4.3 Ecological Indicators

A map was produced of the vegetation types covered and their relationship to the insect trap locations (Figure 1h).

5.0 CONCLUSION AND DISCUSSION

Some of the issues of the management of natural resources can be displayed in a practical manner by the use of GIS. GIS maps assist with demonstrating the locations and extent of areas potentially affected by planning decisions, and help to highlight where results from different analyses coincide. The examples in the paper are reasonably simple, making use of only the type of land-based digital data and GIS capability typically available to organisations such as a regional council in New Zealand, but serve to illustrate further uses of such data and capability.

There are, however, still limitations to this approach. Although increasing amounts of GIS data are becoming available with many refinements on quality, content and resolution, there is still a long way to go before all the complexities of land management can be demonstrated.

Future potential refinements to this research include

- 3-dimensional analysis such as visibility analysis, for example, areas visible from main routes through or at specific locations in the landscape
- given property ownership information, people affected by a planning decision can be identified
- delineation of areas that are sensitive to public perceptions
- identification of and compilation of information on remnants of pristine nature
- identification of ecological patterns and features, and issues such as fragmentation
- investigation of the ways in which the presentation of information in map form influence decisions

The transition zones from natural to modified landscapes are particularly important in this type of analysis. GIS can help to clarify and make more explicit information and effects of decisions on natural resource management.

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