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GIS and Ecosystem Management Tools – a process for sustainable development on Great Barrier Island.

Abstract

Great Barrier Island has a rich set of natural resources. Human activities have modified the land; however the life supporting capacity of the islands ecosystems, and the abundance and biodiversity of the native fauna and flora remains great. The majority of the Island remains in conservation estate. Conservation imperatives, a rigorous planning context and significant technical issues for development provide a complex set of constraints to consider for the planning of sustainable land use. In order to proceed, development needs to work within these constraints to fit the land.

Economic objectives for land use, and motivations for land owners can be divergent with sustainable land management principles. This can lead to the crucial early stages of land use planning omitting key environmental constraints. Land use decisions are made to meet human objectives at the start of the design process. A consideration of environmental constraints is then undertaken when the attempt is made to obtain a resource consent.

This paper describes a case study where geographic information systems and an ecosystem management approach are used to record, manage and present site information regarding natural values and constraints for large scale private development on Great Barrier Island.

This process provides an efficient tool to visualise and communicate the environmental constraints on development. By initiating the design process with this broad understanding, the environmental values and constraints can form the basis of land use decisions.

In the next stage of the subject project, modelling and matrix analysis tools will be used to evaluate locations and options for land use against sustainability drivers. The final goal for this project is the production of a land management plan that optimises the trade-offs between the capacity of the land to support plants and wildlife, and human development objectives.

1. Introduction

1.1. *Background*

Great Barrier Island (or Aotea) is located on the North East Coast of New Zealand. This Island is approximately 37 kilometres long and forms a barrier along with the Coromandel Peninsula to enclose the Hauraki Gulf on Auckland City's eastern doorstep.

Great Barrier Island remains a relatively natural environment with distinct natural character. The proximity of Auckland City to Great Barrier heightens the contrast offered by Great Barrier Island's wilderness. This has resulted in the importance of the tourism and recreational industries for Great Barrier Island which rely largely on the sustained natural character and healthy ecosystems of the island.

Historical activities on the Island have included:

- silver and copper mining;
- Kauri logging and timber milling;
- firewood harvesting and clearance for farming;
- whaling and fishing.

These activities have impacted on ecosystems to various extents. In particular, vegetation clearance has modified the diversity and patterns of the terrestrial ecosystems. However, Great Barrier Island still has great natural capital. Some examples of the rich natural resources of the Island as indicated by Armitage et. al. (2001) include:

- Kaitoke Swamp and Whangapoua Wetland, both recognised by The Department of Conservation (DoC) for their naturalness and importance;
- More than 60% of the land mass administered by the DoC as conservation estate;
- Absence of the key NZ pests, possums, ferrets, stoats, Norway rats and hedgehogs;
- Breeding populations of rare or endangered birds including pateke, black petrel, North Island kaka, banded rail and NZ dotterel;
- Rare plant and animal species including:
    - 3 threatened endemic plant species;
    - 13 species of lizard including the endemic Chevron Skink.

This unique and valuable native biodiversity has led to the development of conservation activities on the Island with several charitable trusts and private groups being active, in addition to a large DoC presence on the Island.

Great Barrier Island is under the jurisdiction of the Auckland City Council (ACC). ACC have developed a district plan for the Hauraki Gulf Islands that includes planning regulations and controls for the Island. This plan has a large focus on protecting the natural value of the Island through sustainable development.

The human population of Great Barrier Island is dropping. Land prices have skyrocketed along with rates and there has been a shift to off -shore ownership largely for holiday purposes. Remoteness and access difficulties form a barrier to development which limits the feasibility of certain activities. For some Island residents, this has lead to a sense of struggle against their environment. This results in a contrasting view between residents and regulators as to what constitutes an acceptable environmental impact in achieving land utilisation objectives.

Legislative and institutional efforts to protect the natural environment are often viewed by Islanders as restrictive. Some large landowners are finding it complicated to subdivide to realise some of their capital, and maintain economic security. This can develop into a sense of frustration with the bureaucratic process and cynicism towards the conservation industry. This conflict of ideas has been demonstrated through the current process undertaken by the DoC to establish a marine reserve. This engendered both fierce support and fierce opposition from local and off Island groups.

Some large projects on Great Barrier Island have failed to make it through the consenting process as they have not achieved satisfactory buy-in from concerned residents and conservation groups that they were appropriate designs for the environment.

Alternatively, works have been undertaken without resource consent due to the perceived impossibility of achieving a path through the resource management process. A revised District Plan is currently going through the notification process. At the time of writing, this is also generating significant resistance from the Island population as it is seen as added bureaucracy and further compromise of personal freedoms in land use

For some time on the Island, the tourism industry has offered income for many island residents. Sustainable tourism has been the vision for a solution to economic recession that is congruent with conservation goals.

In the context of strong motivations for sustainable design and resistance to perceived draconian legislation, there is an opportunity for an improved process for land use and development projects to simplify consenting and aid in the implementation of sustainable development for landowners.

1.2. Low Impact Design Processes

Low impact design and low impact urban design and development are terminologies relating to the design process to reach outcomes that minimise negative environmental effects. Integration is the process of combining or accumulating elements. Low impact design relies heavily on integration to incorporate potentially divergent interests

The Institution of Engineers Australia says:

> *"Design requires the consideration and identification of a problem or opportunity to improve. Design is a conceptual process used to bring together innovation, aesthetics and functionality to plan and create an artefact, a product, a process or a system to meet the requirement of an individual or group."*

Designers have faith that in undertaking a design process, they can reach an outcome or resolution. By embracing a process that targets integration, we can have confidence in the integrative nature of the outcome. A typical engineering design process is as follows:

1. Set Objectives
2. Scoping/Feasibility Analysis
3. Preliminary Design
4. Detailed Design
5. Implementation/monitoring

Through this process, the decision making that represents the opportunity to take a low impact design approach is in Stage 1 or Stage 2. It is at this conception that the objectives of environmental and ecological health or the needs of future generations need to be spoken for and specified relative to the particular site.

Therefore, a comprehensive assessment of site constraints, features and values is important early on in the design process. This supports the development of an integrative solution to be reached and honed in later project phases to implementation.

The resolution of the field investigation is also an important factor. Often private developers have limited resources for their projects. It is costly to undertake detailed surveys using theodolite, subsurface analysis and detailed ecological methods. It is also important to focus these detailed methodologies to a limited area to minimise costs. This would typically occur during the preliminary design phase where there is an idea of the preferred development option. This highlights the benefit of adopting a scale of investigation that is manageable.

Management of design complexity is an integration process that can be aided by appropriate tools. In recognition of the spatial context to understanding land ecosystems, a GIS basis has been adopted by the consultant. This enables the organisation and communication of data. Once we can see the information in this format, it is easier to find integrated design options. The information that has fed into the decision making process can be communicated and the decisions justified for required consultation and council buy-in.

1.3. Purpose

A case study for this paper is the development of a Rural Property Management Plan for a 116 Ha site in Allom Bay on Great Barrier Island. The objective is to develop land use proposals that are consistent with the District Plan with its stated intent of sustainable management.

Land use of this property has been predominantly restricted to several housing and orchard clearings and limited road and foot-track access-ways. The majority of the property has been allowed to regenerate into a healthy bush cover, with thriving associated ecosystems. Photograph 1 shows a view over the subject property.

Photograph 1 – Subject Property, Allom Bay – Great Barrier Island

The approach used is to obtain field data using Global Positioning Systems (GPS) for development of Geographic Information System (GIS) maps of the site and environmental characteristics of the subject property. This methodology provides advantages in terms of:

- providing enough detail to record sufficient information for scoping and planning design;
- being coarse enough to be achievable on limited budgets;
- having greater feasibility of one off data input and processing shortcuts;
- creating a database of standardised geo-referenced information for future comparison.

The concept of ecosystem management is outlined by Bailey (1996). Land management is moving from the management of single resources, to managing ecosystems. Maps are required to display ecosystem distribution and hierarchy, and to allow understanding and recording of the integration of ecosystems and their components. Ecosystems can be defined either by identifying the constraining factors that lead to the development of certain ecosystems, or by identifying indicators such as vegetation that reflect the results of environmental constraints.

An example of the ecosystem management approach is the LENZ classification undertaken by Landcare Research and the Ministry for the Environment outlined by Leathwick et. al. (2002), which developed a set of environmental variables, particularly used to predict forest pattern. This provides ecosystem-based classifications of New Zealand's landscapes. The Hauraki Gulf Islands District Plan divides Great Barrier Island into land units based on common features of the physical and natural landscape for the purpose of resource management.

The objective of adopting an ecosystem management approach, is to define boundaries along which the property can be broken into zones to be managed or protected accordingly to the sensitivity of the ecosystems impacts, or the constraints that the separate zones place on land use potential. Vegetation is the main indicator for development of these ecosystem zones and has been used in this instance.

This approach allows zones to be defined along with specific management measures or land uses that can address suitability for development and threats to ecosystem health.

The disadvantages which must be recognised include the possibility of overlooking details and small scale variations. Any attempt to group ecosystems results in simplification of the complexity of ecological systems. Delineation of ecosystem boundaries requires assumptions to be made regarding the extent of separate zones. The collection of on site validation data including vegetation, wildlife and soil surveys can be used to validate zone definitions, however generalised groupings must be made to set a feasible scale for zone delineation. Therefore there is an element of subjectivity to ecosystem boundary definition.

2. Methodology

2.1. Infrastructure

The field GPS equipment included:

- A Personal Digital Assistant (Hand held computer);
- ESRI ARCpad software;
- Bluetooth GPS device;
- Staff to raise GPS above topographical and vegetation obstructions to improve satellite reception.

This equipment enabled data capture to an accuracy of better than 10 metres. The equipment can be used with waterproof covers in the rain. This facilitated field data recording and background map reading at any scale.

Base Maps were utilised including:

- Aerial photos;
- Cadastral boundary;
- Contours;
- Stream centrelines;
- Soil Information;
- District plan maps.

Auckland City Council is in the process of producing aerial ortho-photography at 0.125m pixel size, with accompanying Digital Terrain Models (DTMs) for many areas on Great Barrier Island. This will greatly improve the quality of the base maps for future investigation.

2.2. Application

The following information was recorded in the field:

- **Infrastructure –** Access roads, foot tracks, house sites, vegetation clearance;

- **Vegetation Assessment** – Qualitative assessment of cover and abundance of plant species within tiers was undertaken by point survey, with species lists generated;
- **Biodiversity Information** – Species were recorded as observed, with the use of various techniques including netting aquatic macroinvertebrates and fish and transect surveys of bird life;
- **Surface waters** – Surface water systems were located and categorised and drainage infrastructure recorded. Water quality data was collected;
- **Stream Geometry** – Stream channels requiring hydraulic analysis for flood hazard assessment or at potential access crossings were surveyed for geometry using GPS, tape and levelling instruments;
- **Slope** - Slope measurements were recorded for confirmation of desktop slope analysis.

Following field survey, data was verified and combined into a series of maps and schedules to present the information.

Analysis included integration of site data, aerial photography and historical evidence (to determine the key ecosystem/vegetation zones), and modelling of soil types and slopes (to provide indicative mass wasting potential). Legislative controls are represented by planning maps that can be combined with the underlying GIS survey layers. Biodiversity data provides additional information regarding the sensitivity of different ecosystem management zones.

3. Results

The pattern of the subject property is focussed around the topographical constraints. Figure 1 shows access dwellings and vegetation clearance focussed around the flatter grades lower down on north facing slopes with moderate soil moisture.

The main ecosystems areas are:

- Manuka/Kanuka scrublands;
- Manuka/Kanuka regenerating bush;
- Riparian vegetation;
- Mixed broadleaf forest;
- Pine dominated Manuka scrub;
- Pasture orchards and house clearings.

Figure 2 shows the layout of the ecosystem zones. Remnant forest to the rear of the values maintains high diversity as does the riparian corridors. Regenerating manuka/kanuka vegetation zones exhibit various rates of growth and diversity dependant on soil chemistry and moisture, aspect and exotic species.

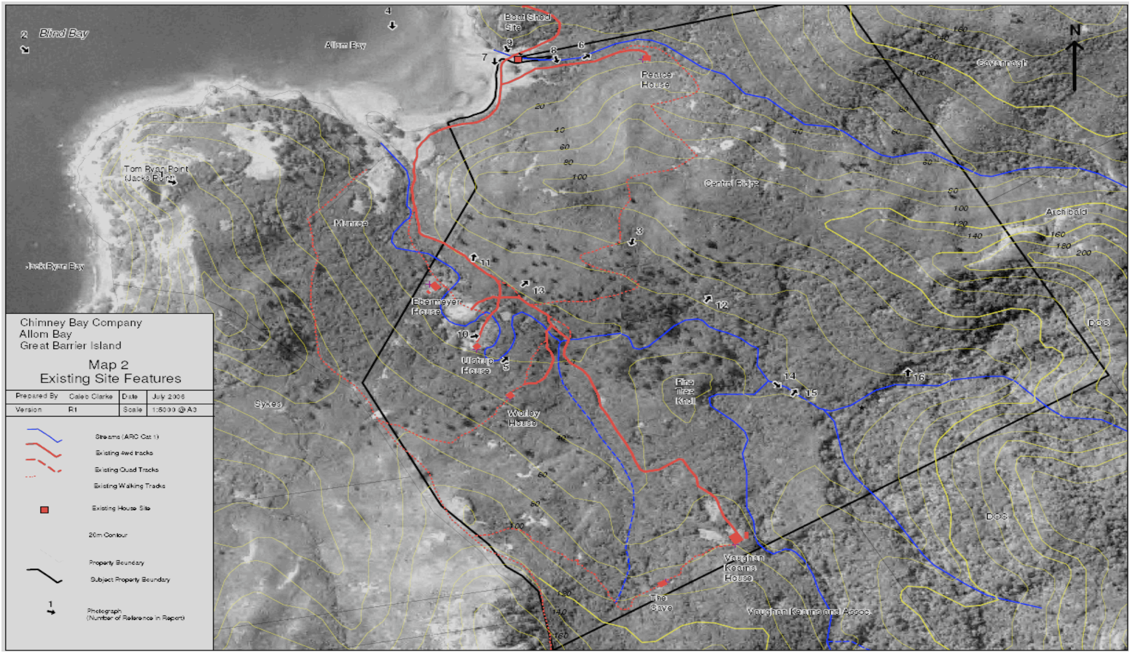

Figure 1 – Plan of Existing Site Features

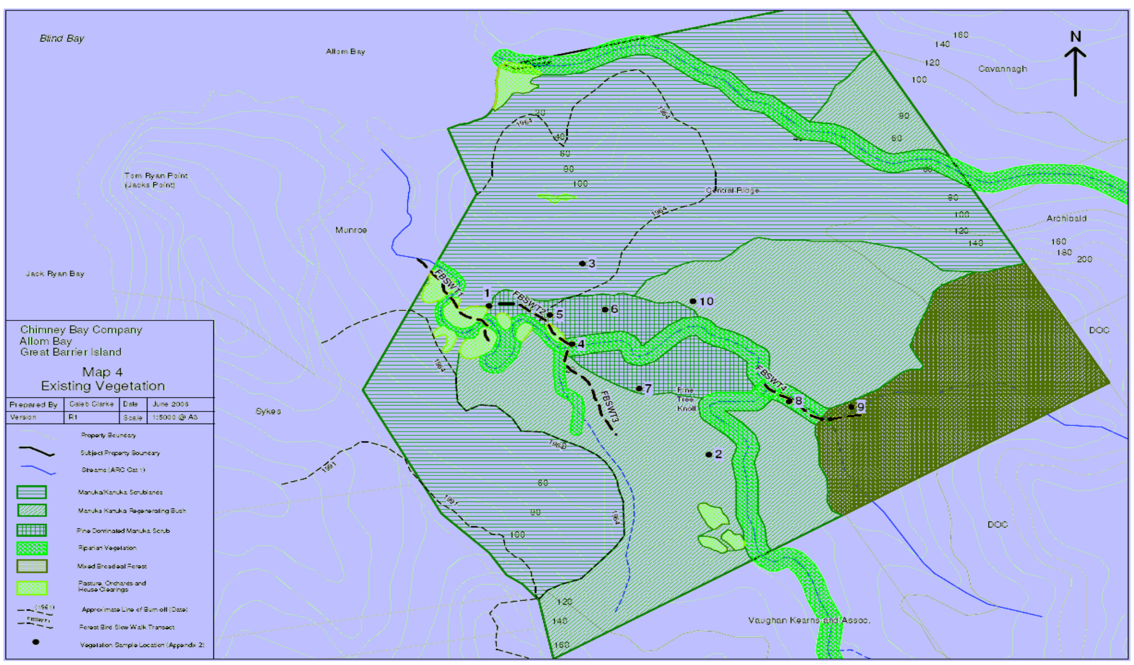

Figure 2 – Plan of Existing Vegetation

Slope and soil type were run through a simple model to predict the mass wasting potential on the property, highlighting areas with a higher risk of instability (Figure 3).

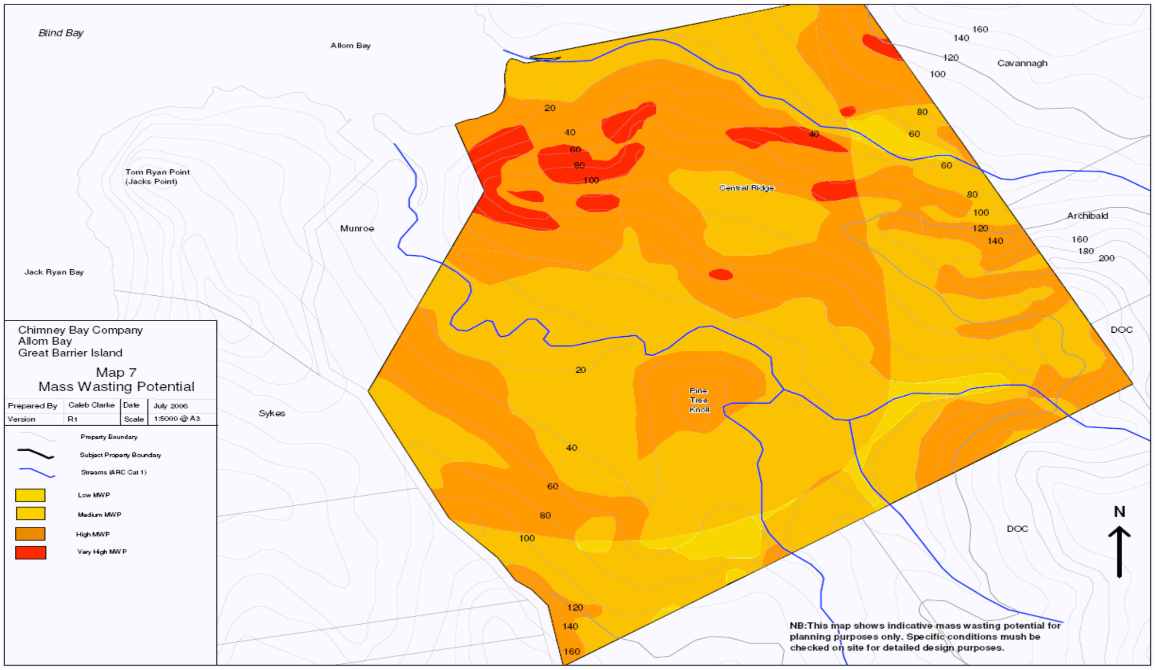

Figure 3 – Plan of Mass Wasting Potential

Opportunities for improvement of the methodology include:

- Greater resolution of ecosystem delineation against and soil moisture criteria.
- Manuka endocrinology – measurement of growth rings to define age and compare regrowth rates
- Improved aerial photo and LIDAR information.
- Rangefinder positioning for remote data capture

Option development and evaluation on this project is underway at the time of writing, with the objectives of landowners and stakeholders undergoing further definition. Flood hazard modelling and fire risk assessment are being undertaken in order to quantify further key constraints for development. The changes to the district plan will also need to be incorporated into the evaluation of potential options

The base information and maps that have been produced provide spatial locations and values of terrestrial and aquatic ecosystems, as well as slope stability constraints. The following elements are proposed for translation of these values to positive management decisions focussed on sustainability.

- Definition of development setback zones including riparian/flood protection widths
- Definition of ecosystem zones to be protected with covenants or similar mechanisms.
- Definition of most appropriate stream crossing points
- Assessment of allowable water extraction
- Management measures for all ecosystems including:
    - riparian zones,
    - eroding slopes,
    - exotic/forestry zones, and
    - coastal margins.

The feedback from the landowners is that this information has provided them with an appreciation of the layout and values of their property, and already make it clear which areas should be preserved and which areas lend themselves to more development. Perhaps this education of the land owner is the greatest benefit, leading to appreciation of the natural values and greater buy in for land uses that are consistent with regulation.

Options evaluation will be conducted using a matrix evaluation which includes spatially specific weightings for the sensitivity of the particular zone to development effects.

4. Conclusions

Great Barrier Island represents a unique environment for resource management in regional, national and international contexts. Significant natural value, a large Department of Conservation presence on the island and the local governance of Auckland City Council provide a strong imperative for the integration of conservation with development and land use activities on the island. Uncertainty and frustration with the resource management process raise the need for tools and processes to facilitate integrative design for sustainable land use.

The methodology of GIS site survey and ecosystem mapping has been applied on Great Barrier Island to provide a cost effective and practicable means to obtain environmental information for the whole site early on in the design process. Point source data collection for vegetation and slope can gain a picture of the key capacities of the land. Linear survey of the fresh water systems confirms the geometry, morphology and the sensitivity of the receiving environments to land use effects. Definition of the major ecosystems can be achieved largely based on vegetation, with reference to historical land use that modifies terrestrial ecosystems to varying degrees. Additional delineation could be undertaken based on slope, aspect, or soil moisture content.

The goal of sustainable development is entrenched in the legislation and embraced by many stakeholders on Great Barrier Island. There are conflicting perspectives as to the balance of conservation and the ability of a landowner to utilise their land. GIS and ecosystem management tools can simplify the inclusion of environmental constraints in design of land use, and can aid in the syncretism of these conflicting perspectives.

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