Monitoring Biodiversity of Select Restoration Sites in New Zealand

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ABSTRACT

Much of New Zealand in now covered by non-native plants and animals. In recent years there has been increased effort to mitigate these effects through a process of ecosystem restoration. The GLOBE Land Cover/Biology Investigation Team at the University of New Hampshire, working collaboratively with GLOBE New Zealand (Dr. John Lockley) and Landcare Crown Research Institute (Dr. Daniel Rutledge) at the University of Waikato, Hamilton, New Zealand, will use GLOBE student collected land cover data to create land cover maps and perform change analysis in order to monitor land cover changes at selected ecosystem restoration sites in New Zealand. A crosswalk between GLOBE's Modified UNESCO Classification (MUC) system and the Land Environments of New Zealand (LENZ) system will be developed to allow for the effective sharing of data between these projects.

Introduction

The New Zealand Government has recognized and taken steps to halt the loss of native biodiversity within the country. Initially, restoration efforts were focused on offshore islands. Current efforts extend to mainland islands, restoration sites within a larger landscape that are isolated by a natural or constructed barrier. Student data will be collected in and around these sites and used as part of a larger data set to develop thematic land cover maps. Numerous pre-processing, data exploration, classification and change detection techniques will be used in this project. The three main outputs from this project will be the thematic land cover maps, change detection information, and a crosswalk between the Modified UNESCO Classification (MUC) system and the Land Environments of New Zealand (LENZ) system.

New Zealand

As a result of 80 million years of isolated evolution, a majority of the flora and fauna found in New Zealand are unique in the world. Over 80% of the native vascular plants in New Zealand are endemic. Although New Zealand was one of the last major land areas to be impacted by human settlers, these impacts have been intense. By the late 20th century, more than 60% of the land has been converted from native vegetation through human activities, including development, farming and exotic forestry. Much of the remaining native vegetation exists in isolated pockets in the mountains and other areas that have been inaccessible or are not economically feasible to develop. The result can be seen in the New Zealand Biodiversity Index, a measurement developed by the New Zealand Department of Conservation that shows a steady decline in biodiversity since the time of settlement (New Zealand Department of Conservation, 2000).

Human settlers carried with them many species of plants and animals to New Zealand. These exotic species have had a dramatic influence on the landscape. Introduced species, both in the wild and cultivated, outnumber native and naturalized species. Native wildlife is affected by this shifting land use. Many species are unable to survive in these modified habitats, leading to small, fragmented populations and widespread extinctions (New Zealand Department of Conservation, 2000).

The New Zealand government has recognized both the intrinsic and economic values of biodiversity. The native flora and fauna represent the unique characteristics of New Zealand. The kiwi, a flightless bird, and the silver fern are national icons, and both are being pushed toward extinction by current land uses. The Maori, the indigenous people of New Zealand, believe humans have a common ancestry with animals. They are very concerned with the loss of biodiversity (New Zealand Department of Conservation, 2000).

Tourism is an important part of the economy of New Zealand. The distinctiveness of the natural environment and New Zealand's clean and green image are the major draw for tourists. Restoration of native ecosystems is necessary to maintain this segment of the economy. Patterson and Cole (1999) have estimated the total value of New Zealand's indigenous biodiversity, including direct economic benefits and intrinsic values, to be twice the New Zealand Gross Domestic Product. The government of New Zealand has developed *The New Zealand Biodiversity Strategy* to address these concerns. Many branches of government are implementing the strategy. One important aspect of this strategy is to integrate biodiversity considerations into the National Strategy for Education (New Zealand Department of Conservation, 2000). This collaborative project between GLOBE New Zealand and the Land Cover/Biology Team will expose students to the techniques that can be used to monitor biodiversity.

Remote Sensing and Land Cover Mapping

Remote sensing provides an opportunity for large-scale measurements. Ground-based reference data increases the usefulness of these data (Botkin and Estes 1984). Data gathered by remote sensing can be analyzed to develop land cover classification maps and detect land cover change (Green et al. 1994). Accurate reference data are necessary to validate the interpretation and mapping of remotely sensed land cover data but has not always been collected (Becker et al. 1998).

Land Environments of New Zealand (LENZ), launched in June 2003, is a quantitatively-based landscape classification scheme that aims to assist biodiversity conservation and natural resource management. This classification relies on the relationships between species and their environment in order to group landscapes with similar ecological characteristics, not just land cover. One of many advantages of this system is the ability to predict prehistoric land cover based on existing and historical characteristics of disturbed sites (Landcare Research http://lenz.landcareresearch.co.nz/).

GLOBE

The GLOBE Program was introduced to New Zealand in 2000. The first schools were trained in the beginning of 2001 (Lockley, 2002). At present, there are over 100 schools involved with the GLOBE program throughout New Zealand. The GLOBE Program in New Zealand is an important part of the growing area of environmental education (Lockley, 2002).

One goal of the Land Cover/Biology Team at the University of New Hampshire is to use student data to validate thematic land cover maps created from satellite images (Fried 1997). In order to do this, the Land Cover/Biology Team first had to develop a suitable classification scheme. The MUC (Modified UNESCO Classification) system was developed by adding two developed classes to the existing UNESCO classification system (Becker et al. 1998; The GLOBE Program 2000). The MUC system was designed to be suitable for any location globally. Then, the Land Cover/Biology Team developed standardized collection protocols that instruct the students how to collect land cover and biology data (Becker et al. 1998; Rowe 2001).

Data Collection, Accuracy Assessment, Land Cover Mapping

Rock and Lauten (1996) have shown that data collected by students as part of the *Earth Day: Forest Watch* program at the University of New Hampshire may be reliable and accurate. Furthermore, they have found that the data can be a great contribution to research by increasing the sample population and expanding the study areas. Budd (1997) and Rowe (2001) have shown that data collected by GLOBE students in the United States have an acceptable level of accuracy.

Reference data must be used to check the accuracy of a classified map (Plourde and Congalton 2003). The most common method of assessing accuracy of a land cover classification map is to create an error matrix (Congalton 1991; Plourde and Congalton 2003). In order for this assessment to be valid, it is necessary for the reference data to be highly accurate (Congalton 1991).

Chuvieco and Congalton (1988) have described three phases for computerized classification of remotely sensed data: training, assignment of non-sampled pixels, and output and assessment. Training may be the most important step in the process. Significant error can result from bad training, biasing the results.

Change Detection

Digital change detection attempts to measure differences in land cover between two points in time by focusing on certain variables of interest (i.e. spectral reflectance of land cover) and controlling other unwanted variation (i.e. atmospheric conditions, sensor differences) (Green *et al.*, 1994). There are many different techniques used for multi-date digital change detection. Change detection can be performed on imagery acquired from airborne sensors or on thematic maps created from those images. Each technique has associated advantages and disadvantages. Image-to-image change detection techniques generally require less effort and provide change/no change information. Map-to-map change detection techniques require more effort from the analyst but provide detailed change-from/change-to information. Map to map change detection accuracy is highly dependent on the skill of the analyst (Jensen, 1996).

Approach and Methods

- Develop contacts with New Zealand teachers interested in the GLOBE Program
- Train New Zealand students in GLOBE protocols
- Assist New Zealand students conducting data collection
- Collect reference data
- Create thematic land cover maps
- Perform a digital change detection for each site to analyze “from-to” change

- Develop a crosswalk between the LENZ and MUC classification systems

Study Areas

There are a number of sites undergoing restoration in New Zealand. This project will focus on four of those sites, Maungatautari, the Karori Wildlife Sanctuary, Bushy Park and Rotoiti. These sites were selected because of their size, accessibility, and their proximity to GLOBE schools. Landsat imagery from 1990, 2000, and 2002 is available for three of the sites. Currently, imagery containing the Bushy Park site is only available from 2002.

Maungatautari is a volcanic dome that rises alongside the Waikato River, surrounded by farmland of the central plain of the North Island of New Zealand. A 3400-hectare native forest covers the mountaintop. Construction of a 47 km pest-proof fence that will eventually surround the forested peak has begun. Once the fence is completed, all warm-blooded animal pests will be removed (Maungatautari Ecological Island Trust http://www.maungatrust.org).

The Karori Wildlife Sanctuary is a 252-hectare native forest 2 km from Wellington, the capital of New Zealand. An 8.6 km pest-proof fence surrounds the sanctuary. Restoration efforts are in progress. About 50% of the sanctuary will be restored; the rest will be allowed to develop naturally (Karori Wildlife Sanctuary http://www.sanctuary.org.nz).

Bushy Park is a small (88 hectare) native forest in Wanganui on North Island. The forest is part of a homestead donation. The wetland forest is a major attraction for guests staying at the homestead (Bushy Park Homestead http://www.bushypark-homestead.co.nz).

The Rotoiti site is located in the Nelson Lakes region of the northern South Island. Restoration efforts focusing on 825 hectares of native southern beech (*Nothofagus* sp) forest on the shore of Lake Rotoiti began in 1997. This area is managed as a mainland island and extensive work has been conducted to eradicate non-native species (New Zealand Department of Conservation http://www.doc.govt.nz).

Tools

The most important tool for data collection on the GLOBE Land Cover Sample Sites is the *GLOBE Teacher's Guide* (The GLOBE Program 2003). The guide contains all of the protocols and data sheets for collecting data. It also contains instructions and templates for constructing low-cost clinometers and densiometers. In order to collect the data, students will need a Landsat TM image showing their study area, a *MUC Field Guide* or *MUC System Table* and *MUC Glossary of Terms*, a GPS receiver, a camera, a compass, measuring tapes, vegetation field guides, grass clippers, a densiometer, and a clinometer. The equipment will be supplied by the GLOBE schools.

The students will create a land cover map using MultiSpec software, a freeware image processing package. The UNH Team will create land cover maps and perform change detection using both MultiSpec and ERDAS Imagine 8.6 along with ESRI's suite of GIS tools.

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