Establishing long term Monitoring sites within mangrove and associated communities of Moreton Bay, South-Eastern Queensland, Australia.

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ABSTRACT

Climate change is expected to have its largest impact on communities situated at geographic and topographic extremes. While projected warming will affect communities at high elevation, coastal communities will have the compounded effects of warming, reduced precipitation, sea level rise and changes to runoff. This is expected to result in ongoing impacts to mangrove and associated communities around the world. The Queensland Herbarium has commenced a mapping and monitoring project within Moreton Bay. This project is establishing 20 long-term monitoring sites within mangrove and associated communities and aims to document past and ongoing changes. These long term monitoring sites are a subset of sites established during the late 1990s providing historical site change information over the last 13 years. The sites will be re-visited periodically in the future. The selected sites will be correlated with regional Lidar (Light Detection and Ranging) technology derived community structural attributes, such as tree height and density, providing a scaling up approach. A decadal time series of aerial photography from the 1940s to present will be established and will provide historical information and the basis for monitoring. An approach using vegetation indices applied to a time-series of imagery will help to distinguish between small seasonal differences and larger, more permanent changes such as mangrove dieback. This project based on over 70 years of information will provide a better understanding of the past and present dynamics of mangrove and associated communities in Moreton Bay. It will also provide a basis to project future community and species distributions while taking into account climate change.

INTRODUCTION

South East Queensland has over the last 10 to 15 years been undergoing a massive population boom and it is expected that this will continue into the foreseeable future. Moreton Bay is part of this region and is therefore being impacted by this development. Moreton Bay (defined as the area from Caloundra to Southport; Figure 1) contains in excess of 18,500 ha of a diverse range of intertidal vegetation communities including mangroves and associated saltmarsh communities (Dowling and Stephens 2001).

In recent years the local communities have become more aware of the value and significance of these intertidal areas, both for recreational purposes and as fish habitat and breeding areas. Consequently they are observing, noting and reporting changes within these tidal communities, especially at the local level.

The mangrove and associated communities within South East Queensland have been mapped to the same consistent standards and protocols twice over the last thirty five years (Dowling, 1986 and Dowling and Stephens, 2001). These studies were based on 1974 aerial photographs and 1998 digital ortho-photographs respectively. The same mapping classification and scale was applied in the above two studies providing a consistent baseline for monitoring the mangrove and associated communities of Moreton Bay. The floristic classification used in these studies provides an important baseline to assess and quantify changes at a species level within mangrove communities as well as their distribution within the Bay. The temporal change available will provide the time frames over which change has occurred and when and where these changes have occurred as well as potentially indicating causes of any changes.

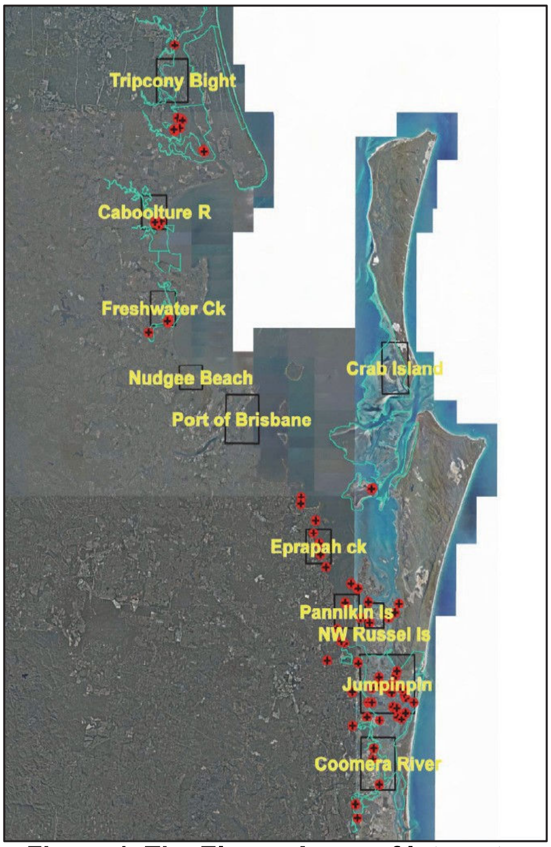

Figure 1. The Eleven Areas of Interest where mangroves and associated communities monitoring plots are located.

To determine changes in the inter-tidal mangrove and associated communities a program of monitoring of these dynamic communities over time is being established. The program will assess both the health and changes within the mangrove and associated communities within Moreton Bay. In addition to a snapshot in time the longer temporal changes need also to be monitored so that changes can be understood and put into context. These communities are essential for both fisheries production as well as for coastal and marine health. While these communities are currently protected from development and destruction under the Fisheries Act (1994) they are vulnerable to effects from adjacent onshore developments (anthropogenic) as well as natural causes such as siltation, runoff and climate induced effects such as drought and sea level rise.

METHODOLOGY

This paper presents methods and capabilities of newly mangrove monitoring program and as such no results are presented. It is intended that the monitoring program consist of two parts namely: a permanent base plot monitoring component; and a mapping component including an automated change detection capabilities.

Permanent Base Plot Monitoring

The Queensland Herbarium is aiming to establish at least 20 long-term monitoring sites within mangrove and associated communities within Moreton Bay and aims to document both past and ongoing changes. These long-term monitoring sites are a subset of sites established during the late 1990s (Dowling and Stephens, 2001) as part of a coastal wetlands survey in South East Queensland. The sites provide historical site-based change information over the last 13 years and will enable a longer timeframe of monitoring. Permanent plots will be established within each of these sites. It is intended that these sites will be re-visited on a three-yearly basis in the future. Eleven Areas of Interest AOI within Moreton Bay have been selected. Seven were chosen by Queensland Fisheries (DEEDI) while four additional AOIs where selected by the Queensland Herbarium to provide adequate representation of vegetation communities for Moreton Bay. The red crosses in Figure 1 show the location of the survey sites of Dowling and Stephens (2001) within mangrove and associated communities within Moreton Bay. Sites were selected within the AOIs to cover the diverse range of intertidal communities including mangroves and associated saltmarsh, claypan, samphire, and grassland (marine) communities within Moreton Bay. Table 1 lists the intertidal communities that are to be monitored within Moreton Bay (Dowling and Stephens 2001). A series of at least 20 monitoring plots will be established within the 11 AOI and are a subset of Dowling and Stephens (2001) sites shown in Figure 1. The plots will be distributed across Moreton Bay to detect change across the geographic extent of the study area. The locations of the 20 monitoring plots were chosen after extensive analysis of the vegetation types and their distribution within Moreton Bay to ensure that the plots were representative of the vegetation types and their distribution. The sites and their locations were also assessed against 1950s photography to include areas that have changed over the last 60 years and sites that have been stable over this period (Figure 2). The selection of the sites include nine different vegetation types which expert advice indicated were the most likely to show change due to rising sea levels, climate, change and physical or anthropogenic effects. The sites were selected from within the eleven AOIs. Table 1 illustrates that the area of these nine monitored communities represent 82.7% of the area of mangroves and associated communities within Moreton Bay. Over 44 percent of the area of the nine monitored communities within Moreton Bay is captured by the eleven AOI.

Table 1 Map Units selected for long term monitoring.

Vegetation Code (Dowling and Stephens 2001)	Total Area in Moreton Bay (ha)	Area in the Eleven AOIs	Percentage of Vegetation Type in Moreton Bay within each AOI	Map Unit Description
1B(i)	4673	2231	48%	*Avicennia marina* closed-forest, open-forest, woodland, low closed-forest, low open-forest, low woodland, low open-woodland
1B(ii)a	4034	1598	40%	*Avicennia marina* closed-scrub, open-scrub
1B(ii)b	1873	934	50%	*Avicennia marina* tall shrubland, tall open-shrubland
1B(ii)c	70	43	61%	*Avicennia marina* tall shrubland, tall open-shrubland that are dying due to waterlogging
1B(iii)	687	189	28%	*Avicennia marina* low open-scrub, low shrubland, low open-shrubland
1D(ii)	198	78	39%	*Ceriops tagal* low open-scrub, low shrubland, low open-shrubland
2	2095	911	43%	Claypan
3A(i)	397	174	44%	*Sarcocornia* spp., *Suaeda australis*, *Suaeda arbusculoides* dwarf closed shrubland,dwarf shrubland, dwarf open-shrubland, dwarf sparse-shrubland
4A(i)	1330	673	51%	*Sporobolus virginicus* closed grassland, grassland
Total	**15357**	**6831**	**44.5%**	

The 20 selected sites included a replication of each of the nine vegetation communities to cover potential variations and to accommodate likely changes within types across Moreton Bay. All sites are located between Highest Astronomical Tide (HAT) and 1.5m below HAT based on Lidar-derived contours capturing the elevation variability of mangroves occurrences.

At each of the sites detailed CORVEG information is gathered including site information and full floristic data (Neldner et al. 2005). Further ground elevation, tree height, girth and density information is collected.

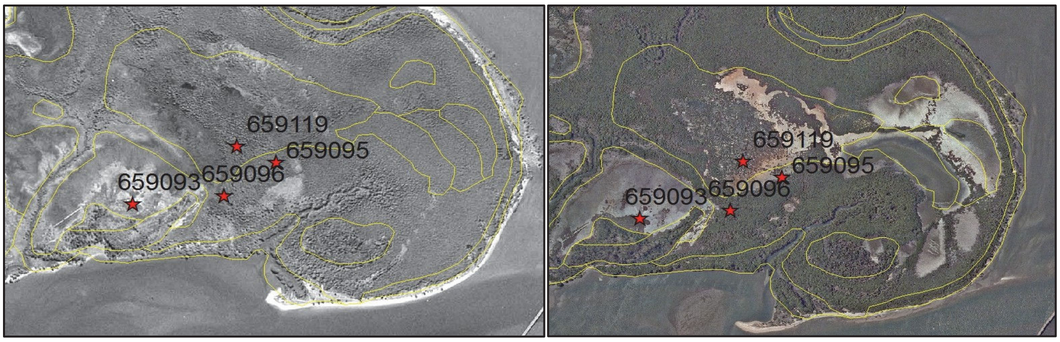

Figure 2. Sites in the Fresh Creek area, imagery 1950s (left) and 1997 (right) including 1997 vegetation line work (Dowling and Stephens 2001).

These ground and tree measurements can be correlated to the Lidar derived structural information including ground DEM, tree height and density (Figure 3). While it is very unlikely to have a repeat Lidar information over the whole area, the Lidar information provides essential information for the establishment of the monitoring. Future satellites (e.g. Discovery) may have Lidar capacities.

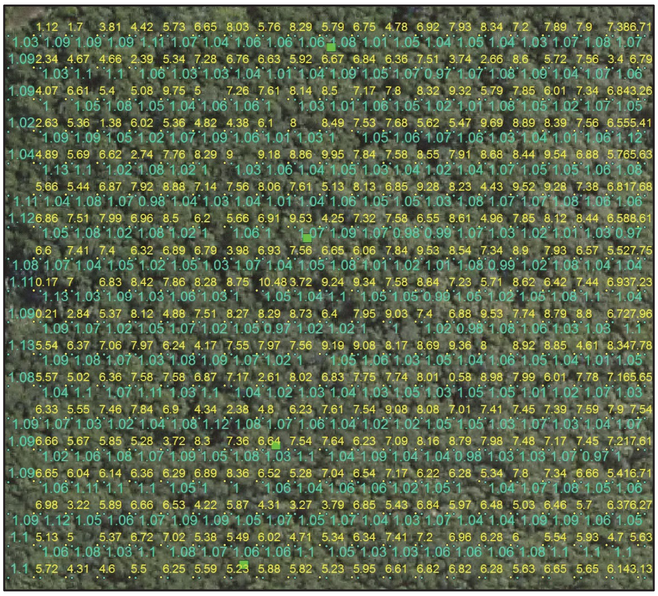

Figure 3. Site 659096 lined by the green dots including Lidar Derived ground DEM (meters above sea level in yellow), and Tree heights (meters above ground in blue).

Mapping Component

The monitoring will be derived by aerial photography interpretation and supported by field assessment. The monitoring will be applied at 1: 10,000 scale which enables detecting changes of about 30m on the ground (Anon. 2009). Some issues exist with the historical information. These include image rectification and differences in spatial interpretation. The ortho-photographs from 2002 onwards provide a stable platform to map, assess and monitor changes in coastal communities. To enable comparison of changes over time, the available historical mapping (1974, 1998) will be digitally aligned to the current data sets.

Areas of change are defined and attributed as either:

i. a shift from one community type to another, or
ii. as dieback or
iii. growth, or
iv. expansion as appropriate.

Historical photography of the 1940s and 1950s will provide the base of establishing the pre-clearing extent of mangroves and associated communities in Moreton Bay (Neldner et al. 2005). The 1998 mapping (Dowling and Stephens 2001) updated with the more recent ortho-photography captured in 2002 will set a baseline to monitor change. The classification and methodology established by Dowling (1986) and Dowling, R.M. and Stephens, K.M. (2001) will be followed.

Change detection automation in mangrove and associated communities

The high resolution and consistent series of ortho-photographs available through Queensland Government acquisitions (e.g 2002-2003, 2008-2009) will provide critical information for the repeat period of monitoring. An automated approach will be developed to assist in monitoring changes in mangrove and associated communities within Moreton Bay. The method will provide cost efficient and consistent process to monitoring change within the mangrove and associated communities within Moreton Bay. Digital imagery change detection has been reviewed and documented (Coppin & Bauer 1996 and Mouat et al. 1993) and can be approached in a number of ways including:

i. Change detection (with mask for the areas that we are looking for change);

ii. Classification approach using supervised/unsupervised classification or object oriented (e.g. Definiens' Ecognition software);

iii. Time-series approaches which will can provide a tool to distinguish between small seasonal differences (which should not be accounted as change) and large and/or more permanent changes such as dieback; and

iv. Vegetation indices approach. Where classification provides a clear visual distinction between the different classes, supervised and in some cases unsupervised classification may illustrate changes within a class or shifts of one class to another. Vegetation indices approaches (e.g. Normalized Difference Vegetation Index (NDVI) and Infra Red band over Red band (IR/R)) are being tested (Figure 4).

A working process to detect change in mangrove and associated communities is being developed using one or a combination of the above approaches.

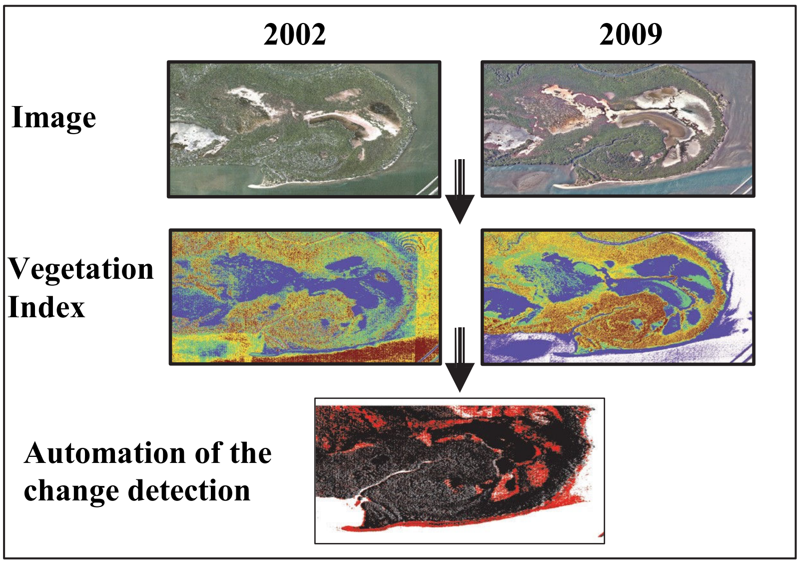

Figure 4. Automation of the change detection process using vegetation Indices.

These indices can be compared to detect a change in classification.

These indices are subtracted to highlight areas that change (in red).

DISCUSSION

The establishment of 20 monitoring sites across the Moreton Bay area over existing sites that were measured in the late 1990s provides a comprehensive source of information for a decade of change which will be assessed in the first year of the project. Coupling these monitoring sites with a mapping and monitoring program utilising high resolution ortho-photography will allow detection of changes which may be otherwise missed due to site sampling. Similarly, site visits may capture changes not detected remotely. Further understating the accuracy of new technologies such as Lidar ground level and tree height measurements will not only assist in establishing the permanent monitoring sites, but will provide future information as these technologies become more readily available. Access to historical aerial photograph will facilitate understanding of past processes of the mangrove and associated communities and will provide invaluable information to the current monitoring program. The monitoring program aims to establish decadal change detection maps of these communities to the present. This will document historical change which can be correlated to specific events at the time or prior to the event.

Projected sea level rise, increasing ocean acidity and temperatures and changes to runoff as a result of climate change will have ongoing impacts on fish habitats and on local and regional fisheries productivity. Findings from this program will provide essential information to the Fisheries Queensland project which maps the vulnerability of marine fish and plant communities to the physical impacts of climate change.

ACKNOWLEDGMENTS

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CONCLUSIONS AND TAKE HOME MESSAGE

To provide a robust monitoring program for dynamic communities such as the mangrove and associated communities it is important to establish a consistent and repeatable program coupling ground information collected from permanent sites across the study area with an over arching image change detection capability.

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