LONG TERM MONITORING OF SEAGRASS DISTRIBUTION IN MORETON BAY, AUSTRALIA, FROM 1972-2009 USING LANDSAT MSS, TM, ETM+

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1. INTRODUCTION

Seagrass communities are well known to provide essential ecosystem services and biodiversity to coastal systems [1, 2] and the spatial distribution of seagrass beds determines their effectiveness as ecosystem stabilisers. Thus, disturbances to seagrass, in particular habitat fragmentation, can potentially effect the entire coastal ecosystem [1-3]. Recent studies have shown that around the world seagrass populations are generally in decline [4, 5]. Seagrass communities in Moreton Bay are affected by multiple damaging pressures – declining water quality [1, 2, 6], dredging [7], harmful algal blooms (eg. *Lyngbya Majuscula*) [8], anchor damage [9], other physical disturbances [10], subsequent habitat fragmentation [3], and other negative feed-backs that can result from these disturbances or occur during recovery phases [11-13]. The ability to operationally map the distribution of seagrass is a critical component to monitoring and actively managing its health over space and time. The ability to retrospectively map seagrass distribution can provide a baseline assessment for which to compare current trends in growth and decline. This study demonstrates a method to map seagrass and benthic cover distribution from a complete Landsat archive including MSS, TM and ETM+ image data. The result is over 60 seagrass cover maps from 1972 to 2009, allowing baseline assessments, delineation of trends in growth patterns over both space and time, and providing the fundamental data set for exploring how seagrass communities respond to environmental/anthropogenic factors and thus facilitating the prediction of responses under future change scenarios (eg. sea level rise).

2. STUDY SITE

Moreton Bay is situated on the middle of the east-Australian coast (≈27˚15'S 153˚15E), approximately 400 km south of the Tropic of Capricorn, giving it a typical coastal sub-tropical climate. Moreton Bay has a total size of approximately 1500 km^2 and is mostly enclosed by large sand islands. The eastern regions of the bay are well flushed by oceanic water, resulting in optically clear waters almost all year round. The western regions are dominated by terrestrial input from rivers. Combined with wind-driven re-suspension and high residence times, the western regions can be turbid for significant portions of the year. Benthic cover in the bay is dominated by mangroves, mudflats and seagrass beds, as well as both hard and soft coral communities.

3. METHODS

3.1 Data and Pre-processing

For this study, 66 Landsat MSS, TM and ETM+ images were acquired from the United States Geological Survey (USGS) and the Queensland Department of Environment and Resource Management (DERM) from 1972 to 2009 on at least an annual interval (except 1980-1988 – for which no data were available). The remote sensing group at DERM have an automated, operational and validated routine for geometrically and radiometrically correcting TM and ETM+ imagery [14, 15], thus all imagery was pre-processed using this routine. The MSS imagery acquired from the USGS were corrected by applying the DERM routine manually.

3.2 Seagrass mapping

Seagrass mapping and monitoring in Moreton Bay has been relatively well studied in the past both historically [16, 17], and in recent times [18-21]. Recent studies have shown that seagrass cover can be reliably mapped in broad cover classes but species composition mapping is not yet feasible [18, 19, 21]. With the exception of [22], very limited work has been published on retrospective mapping and change in seagrass distribution in Australian environments and no published studies have utilised complete long-term image archives. In this study, a seagrass cover map was produced for all 66 images. The seagrass maps included seagrass projected horizontal foliage cover in three classes; sparse (approx. 1-40% cover), medium (40-80%) and dense (80-100%), as well as a sand and mud class. Mapping seagrass distribution in simple presence/absence classes would be satisfactory for many management agencies, but seagrass was further delineated into cover classes due to its importance on habitat function/faunal assemblages [4, 23-25]. An integrated per-pixel and object-based approach was used where water and exposed inter-tidal are separated using standard per-pixel techniques and then seagrass, mud and sand categories are classified using an object based approach[26, 27] (using Definiens eCognition). A detailed class hierarchy and basic membership rules are shown in figure 1. Validation of the seagrass maps was only possible for image dates where validation data (incl. aerial photography and field survey data) was available at approximately the same time stamp. A validation point file (a table of coordinates and corresponding cover type) was created for each date/set of validation data. An automated Python script was programmed to directly compare a point file to the corresponding seagrass cover map. The output is a range of standard accuracy statistics (overall, producer, user, kappa and tau [28]). Accuracy levels for validated maps act as a proxy for accuracy levels of seagrass maps where validation data is not available. A basic thematic change detection analysis was performed on the time-series of seagrass cover maps, which was able to highlight broad scale changes in seagrass cover and distribution across the bay. Future research will involve deeper time-series analysis, analysing specific seasonal and inter-annual trends.

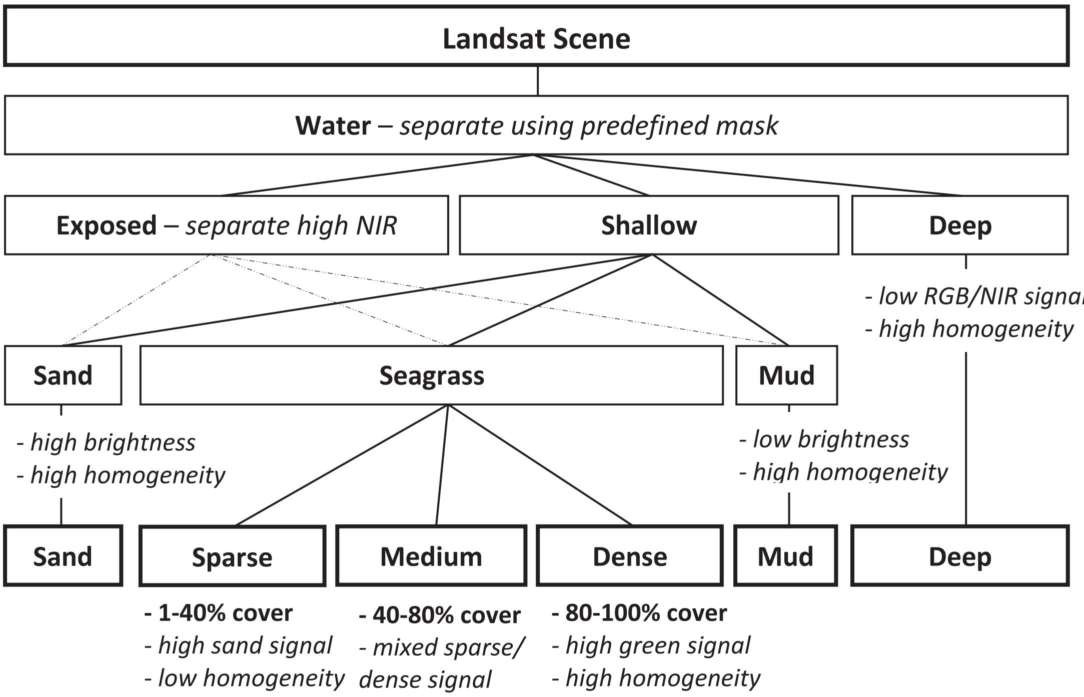

Figure 1. Classification hierarchy for classifying a Landsat image into a seagrass cover map, showing basic membership rules to be used in Definiens eCognition. N.B. Water mask was created using maximum high tide image and was edited/re-applied when known modifications to coastline occurred.

4. RESULTS AND CONCLUSIONS

The purpose of this study was to develop an operational method for processing and mapping seagrass cover from long term image archives. The study also provided, for the first time, information on the long term spatial and temporal dynamics of seagrass distribution in Moreton Bay. 66 seagrass cover maps were produced from 1972-2009 from the Landsat image archive. 10 seagrass cover maps (dates where validation data existed), spaced approximately evenly from 1972-2009 were assessed for accuracy and had a range of 50-80%. It is therefore reasonable to assume that the majority of the remaining seagrass cover maps would be between 60-70% accurate. Neglecting the propagation of accuracy errors through the time-series, the change detection analysis showed that for the whole bay, there was a small declining trend in seagrass cover, no change in extent in the eastern bay and an increase in extent in the western bay, where sand flats had morphed into mud flats. This study emphasises the importance and power of utilising the wealth of newly available long term image time-series. This study also demonstrates that past limitations to utilising long or dense time-series due to (1) availability of time-series data, (2) processing ability and (3) appropriate/available methods, can and have been overcome.

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