Moreton Bay and catchment urban expansion and vegetation change

Abstract

Here we describe changes in the Moreton Bay catchment via two remote sensing trajectory analysis methods, both of which are derived from Landsat satellite imagery. First, we describe changes in vegetation cover from a time-series of woody vegetation cover products. We focus on the absolute areas and spatial patterns in vegetation clearing across a time series between 1988 to 2015, focusing on the Brisbane, Pine, Logan and Caboolture River Catchments. We highlight several heavy clearing hotspots, as well as individual years in which clearing increased markedly. Second, we summarise the historical change from a time-series of categorical land cover and land use maps, with a focus on urban expansion. Our analysis shows a steady spread of urban areas outwards from highly developed areas, and a spread of lower density urban areas consistent with the increase in ‘rural residential’ and ‘lifestyle block’ developments.

Keywords: Landsat, remote sensing, time series, urbanisation, tree cover, satellite image

Introduction

As described in detail in the papers in Chapter 3, this volume, south east Queensland’s catchment has been significantly modified since the 1970s, including: extensive urbanisation; construction of dams and water impoundments; decreases in agricultural land use; and significant changes in vegetation cover. The availability of long term satellite image archives, along with modern computing resources, has seen a rapid growth in methods that utilise time-series analyses for studying and detecting changes in land use and land cover dynamics. Trajectory analysis (as these methods are commonly referred to) from landscape scale analysis from satellite imagery is generally divided into two main approaches: (i) those that detect either abrupt or long-term change that moves a system from one state to another, or (ii) those that explicitly aim to detect and monitor disturbance and recovery trends (1). We describe changes in the Moreton Bay catchment via two such trajectory analysis methods, both of which are derived from Landsat satellite imagery. First, we describe changes in vegetation cover from a time-series of woody extent and foliage projective cover (%), with a focus on land clearing. Second, we summarise the historical change from a time-series of categorical land cover and land use maps, with a focus on urban expansion.

Land clearing in south east Queensland (SEQ)

The Statewide Landcover and Trees Study (SLATS; https://www.qld.gov.au/environment/land/management/mapping/statewide-monitoring/slats) is a vegetation monitoring program, coordinated by the Queensland Government's Department of Science, Information Technology and Innovation (3). The program maps and monitors the extent of woody vegetation, with a focus on determining the location, timing and extent of vegetation clearing. The methods include a combination of automated and manual mapping techniques, based on ancillary field data and Landsat satellite imagery. The backbone of the methodology is estimation of foliage projective cover (FPC), the fraction of ground covered by foliage from a 'birds eye view', in each Landsat pixel. Time-series of this information was then used to estimate the change in extent of woody vegetation (trees, shrubs and lianas) and the associated clearing rates. Danaher et al. (2) give background on the approach, and the SLATS website (3) describes current methodology, publications and products.

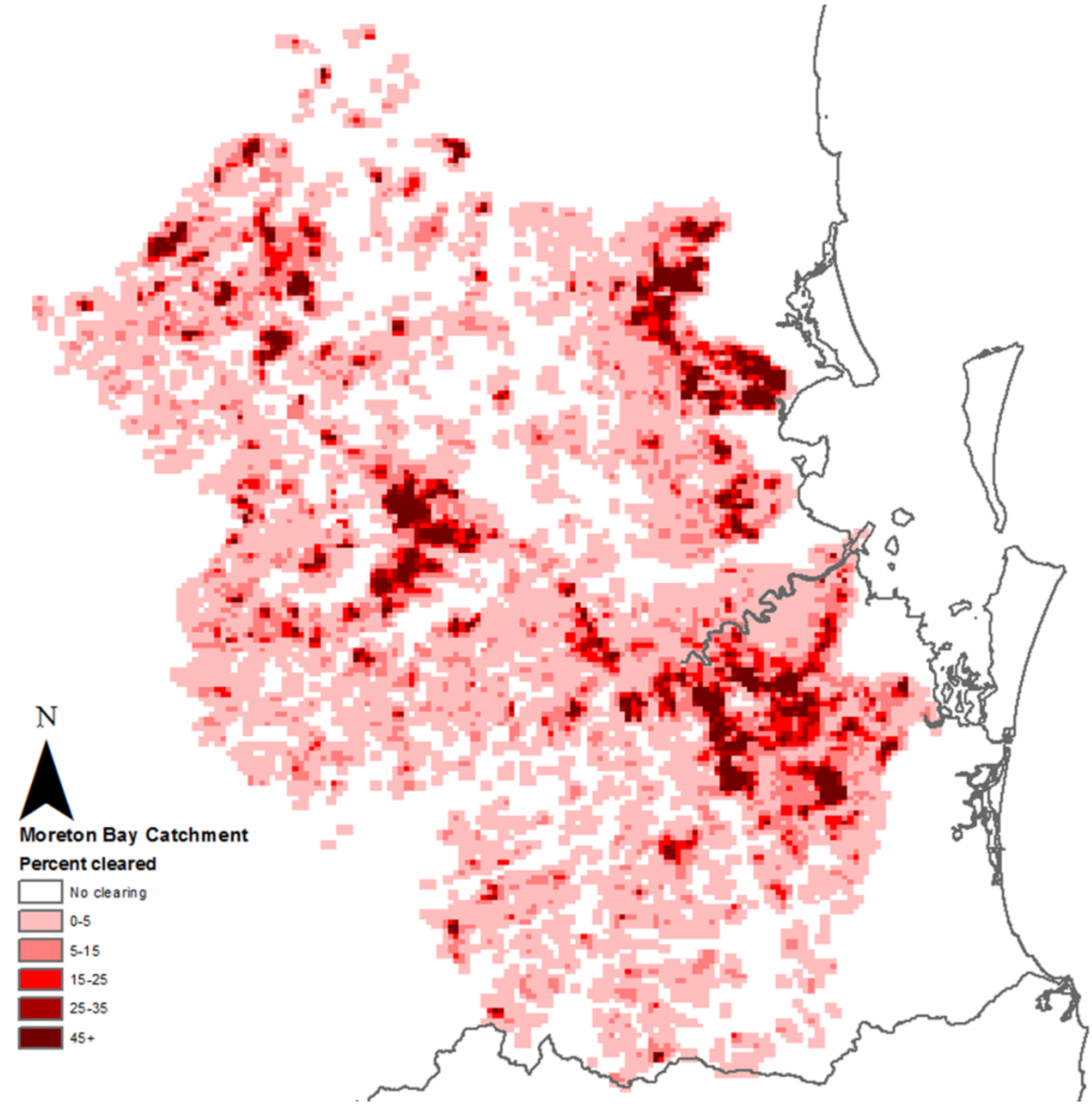

Figure 1. Woody vegetation clearing intensity in south east Queensland from 1988 to 2015, in the Brisbane, Pine, Logan and Caboolture River Catchments. Data come from the Queensland Government’s Statewide Landcover and Tree Survey (SLATS)(3)

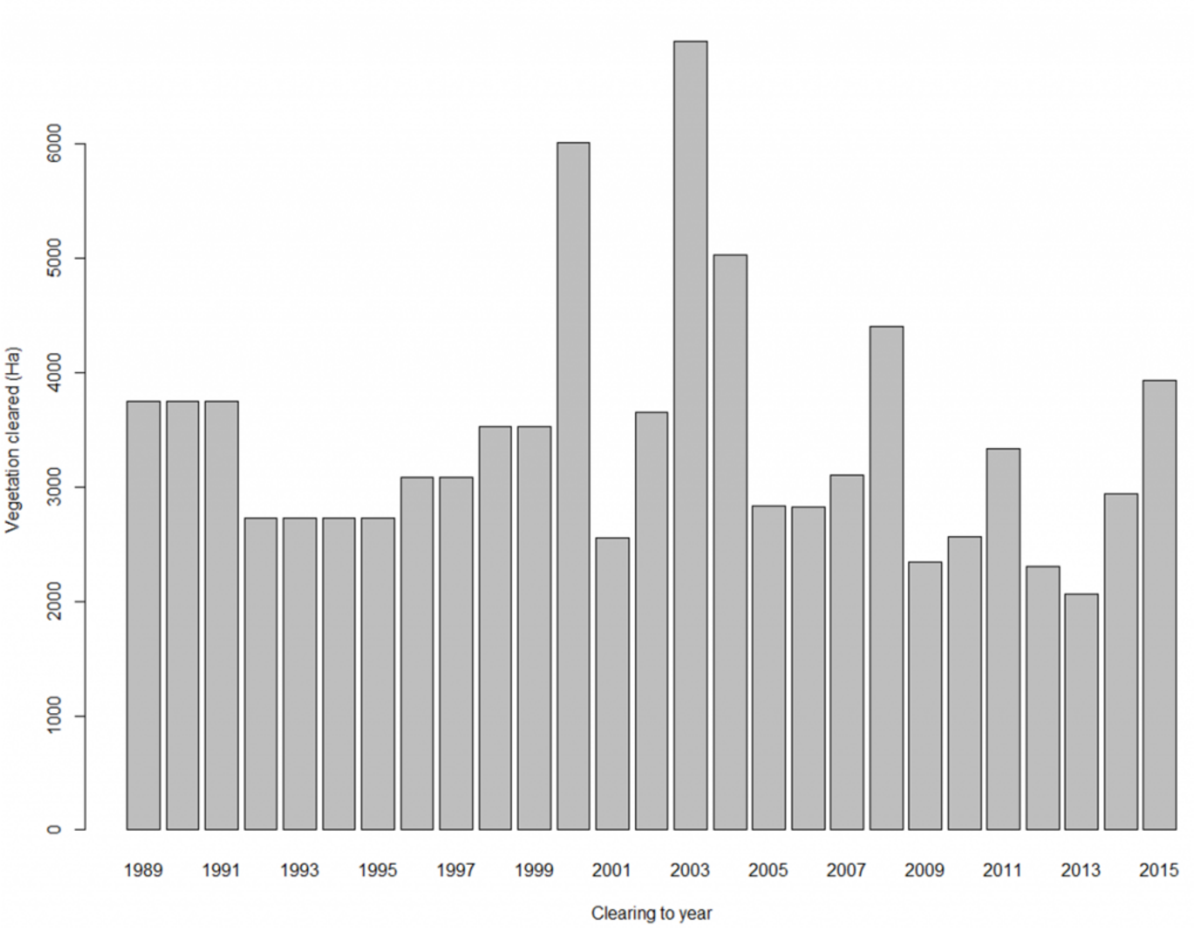

Figure 2. Woody vegetation clearing in south east Queensland from 1988 to 2015, in the Brisbane, Pine, Logan and Caboolture River Catchments. Data come from the Queensland Government's Statewide Landcover and Tree Survey (SLATS)

The FPC products are able to show the temporal trend in the intensity of woody vegetation clearing in SEQ between 1988 and 2015 (the years Landsat has been collecting imagery) for the Brisbane, Pine, Logan and Caboolture River Catchments (Fig. 1). Note the clusters of heavier clearing activity, corresponding to a mixture of the development of Brisbane's residential and commercial property, as well as clearing for agriculture and forestry. Examples include housing development at Springfield Lakes, development and clearing at Yarrabilba, Esk State Forest and the Mount Hallen rural developments, and agricultural and commercial development around the mouth of the Caboolture River. The FPC data can also be summarised to show the yearly clearing totals from 1988 to 2015 (Fig. 2). Note the peaks and troughs in clearing activity, some of which may correspond to changes in clearing legislation, but would need to be confirmed with more detailed study. The FPC mapping and clearing statistics process also provide a more detailed summary on the types of land use that replaces woody vegetation from 1988 to 2015 (Table 1).

Table 1. Woody vegetation clearing (in hectares) by replacement land cover (1988 to 2015) in the Brisbane, Pine, Logan and Caboolture River Catchments. Data come from the Queensland Government's Statewide Landcover and Tree Survey (SLATS).

epoch	pasture	settlement	mine	infrastructure	timber	thinning	missed	natural
1988-91	5883	3561	211	167	1203	0	0	0
1991-95	5001	3907	153	50	1640	0	0	0
1995-97	5877	1870	113	294	995	0	0	0
1997-99	3415	1411	174	370	1578	0	0	0
1999-00	3725	766	42	309	1091	59	0	0
2000-01	1538	329	26	69	596	0	0	0
2001-02	2192	632	17	111	691	1	0	0
2002-03	3413	2292	41	264	862	10	0	0
2003-04	2417	1494	40	166	609	269	0	0
2004-05	1767	685	7	81	258	25	17	0
2005-06	1646	496	43	65	537	0	1	32
2006-07	2023	239	34	331	370	101	3	0
2007-08	2045	1209	112	577	435	24	0	0
2008-09	1053	871	29	173	203	0	17	0
2009-10	958	577	46	430	394	140	21	0
2010-11	866	669	54	92	658	119	56	818
2011-12	1139	532	36	105	341	119	34	0
2012-13	803	457	22	86	294	294	94	6
2013-14	1072	646	17	120	430	575	0	5
2014-15	1866	976	63	24	728	189	16	0

Urbanisation in south east Queensland

Using an archive of maps of South East Queensland from Lyons et al (4; https://doi.pangaea.de/10.1594/PANGAEA.843545), we examined the progressive change in the extent of urban areas over the past few decades. The maps were derived from Landsat satellite imagery using object-based image analysis. The maps summarised land cover and land use into the following categories: urban (urban or built area and urban-vegetation mixture); agricultural, non-persistent vegetation (grass, sparse/non-photosynthetic vegetation; bare sand, bare ground); and forest vegetation (closed canopy forest and other dense vegetation, and open canopy forest). Full details on the methods are given in Lyons et al. (4). This approach differs from the SLATS woody cover analysis because the urban cover classes were explicitly mapped as opposed to vegetation being the only parameter of interest.

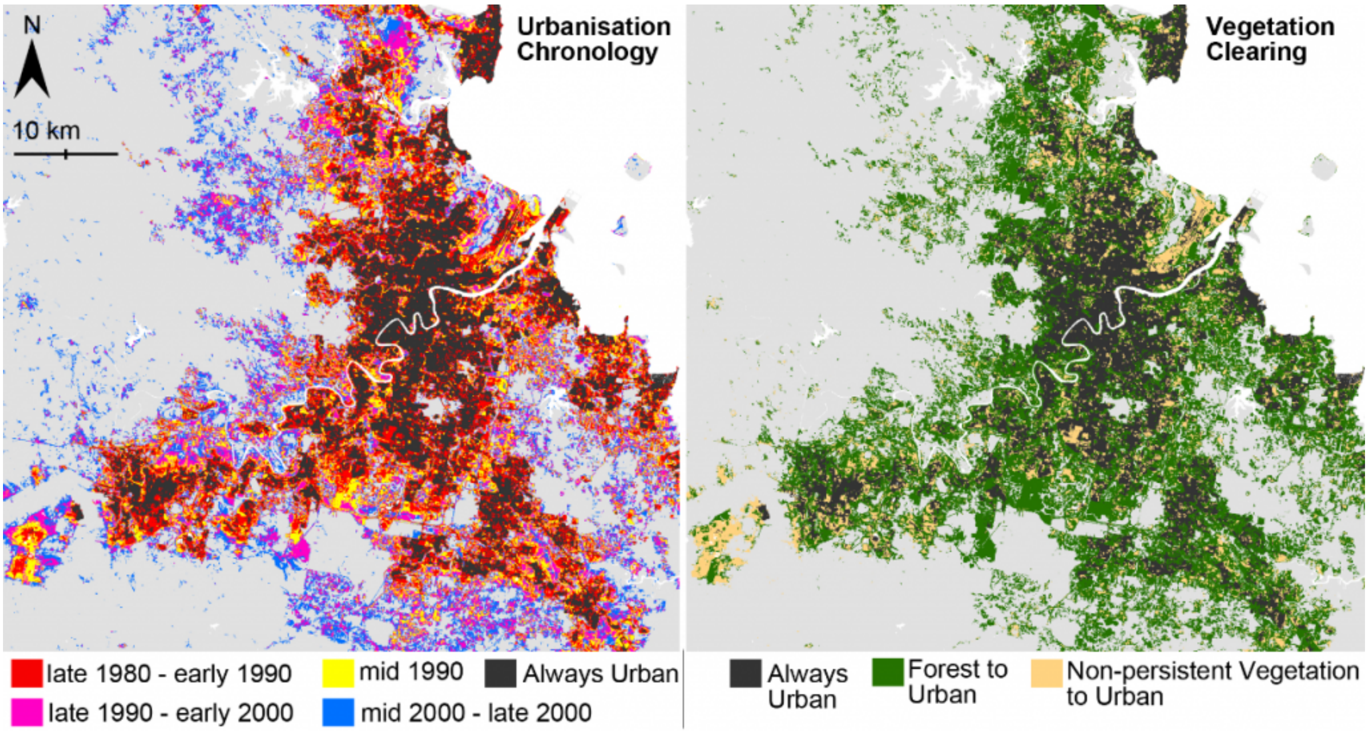

Figure 3. For south east Queensland, (a) the decadal patterns in urbanisation from date 1988 to 2013 and (b) the corresponding type of land cover clearing the urbanisation corresponded to over that period. Data derived from Lyons et al. (4).

South east Queensland has experienced rapid and wide spread population growth in the last few decades, and a very clear spatial trend of continued outward urban expansion was visible across the time-series (Fig. 3a). The trend showed that the later stages of development were encroaching on a larger spatial extent of the landscape, but the total area of new developed land was not increasing. That is, smaller individual developments or low density developments were built over relatively large areas. This is consistent with the increase of “rural residential” and “lifestyle block” type developments, where areas between developed sites are still mapped as vegetation proper. The corresponding map of vegetation clearing (Fig. 3b) showed that forest cover was the main vegetation type to be cleared for development. Note that the map of vegetation clearing does not necessarily match the chronology of urban development, since development does not always directly follow land clearing. For example, clearing rates were higher than average in 2003 (see Fig. 2) and trended downwards to 2013 whereas development did not reflect this trend.

Conclusion

Remote Sensing provides a powerful tool to examine historical changes and trends in land cover change. We have shown two remote sensing-based trajectory analysis methods that provide insight into the historical trends of vegetation clearing and the patterns of urbanisation in South East Queensland. The results from these analyses can be further interrogated and used to make explicit links between past actions, threatening processes and potential mitigation or palliative action. Key items of interest would be: (i) examining the spatial distribution of development and development types (e.g. low- vs high-density), and linking these analyses to biodiversity outcomes, and (ii) analysing the trends over time in clearing rates (e.g. the cyclical nature of the clearing totals) and how this potentially relates to changes in vegetation and biodiversity legislation as well as government cycles. Overall it highlights the importance of continuing to invest in remote sensing-based methods as new imagery is acquired into the future.