Land Management Impacts on Water Quality in New Zealand across Political Boundaries

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Introduction

The most immediate and widespread driver of land cover change is land management, such as forest clearing for livestock farming or grassland conversion to plantation forests for timber production. These land management decisions are heavily influenced by regional policies, and thus analyses of the socioeconomic drivers for land cover change need to occur at these regional levels. Evaluation of environmental impacts of land management is difficult because regional political boundaries rarely coincide with environmental boundaries such as catchments. In 1991, New Zealand (NZ) adopted the Resource Management Act, which redefined the political boundaries of the nation to coincide with catchment boundaries so that each Regional Council would be solely responsible for their water resources, particularly water quality of their rivers, lakes, and coastal environments. **The goal of this project is to use NZ as a case study where land use change analyses at fine spatial and temporal resolutions are used to understand how regional land management impacts water quality.**

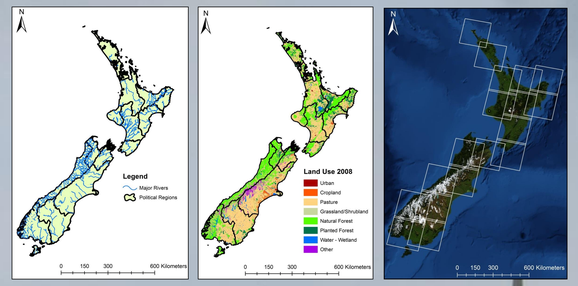


Figure 1. (Left) NZ is the only nation where its political boundaries coincide with catchment boundaries. (Center) Because most land management decisions are made at the Regional level (black outlines), land use varies considerably among the 16 Regions. (Right) NZ is covered by 25 Landsat scenes, which we will analyze from 1990 to 2014 in order to assess the impacts of the Resource Management Act.

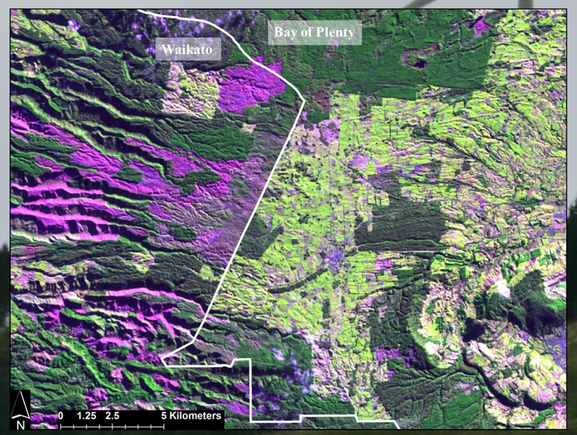


Figure 2. Central North Island, NZ (Landsat [5,4,3], June 30, 2004). While land management differences among Regions are pronounced at Regional levels (Fig 1), there are instances like this one, that clearly illustrate cross-border land use differences between Regional Councils. Here, Waikato Region is more concerned with foresting stream headwaters to protect their water quality; whereas, Bay of Plenty Region has promoted pastoral agriculture for economic development. Due to declining water quality, Bay of Plenty Region has since been converting pastures to plantation forest (purple areas denote recently harvested forests) in an effort to reduce sediment and nutrient runoff.

Approach

In order to assess the effectiveness of regional policies in improving or preserving water quality, we will create high-resolution (8-day, 30 meter) land use and water quality time series and then overlay them onto socioeconomic timelines for the period 1990 - 2014. The key products of this research will be: (1) a fused 30 m land use time series for all of NZ and one of the most comprehensive spatiotemporal analyses of strip grazing and plantation forestry land uses; (2) empirical models, based on over a hundred catchments with 24 years of monthly data, that quantify relationships between land use, weather, and water quality (turbidity, dissolved organic matter, total and dissolved forms of nitrogen and phosphorous); and (3) an assessment of the effectiveness of catchment-scale land management in terms of water quality.

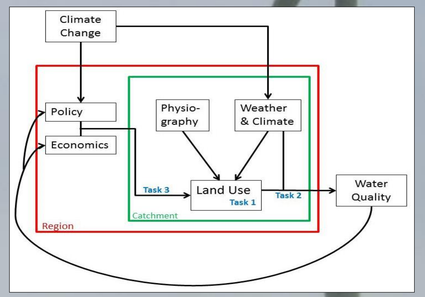
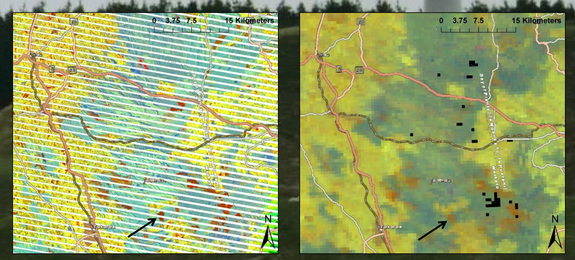


Figure 3. Project workflow and variables assessed.

Plantation Forestry Pilot Study



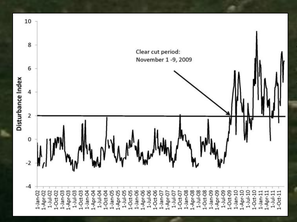


Figure 4. (Top-Left): Landsat brightness, greenness, wetness. Clear cut areas stand out in red because they are brighter, less green and less wet than forested areas. (Top-Right): MODIS image over same area and at the same date. (Left): MODIS disturbance index from 01/2002 through 12/2011 over one pixel (at the black arrow). Based on the MODIS time series we can determine that this particular pixel was cut November 1-9, 2009.

Strip Grazing Pilot Study

Figure 5. Example of strip grazing in the Waikato Region during Winter of 2010. Winters in NZ are characterized by low sunlight, relatively high rainfall, and lower pasture recovery rates. These combined effects can lead to high sediment runoff events and degraded water quality.

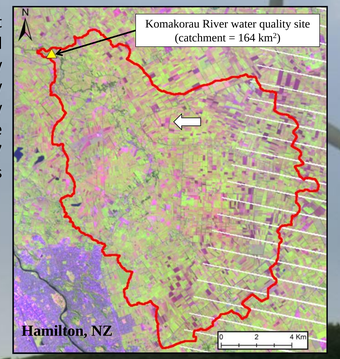


Figure 6. Komakorau catchment (red outline) in the central Waikato Region. The highly fragmented and spatially variable grazing areas are easily discernible on this Landsat image (March 29, 2011; Landsat 7 ETM+). The white arrow shows Location of Figure 5.

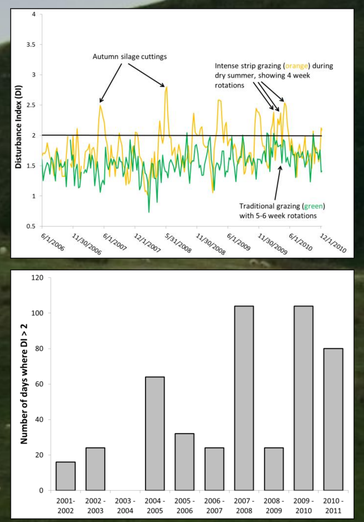


Figure 7. (Top): The tasseled cap disturbance index for two MODIS pixels (500 m) in the Komakorau catchment, both classified as improved pasture. The orange time series is for a pixel completely covered by strip grazing (Fig 5), while the green time series is covered by less intense traditional grazing. Any DI > 2 indicates severe disturbance. (Bottom): Number of days during each growing season with DI > 2 for entire Komakorau catchment. The year 2003-2004 (wet summer) did not have any days with DI > 2; whereas 2009-2010 (dry summer) had 104 days with DI > 2.

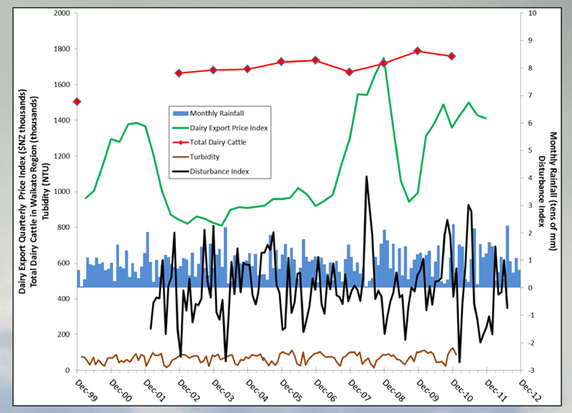


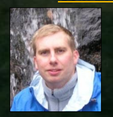
Figure 8. Time series of land use disturbance, rainfall, water quality, and economic data for Komakorau catchment. The disturbance index (DI) was high during periods of low precipitation but was also influenced by silage cuttings and periods of intense grazing (Fig 7). DI has an increasing trend from 2000 to 2012, likely due to increasing numbers of grazing dairy cattle, which is influenced by the dairy export price index. The highest river turbidity values occurred when high rainfall coincided with high DI. The transition from event-based turbidity to more seasonal trends suggests that intensifying strip grazing has transformed this catchment into transport-limitation (in terms of sediment runoff) when it was previously supply-limited.

Summary

When combined, the three tasks in Figure 3 will allow us to assess and model the relationships among regional policy/economics, land use change, and water quality (e.g. Fig 8). These multi-dimensional timelines and time series will be overlain in order to understand the socioeconomic drivers for land use change in NZ across political boundaries defined by catchments, and ultimately impacts on water quality. The effectiveness of catchment-based management and policies will also be assessed, providing a foundation (or at least a comparison) for environmental resource management initiatives in other parts of the world. Indeed, many states and regions in the US are starting to use watershed boundaries as management units.

Project Team

United States



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