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.**
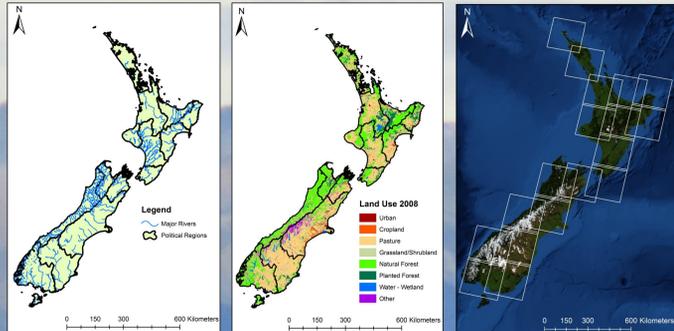

Figure 1. NZ is the only nation where its political boundaries coincide with catchment boundaries (left). Because most land management decisions are made at the Regional level (black outlines), land use varies considerably among the 16 Regions (center). NZ is covered by 25 Landsat scenes (right), which we are analyzing from 1990 to 2014 in order to assess impacts of Regional policies. We use Landsat TM/ETM surface reflectance to obtain high spatial resolution (30 m) and we use MODIS Nadir BRDF-adjusted reflectance (NBAR) to obtain high temporal resolution (8 day). By fusing these two datasets into one time-series, we can assess with fine detail how land management practices like the ones below affect land cover changes.

Figure 2. Plantation forestry is one of the dominant land uses in NZ, particularly on steep slopes (top). The other dominant land use in NZ is livestock grazing, with some areas like this one in the Waikato Region being managed intensively (bottom). Both forest harvesting and strip grazing can convert a vegetated surface to bare soil in just days, which we refer to as a significant land disturbance. Intense rainfall following these land disturbances can lead to considerable amounts of erosion (even landslides on steep slopes) that contribute to degraded water quality for extended periods. In order to assess the relationships among land disturbance, weather/climate, and water quality, high-resolution spatio-temporal datasets are needed for all three variables.

Forest Disturbance Index

- Tasseled Cap:
  - Linear transformation of reflectance bands into three indices: *Brightness, Greenness and Wetness*

- Each component is rescaled to a normalized distribution:

$$B_n = \frac{B - B_\mu}{B_\sigma}$$

Forest Disturbance Index

$$\text{Brightness}_n - (\text{Greenness}_n + \text{Wetness}_n)$$

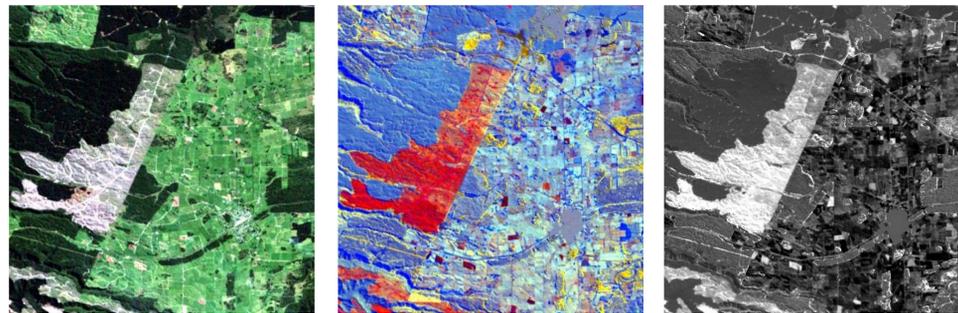**Figure 3.** Forest disturbance effect on Tasseled Cap indices.

Figure 4. Landsat True Color image (left). Landsat Tasseled Cap composite (center). Landsat disturbance index (right).

Grassland Disturbance Index

Grassland Disturbance Index

$$- (\text{Brightness}_n + \text{Greenness}_n + \text{Wetness}_n)$$

Figure 5. Grassland disturbance effect on Tasseled Cap indices (above). Grazing areas shown in Landsat True color (right).

Figure 6. Original disturbance index (above). Modified disturbance index (right), showing clear disturbance signal in grazed pastures.
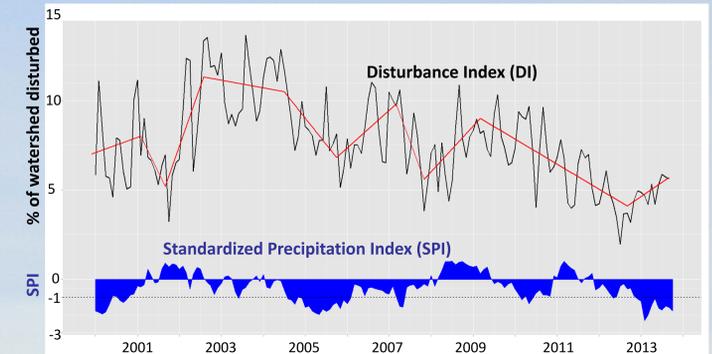
Case study: Hoteo Catchment

Figure 7. Mean monthly Disturbance Index (**DI; black line**) for the Hoteo Catchment, which contains a combination of livestock grazing and plantation forestry. Piecewise regression (red line) was fitted on DI to capture trends possibly associated with the Standardized Precipitation Index (**SPI; blue columns**): wet periods (positive) vs. dry periods (negative). Generally, DI increased during prolonged droughts (SPI < -1) and DI decreased during wet periods. We are currently investigating if deviations from this relationship are due to changes in land management resulting from agricultural markets (i.e. less forest harvesting with reduced timber prices) or climate adaptation (i.e. less cows on the land during droughts).
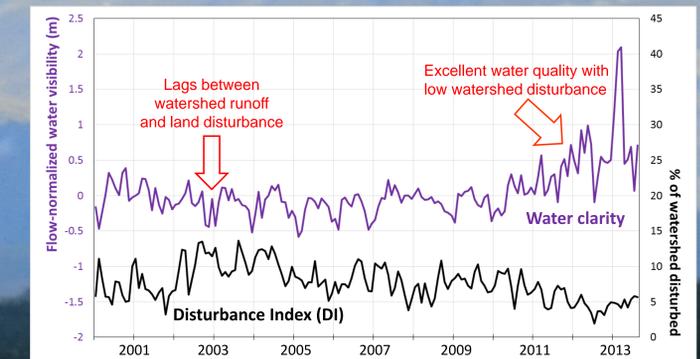

Figure 8. Flow-normalized water visibility (purple line) in the Hoteo River was compared to the land disturbance index (DI; black line). Generally, water clarity was higher than expected (positive) when DI was low, and lower than expected (negative) when DI was high.

Project Team