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A FUSED DISTURBANCE MODEL FOR LAND MANAGEMENT ANALYSIS IN NEW ZEALAND

using MODIS and Landsat time series



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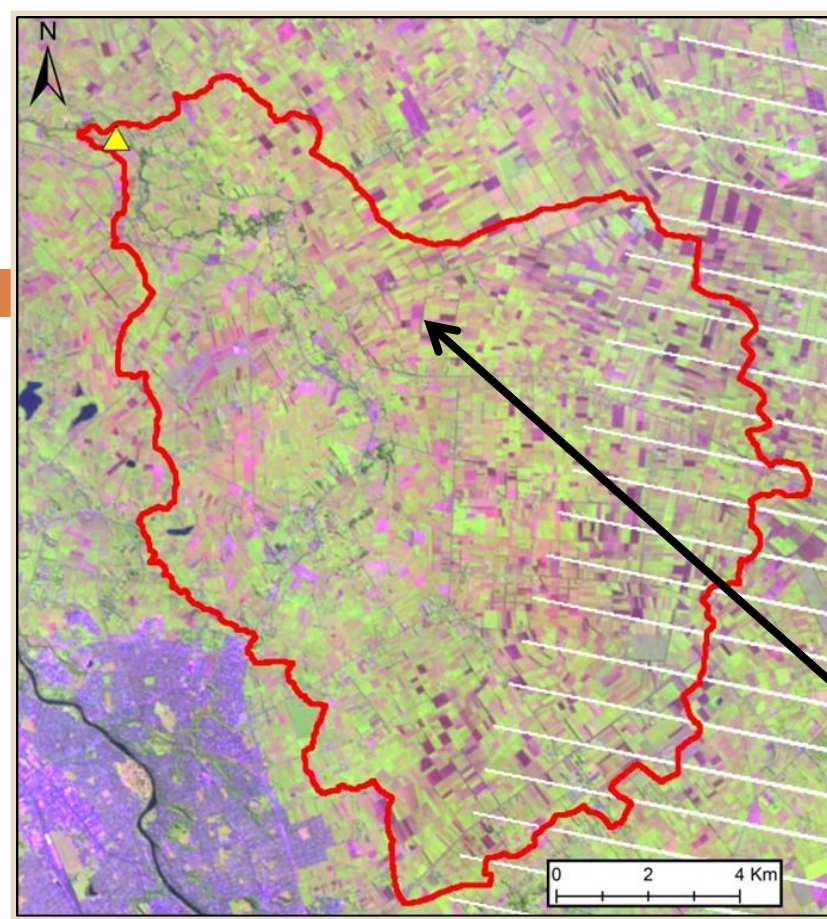
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Research Focus

- Employ the latest disturbance detection methods combined with analysis of water quality data to assess the environmental impact of land management practices in New Zealand.
- Combine high spatial resolution Landsat data with high temporal resolution MODIS data to detect landscape changes more precisely.

Ecological Concerns

300,000 more
cattle since 2000



Hamilton, NZ



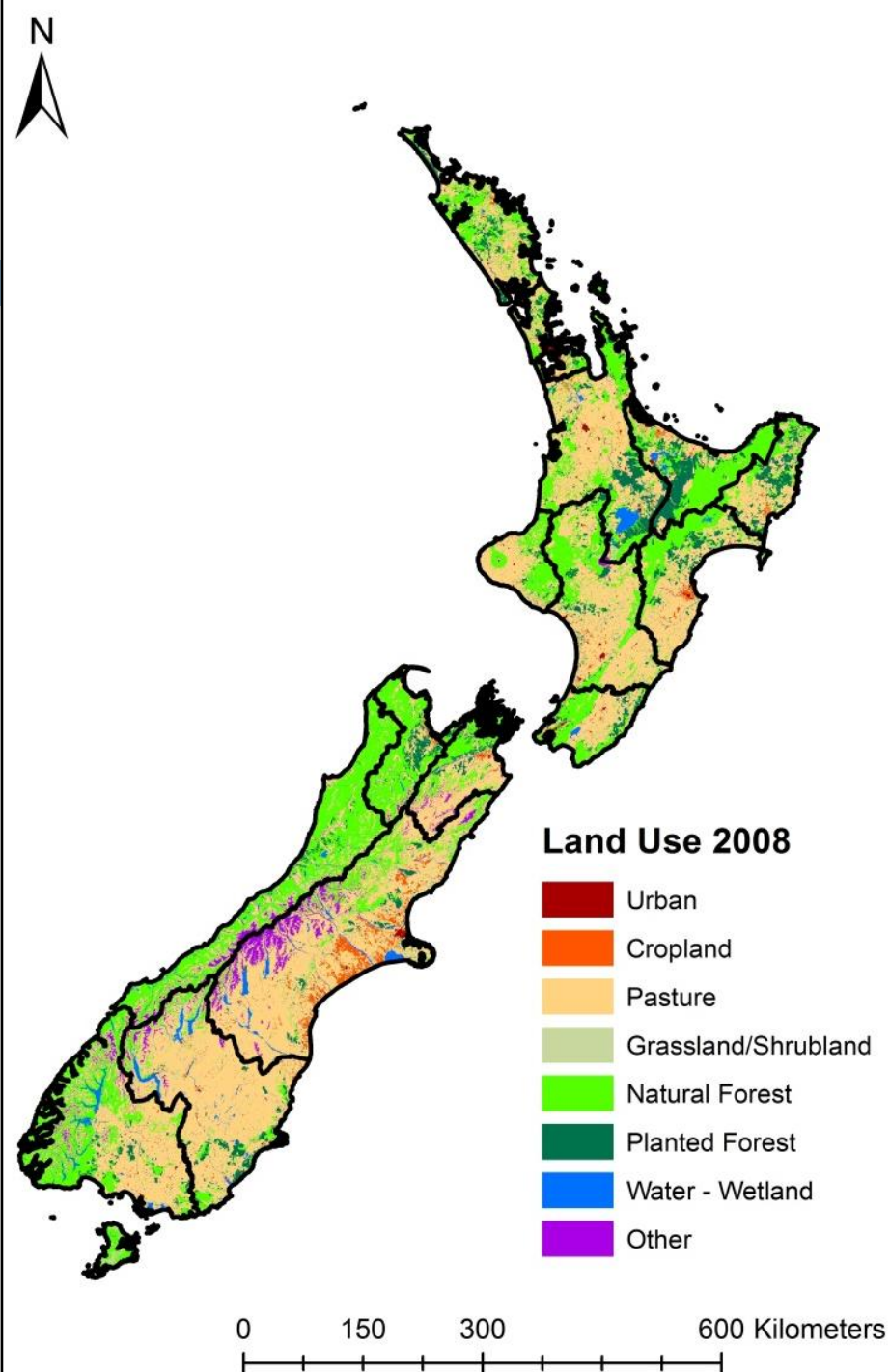


**Growth in
plantation forestry**



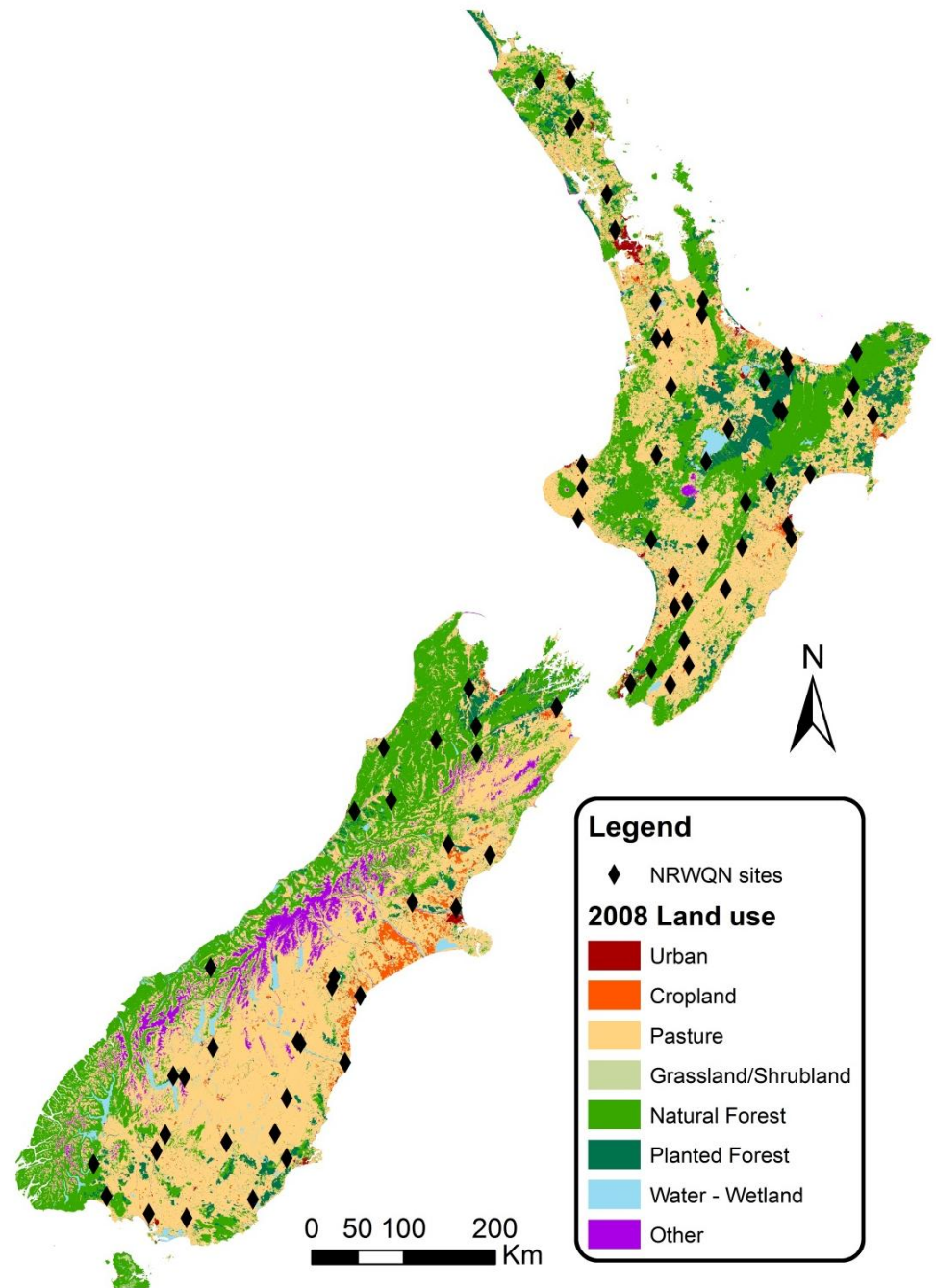
Study Area

- Regional/Catchment Boundaries
- Land Cover
 - ▣ Deciduous Forest
 - ▣ Exotic Forest
 - ▣ Low Producing Grassland
 - ▣ High Producing Grassland



Water Quality

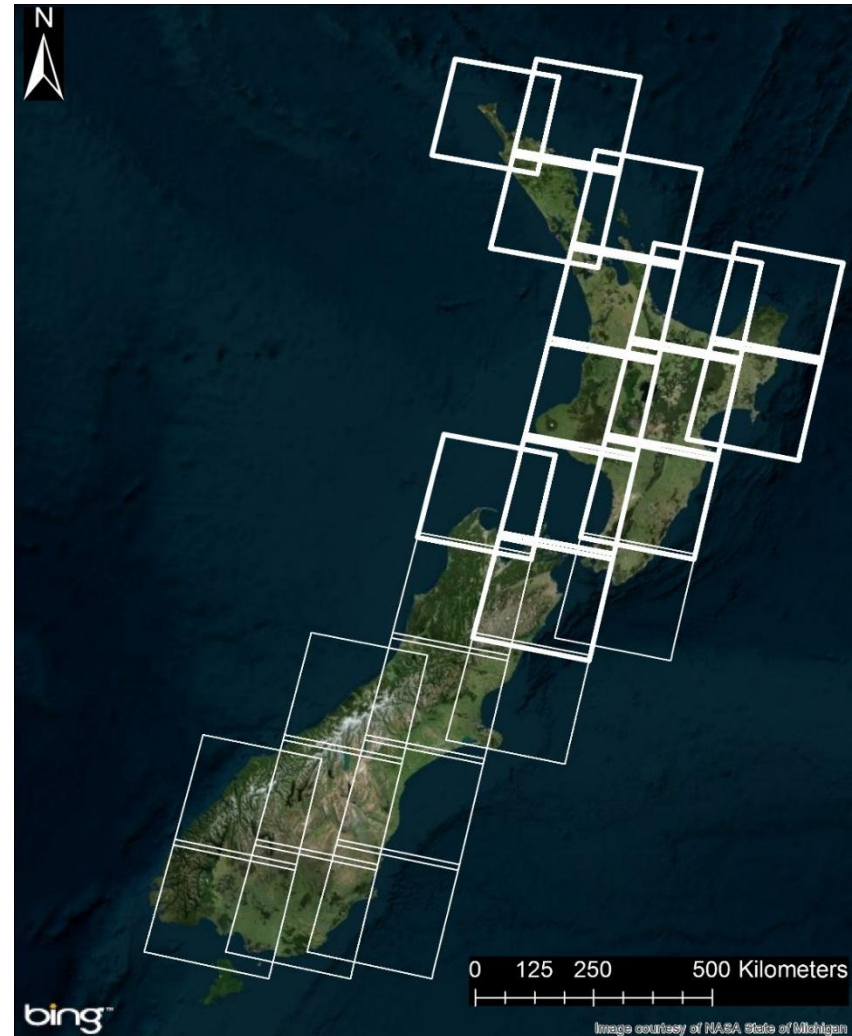
- 77 Watershed Monitoring Sites
- Daily to Monthly Monitoring
 - Turbidity
 - Clarity
 - Phosphorous
 - Nitrogen



Remote Sensing Data

- 25 Landsat Path/Rows
 - TM/ETM+
 - 30m resolution
 - ~220 images each
 - ~30 years (mostly since 1999):
 - July 1999 – July 2012

- 5 MODIS Tiles
 - MCD43A4 (Schaaf et al., 2002)
 - Nadir BRDF-Adjusted Reflectance
 - 500m, 8-day resolution
 - 638 images each
 - ~14 years of data:
 - Feb 2000 – Dec 2013



Data Processing

Data Sets Used:

Landsat 5 & 7
TM/ETM+
Corrected to
Surface
Reflectance
using LEDAPS

MODIS Nadir
BRDF-Adjusted
Reflectance
(MCD43A4)

Landsat (14 of 25)		MODIS (5 of 5)	
Path/Row	No. of Images	Tile	No. of Images
71086	229	h29v13	638
71087	226	h30v13	638
72086	219	h31v12	638
72087	201	h31v13	638
72088	199	h32v12	638
73085	254	Total	3190
73086	239		
73087	212		
73088	230		
73089	231		
74084	197		
74085	240		
74088	238		
75084	223		
Total	3138		

Tasseled Cap

- Linear transformation of reflectance bands into three indices:
 - Brightness
 - Greenness
 - Wetness
- Calculated based on coefficients developed by Crist (1985) for Landsat TM and Lobser et al. (2007) for MODIS.

Normalized Tasseled Cap

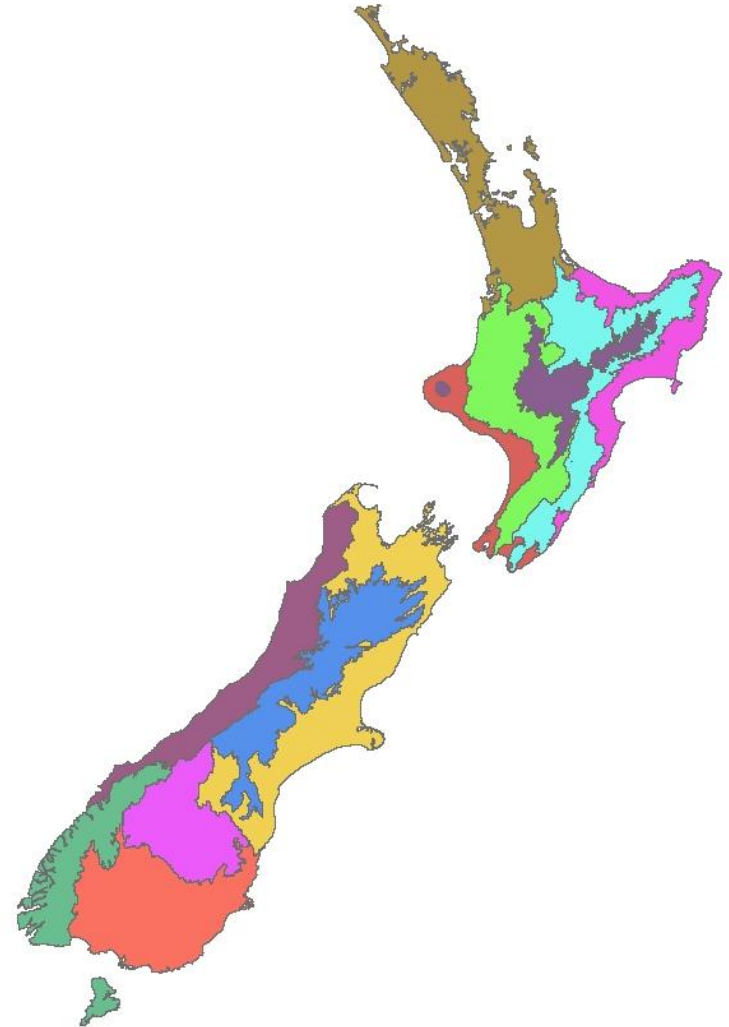
- Each component is rescaled to a normalized distribution:

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

- Standardized using the mean of consistent land cover pixels across both 2001 and 2008 land cover maps (LCDB from New Zealand's Landcare Research).

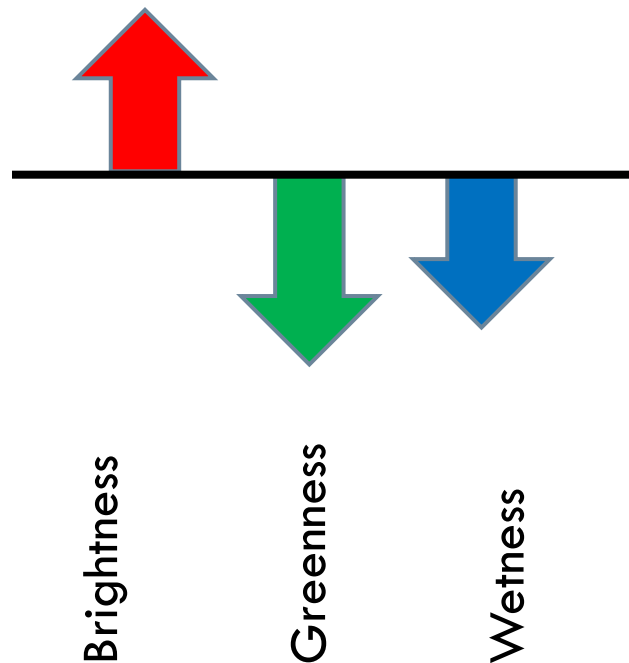
Standardization

- Landsat
 - ▣ Path/Row
 - ▣ Land cover
 - ▣ Aspect
- MODIS
 - ▣ North Island/South Island
 - ▣ Land cover
 - ▣ Climate Zones
 - Median annual rainfall, temperature, and sunshine hours (1980-2010) from NIWA



Different Land Cover Types

- Disturbed Forest
 - Becomes brighter
 - Less green and wet



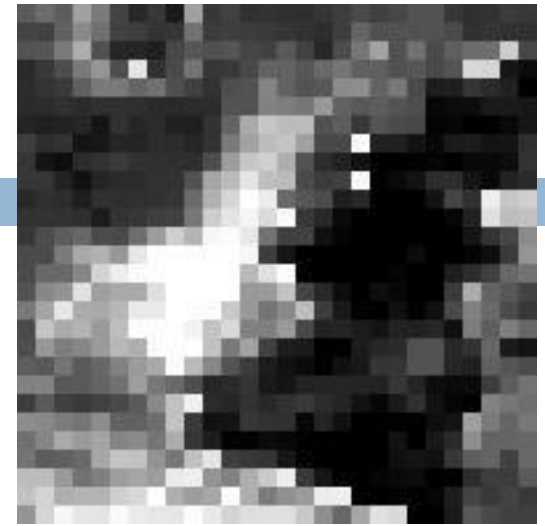
Disturbance Index

The disturbance index was developed for forests and is very effective in identifying significant changes. The index is based on standardized components of the Tasseled Cap. (Healey et al., 2005)

- Forest Disturbance Index:
 - $Brightness_n - (Greenness_n + Wetness_n)$
- Higher values indicate disturbed areas

Forest Disturbance

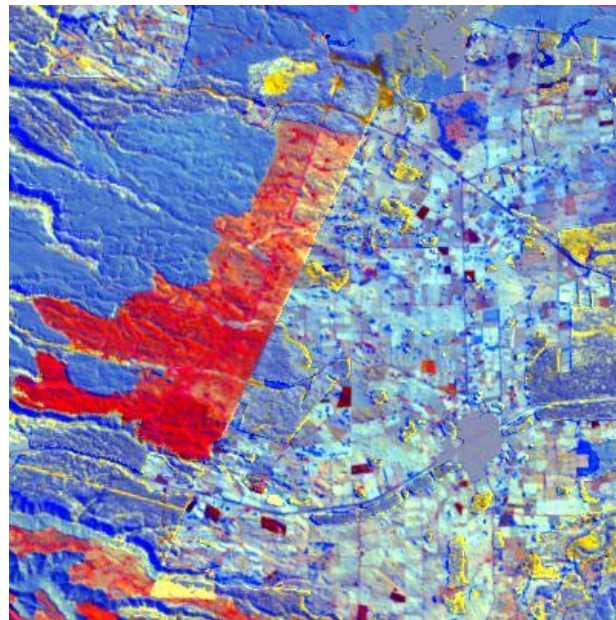
- Forested area on the border between Waikato and Bay of Plenty in 2000



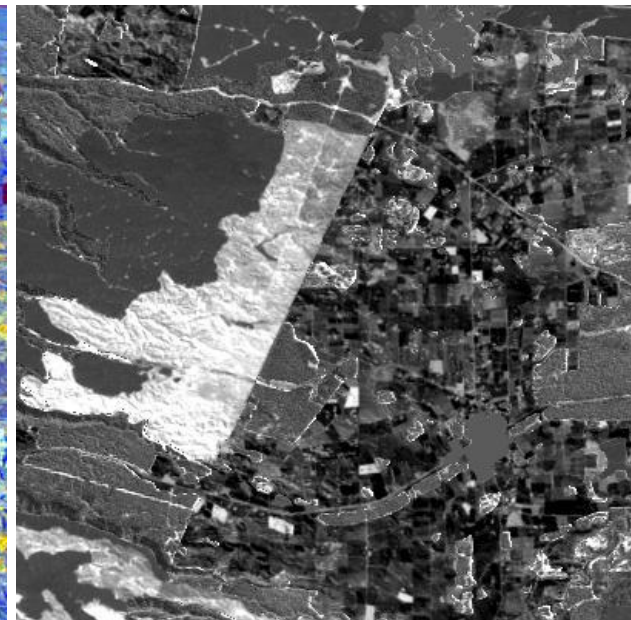
MODIS Disturbance



True Color Landsat image



Landsat Tasseled Cap

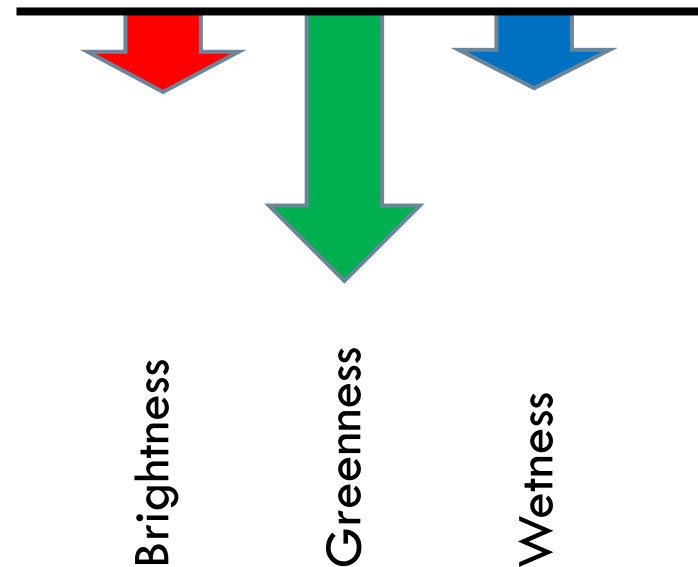


Landsat Disturbance

Different Land Cover Types



- Disturbed Grassland
 - Becomes darker (or stays the same)
 - Much less green



Disturbance Index

Originally developed for forests but modified form works well in grasslands. Both forms combine standardized components of the Tasseled Cap.

- Forest Disturbance Index:

- ▣ $Brightness_n - (Greenness_n + Wetness_n)$

- Grassland Disturbance Index:

- ▣ $-(Brightness_n + Greenness_n + Wetness_n)$

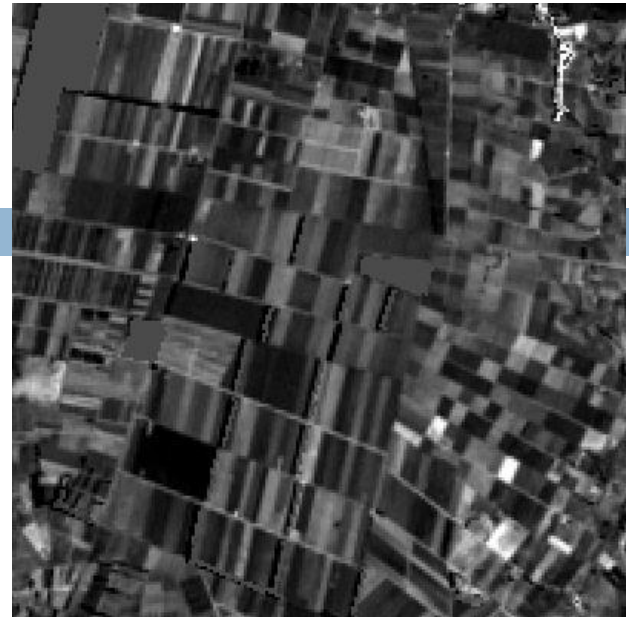
- Higher values are disturbed

Grassland Disturbance

- Typical grazing area southeast of Hamilton, NZ

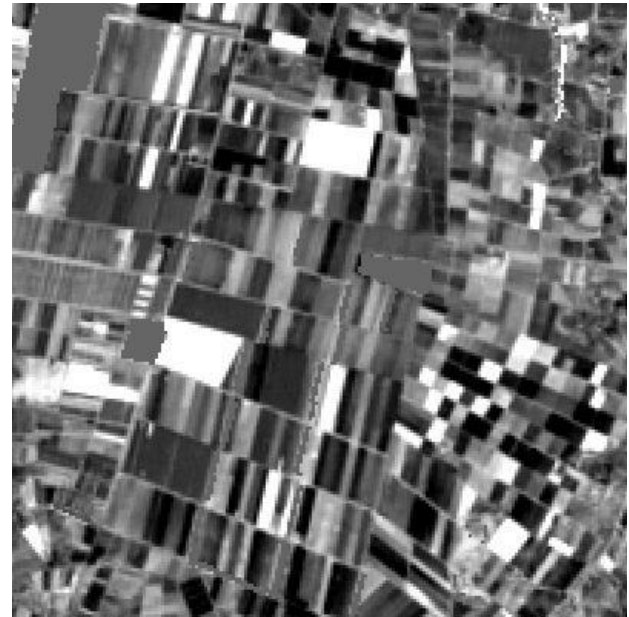


True Color Landsat image

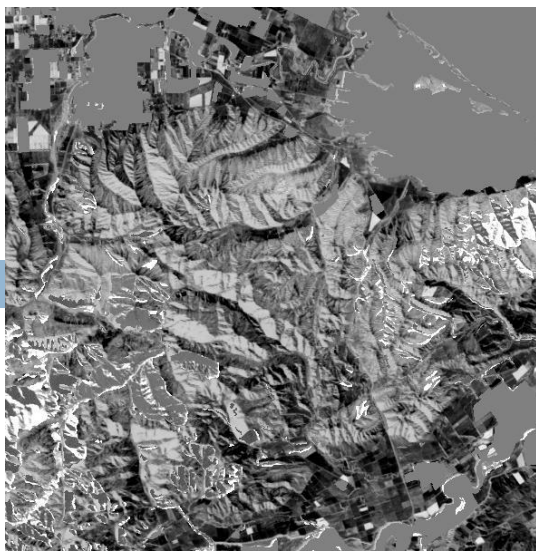


Top: Forest Disturbance Index

Bottom: Modified Grassland Disturbance Index

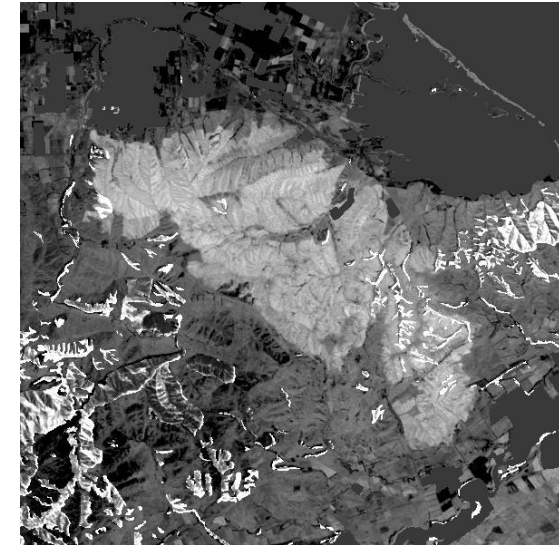
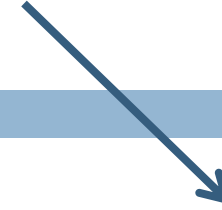


Fusion

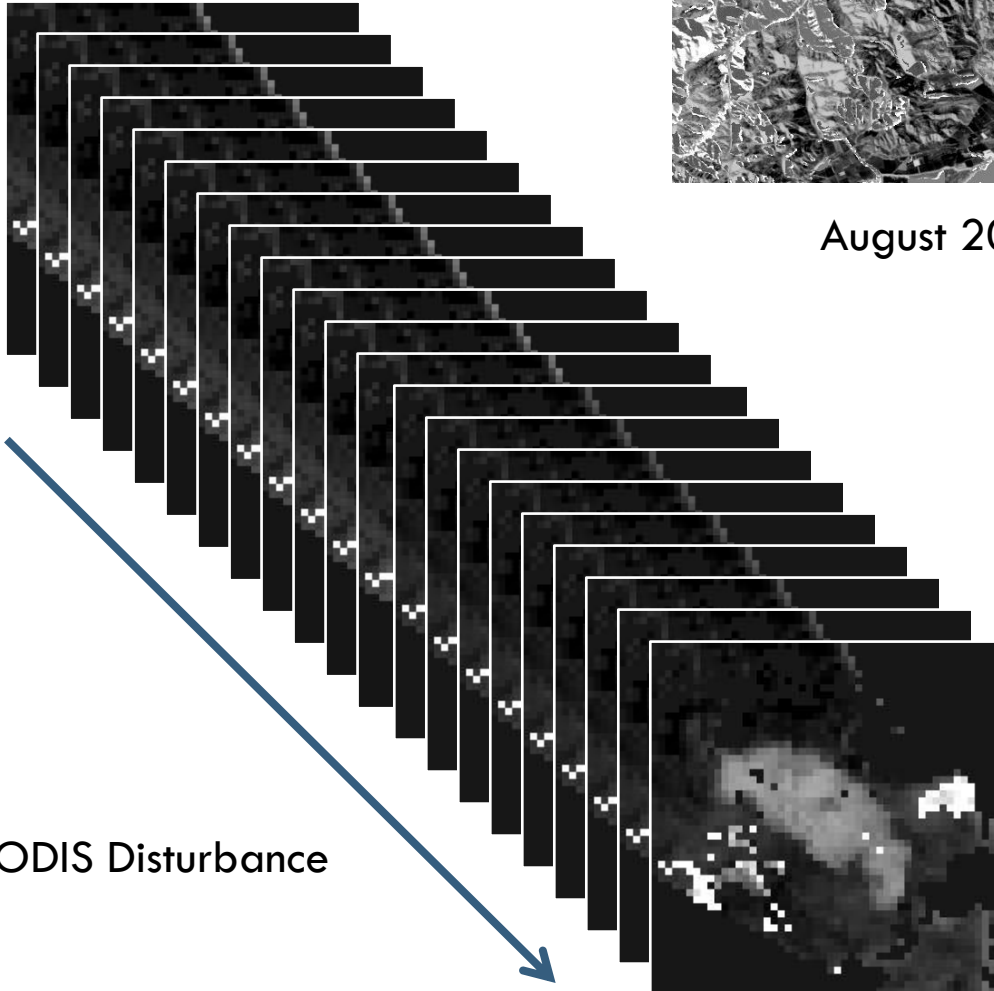


August 2000

Landsat Disturbance



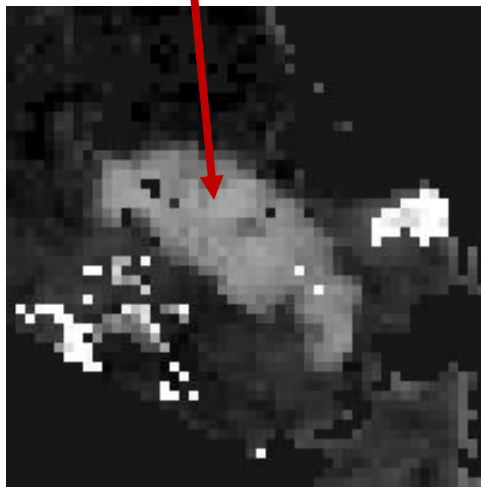
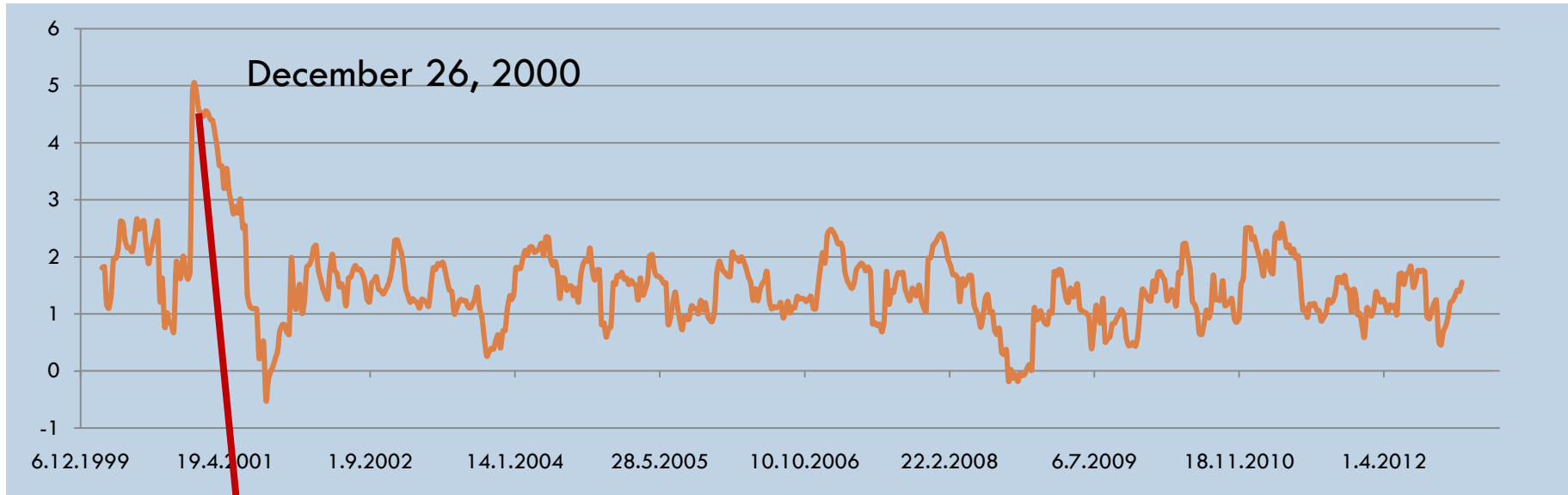
Feb 2001



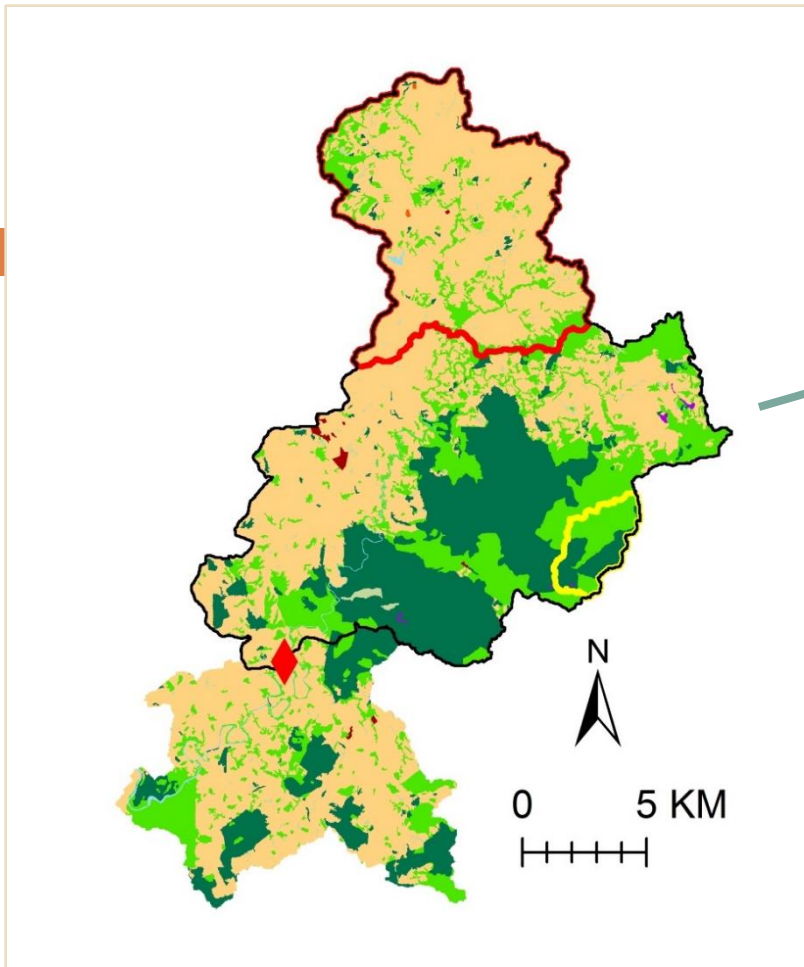
MODIS Disturbance

Disturbance occurred some time between August 2000 and February 2001.
But when exactly?

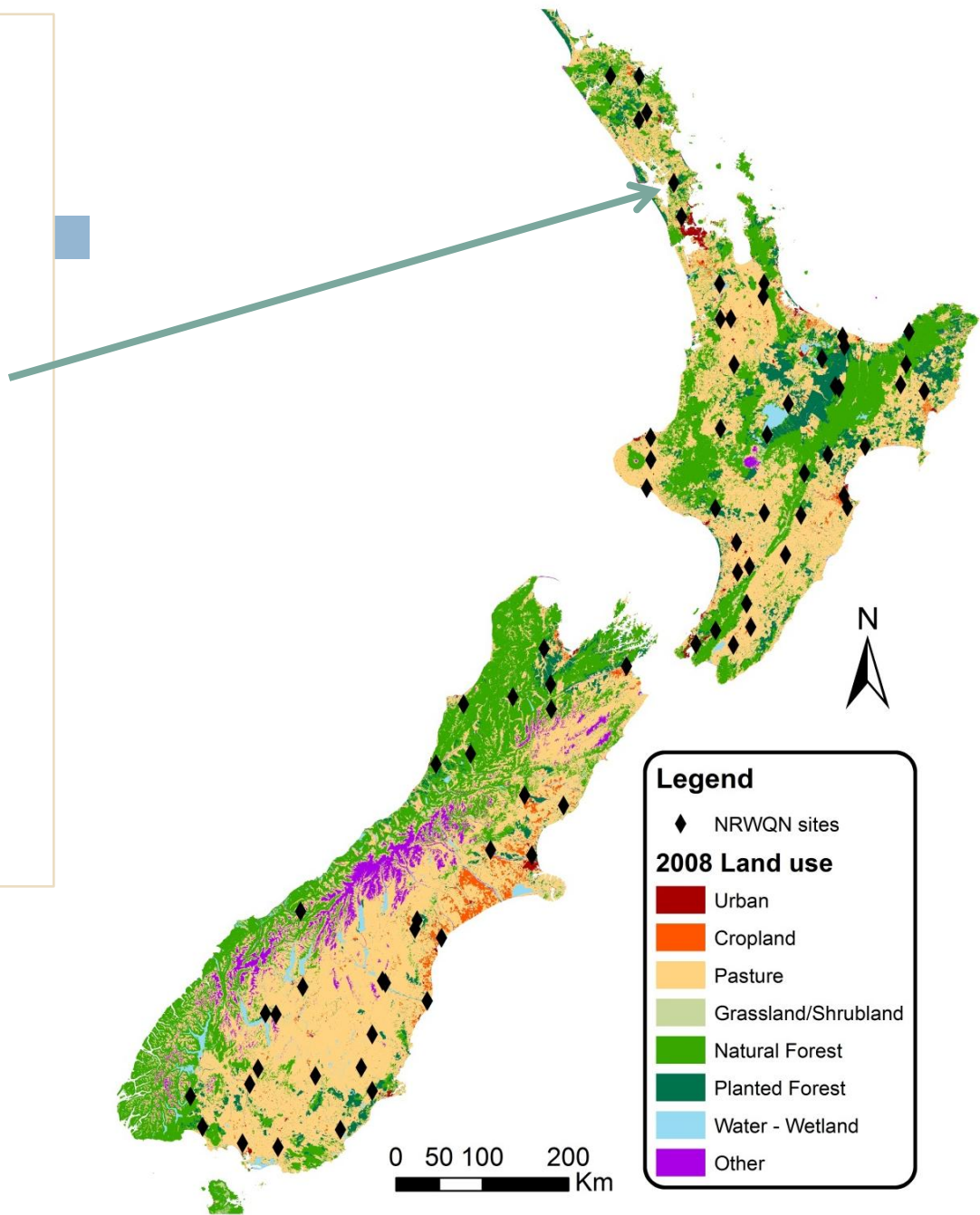
Disturbance and Recovery



- Disturbance time series for one MODIS pixel
- Recovery trajectory and disturbance pattern



Hoteo Catchment



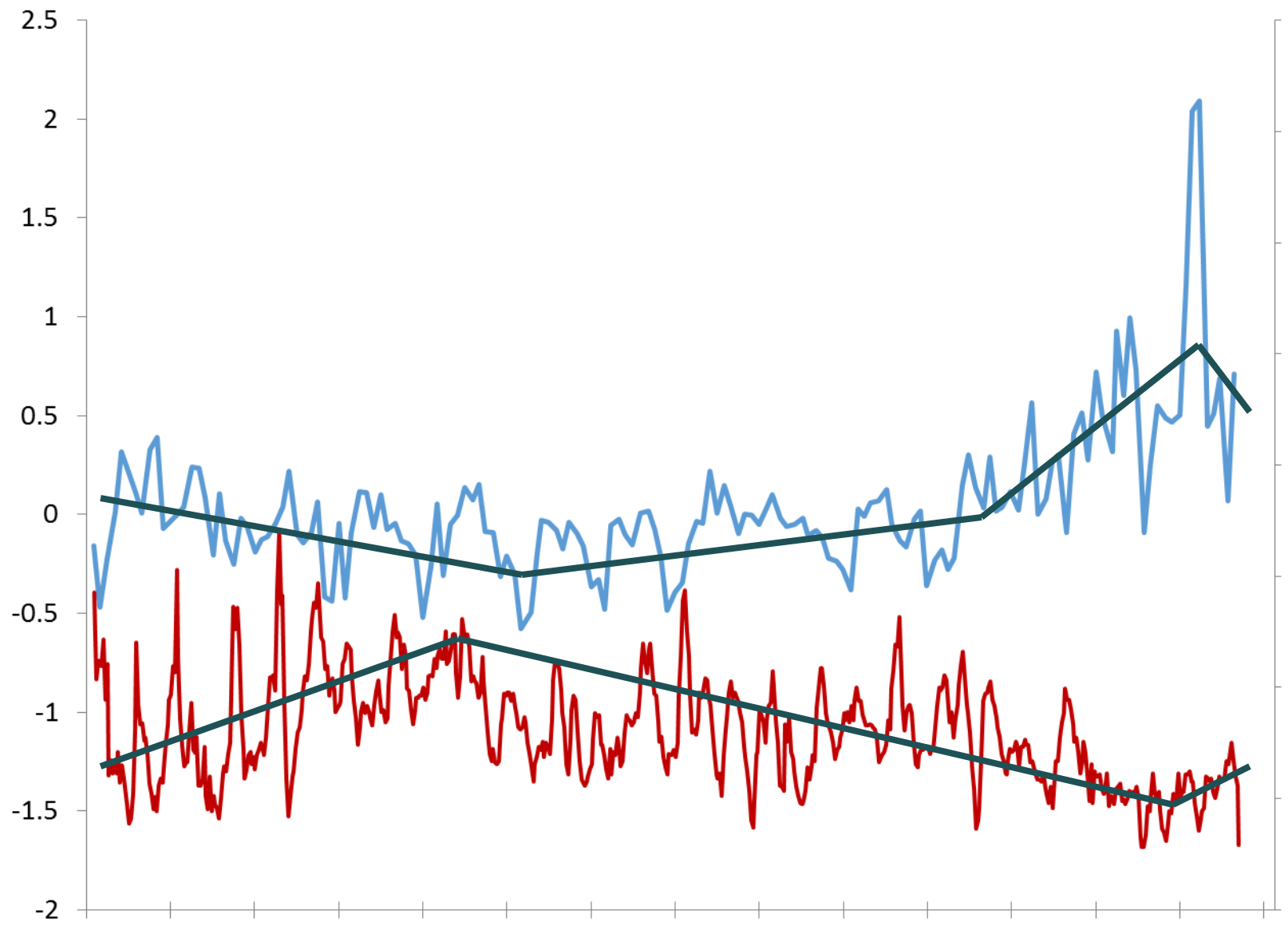
Legend

- ◆ NRWQN sites

2008 Land use

- Urban
- Cropland
- Pasture
- Grassland/Shrubland
- Natural Forest
- Planted Forest
- Water - Wetland
- Other

Flow-normalized horizontal water visibility (m)



Percentage of watershed disturbed

Acknowledgments

- Research supported through the NASA LCLUC program.
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- Software tools provided by Oak Ridge National Laboratory (Masek et al., 2013) and the MODIS land quality assessment group (Roy et al., 2002)

Website for more details and manuscripts:

<http://geography.ou.edu/lcluc>

