

Improving estimates of nutrient loads to the Chesapeake Bay through satellite imagery-based forest disturbance metrics



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Forest disturbance

Forests make up about **60%** of the land cover in the Chesapeake Bay watershed (CBW)

Disturbances, such as insect defoliation and forest harvests, influence nutrient retention and export (Eshleman *et al.* 1998, 2000, 2001; Swank *et al.* 1981; Lovett *et al.* 2002; Townsend *et al.* 2004; Likens *et al.* 1970, 1979; Vitousek and Reiners 1975; Beck and Hooper 1986; Martin *et al.* 1984; Lynch and Corbett 1991)

“Pulse” of nutrient export after disturbance events

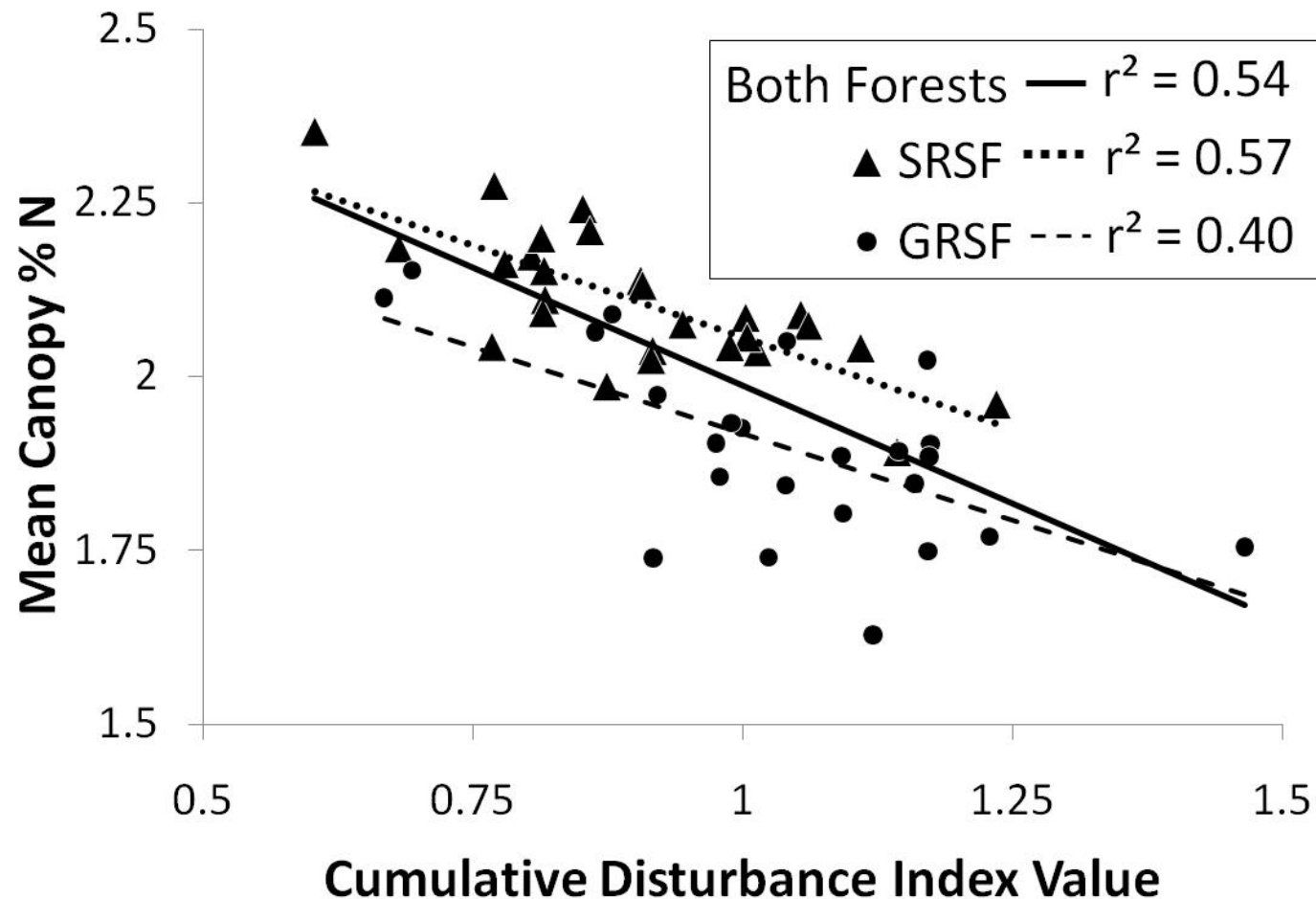
Disturbance effects may **accumulate** over time
(Deel *et al.* 2012)

Forest disturbance

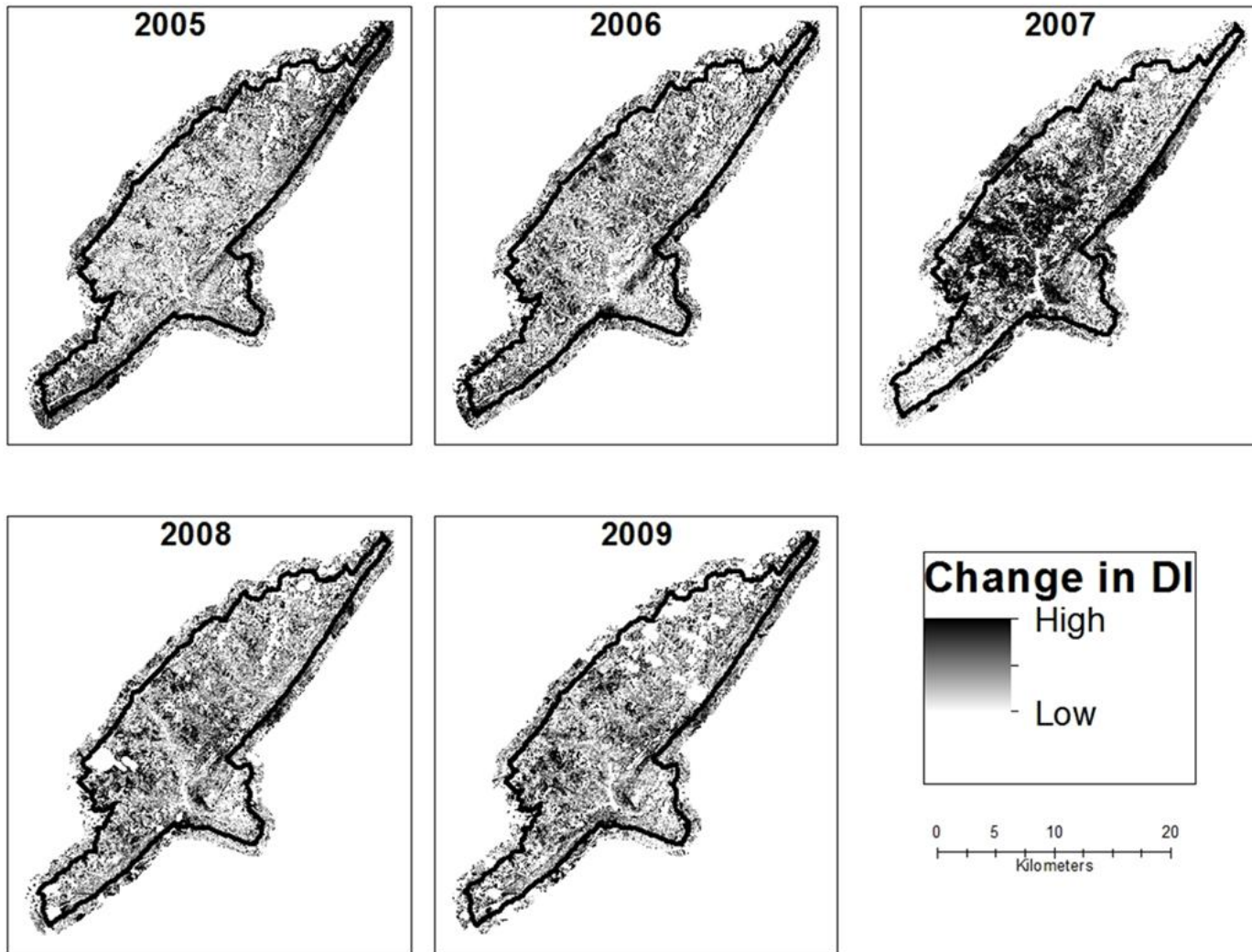
3 Hypotheses:

1. Reduced Canopy Cover (C)
2. Reduced Canopy Nitrogen (N)
 - Deel *et al.* 2012 RSE
3. Increased, but varied, response in stream water N export based on disturbance type and intensity
 - *In progress*

Disturbance and forest canopy



Complementary work



Complementary work

Stream water response to disturbance

Eshleman KN, McNeil BE, and Townsend PA. 2008. *Ecological Indicators*.

Relationship between change in disturbance and total dissolved N export

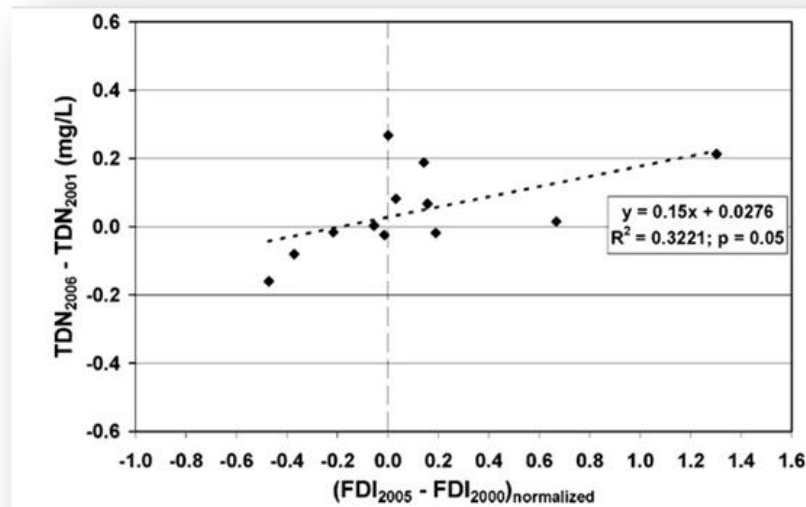


Fig. 6 – Linear relationship between Δ TDN from 2001 to 2006 and normalized Δ FDI from 2000 to 2005 for 12 independent sites with >90% forest cover.

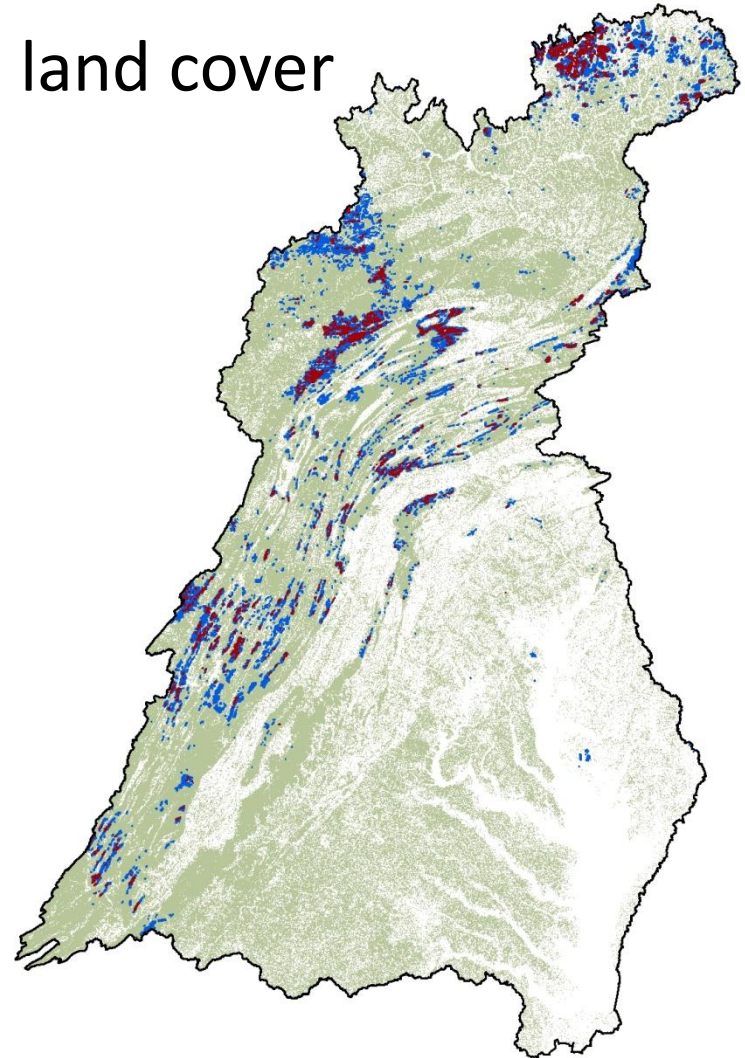
Disturbance in the CBW

Forests make up 60% of the land cover in the CBW

Gypsy moth defoliation

Blue = defoliated 2 out of the past 10 years

Red = defoliated 3 or more times in the past 10 years



Model assumptions

The Watershed Model

Forests, woodlots, and wooded land-use type

One percent harvested annually

Increased N loads for 3-5 years after harvest

Median of 3.1 lbs/ac-yr (moderated by N dep)

21.4 lbs/ac-yr from harvested

Contribution: *Spatially explicit* estimates of forest condition throughout the watershed and *statistical relationships* between forest condition and nutrient export

Satellite imagery

Satellite imagery has been successfully used to map forest disturbance (McNeil *et al.* 2007; de Beurs and Townsend 2008; Healey *et al.* 2005; Hais *et al.* 2009; Eshleman *et al.* 2009; Kennedy *et al.* 2007, 2010; Huang *et al.* 2010; Cohen *et al.* 2010)

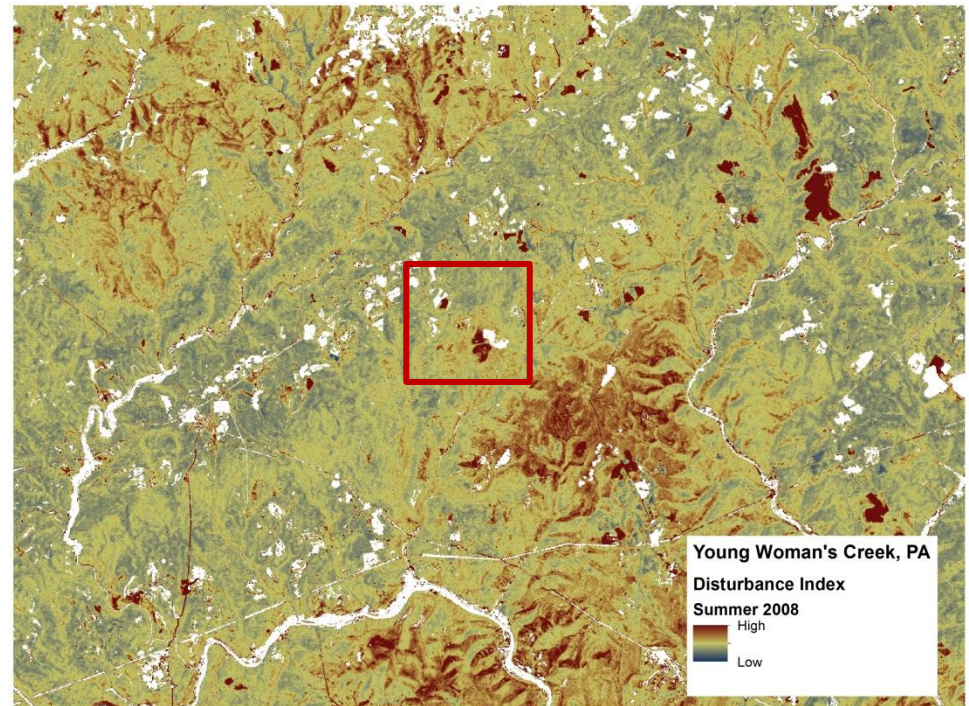
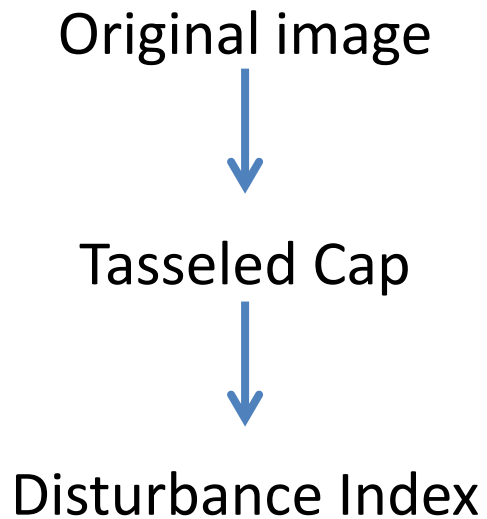
Moderate Resolution Imaging Spectroradiometer (MODIS)

- Images entire earth every 1-2 days
- 36 spectral bands (wavelengths)
- 500m resolution (for MOD09A1 – surface reflectance product)

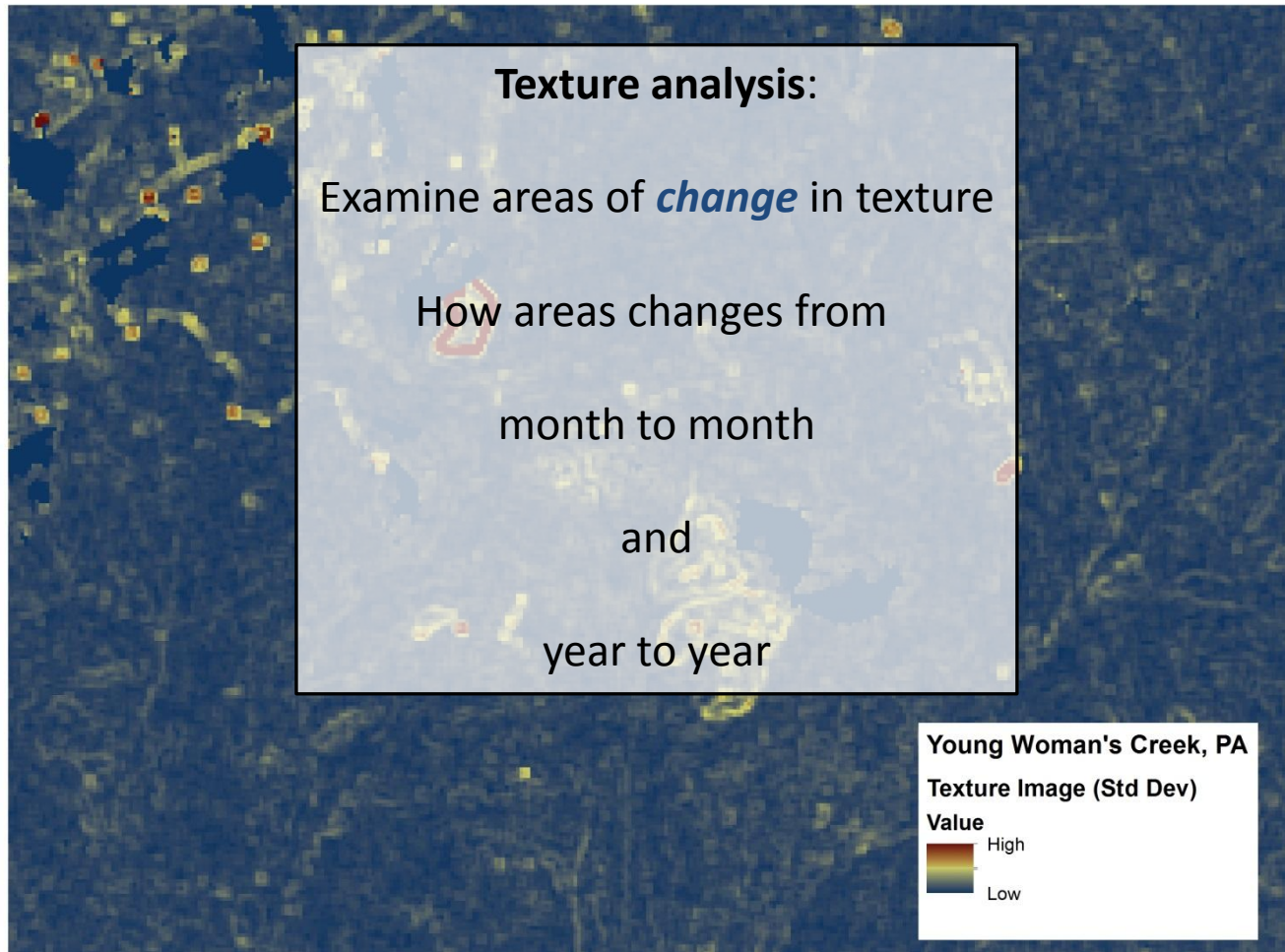
Landsat TM 5 and Landsat 8

- Images approximately every two weeks
- 7 spectral bands (wavelengths)
- 30m resolution

Data & Methods



Data & Methods



Data & Methods

Watershed-scale nutrient and sediment export data

- Functional linear concurrent models (FLCMs) – regression-based for time series data
- USGS Spatially Referenced Regression on Watershed Attributes (SPARROW)
- Angelica Gutierrez-Magness (NOAA)

Expected results

Disturbance type **classification** and **estimate** of total area disturbed

Statistical relationships between disturbance type and streamwater N export

Interpretation of the **variability** in streamwater N export attributable to different disturbance types

Potential implications

Model refinement

Direct and/or indirect policy implications

Greater insight into the regional nutrient dynamics of the CBW

Ultimately, improved health of the Bay due to more targeted management

Questions/Comments

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