



Distinguishing ephemeral from seasonally persistent forest disturbances using NDVI time series



William M. Christie¹, Steven P. Norman¹, William W. Hargrove¹, and Joseph Spruce² (¹USDA Forest Service, Southern Research Station, Asheville, NC; ²Self-represented)

INTRODUCTION: Efforts to quantify the relative importance of forest disturbances using remote sensing have been limited by our ability to efficiently and accurately recognize the *intensity* and *duration* of impacts. To date, far more attention has been afforded to mapping the intensity of immediate effects than how disturbances persist within a growing season or across years. These two indicators of disturbance severity—*intensity* and *duration*—are not necessarily correlated, as many forest species rapidly resprout or re-leaf after intense spring or early summer insect defoliation or abiotic damage. That is, equally intense disturbance effects can be *ephemeral* or *persistent*. Meanwhile, the implications of gradually unfolding disturbances that take several weeks or months to develop may not be captured by imagery from a single date, yet that is how disturbance intensity is generally mapped.

METHODS: We used the *ForWarn* forest change recognition and mapping system (forwarn.forestthreats.org) to provide a single 8-day period indication of disturbance intensity compared to a phenologically-comparable prior year baseline for three types of disturbances that have affected forests of the Eastern United States—an insect defoliation, a wildfire and a tornado. To estimate the persistence of these disturbances during the growing season, we summed the periods that fell below a 5% change threshold over six 8-day periods from June 25 – August 4. The single period map shows intensity as the degree of departure in NDVI (disturbance magnitude), while the persistence map distinguishes ephemeral from seasonally-persistent duration.

SUMMARY: This research advances two separate within-growing-season tools for characterizing disturbance effects—near-real-time monitoring of disturbance magnitude and within-season duration. In many natural systems, disturbances can have seemingly severe impacts, but these may be of minor consequence for the annual growing season overall when leaves regrow, shrubs rapidly resprout, or when disturbance occurs late in the growing season. When used in combination, maps of magnitude and duration help us document which localities experience ephemeral vs persistent disturbance and which have high and low magnitude effects. Both measures help us identify where impacts may be more likely of consequence. For applied end users who are interesting in mapping and summarizing disturbance, seasonal persistence products may expedite their work.

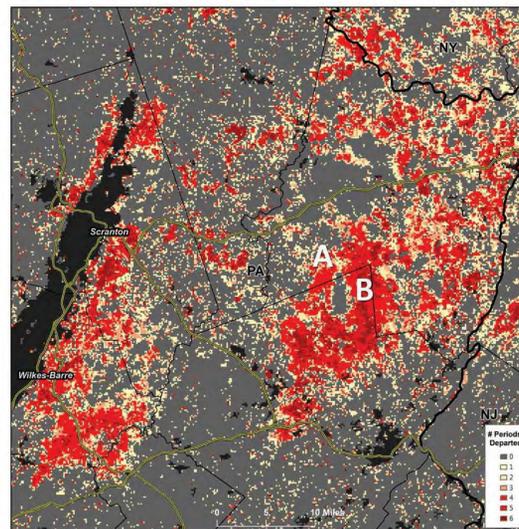
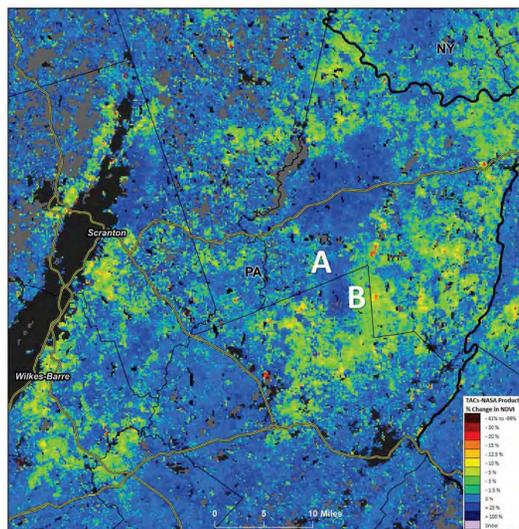
Disturbance Magnitude

Single-period NDVI departure from prior year for August 4

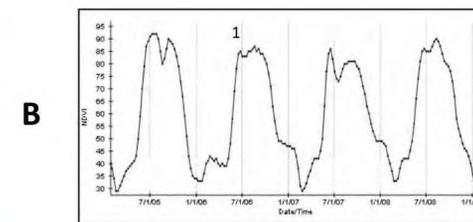
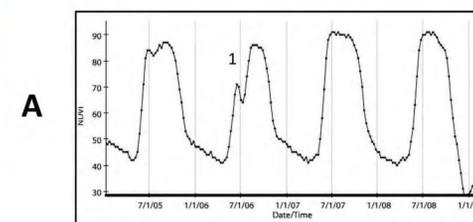
Disturbance Duration

Count of 6 periods from Jun. 25–Aug. 4 with $\geq 5\%$ NDVI departure from prior year

Gypsy Moth Defoliation 2006 PA-NY-NJ



Phenological Profile



Interpretation

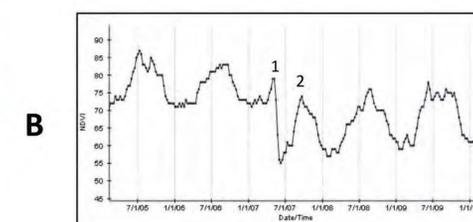
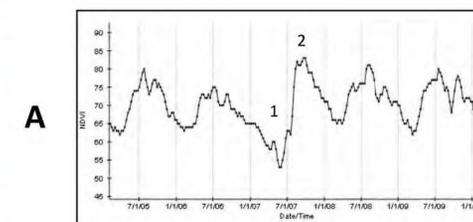
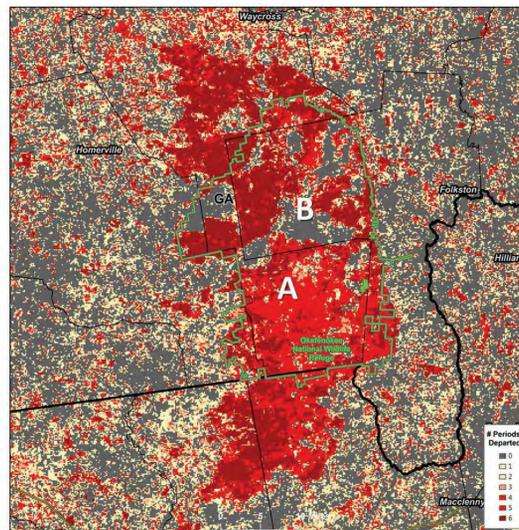
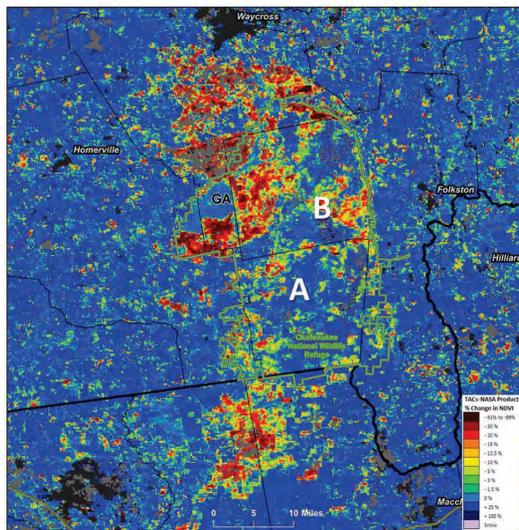
Ephemeral Disturbance

- (1) Defoliation begins to show at this site in late June, 2006, has a setback for three weeks, then spring greening returns. Note that the mid and late growing season resemble that of 2005.

Persistent Disturbance

- (1) While of lower magnitude than the site above, defoliation here lasts over the entire growing season of 2006. Note the subsequent, slightly more severe, but equally persistent defoliation in 2007.

Wildfire 2007 Okefenokee National Wildlife Refuge, GA



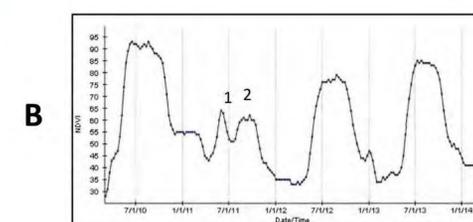
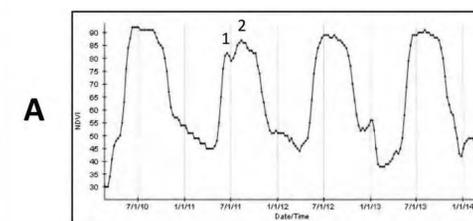
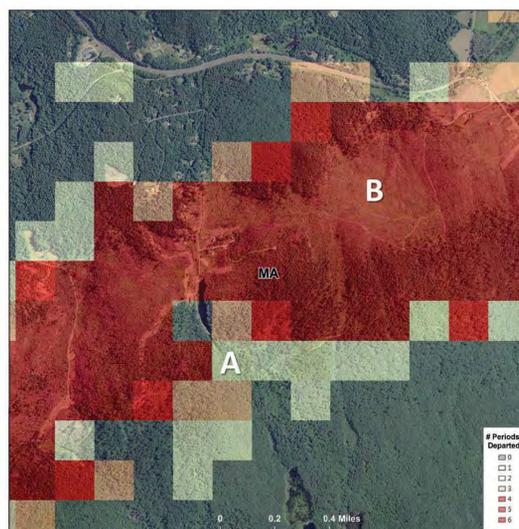
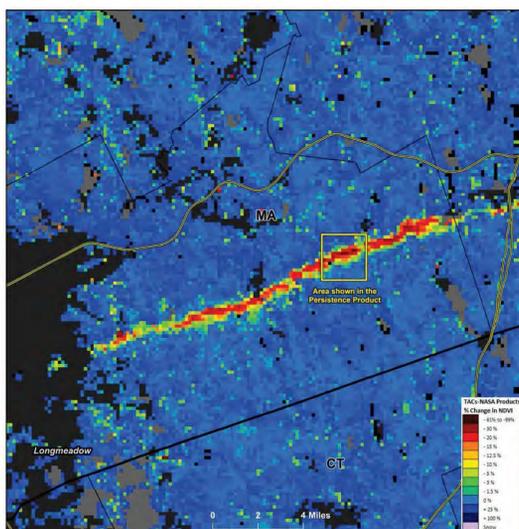
Ephemeral Disturbance

- (1) The fire occurred after months of drought—both lowered NDVI compared to 2006.
- (2) By July and August, NDVI values exceeded those of the prior year.

Persistent Disturbance

- (1) At this site, drought impacts are less obvious, but the fire response was most severe.
- (2) By mid summer, NDVI had not recovered, likely due to the severity of fire effects. Note that NDVI also remained below that of 2005 and 2006 through 2009.

Tornado 2011 Hampden Co., MA



Ephemeral Disturbance

- (1) Wind may have just stripped leaves off trees at the tornado's edge based on the minor immediate decline.
- (2) Slight persistence through the growing season suggests that some trees may also have fallen.

Persistent Disturbance

- (1) In the central devastation zone, magnitude was severe.
- (2) Decline was also persistent for the growing season. Note the gradual recovery in NDVI during subsequent years.