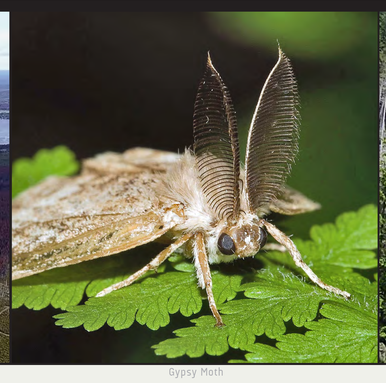
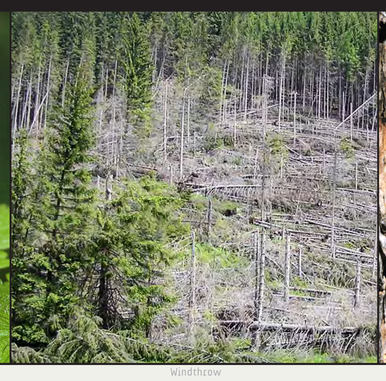
Forest Tent Caterpillar

Mountain Pine Beetle


Gypsy Moth


Windthrow

Pine Butterfly

Western Pine Beetle

Baldcypress Leafroller

Using MODIS Imagery to Track Changes in Forest Conditions

Robert Chastain, USDA Forest Service, Remote Sensing Applications Center, Salt Lake City, Utah

The objective of the Real-Time Forest Disturbance [RTFD] project is to provide timely information regarding changes in forest conditions to assist the digital aerial sketch-mapping community in flight mission planning.

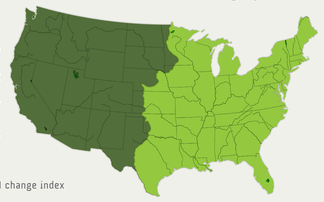
To this end, a digital change detection methodology has been developed and implemented over the conterminous 48 U.S. states [CONUS] in 2008, 2009, and 2010 to track forest disturbances in near real-time [updated every 8 days]. The RTFD approach uses MODIS satellite imagery, which provides daily observations to track developing disturbances that may also be ephemeral in nature. Also, the spectral grain of MODIS data permits the calculation of spectral indices, which the RTFD approach uses to characterize changes in forest condition. Baseline image data used in the RTFD method are produced using MODIS data composited from five years prior to the current growing season. In 2011, an additional 3-year baseline has been used in the change detection process. The RTFD approach has detected and tracked numerous defoliation events in the eastern deciduous biome, decline and mortality associated with beetle activity in the western coniferous biome, and forest damage associated with severe weather events.

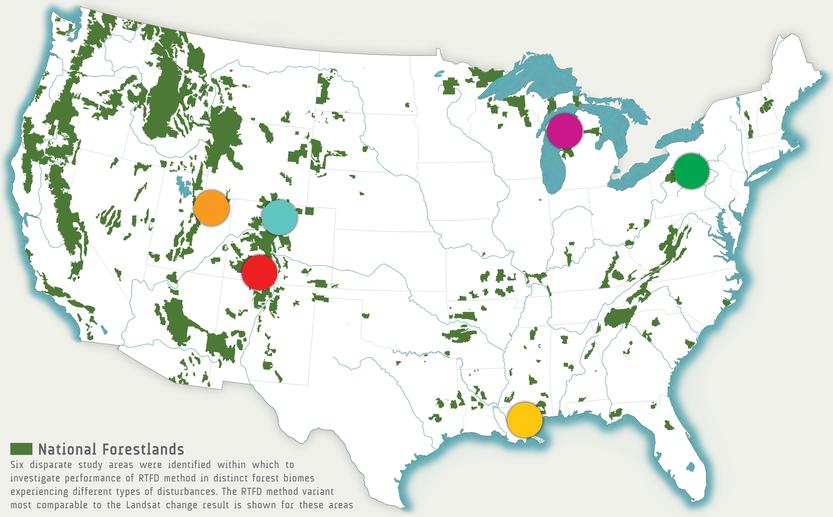
A quantitative retrospective assessment of 2010 RTFD results was performed to identify potential modifications to the analytical logic of the RTFD approach in order to improve detection efficiency. This assessment was performed within six study areas wherein forest disturbances occurred during 2010. Various methodological alterations were assessed within these study areas; principally, the use of different vegetation indices and alterations in baseline definition. Two-date Landsat change detection results acted as reference data to which RTFD results were compared. Differences in levels of agreement between various RTFD results and Landsat results were evaluated for significance using McNemar's test. The findings of this retrospective assessment indicate that a one-size-fits-all paradigm is not the most effective approach to identify and track forest changes across the CONUS. Specifically, two fundamental conclusions were drawn from this assessment:

1. **NDVI is a more effective change index for use in the eastern deciduous biome, with a baseline defined using per-pixel median values of NDVI from input imagery.**
2. **NDMI is a more useful change index in the western coniferous biome, with a baseline defined using per-pixel maximum values of NDVI from input imager**

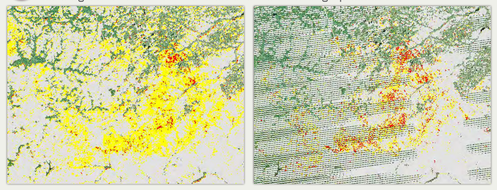
■ In the eastern study areas, using NDVI as a change index with a median baseline compared best with Landsat results in 60 percent of case studies. Agreement of RTFD and Landsat change results was significantly better than the initial result obtained in 2010 for all cases.

■ In the western study areas, the maximum baseline RTFD results compared most favorably to the Landsat change results in 80 percent of the cases, with NDMI providing the best comparison in four of those eight cases [significantly better twice]. Various alterations have been implemented in the RTFD approach for the 2011 growing season to incorporate these findings. Foremost is the use of NDVI to characterize forest changes in the deciduous forests of the eastern US, and the adoption of NDMI as change index in the primarily coniferous forests of the western US. The RTFD change products are generated separately within 14 USGS multizones, so these boundaries were applied to separate the CONUS into eastern and western biomes so that these disparate analytical approaches could be pursued separately before being merged into single CONUS-wide RTFD change products for the 2011 growing season.

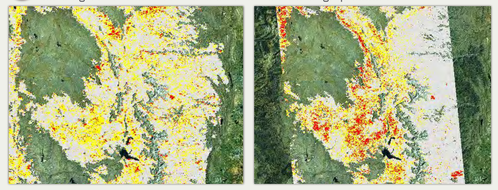




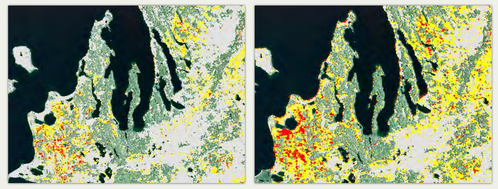
Path-row 16031: Forest Tent Caterpillar
56% agreement between Landsat and MODIS change products


MAY 25-JUN 09 NDVI median baseline — Landsat ETM+ MAY 2007-MAY 2010 NDVI

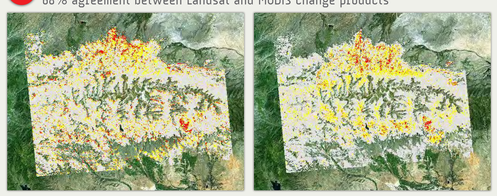
Path-row 34032: Chronic Mountain Pine Beetle Activity
58% agreement between Landsat and MODIS change products


AUG 29-SEP 13 NDVI maximum baseline — Landsat 2006-2010 NDMI difference

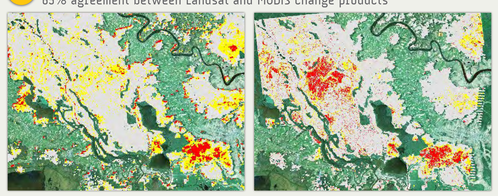
Path-row 22029: Forest Tent Caterpillar and Gypsy Moth
61% agreement between Landsat and MODIS change products


MAY 25-JUN 09 NDVI median baseline — Landsat TM JUN 2007 - MAY 2010 NDVI

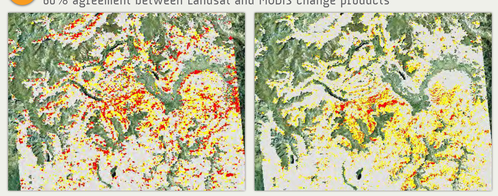
Path-row 34034: Chronic Western Bark Beetle Activity
68% agreement between Landsat and MODIS change products


AUG 29-SEP 13 max baseline NDMI — Landsat AUG 2004-AUG 2010 NDMI difference

Path-row 22039: Forest Tent Caterpillar and Baldcypress Leafroller
65% agreement between Landsat and MODIS change products


APR 15-30 NDMI median baseline — Classified Map from MAR 29, 2010 Landsat TM

Path-row 37032: Mountain Pine Beetle and Spruce Beetle
60% agreement between Landsat and MODIS change products


AUG 29-SEP 13 NDFI maximum baseline — Landsat AUG 2006-SEP 2010 NDMI difference

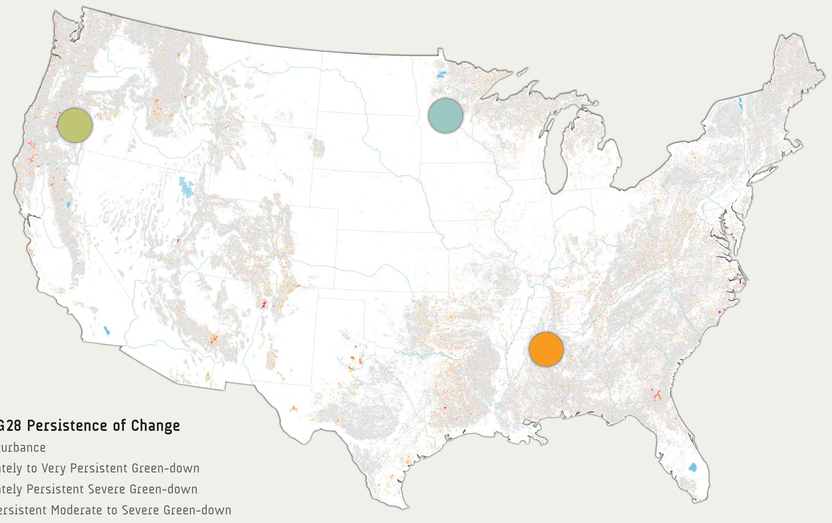
No Change — Moderate Change — Severe Change

Modifications in 2012 RTFD Analysis and Product

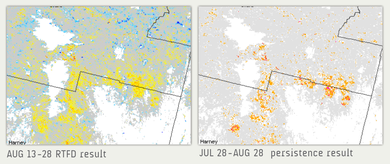
Persistence of Forest Change. The temporal persistence of apparent changes in forest conditions is used to generate a CONUS-wide persistence product, which is developed by combining the results of the last three 16-day compositing period RTFD change products. To eliminate noise from the individual compositing period change products which arise from persistent cloud cover and other MODIS data ephemera, a classification scheme was developed which combines the number of times a pixel was apparently disturbed in the last three compositing periods with different levels [standard deviations] of departure from expected RTFD values. To be flagged as disturbed in the disturbance persistence raster layer, a pixel must have a value at least one standard deviation lower than the expected value for at least two out of the last three compositing periods. Successively more disturbed pixels that have RTFD values more than two standard deviations lower than the expected value in two or all three compositing periods are displayed in hotter colors.

Class	JUL28-AUG12	AUG 05-20	AUG 13-28
1	1	1	1
2	1	2	2
3	2	1	2
4	2	2	1
5	2	2	2
6	3	2	2
7	2	3	2
8	2	2	3
9	3	3	1
10	3	1	3
11	1	3	3
12	3	3	2
13	3	2	3
14	2	3	3
15	3	3	3

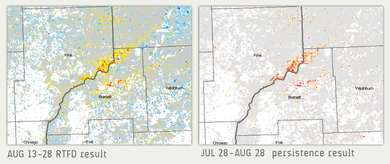
1 = > -1 Std Dev
2 = -1 Std Dev > x > -2 Std Dev
3 = < -2 Std Dev



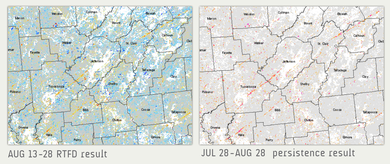
Oregon: Pine Butterfly Defoliation


AUG 13-28 RTFD result — JUL 28-AUG 28 persistence result

Minnesota/Wisconsin Border: Wind Damage


AUG 13-28 RTFD result — JUL 28-AUG 28 persistence result

Alabama: Lingering Tornado Damage, Spring 2011


AUG 13-28 RTFD result — JUL 28-AUG 28 persistence result

CONTACT:
Robert Chastain, rchastain@fs.fed.us 801-975-3761