



Land Surface Phenology

Importance

Remote sensing of vegetation condition and snow extent provides information essential to understanding and managing change at broad scales by describing important aspects of ecological and hydrological processes that have cascading effects on other natural resources. Spatial patterns of satellite-derived NDVI (Normalized Difference Vegetation Index), or “greenness,” and vegetation are indicative of long-term climate conditions to which vegetation on the Colorado Plateau has adapted. NDVI also responds to short-term changes in weather and cycles annually with seasons. Changes in precipitation and temperature may cause changes in the spatial distribution of vegetation over time, and changes in NDVI may imply a response to changing climate or changing land condition brought about by human activities or natural disturbance.

Long-term Monitoring

Land-condition monitoring uses MODIS (MODerate Resolution Imaging Spectroradiometer) satellite imagery to measure vegetation greenness and snow-cover extent. NDVI change is related to productivity, based on information derived from the Terra satellite, which images the entire surface of Earth every day at 250-m resolution. NDVI is used to estimate the start and end of the growing season, the time of peak production, and seasonal productivity. Comparison of these attributes among years can indicate substantive changes in the extent of vegetation conditions, changes in the duration of the growing season, impacts due to drought, or large-scale natural or human-caused disturbances. In grassland systems, the shape of the NDVI curve can also indicate the relative extent of exotics (e.g., cheatgrass), because their phenology (timing of significant growth stages) tends to differ from that of native vegetation.

The NCPN and U.S. Geological Survey have developed remote-sensing methods to improve understanding of how broad-scale vegetation condition responds to short-term weather patterns, long-term climate trends, land use, and geographic position. The objective of this protocol is to determine status and trends in snow cover, vegetation condition, and phenology for Northern Colorado Plateau Network (NCPN) parks and adjacent lands. Additionally, the network will explore the reasons behind anomalous departures from previous NDVI trends with information from other vital signs monitoring.



NPS/BRUCE FIELDS

The NCPN is using MODIS satellite imagery to track and compare postfire changes in greenness at Bryce Canyon National Park.

Status and Trends

Work related to this protocol continues to integrate results from monitoring of climate and other processes with phenology monitoring. To date, the scale of NCPN phenology monitoring has ranged—by design—from the park scale, evaluated in our 2011 status and trends report, to more focused analysis of areas of particular management interest. Page 2 of this brief focuses on vegetation condition following two fires that burned at different intensities in Bryce Canyon National Park. The phenology protocol is undergoing peer review.

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Land surface phenology is monitored in all NCPN park units:

Arches NP, Black Canyon of the Gunnison NP, Bryce Canyon NP, Canyonlands NP, Capitol Reef NP, Cedar Breaks NM, Colorado NM, Curecanti NRA, Dinosaur NM, Fossil Butte NM, Golden Spike NHS, Hovenweep NM, Natural Bridges NM, Pipe Spring NM, Timpanogos Cave NM, and Zion NP

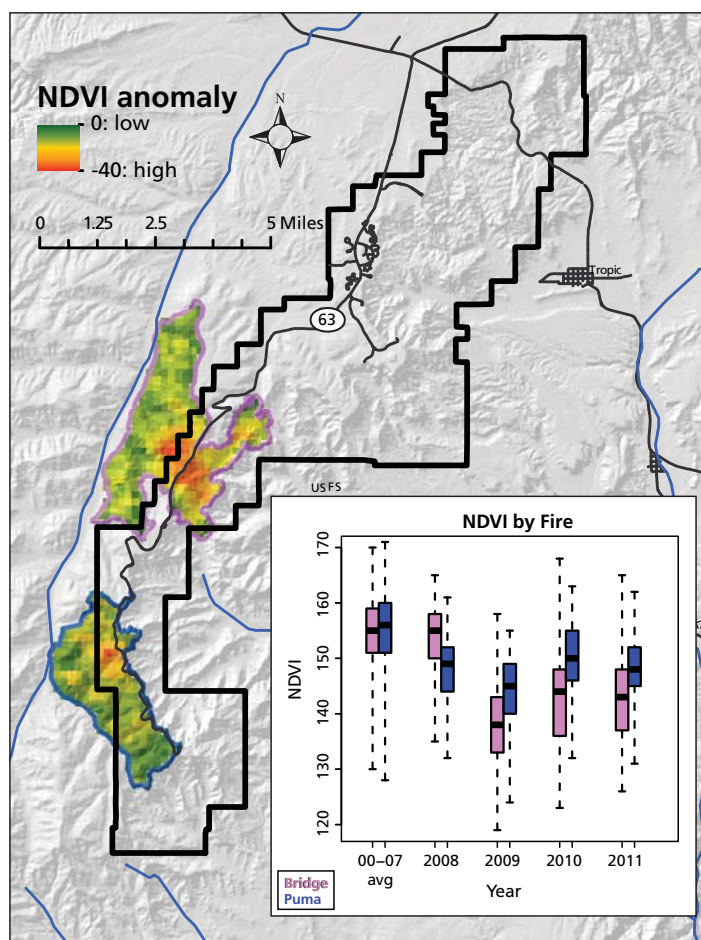
NP = National Park; NM = National Monument;
NRA = National Recreation Area; NHS = National Historic Site

MODIS Imagery Shows Patterns of Postfire Greenness and Interannual Change

In fire-adapted ecosystems, fire is crucial for sustaining ecosystem succession and function. Using MODIS imagery to track postfire patterns in vegetation greenness and how it changes over time can help managers to interpret important ecosystem processes, such as soil erosion and vegetation succession—information that can be used when developing vegetation management plans. A focus on “greenness,” as opposed to “blackness,” coupled with a high temporal frequency of observations, captures the dynamic nature of vegetation response to burn conditions and postfire weather patterns that affect recovery.

At Bryce Canyon National Park, the NCPN is using MODIS satellite imagery to monitor the vegetation response over time to the two largest fires in the park’s recorded history, each with a highly different burn pattern. In 2008, park fire managers, in cooperation with the adjacent Dixie National Forest, used the Puma prescribed fire to burn over 2,000 acres in order to reduce hazardous fuels and promote regeneration of ponderosa pine, quaking aspen, and other fire-adapted native species. On June 14, 2009, lightning ignited the Bridge fire in the Dixie National Forest. The Bridge fire burned at low intensity for a month but then began a run across the plateau, jumping the rim before being extinguished in Bryce Canyon on July 19. It continued to burn on the Dixie National Forest until August 27.

The different fuel loads and weather conditions that affected the extent and severity of each burn may affect regeneration and vegetation succession. To track those changes, the NCPN is using MODIS imagery that measures forest greenness every 16 days. The high frequency of image data allows us to track vegetation change annually, as well as inter-annually.



Dramatic differences in burn severity are apparent in this satellite-derived vegetation greenness anomaly map from October 2009, which depicts the difference between greenness in that post-burn year and average greenness before the burns. The inset box plots show the early October greenness range within each burn unit as an indication of vegetation recovery over time. Center line=50th percentile, top and bottom of the boxes=25th and 75th percentiles, end of whiskers=minimum and maximum range.

A timeseries of 276 satellite images taken from 2000 through 2011 was analyzed to determine both the average and the range of vegetation greenness conditions before and after the burns. An early October time period was chosen as the basis for comparison among years to coincide with the end of monsoon-season growth (see map).

According to Landsat-derived data from the U.S. Forest Service and U.S. Geological Survey, more of the Bridge fire area was classified as high burn severity (23%) than the Puma fire area (4%). MODIS analysis shows that the median greenness of the units prior to the burns was similar. After the burns, the median greenness of the Bridge fire area was below the median greenness of the Puma fire area in 2010 and 2011, but appears to be catching up as vegetation recovery takes place (see inset).

MODIS analysis also shows that before the fires, the range in greenness was greater in the Puma unit than the Bridge unit, because the Puma unit had greater diversity in vegetation assemblage. Since the fires, however, the reverse has been true, because the range of burn severity was greater in the Bridge unit, which burned at both low and high intensities, than the Puma unit, which was a low-intensity, controlled burn. Continued monitoring will reveal how these patterns evolve.