



2010

Land Condition Monitoring

Importance

Information on landscape-scale plant vigor and productivity (land condition) is key to understanding natural and human-caused ecosystem changes. Parks on the Colorado Plateau are embedded in larger landscapes where land condition is influenced by climate, grazing, fire, and exotic-plant invasions. Adjacent land-use activities, such as housing development, livestock grazing, recreational off-road travel, and agricultural production, can impact park systems indirectly by increasing the contrasts along the park-non-park interface, and directly by increasing wind and water erosion of soil along park boundaries. Climate change is another likely influence that interacts with and drives some of these factors. Understanding broad-scale changes in land condition will help park managers to make better-informed management and mitigation decisions in a context of complex change.

Long-term Monitoring

Land condition monitoring uses MODIS (MODerate Resolution Imaging Spectroradiometer) satellite imagery to measure vegetation productivity and snow-cover extent. The Normalized Difference Vegetation Index (NDVI) is a measure of vegetation greenness, or productivity, derived from the Terra satellite, which images the entire surface of Earth every day at 250-m resolution. NDVI is calculated 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), due to phenology that differs 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 and the seasonally integrated NDVI 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.

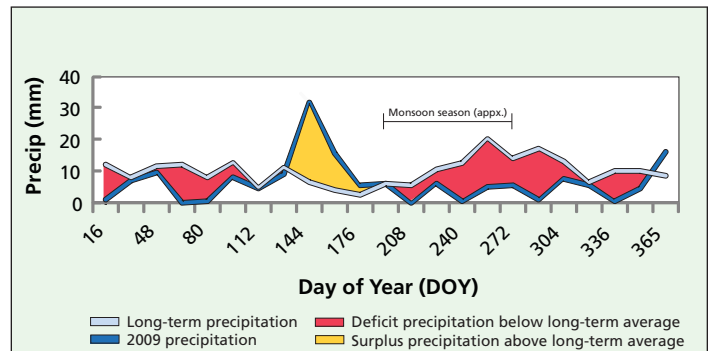


Figure 1. Precipitation (long-term and 2009) summed on 16-day time-steps, commensurate with 16-day NDVI (see Figure 2), Hovenweep NM.

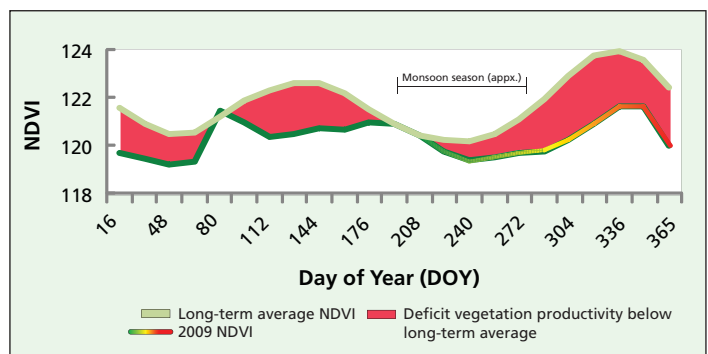


Figure 2. Average NDVI determined on 16-day time-steps, Hovenweep NM, 2000–2010.

Status and Trends

Although there is no strong multi-year trend in precipitation across NCPN parks (see the network's brief on climate monitoring), monsoon precipitation in 2009 was lower than normal for most parks in southern Utah, including Hovenweep NM (Figure 1), which had the lowest vegetation productivity in 10 years for the same period (Figure 2).

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Network park units where land condition is monitored

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

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

Relationships between Precipitation, NDVI, and Spring Flow at Hovenweep NM in 2009

Background

The 10-year record of NDVI, averaged across all units of Hovenweep NM (Figure 3), shows that in most years there are two peaks in vegetation greenness: one in spring, related to cumulative soil-moisture recharge from the previous fall, winter, and early spring; and another in late summer, stimulated by monsoon weather patterns. NDVI peaks, and their timing, result from the interaction of plant functional types (annual/perennial, early season/late season), phenology, substrate, and suitability of moisture and temperature for growth. Below-normal fall, winter, and spring precipitation resulted in poor vegetation condition in spring 2002 and 2006, whereas below-normal monsoon precipitation seems to explain poor vegetation condition in late summer 2009.

What Happened in 2009?

A closer look at NDVI and precipitation indicates how different 2009 was from previous years. In 2009, there were more periods of below-normal than above-normal precipitation relative to the historical mean, most noticeably during the monsoon season (see Figure 1). The magnitude and duration of the corresponding impact to vegetation can be seen in the NDVI deficit, as NDVI was well below the historical average during the monsoon season (see Figure 2). In 2009, monsoon precipitation (DOY 208–288), which sustains plant growth for the remainder of the year, was 62.4 mm (or 77%) below the historical average for the same period. Post-monsoon NDVI was 19.8 (8.1%) below the historical average.

The timing of precipitation is important for plant growth. For instance, although 32 mm (1.3 in) of precipitation fell near DOY 144 (May 22–May 31; Figure 3), this moisture likely occurred too late to effect a response in early-season plants (at that time, early season species were already mature), but was too early or insufficient to stimulate abundant late-season growth without additional monsoon precipitation, as indicated by a below-normal late-season NDVI. The weak monsoon in 2009 corresponded with dramatically low late-season productivity and the lowest spring flow and pool elevations observed since measurements began in 2004 (Figure 4).

Tying it All Together

The time series of precipitation and NDVI paint a clear picture of the importance of precipitation abundance and timing for plant growth and, apparently, spring flows at Hovenweep NM that was previously not well understood. Initially, the dramatic NDVI deficit prompted a closer look at precipitation data, which in turn showed a shortfall in 2009. When these data were examined in conjunction with pool-elevation data collected by

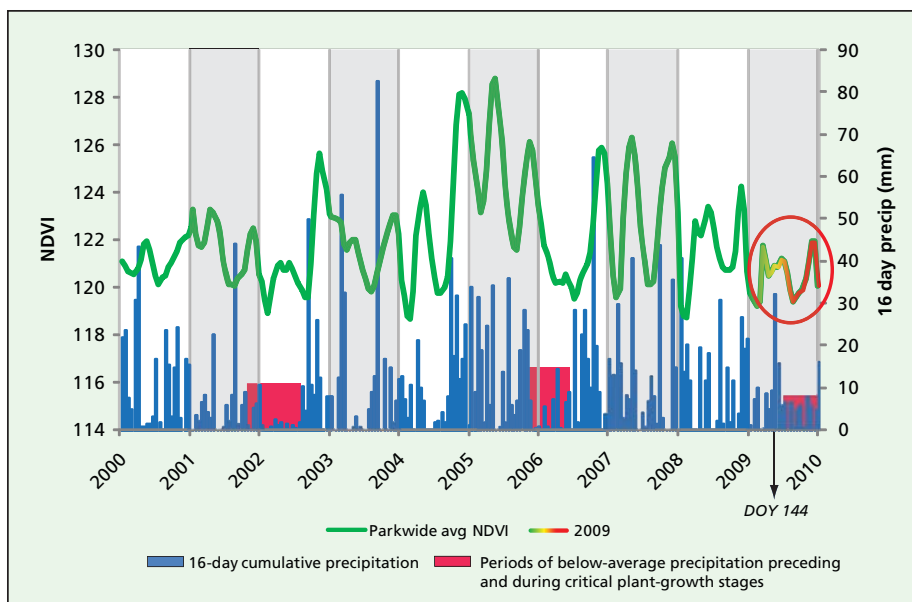


Figure 3. The 10-year record of Normalized Difference Vegetation Index for Hovenweep NM, with the anomalous year 2009 circled. Late-season productivity (yellow/red line) was the lowest in 10 years at the park, corresponding with the lowest spring pool levels since 2005. This may indicate a short-term link between precipitation timing and groundwater recharge.

Southeast Utah Group staff, it soon became clear that at least some springs and pools respond to short-term fluctuations in precipitation.

Having the ability to quantitatively monitor vegetation response to abundance and timing of precipitation over large areas will improve our overall understanding of biophysical relationships in NCPN parks. At Hovenweep NM, knowing that recharge rates for some springs and pools is fairly brief can aid interpretation of spring and seep monitoring results, as monitoring of plant growth and spring flows continues under a changing climate. This information could also improve understanding of the fate of the monument's ancient architects.

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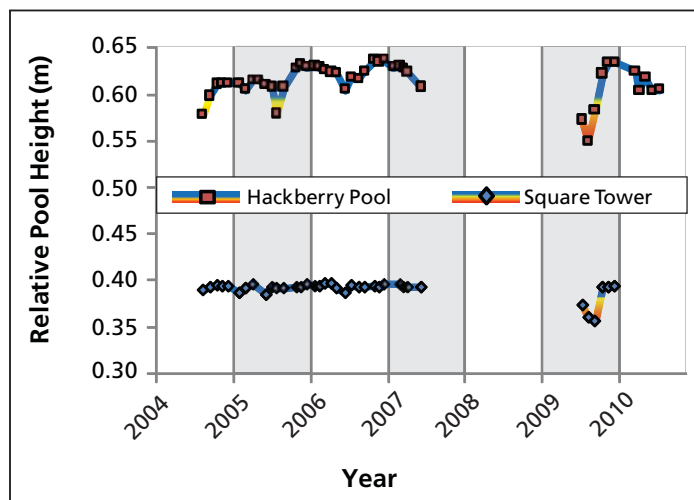


Figure 4. Square Tower and Hackberry Spring pool stage. July, August, and September 2009 had the lowest pool stages recorded since monitoring began in 2004, corresponding with lower than normal precipitation and vegetation growth for the same period.