

Northern Colorado Plateau Network

Monitoring Brief

National Park Service
U.S. Department of the Interior

Intermountain Region
Inventory & Monitoring Program



Land Condition Monitoring

2011

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.

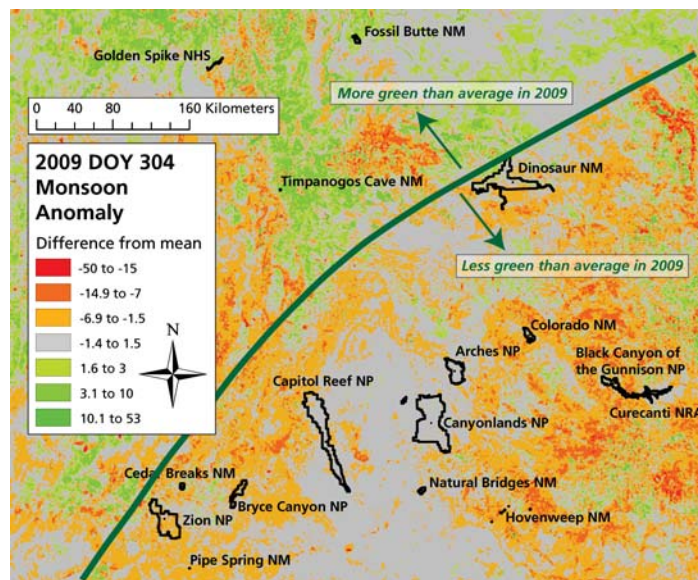
Long-term Monitoring

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.

Status and Trends

Released in 2011, the first report on NCPN land-condition monitoring analyzed MODIS snow-cover extent and NDVI image products from 2000 through 2009 for all 16 NCPN park units (see next page). Relationships between precipita-



Monsoon anomaly in 2009, mapped as 2009 NDVI minus historical average on DOY 304 (October 31). Darker green indicates higher greenness on this day in 2009 than in previous years. Orange and red indicate lower greenness than on this day than in previous years. October 31 was chosen to represent vegetation response to the monsoon precipitation season, which is an important determinant of growth for most NCPN parks. Monsoon-season rainfall in 2009 was below average at most parks south of the green arc.

tion abundance and timing, as well as temperature, with NDVI were apparent for most parks where NDVI response mirrored, but lagged precipitation by 2–4 weeks, depending on season. The importance of winter soil-moisture recharge was made apparent by below-normal NDVI in years of lower-than-normal winter precipitation. There were clear spatial trends in the 2009 monsoon NDVI anomaly (see map), likely because monsoon storms tracked a more northerly direction than in previous years (anomaly mapping compares pixel value at a point in time against the long-term average of that pixel's value). Trends in NDVI and snow cover at the park scale were inconsistent, which is not unexpected for a short, 10-year record across disparate parts of the Colorado Plateau landscape—even if significant change may have occurred.

Land condition 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

Results from 10 Years of Remote Sensing Data: General Conclusions and Management Applications

The first report (Thoma 2011) to evaluate vegetation condition using MODIS satellite products for national parks on the Northern Colorado Plateau combined measures of vegetation condition with snow extent and weather-station data for 2000–2009. Most of the insights and relationships illuminated through this analysis were expected, but they can now be quantified for use in management applications that require an understanding of processes at broad spatial and temporal scales. At this stage, several conclusions can be drawn that suggest potential management applications:

- 1) Quantitative estimates of vegetation condition that provide a means to compare condition and trend over short and long time frames can be made annually and on 16-day intervals.
- 2) Even distribution of precipitation through time is a more important determinant of productivity than cumulative annual precipitation.
- 3) Winter soil-moisture recharge *and* spring precipitation are required for abundant spring growth in lower-elevation parks.
- 4) There may be a direct relationship between snow extent and start of season at higher elevations.
- 5) Because smaller analysis scales dramatically increase variability of NDVI signal in low-productivity environments (to the point where it can cease to be meaningful), regional perspectives may provide more information that is relevant to park managers and not obtainable by other means.
- 6) Anomaly mapping is an effective tool for determining extent and severity of fire and subsequent recovery processes and may be sensitive enough to monitor other kinds of disturbance, such as beetle kill in pine forests, noxious weed invasions, and tamarisk defoliation in riparian areas.
- 7) Seasonality is generally bi-modal at lower elevations and latitudes and uni-modal at higher elevations and latitudes on the Colorado Plateau. Some parks may have areas that are both bi-modal and uni-modal.

Because a time-series longer than the 10-year MODIS record would be necessary to characterize trends in cycles with in-

terannual variability, few statistically significant trends were apparent in the phenology and snowmelt data for the years covered in the recent NCPN report. As such, the trends identified in the report should be viewed more as a demonstration of capability that may be more definitive in the future, with a longer record of observation. However, the potential utility of these analyses is great, exciting, and diverse. For instance:

- 1) After the relationships between precipitation timing, temperature, and vegetation response are refined, these relationships may be used in scenario planning for climate change.
- 2) Spatial and temporal patterns of vegetation condition can be determined for areas of interest as defined by management questions.
- 3) Animal population distributions may be evaluated spatially and temporally with vegetation condition to answer a variety of questions, including whether productive vegetation years correlate with productive years for species of interest.
- 4) Fire severity and recovery may be evaluated by examining time-series NDVI for burned areas.
- 5) NDVI may be correlated with biomass for fire management planning purposes.
- 6) The broad scale and high frequency of observations can provide insight to beetle-kill timing, expansion, and severity; broad-scale tracking of exotic-weed dispersal based on phenology; and potential effects of grazing on vegetation condition.
- 7) Watershed-scale vegetation condition may be correlated with stream and spring hydrology.
- 8) Relationships between snowmelt, weather, and dust may be determined at regional scales using gridded climate data and air quality station data.
- 9) Changes in phenology metrics may be tracked and used to interpret upland vital signs results as monitoring continues.

For more information, see <http://science.nature.nps.gov/im/units/ncpn/LandConditionBrief.cfm> and/or

Thoma, D. P. 2011. Remote sensing of vegetation phenology and snow-cover extent in Northern Colorado Plateau Network parks: Status and trends 2010. Natural Resource Technical Report NPS/NCPN/NRTR—2011/455. National Park Service, Fort Collins, Colorado.

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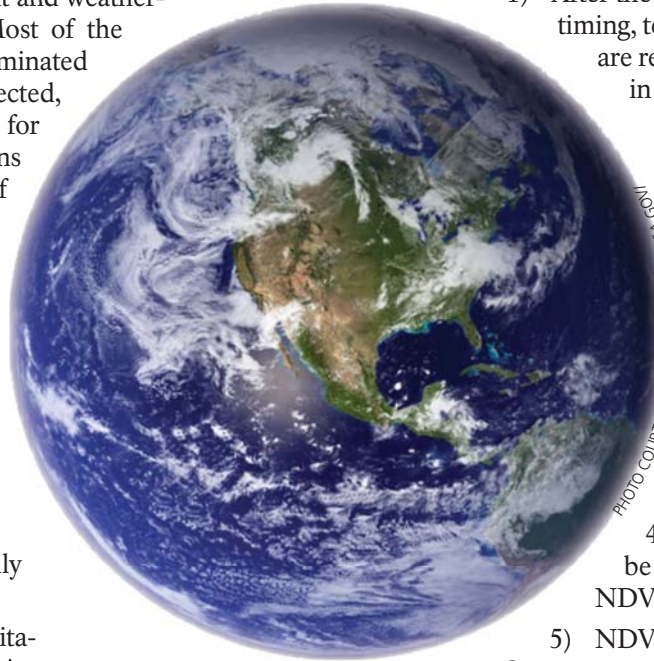


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