



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., cheat-grass), 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/SARAH TOPP

Pretty buckwheat (*Eriogonum bicolor*).

Status and Trends

This protocol continues to integrate results from monitoring of climate and other vital signs. 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 analyses of areas of particular management interest, such as vegetation condition following two fires that burned at different intensities in Bryce Canyon National Park (see 2012 brief). In this brief, we discuss how the NCPN is using climate data to help understand differences in vegetation condition in NCPN parks over a decade that included large variations in weather, with emphasis on the differing roles of precipitation and evapotranspiration in assessing NDVI. The protocol is undergoing formal peer review.

Contact

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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

Evapotranspiration, Precipitation, and NDVI

From the sandy desert of Arches National Park to the grassland of Fossil Butte and the alpine of Cedar Breaks, broad differences in elevation and climate contribute to a remarkably diverse range of vegetation productivity and ecological diversity across the 16 NCPN parks. The biological engine of all these parks—photosynthesis—is fueled by water and sunshine. Although years with heavier precipitation are often assumed to be associated with seasons of more productive growth, it's the variation in the magnitude and timing of available water, and the temperatures suitable for growth, that strongly influences vegetation geography and condition from year to year. Evapotranspiration (ET) is the movement of water from soil through plants to the atmosphere during photosynthesis—a process that supplies nutrients to plants, enabling growth.

The NCPN is currently testing a mathematical model of ET to see if it can provide insight to interactions between climate and vegetation. The NCPN model of ET allows a “look under the hood” at the biological engine. Such models help us to better understand the complex interactions between temperature, precipitation, and vegetation condition that change spatially, seasonally, and annually.

For instance, at Cedar Breaks NM, much of the annual precipitation falls as snow that cannot be used by plants until snowmelt recharges soil moisture and temperatures become warm enough for growth. For this reason, we expect the relationship between ET and plant growth,

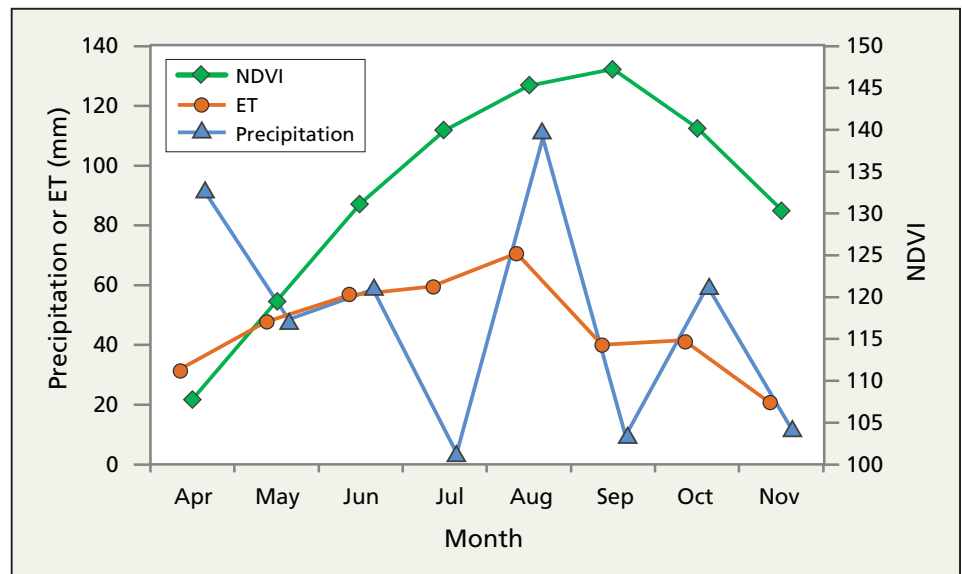


Figure 1. Seasonality of precipitation, evapotranspiration, and NDVI at Cedar Breaks NM, 2005. The more similar curves of NDVI and ET demonstrate a stronger relationship between those factors than between NDVI and precipitation, which tends to be more erratic.

as measured by NDVI, to be stronger than the relationship between NDVI and precipitation, which is strongly seasonal and at times erratic in NCPN parks. The stronger relationship between ET and NDVI was apparent in 2005, when much of the annual precipitation fell in late winter and spring but was not transpired (according to the model) by plants until temperatures warmed suitably for plant growth (Figure 1).

Although the strength of the ET/NDVI relationship varies at park and sub-park scales, their relationship is stronger at broad scales and over long periods of time than the relationship between NDVI and precipitation. In 2000–2009, the relationship between ET and NDVI

was more linear and stronger across most NCPN parks than the relationship between annual precipitation and NDVI (Figure 2).

It is hoped that refinements to the ET approach can help park managers make better use of climate data to assess ecological condition and function because it relates fuel consumption (sunshine and water) to the performance measure (NDVI) of productivity. Ecosystems have inherent productivity limits, depending on climate and soil attributes, so tracking their performance over time provides a means of assessing ecosystem health that can alert managers to signs of stress or the possibility of change into undesirable conditions.

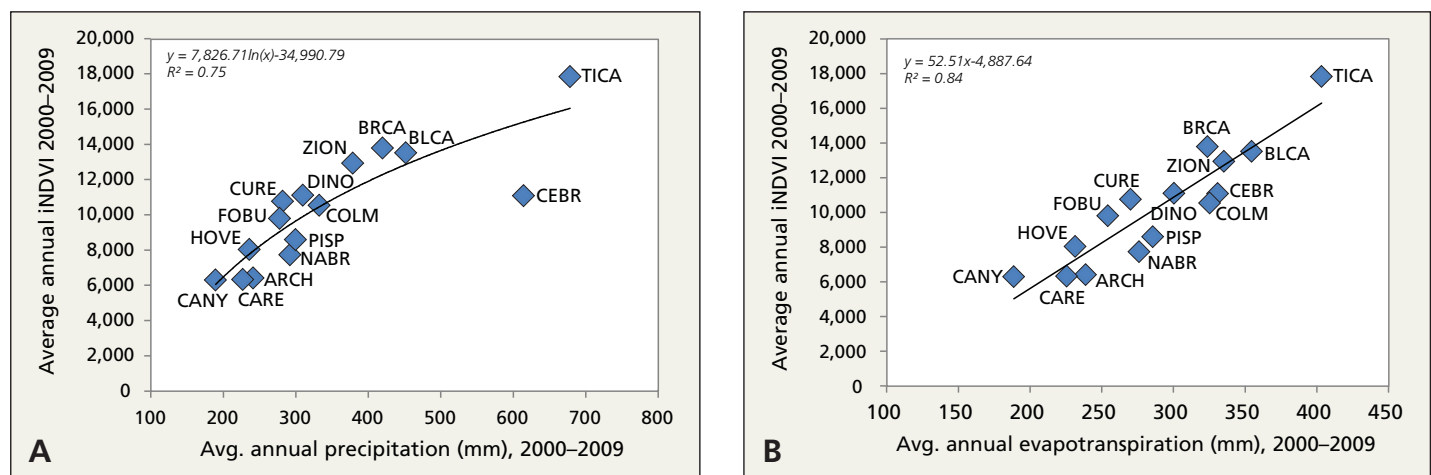


Figure 2. Decadal average integrated NDVI at park scale versus (A) average annual precipitation and (B) average annual evapotranspiration. This demonstrates a stronger relationship between NDVI and ET than between NDVI and precipitation across the broad environmental gradient of NCPN parks.