

## Introduction

Range conditions can be assessed weekly from your desktop PC using *PhenoMap*, the phenology monitoring web browser application developed by the Western Wildland Environmental Threat Assessment Center (WWETAC). Phenology is the study of recurring biological events such as emergence, elongation, and flowering of grassland plants. *PhenoMap* is a web map built with ESRI ArcGIS On-Line software and it is free and open to all users. No additional software (other than a web browser) is required.

## What can you view in *PhenoMap*?

### NDVI - 'Greenness'

Using remotely sensed data, we can assess vegetation "greenness" using the Normalized Differential Vegetation Index (NDVI) as a proxy for the collective phenology in a ~15 acre pixel. In addition to NDVI, *PhenoMap* also contains information on how the current NDVI value of a pixel compares to its historical (2000-2015) and maximum NDVI. Every Friday, the NDVI values are updated and published online. The current week along with the previous three weeks are displayed in the *PhenoMap* web map (fig. 1).

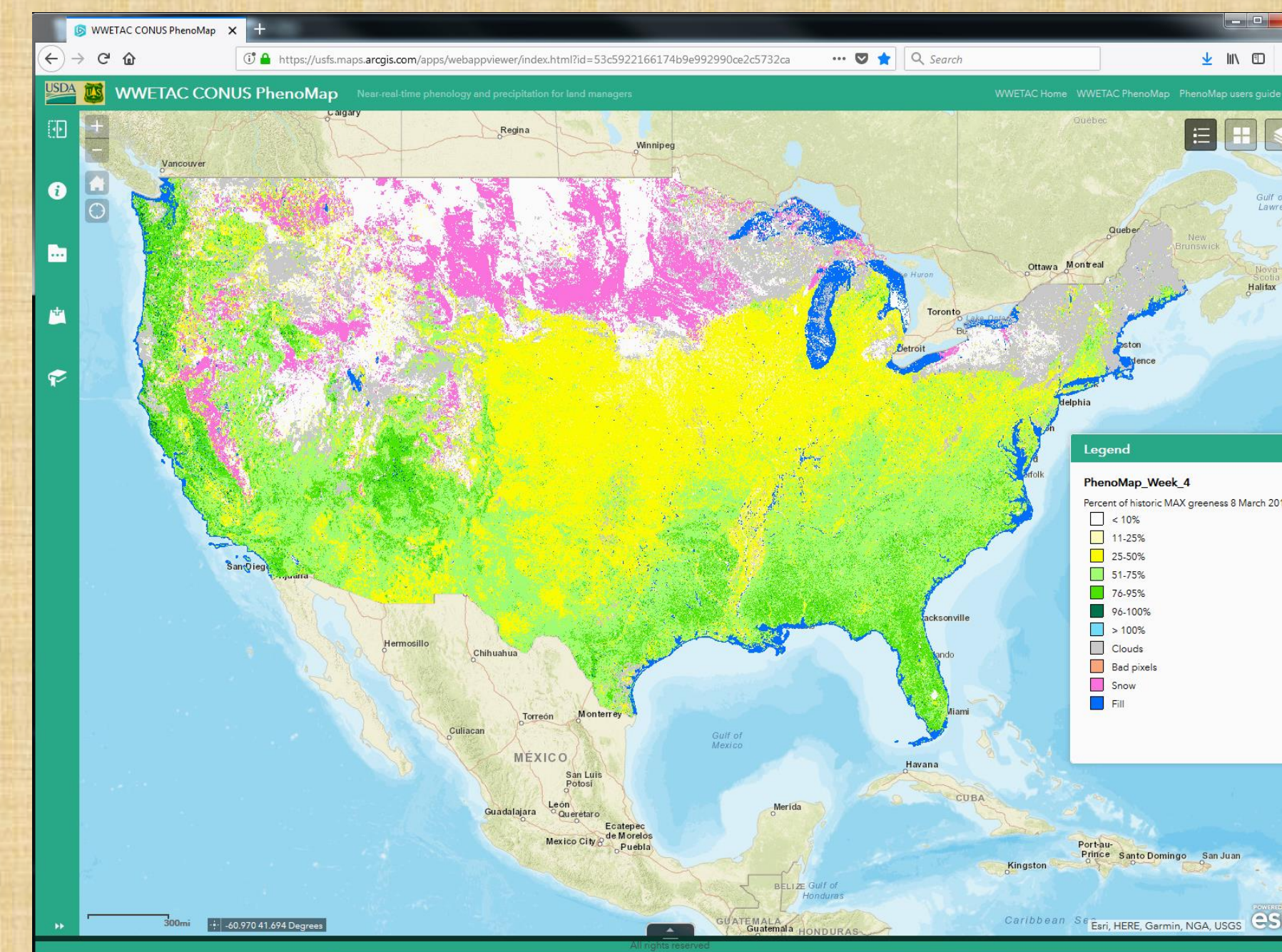


Figure 1: *PhenoMap* web map displaying the percent of historical maximum greenness for 8 March 2018.

### Accumulated growing-degree-day

The growing degree-day is a measure of the daily mean temperature above an established threshold (Base temperature). The seasonal cumulative total (starting 1 January) of these daily values (Accumulated growing degree-day - AGDD) is a strong predictor of phenological events. *PhenoMap* displays AGDD layers from the USA National Phenology Network (<https://www.usanpn.org/>) using 50 degree F and 32 degree F base temperatures. Anomaly layers depict the departure of the current AGDD from the 30 year (1981-2010) mean value for the same date (fig. 2).

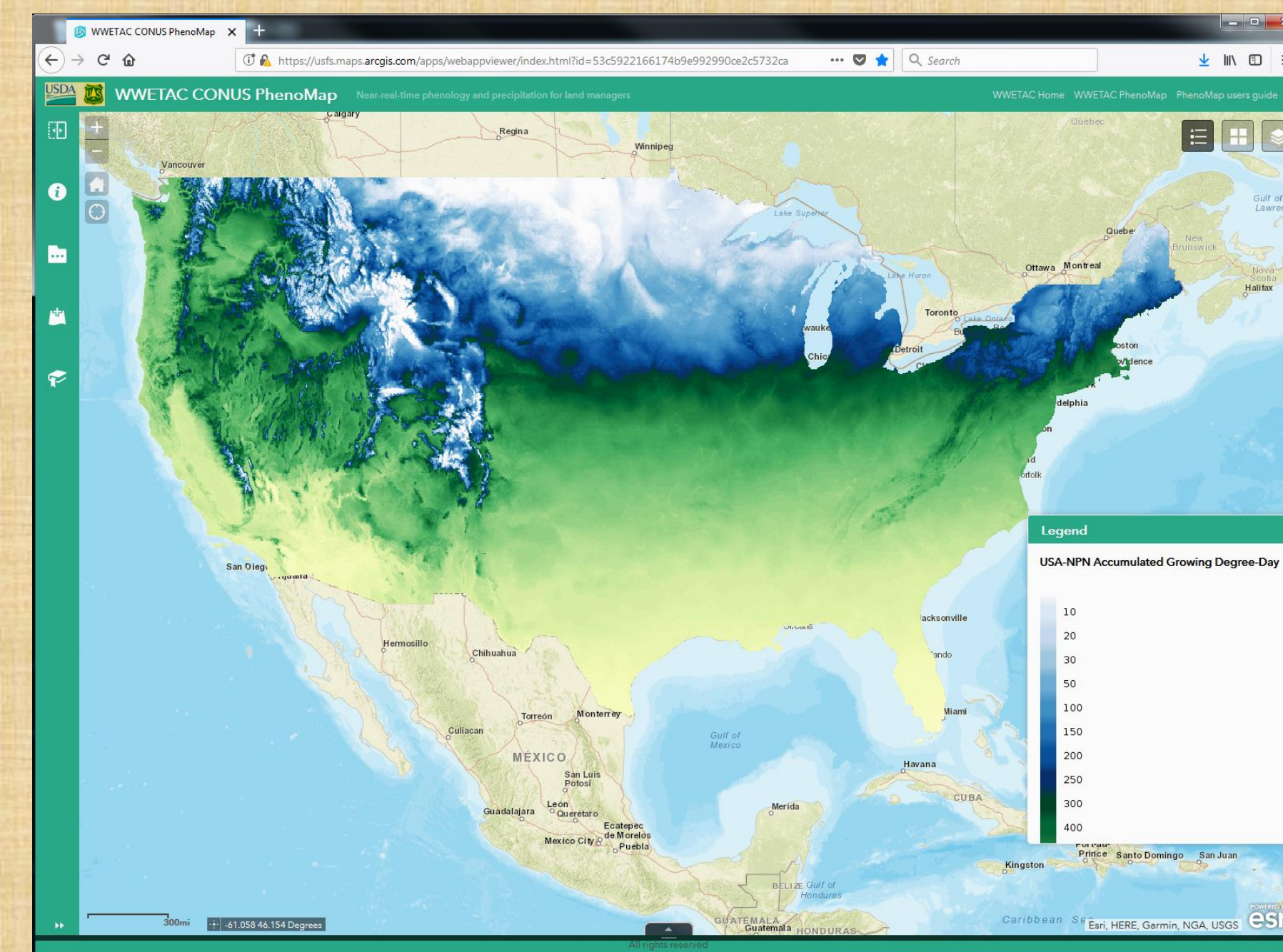


Figure 2: *PhenoMap* web map displaying USA-NPN accumulated growing degree day (32 degrees F base temperature) for 29 March 2018.

### Precipitation

Rainfall can vary widely across space and time from forecast estimates. Knowledge of precipitation amounts in the near (past 14 and 30 days) and mid (past 60 days) can help inform range management, while longer range precipitation estimates provide information for current and out-year planning. *PhenoMap* has 14, 30 and 60 day cumulative estimated precipitation layers, and cumulative estimates for the water year (since 1 Oct) to date produced by the National Weather Service using a combination of satellite and ground observations (<https://water.weather.gov/precip/>)(fig. 3).

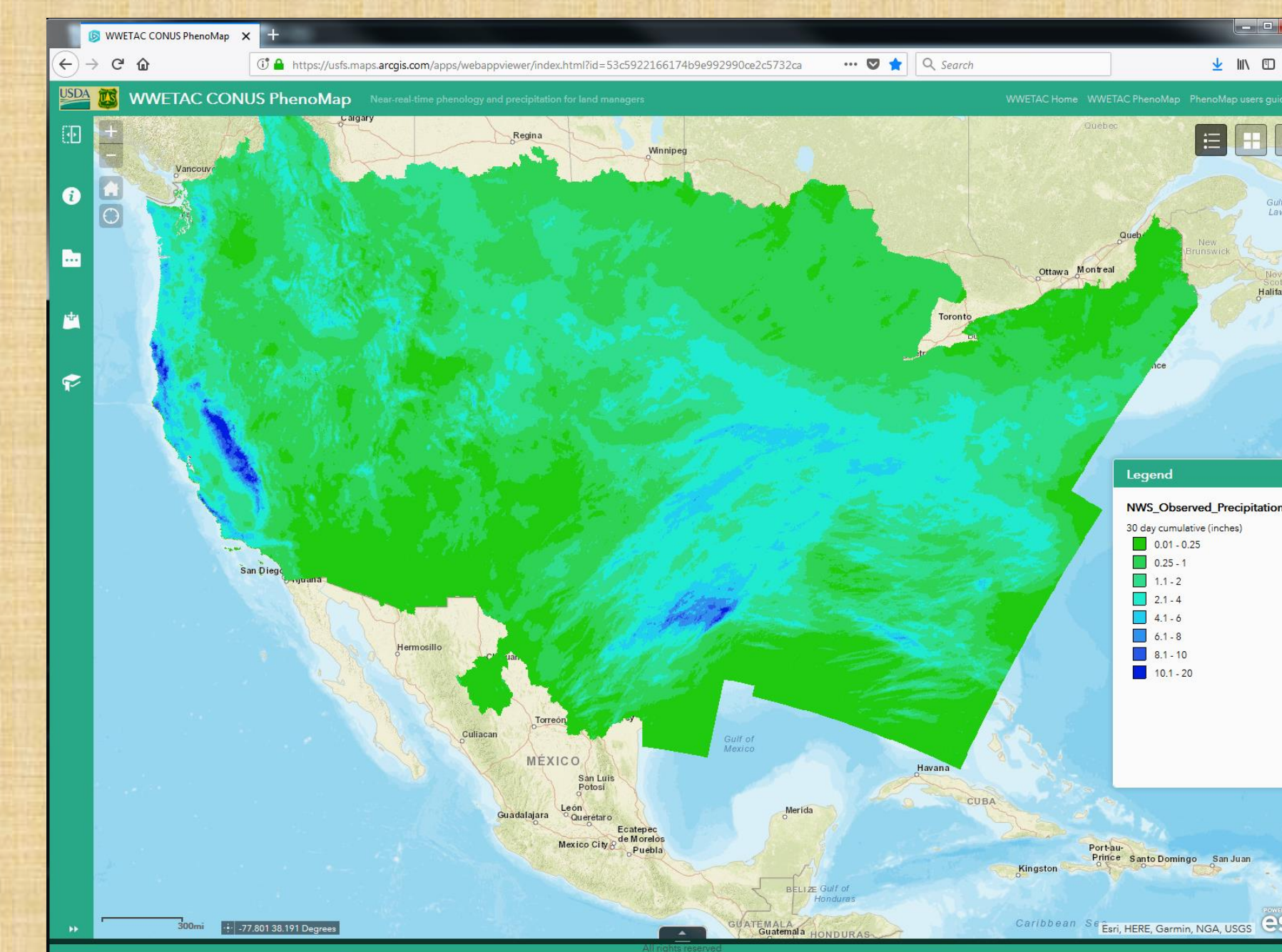


Figure 3: *PhenoMap* web map displaying the 30-day cumulative precipitation for 29 March 2018.

## Validation studies

Those colors on the map are pretty, but what do they mean on the ground? We answered this question with two studies:

1. We conducted a detailed field study on the Buffalo Gap National Grassland in western South Dakota. Weekly in-situ phenology field measurements were taken at 21 sites during the 2016 growing season (fig. 4). The data from these sites was correlated to the weekly NDVI greenness satellite data (fig. 5).
2. As a proxy for field data, we used greenness measures from the *PhenoCam* network of fixed-view digital cameras that collect multiple images per day. These greenness values (green chromatic coordinate - gcc) were correlated with the NDVI values for 2014-2016 (fig. 6).

Both studies showed a strong relationship between the satellite NDVI and the field measurements and *PhenoCam* greenness.



Figure 4: Weekly field measurements were conducted at 21 sites on the Buffalo Gap National Grassland. Measurements included visual obstruction readings (VOR), percentage cover of bare ground, cool and warm season grasses, and leaf developmental stage of the dominant grasses (Moore et al 1991). In this photo, leaf developmental stage of Western Wheatgrass is being evaluated.

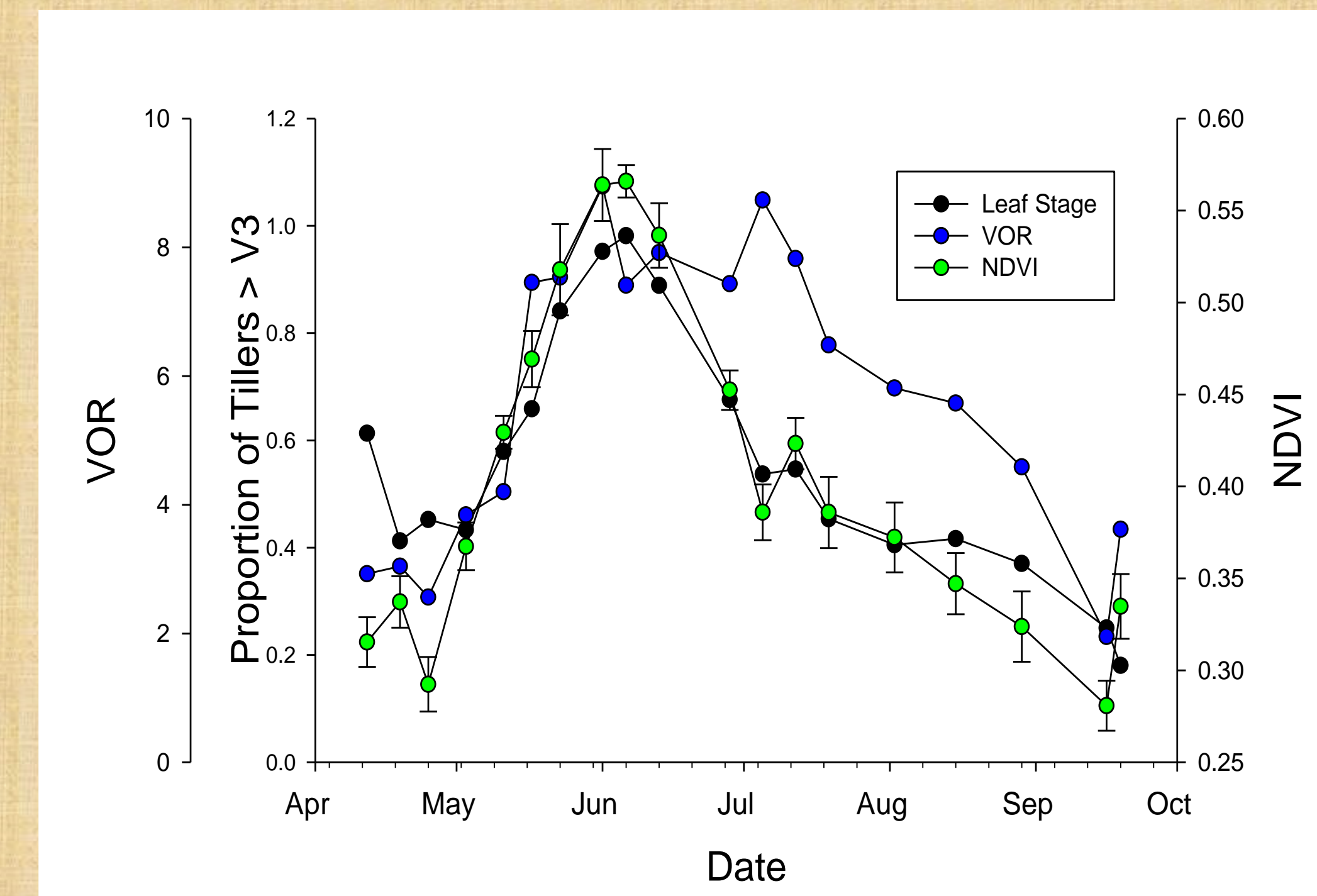


Figure 5: Line graph of the grass development stage (Leaf stage - Proportion of tillers > V3), visual obstruction readings (VOR) and satellite NDVI for 2016. Leaf development stage is for Western Wheatgrass, a dominant cool-season grass in the Northern Great Plains. V3 refers to the 3-leaf vegetative developmental stage. NDVI is closely correlated with leaf stage and VOR (regression;  $NDVI = 0.177 + 0.268 \cdot \text{leafstage} + 0.0137 \cdot \text{VOR}$ ;  $F_{2,16} = 62.64$ ,  $p < 0.001$ ,  $r^2 = 0.89$ ).

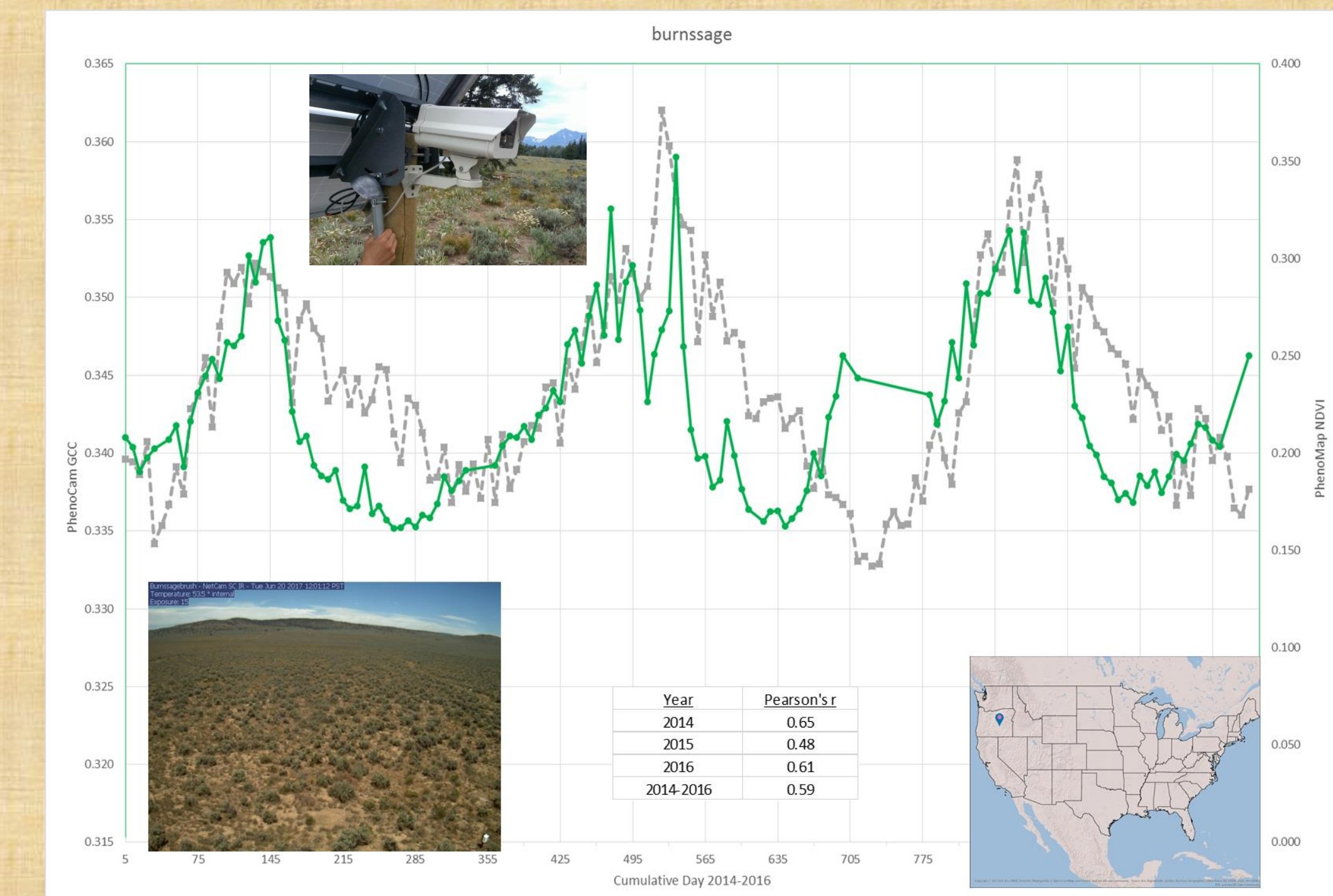


Figure 6: Line graph of the satellite NDVI (green) and *PhenoCam* green chromatic coordinate response for the years 2014-2016. This example is from Oregon.

## Conclusions

*PhenoMap* is a tool designed to help managers assess rangeland and grassland conditions across the vast landscapes under their care. Increasingly volatile climate extremes are resulting in phenological changes across both time and space. *PhenoMap* contains a wealth of information that can help inform management decisions such as stocking rates, rest and rotation, and utilization. It is a new tool in your toolbox for managing rangelands and grasslands.

Launch *PhenoMap* and give us feedback on changes/improvements that would help you do your job!

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For more information, see the following web pages:

<https://www.fs.fed.us/wwetac/threat-map/TRMPhenoMap.php>  
<https://www.fs.fed.us/wwetac/threat-map/threatmapper.php>

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