

# Vegetation Drought Response Index (VegDRI)

*A New Drought Monitoring Approach for Vegetation*

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NIDIS Knowledge Assessment Workshop:  
Contributions of Satellite Remote Sensing to Drought Monitoring

Boulder, CO

February 6, 2008



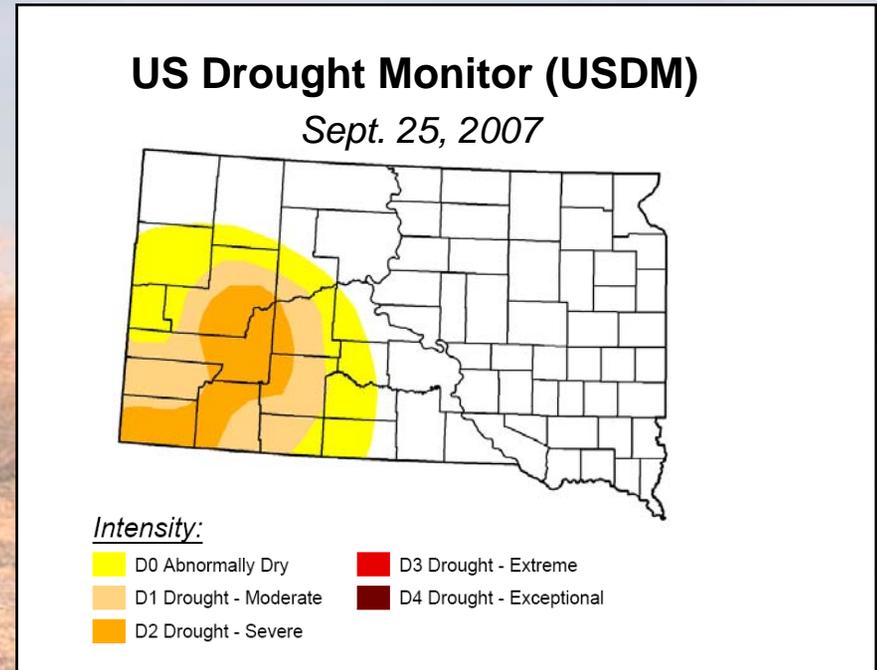
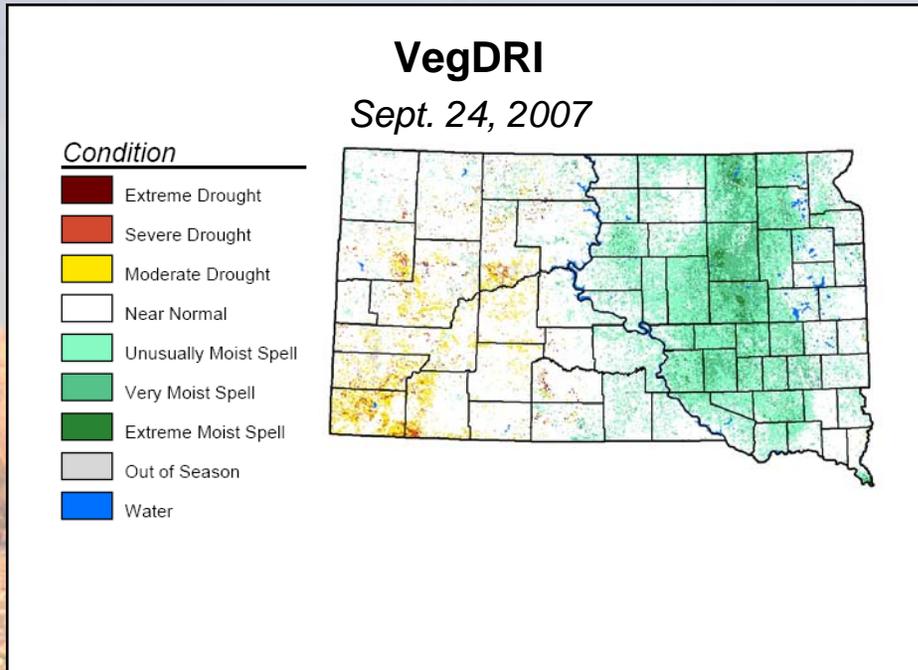
# What is VegDRI?

VegDRI is a new 'hybrid' drought index that integrates:

- satellite-based observations of vegetation conditions
- climate-based drought index data
- biophysical characteristics of the environment

to produce maps of ***drought-related vegetation stress*** that have high spatial resolution (1-km) and are regularly updated (currently at 2-week interval) throughout the growing season.

# A National View With Local-Scale Information

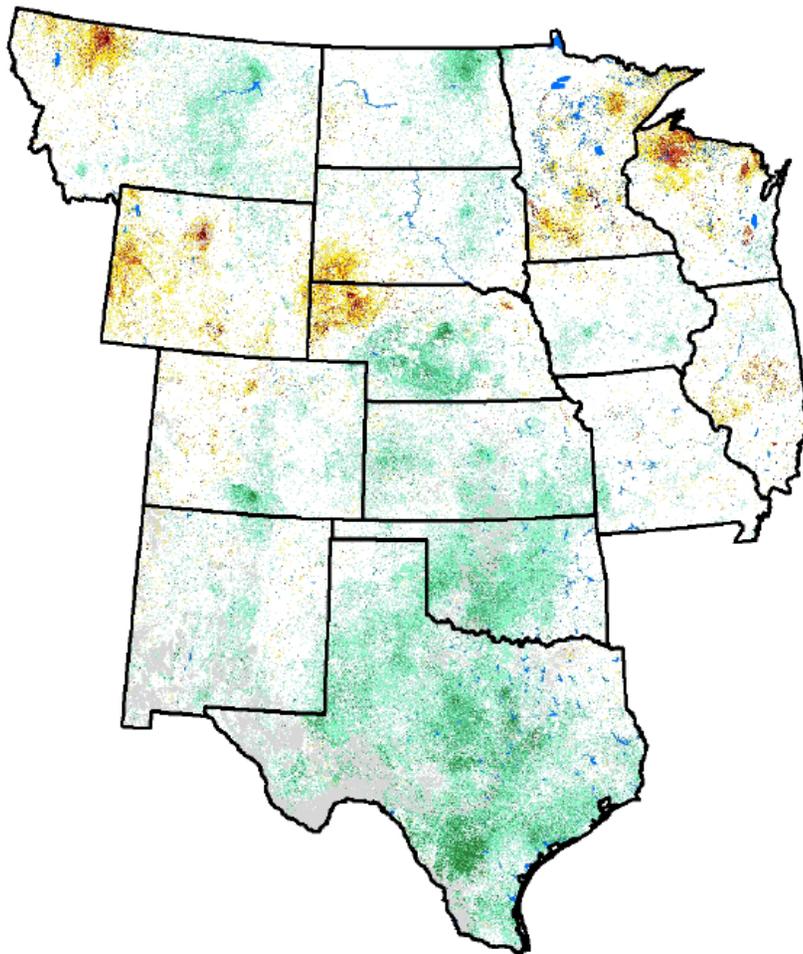


**Goal of VegDRI:** A tool that has national-level monitoring capabilities and can provide local-scale information (i.e., county to sub-county level) regarding the level of drought stress on vegetation in near real-time.

# Vegetation Drought Response Index

Complete

July 30, 2007



## Condition

- Extreme Drought
- Severe Drought
- Moderate Drought
- Near Normal
- Unusually Moist Spell
- Very Moist Spell
- Extreme Moist Spell
- Out of Season
- Water



# VegDRI - An Integrated Approach

## *Remote Sensing Component*

- **VegDRI**: Time-series 1-km NDVI image data from AVHRR provide spatially detailed observations of vegetation patterns and their general conditions.
- NDVI data from satellite-based sensors (e.g., AVHRR & MODIS) have been widely used to map and monitor vegetation from local- to global scales.



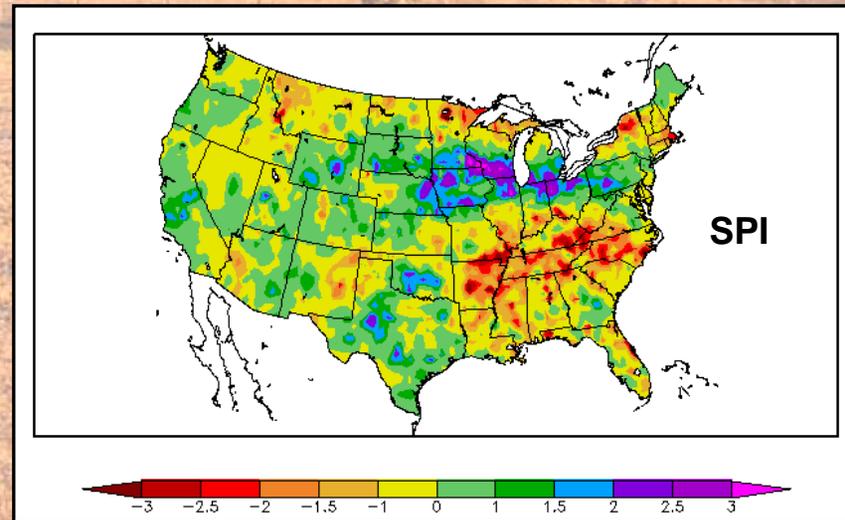
***Limitation:*** Difficult to identify the specific cause(s) of vegetation stress solely from the NDVI data.

Numerous natural (e.g. flooding, fire, & pest/disease) and anthropogenic events (e.g., land use/land cover change) can produced anomalies similar to drought in the NDVI data.

# VegDRI - An Integrated Approach

## *Climate Component*

- **VegDRI**: Climate-based drought index data provides a measure of 'dryness'.
- Indices such as the Standardized Precipitation Index (SPI) and Palmer Drought Severity Index (PDSI) have proven to be useful drought monitoring tools.



# VegDRI - An Integrated Approach

## *Biophysical Component*

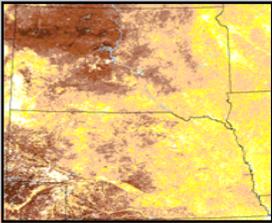
- Different characteristics of the environment are also considered that can influence climate-vegetation interactions.
  - land use/land cover type
  - soil characteristics
  - ecological setting
  - elevation



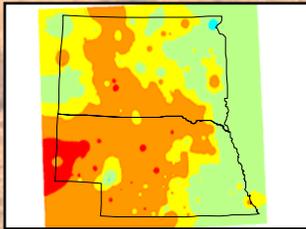
# VegDRI Methodology

## 1. Historical Database Development

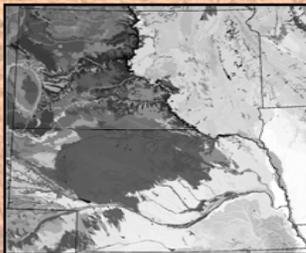
### Satellite Data



### Climate Data



### Biophysical Data



### Data Input Variables

- 1) Percent Annual Seasonal Greenness (PASG)
- 2) Start of Season Anomaly (SOSA)

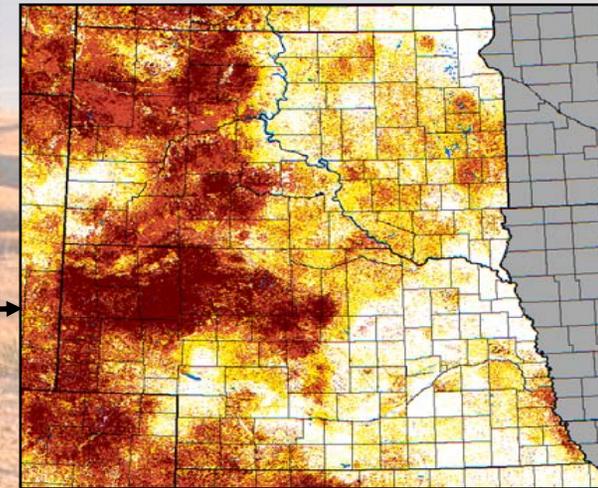
- 1) Palmer Drought Severity Index (PDSI)
- 2) Standardized Precipitation Index (SPI)

- 1) land use/land cover type
- 2) soil available water capacity (STATSGO)
- 3) ecoregion type
- 4) irrigation status
- 5) elevation

## 2. Model Development

Regression Tree Model (\*)

## 3. Map Generation



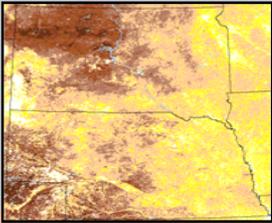
1-km<sup>2</sup> VegDRI Map

(\*) Models developed from a 17-year historical record (1989 – 2005) of bi-weekly climate and satellite observations at 1,600+ weather station locations. Biophysical variables are *static* over time.

# VegDRI Methodology

## *Historical Database Development*

### Satellite Data



### 1) Percent Annual Seasonal Greenness (PASG):

Measure of how vegetation conditions for a specific period during the growing season compare to historical average conditions over the 17-year historical record.

### 2) Start of Season Anomaly (SOSA)

Departure of the start of season (SOS) for a specific year from the average historical SOS.

**Data Source:** 1-km AVHRR NDVI data (1989 – 2005) (Eidenshink, 2006)

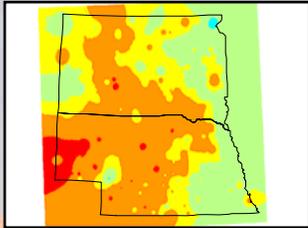
**QA/QC:** Time-series NDVI smoothed to minimize noise & artifacts (Swets et al., 1999)

**Temporal Frequency:** bi-weekly updates for PASG during the growing season  
: annual updates for SOSA

# VegDRI Methodology

## *Historical Database Development*

### Climate Data



### 1) self-calibrated Palmer Drought Severity Index (PDSI)

Based on a supply-and-demand model of the water balance equation that builds on both the precipitation and temperature history for a location. (Palmer, 1965; Wells et al., 2004)

### 2) Standardized Precipitation Index (SPI)

Quantifies the precipitation deficit for a specific time period based on the long-term precipitation record for that that period.

(McKee et al., 1995)

**Data Source:** Applied Climate Information System (ACIS) data from the High Plains Regional Climate Center (HPRCC)

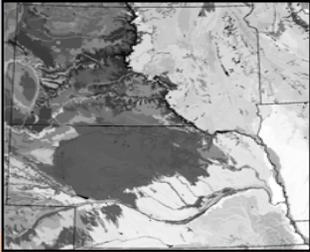
**QA/QC:** Only data from active weather stations with a sufficient historical record length (30 years) and minimal missing data (< 10%).

**Temporal Frequency:** bi-weekly updates of PDSI and SPI during the growing season

# VegDRI Methodology

## *Historical Database Development*

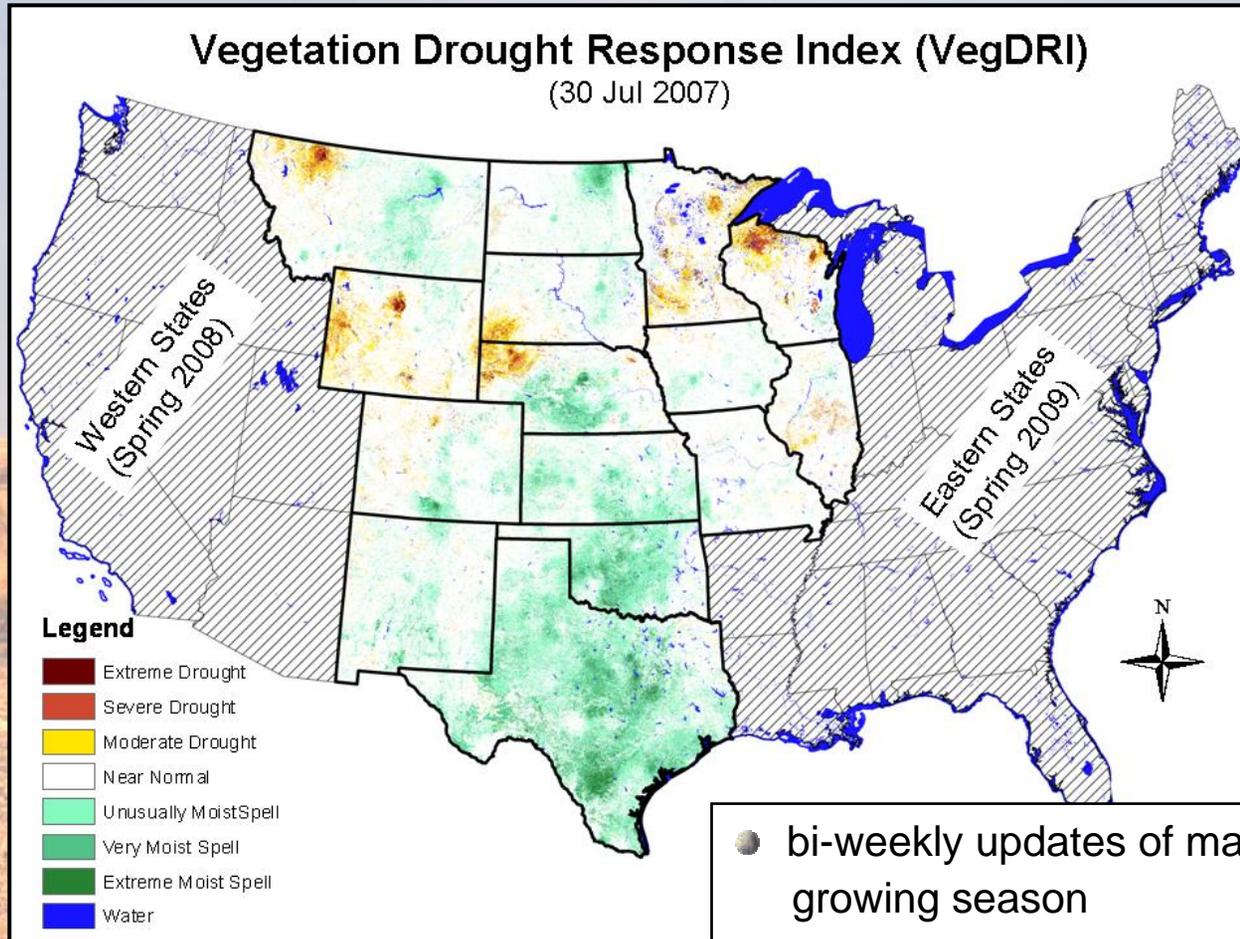
### Biophysical Data



Data Set Name	Source	Reference
Land Use/Land Cover	National Land Cover Database-2001	Homer et al., 2004
Soil Available Water Capacity	STATSGO	USDA, 1994
Irrigated Agriculture	USGS EROS / NDMC	
Ecological Regions	EPA Ecoregions	Omernik, 1987
Elevation	GTOPO30	Gesch et al., 1999

\* All biophysical variables are 1-km gridded data sets and 'static' across the 17-year historical record.

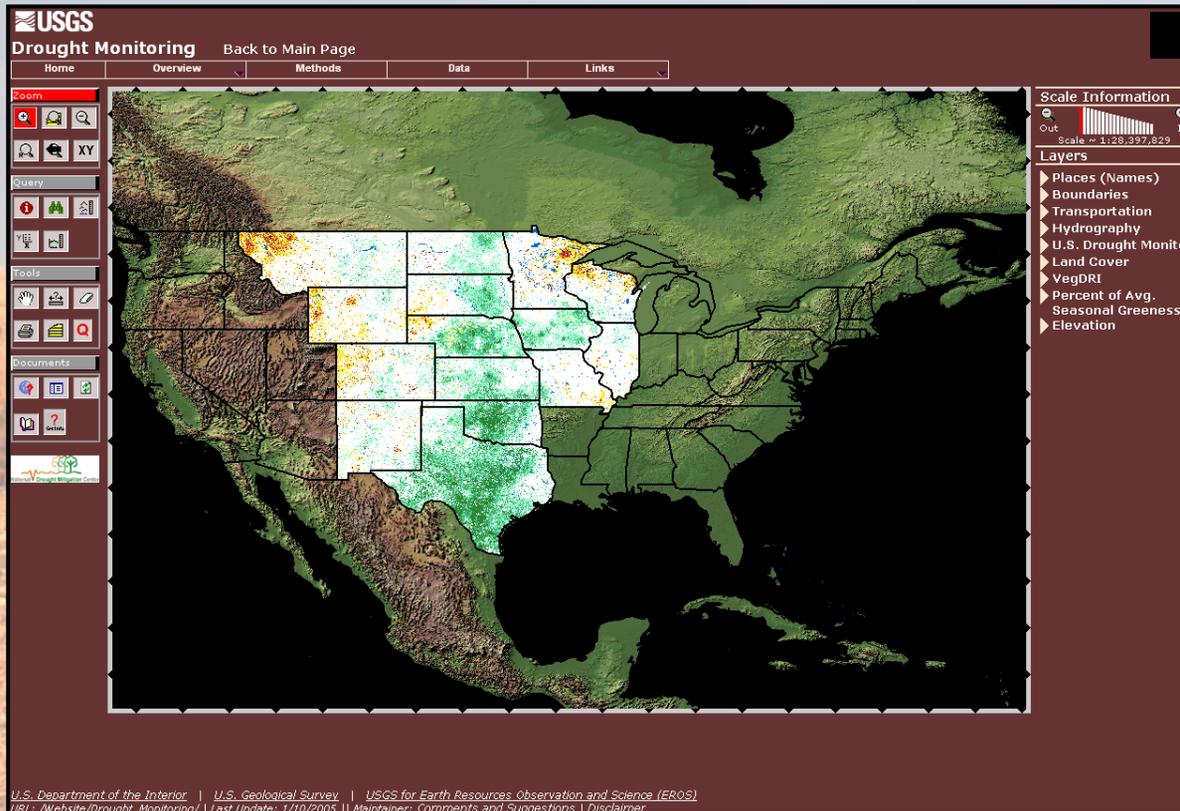
# Operational VegDRI Production



- bi-weekly updates of maps during the growing season
- time series of maps available 2006 & 2007 for 15-states (complete series from 1989 planned for near future)
- nominal 1-km spatial resolution

# VegDRI Products

## 1. Drought Monitoring viewer hosted by the USGS



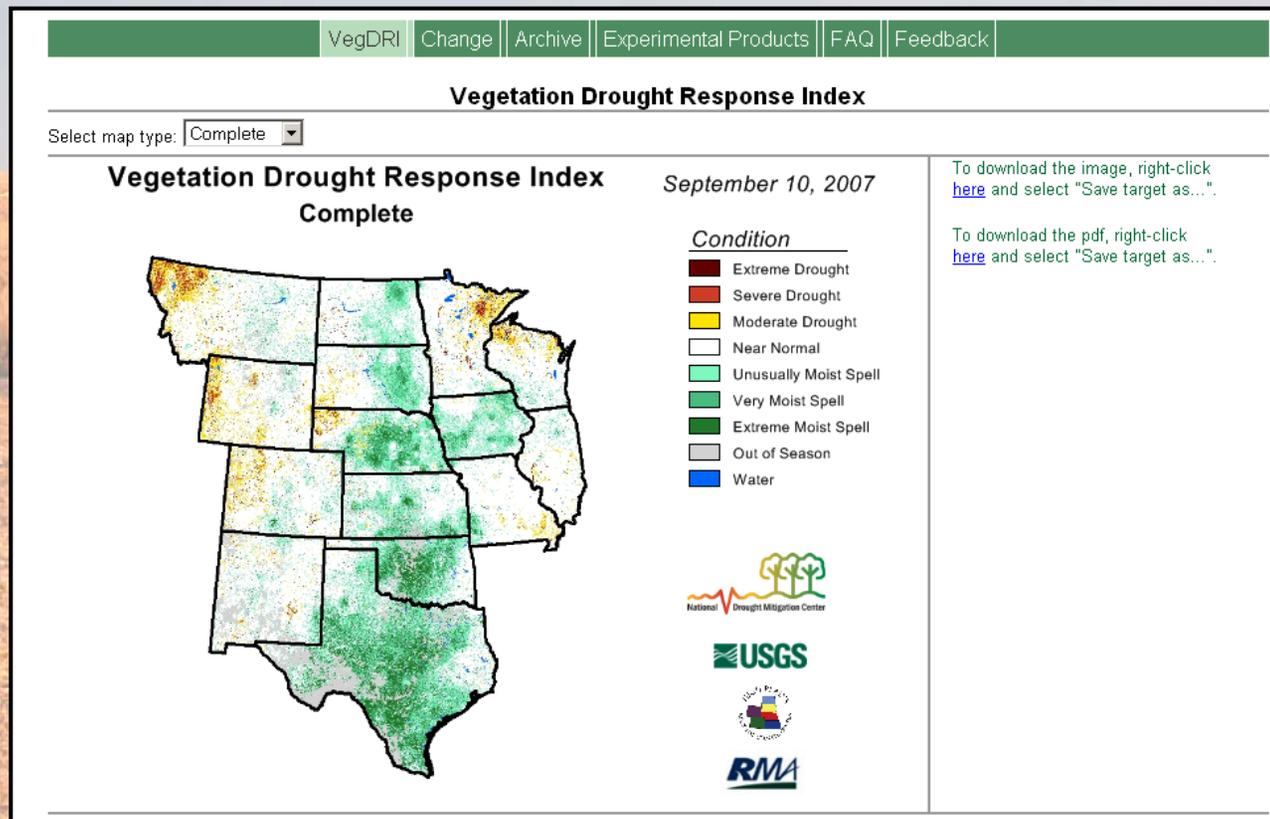
- Time series of VegDRI maps
- Zoom and pan options
- Overlay capabilities
- Multiple layers of ancillary information
  - admin. boundaries, roads, steams, etc.
  - DEM
  - land cover
  - NDVI-derived PASG
  - derivatives of the NWS precipitation analysis data

[http://gisdata.usgs.net/website/Drought\\_Monitoring/viewer.php](http://gisdata.usgs.net/website/Drought_Monitoring/viewer.php)

# VegDRI Products

## 2. VegDRI webpage hosted by the NDMC

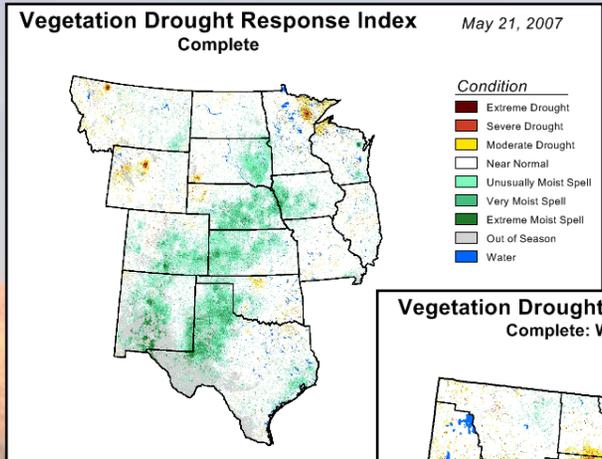
- Provides 'quick view' VegDRI maps, change maps, tabular data, historical archive, new products, and research.



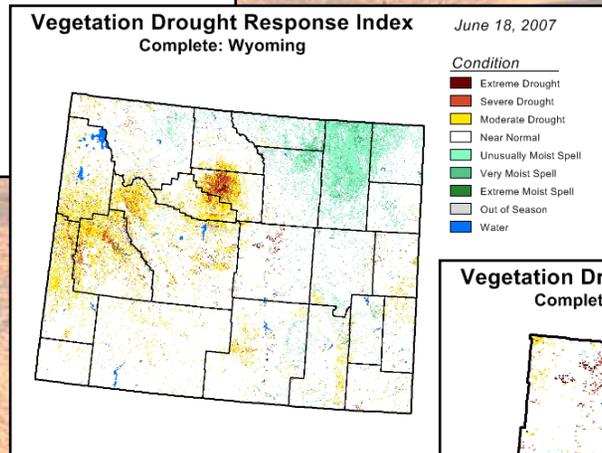
[http://www.drought.unl.edu/vegdiri/VegDRI\\_Main.htm](http://www.drought.unl.edu/vegdiri/VegDRI_Main.htm)

# VegDRI Products

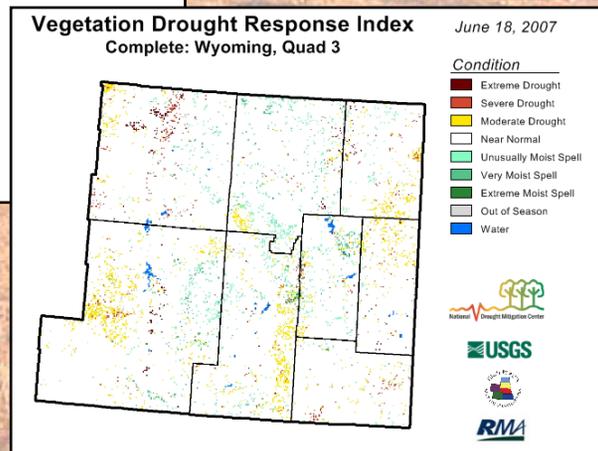
## 'Quick view' VegDRI maps (multiple spatial scales)



**Regional**



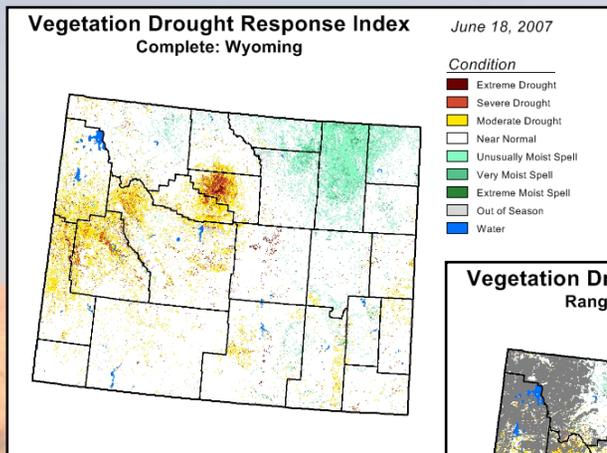
**State**



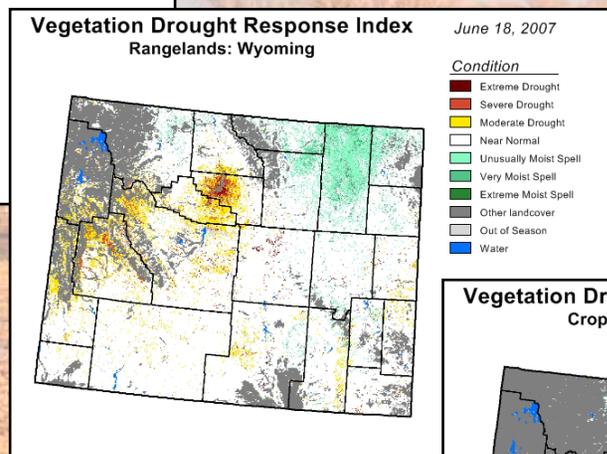
**Sub-state**

# VegDRI Products

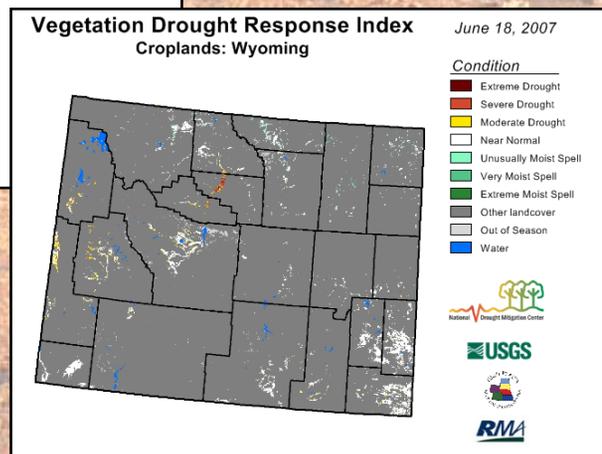
## 'Quick view' VegDRI maps (land cover type)



### Complete view



### Rangeland view



### Cropland view

# VegDRI Products

## Area Statistics (% Area)

### Wyoming – June 4, 2007

Entire state

Week	Extreme Drought	Severe Drought	Moderate Drought	Near Normal	Unusually Moist Spell	Very Moist Spell	Extreme Moist Spell
07/06/04	0.27	1.45	5.57	84.49	5.58	1.45	0.13
07/05/21	0.20	1.27	5.30	89.06	2.45	0.53	0.04
07/05/07	0.10	0.62	2.76	88.60	5.51	1.04	0.12

Rangeland

Week	Extreme Drought	Severe Drought	Moderate Drought	Near Normal	Unusually Moist Spell	Very Moist Spell	Extreme Moist Spell
07/06/04	0.22	1.20	4.35	68.45	5.07	1.28	0.10
07/05/21	0.16	0.96	4.14	72.72	2.19	0.41	0.02
07/05/07	0.08	0.50	2.00	72.00	4.89	0.86	0.11

Cropland

Week	Extreme Drought	Severe Drought	Moderate Drought	Near Normal	Unusually Moist Spell	Very Moist Spell	Extreme Moist Spell
07/06/04	0.03	0.06	0.19	2.94	0.20	0.04	0.01
07/05/21	0.02	0.05	0.15	3.08	0.11	0.04	0.01
07/05/07	0.01	0.04	0.07	3.01	0.23	0.09	0.00

*(currently available at state-level only)*

# VegDRI Products

## Change Maps

### 3 Types:

#### 1) Prior period

ex. - June 4, 2007 vs. May 21, 2007

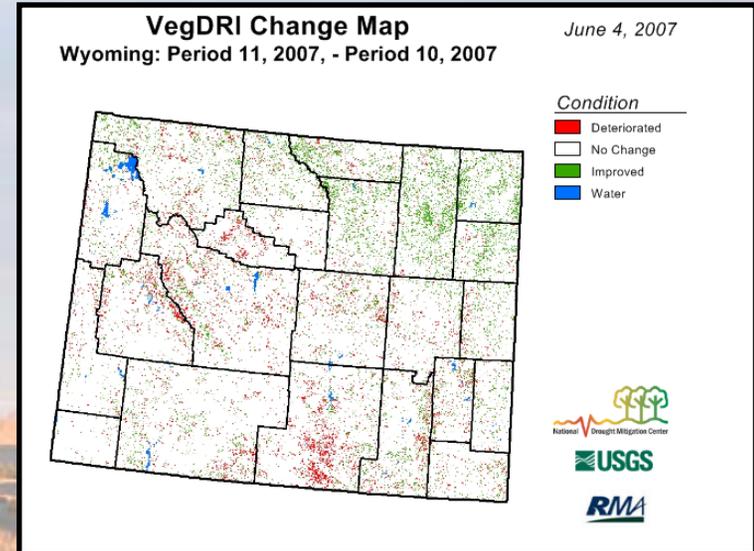
#### 2) Same period from the prior year or a specific year in past

(\* currently not available)

ex. – June 4, 2007 vs. June 4, 2006

#### 3) Historical average (\* currently not available)

ex. – June 4, 2007 vs. average for June 4 (1989 through 2006)



# Validation

## *A Convergence of Evidence Approach*

### 1. Statistical cross-validation of model results

- Correlation coefficient values ranging from 0.81 to 0.88

### 2. Comparison with other drought maps (i.e., USDM)

### 3. Comparison with various ground truth data sets

- USDA crop yields, clip plot biomass, and soil moisture

### 4. Feedback from a network of evaluators

- 2007: 81 evaluators across 15-states
- state climatologists, USDM authors, and agricultural experts and producers
- provide qualitative and quantitative information regarding the maps' accuracy for their respective area

# Applications

- **Recommendation:** VegDRI is appropriate for any user(s)/application(s) that currently utilize NDVI-derived products for drought information related to vegetation.
- Specific user community and applications are currently being identified through workshops and other outreach activities.
- **Examples**
  1. additional indicator in the development of the USDM maps
  2. Rangeland applications
    - Justify sub-county drought declarations for the release of Conservation Reserve Program (CRP) lands for emergency grazing.
    - Gauge rangeland conditions in other states to determine locations to move cattle for grazing and purchase hay and other feed.

# Ongoing Activities

- Expand the evaluator network and identify individuals/organizations collecting drought information that can be used to better characterize the strengths and weaknesses of VegDRI.
- Test the utility of VegDRI in various applications.
- Establish data/product requirements from users.
- Use of MODIS NDVI data.
- Test additional inputs into the VegDRI models.
  - thermal
  - land cover change
  - higher resolution soils data (SSURGO)

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