An Introduction to VegOut:

A tool to predict seasonal vegetation greenness

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Boise, ID
July 27, 2010

National Drought Mitigation Center

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RMA

What is VegOut?

Possible perceptions:

Variety of vegetarian food.

e.g., Veg Out! Austin...where herbivores eat out in central Texas

Source: DailyKos Covers Veg Dining in Austin, http://vegoutaustin.com/

Nachos at Mother Egan's

Thali at Swad Vegifood

TinTinNio pappardelle

Tino's Greek Cafe veggie plate

Pizza at Manolo's Italian Cafe

Soy Nuggets with Broccoli at NuAge Cafe

What is VegOut?

Movie Definition

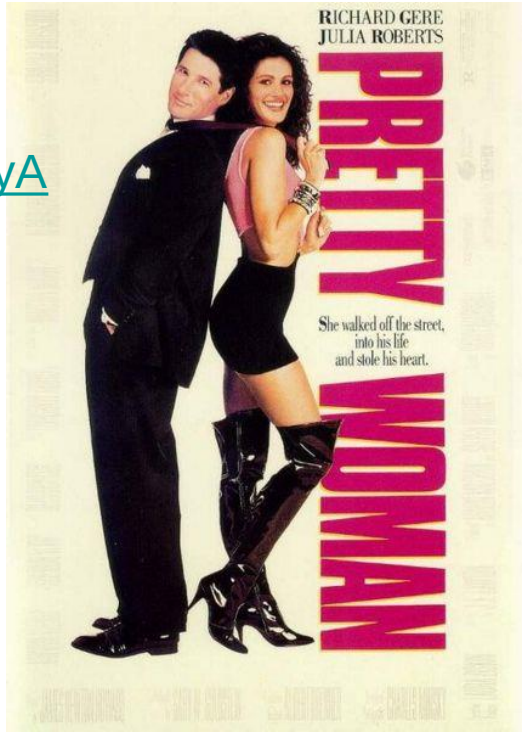
Veg out (Meaning): Relax in a slothful and mindless manner.

- This phrase derives from the association of vegetables with mental in…ty; in the way that mentally disabled people are sometimes referred t… vegetables. 'Couch potato' comes from the same notion.
- The term originated in the 1990s. Most of the early uses …om the London literary elite, although the earliest I've found i… film ***Pretty Woman***. In that, Julia Roberts' ch… this line: **"Let's watch old movies all night, … veg out in front of the TV."** **The Phrase Find…tin**

Ref. http://www.phrases.org.uk/m…400.html

Pretty woman: http://www.y…watch?v=NMmj7dWmiyA (Youtube)

Our VegOut definition is totally different!!!



What is VegOut?

National Drought Mitigation Center–RMA Partnership Agreement Projects

Vegetation Outlook (VegOUT)

Dr. Brian Wardlow, Dr. Tsegaye Tadesse, Dr. Michael Hayes, and Mark Svoboda, NDMC/UNL; Jun Li, NDMC/HPRCC; Ian Cottingham, CSE/UNL; and Karin Callahan, CALMIT/UNL

A new experimental tool to provide future outlooks of general vegetation conditions (seasonal greenness) based on an analysis of information that integrates climate, satellite, biophysical, and oceanic data.

- the term suggested by Mark Svoboda, Climatologist at NDMC

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VegOut Products:

Series of maps depicting future outlooks of general vegetation conditions at a 1-km^2 spatial resolution that are updated every 2 weeks.

1) 2-week Vegetation Outlook map
2) 4-week Vegetation Outlook map
3) 6-week Vegetation Outlook map

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Data Set Name	Type (Update Cycle)	Acronym	Source	Data Set Name	Type	Acronym	Source
Standardized Seasonal Greenness	Satellite (continuous, 14-day)	**SSG**	AVHRR NDVI	**Atlantic Multi-decadal Oscillation Index**	Oceanic/ Atmospheric (same value for all sites, monthly)	**AMO**	CPC/NOAA
Start of Season Anomaly	Satellite (continuous, annual)	**SOSA**	AVHRR NDVI	**Madden-Julian Oscillation**	Oceanic/ Atmospheric (same value for all sites, 14-day)	**MJO**	BoM/ Australia
Standardized Precipitation Index	Climate ASCII (at sites), 1 km raster surface, continuous, 14-day)	**SPI**	ACIS/ HPRCC	**Pacific Decadal Oscillation**	Oceanic/ Atmospheric (same value for all sites, monthly)	**PDO**	JISAO/UW/ NOAA
Ecological Regions	Biophysical (categorical, static)	**ECO**	EPA Ecoregions	**Southern Oscillation Index**	Oceanic/ Atmospheric (same value for all sites, monthly)	**SOI**	CPC/NOAA
Soil Available Water Capacity	Biophysical (continuous, static)	**AWC**	STATSGO	**North Atlantic Oscillation**	Oceanic/ Atmospheric (same value for all sites, monthly)	**NAO**	CPC/NOAA
Digital Elevation	Biophysical (continuous, static)	**DEM**	USGS-EROS	**Multivariate ENSO Index**	Oceanic/ Atmospheric (same value for all sites, monthly)	**MEI**	CDC/NOAA
Land Cover	Biophysical (categorical, static)	**NLCD**	National Land Cover Database	**Pacific North American Index**	Oceanic/ Atmospheric (same value for all sites, monthly)	**PNA**	CPC/NOAA
Irrigated Agriculture	Biophysical (continuous, static)	**IrrAg**	USGS-EROS				

Table 1. List of variables, update cycles, and data sources for the VegOut model.

(Tadesse et al., 2010, GIScience & Remote Sensing)

Types of Vegetation Outlooks

1) Historical-pattern (time-series relationships) – outlooks based on series of historical records

EX - if the current climate, vegetation, and oceanic conditions are similar to previous drought years (e.g., 1989, 2002, etc), then the following 2-, 4-, and 6-week would have similar drought patterns as those drought years.

2) Scenarios - outlooks based on implementation of the model using percentage(s) of precipitation expected over the specific outlook period.

EX. – 50% of normal precipitation over the next 2 week period used to calculate the 2-week VegOut map

- Multiple scenarios using different %
  - 0%, 50%, 100%, and 150% of normal precipitation
- Scenarios can be done over the different time intervals
  - 2-weeks, 4-weeks, and 6-weeks

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Time-series relationship model (Historical Pattern)

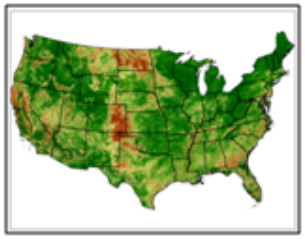
Model

- Method: Given the current independent variables listed, what would be the value in the following 2 week based on the historical pattern? (the next 4 and 6 week?)
- **The VegOut modeling approach:**
  - $VegOut_{t=2\ wk} = f_{t=0}(SSG) + f_{t=0}(SPI, MRLC, Eco_R, Per_Irrig, AWC, SoS_anom,) + f_{t=priorMonth}(MEI, MJO_RMM1, NAO, PDO, SOI, AMO, SSTA, PNA)$

VegOut Methodology

1. Historical Database Development

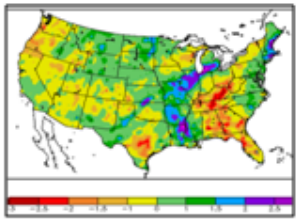
Satellite



Data Input Variables

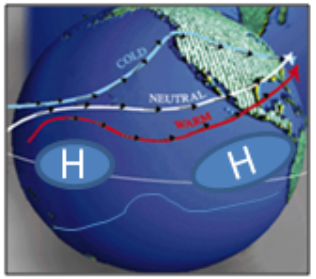
1) Standardized Seasonal Greenness (SSG)
2) Start of Season Anomaly (SOSA)

Climate Data



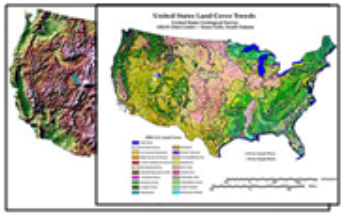
Standardized Precipitation Index (SPI)

Oceanic Data



1) Atlantic Multi-decadal Oscillation index (AMO)
2) Multivariate ENSO Index (MEI)
3) Madden-Julian Oscillation
4) Pacific North American index(PNA)
5) Pacific Decadal Oscillation (PDO)
6) Southern Oscillation Index (SOI)
7) North Atlantic Oscillation (NAO)

Biophysical Data

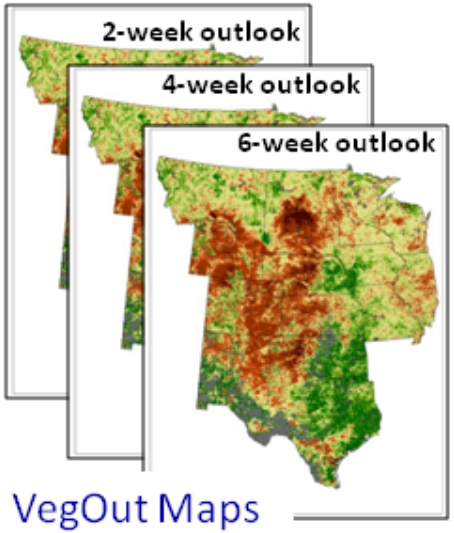


1) Land use/ cover type
2) Soil available water capacity (STATSGO)
3) Ecoregion type
4) Irrigation status
5) Elevation

2. Model Development

Regression Tree Model*

3. Map Generation



VegOut Maps

(*) Models developed from an 18-year historical record (1989 – 2006) of bi-weekly climate and satellite observations at 1,402 weather station locations.

Oceanic data are extracted for the same period of time.

Biophysical variables are *static* over time.

Figure 2. VegOut database, process (regression-tree rules generation), and outlook map production.
(After Tadesse et al., 2010, GIScience & Remote Sensing)

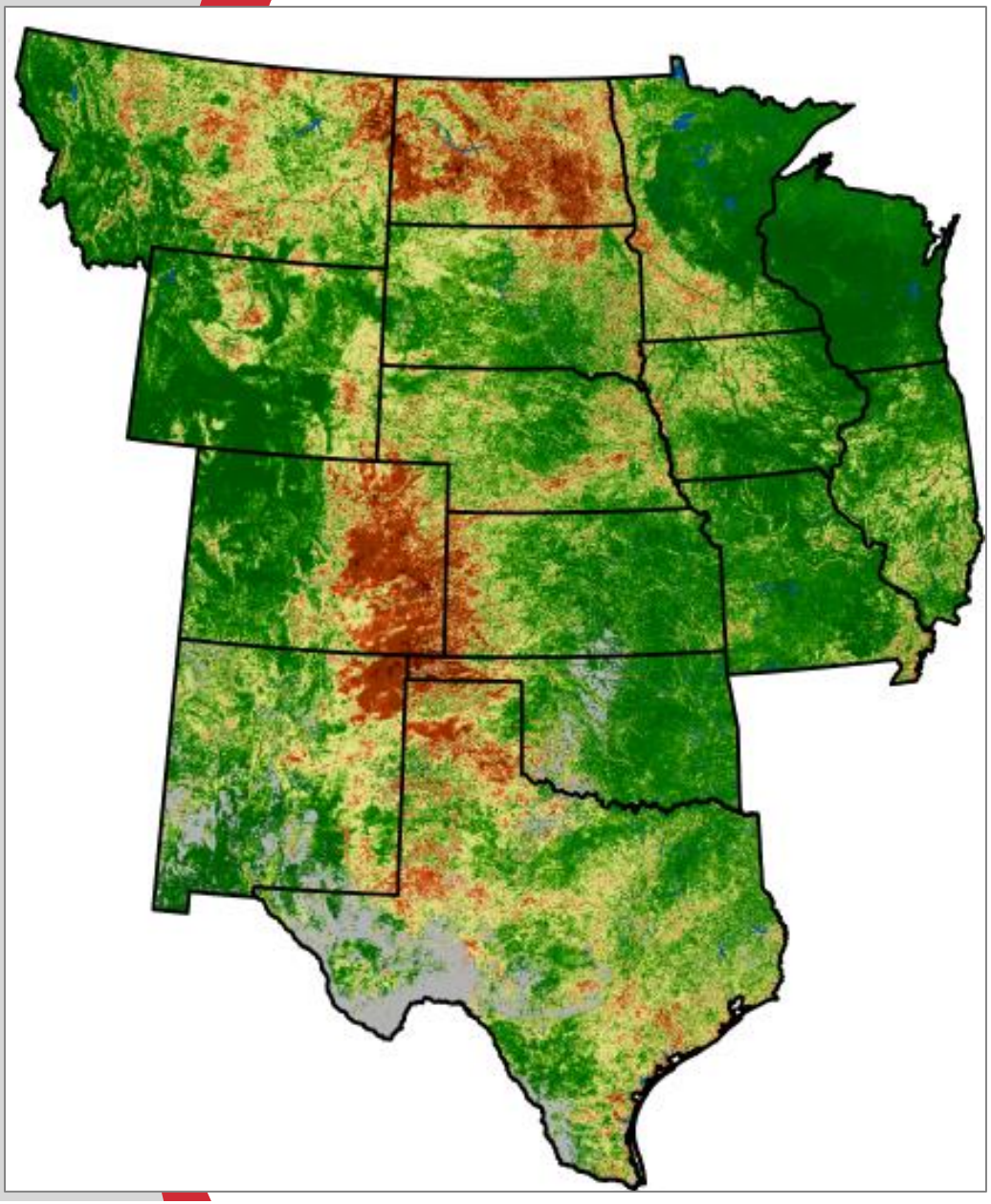


Figure. Observed seasonal greenness (SSG) for July 28, 2008

Table 4. The SSG values were classified into seven general vegetation condition classes based on the standard deviation (STDEV) of the SSG: (1) Extreme stress is less than -2 STDEV, (2) Severe stress is between -2 and -1 STDEV, Poor vegetation is between -1 and -0.5 STDEV, Fair (Near normal) is between -0.5 and +0.5 STDEV, Good vegetation is between +0.5 and +1 STDEV, Very good vegetation is between +1 and +2 STDEV, and Excellent vegetation is greater than +2 STDEV.

Vegetation Condition Classification Scheme	
SSG values (STDEV)	Vegetation Condition
-2.0 and less	Extreme stress
-1.0 to -2.0	Severe stress
-0.5 to –1.0	Poor vegetation
-0.5 to +0.50	Fair (Near normal)
+0.5 to +1.0	Good vegetation
+1.0 to +2.0	Very good vegetation
+2 and above	Excellent vegetation

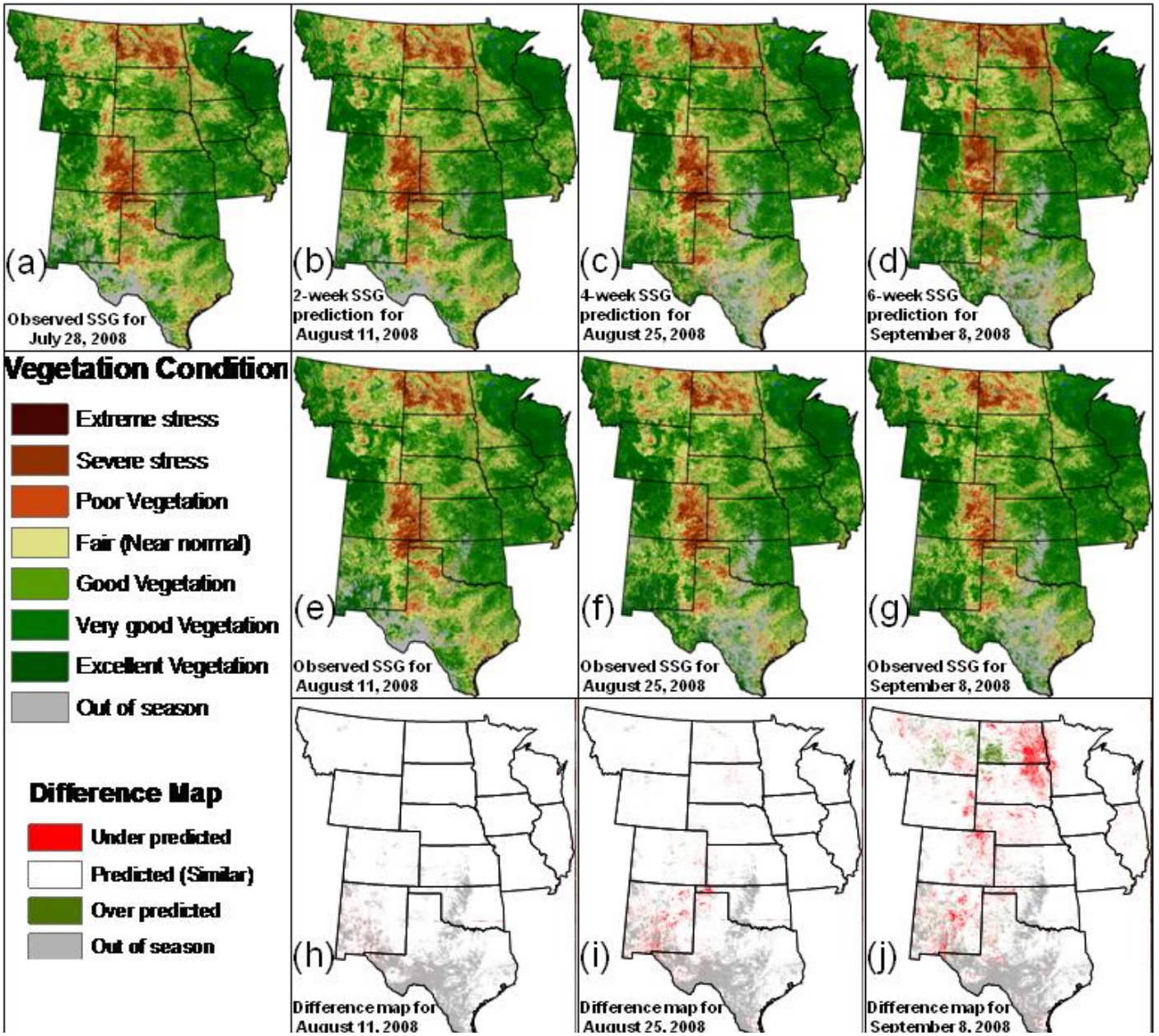
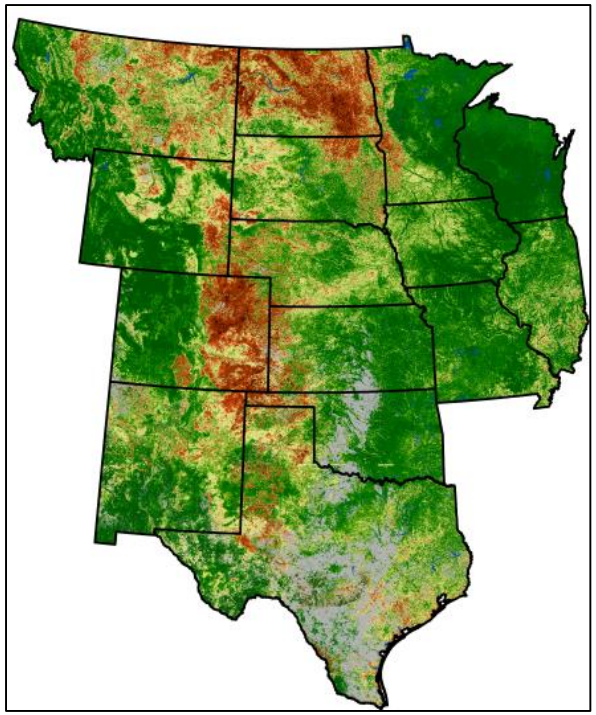


Figure 4. (a) Observed seasonal greenness (SSG) for July 28, 2008; (b), (c), and (d) are 2-, 4-, and 6-week outlooks; (e), (f), and (g) are observed SSG for August 11, August 25, and September 8 that correspond to the 2-, 4-, 6-week outlooks, respectively; (h), (i), and (j) are the change maps (the difference between the predicted and observed) for the 2-, 4-, 6-week outlooks, respectively. (After Tadesse et al., 2010, GIScience & Remote Sensing)

Period	Outlooks	Evaluation on test data			Period	Outlooks	Evaluation on test data		
		MAD (T)	RE (T)	R^2			MAD (T)	RE (T)	R^2
Period 9 (23 April- 6 May)	2-week	0.25	0.37	0.83	Period 14 (2 – 15 July)	2-week	0.09	0.13	0.98
	4-week	0.33	0.49	0.72		4-week	0.16	0.23	0.92
	6-week	0.35	0.51	0.71		6-week	0.20	0.30	0.90
Period 10 (7 - 20 May)	2-week	0.17	0.25	0.92	Period 15 (16– 29 July)	2-week	0.09	0.12	0.98
	4-week	0.25	0.36	0.85		4-week	0.14	0.2	0.94
	6-week	0.31	0.45	0.77		6-week	0.18	0.26	0.92
Period 11 (21 May - 3 June)	2-week	0.14	0.21	0.94	Period 16 (30July-12 Aug)	2-week	0.08	0.11	0.98
	4-week	0.21	0.30	0.88		4-week	0.13	0.18	0.96
	6-week	0.28	0.41	0.81		6-week	0.17	0.24	0.92
Period 12 (4 - 17 June)	2-week	0.11	0.16	0.98	Period 17 (13–26 August)	2-week	0.07	0.10	0.98
	4-week	0.19	0.28	0.92		4-week	0.11	0.16	0.96
	6-week	0.26	0.37	0.85		6-week	0.15	0.21	0.94
Period 13 (18 Jun - 1 July)	2-week	0.10	0.14	0.98	Period 18 (26 Aug – 9 Sept)	2-week	0.06	0.09	0.99
	4-week	0.17	0.24	0.94		4-week	0.10	0.14	0.98
	6-week	0.22	0.32	0.88		6-week	N/A	N/A	N/A

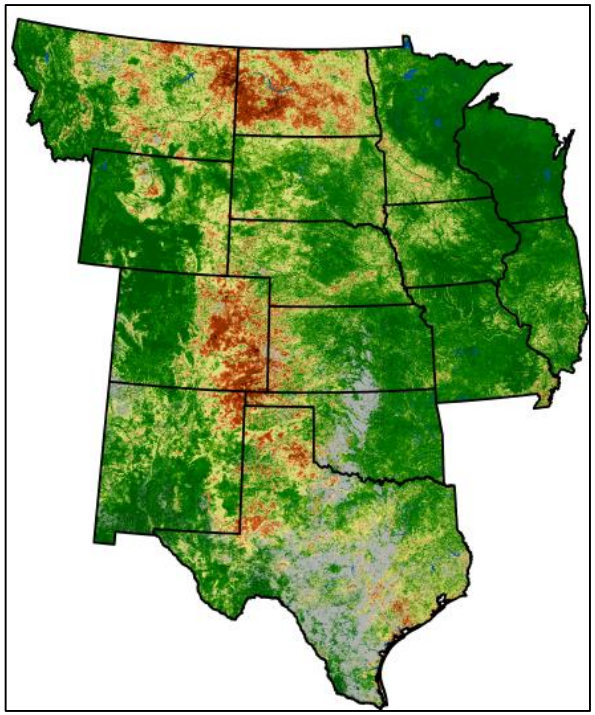
Table 2. Evaluation of the VegOut model. The mean absolute difference (MAD) values, relative error (RE), and coefficient of determination (R^2) between the observed and predicted SSG are shown for each period and the corresponding outlooks in all periods of the growing season. **(Tadesse et al., 2010, GIScience & Remote Sensing)**

Comparing Six-week outlook with actual observation



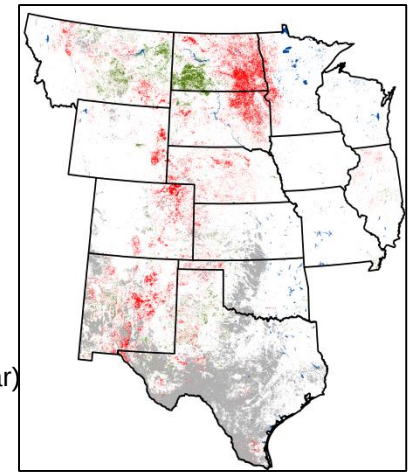
Vegetation Condition

- Extreme stress
- Severe stress
- Poor Vegetation
- Fair (Near normal)
- Good Vegetation
- Very good Vegetaion
- Higher Vegetation
- Out of season
- Water



(a) Predicted seasonal greenness (SSG) for September 8, 2008

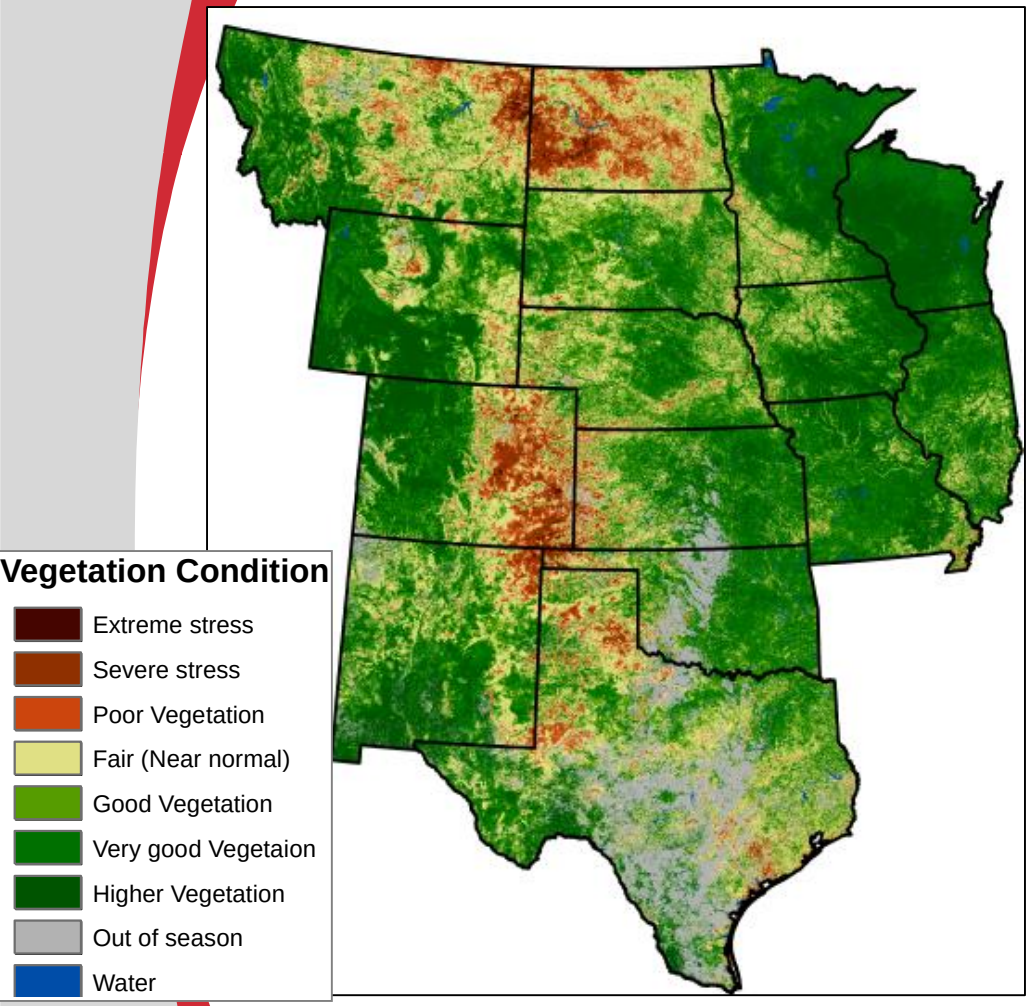
(b) Observed seasonal greenness (SSG) for September 8, 2008



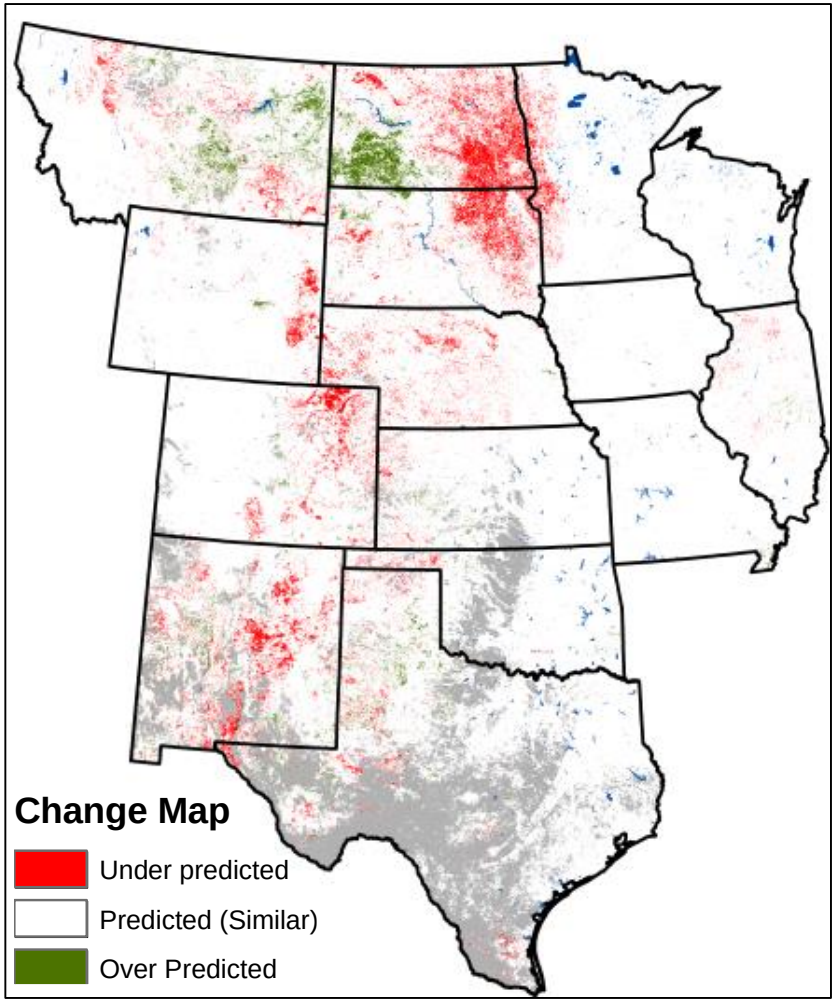
Change Map

- Under predicted
- Predicted (Similar)
- Over Predicted

The Difference Map: Comparing Six-week outlook with actual observation (VegOut minus the observed SSG)



(a) Predicted seasonal greenness (SSG) for September 8, 2008



(b) Predicted (Six-week outlook) minus observed map of SSG for September 8, 2008

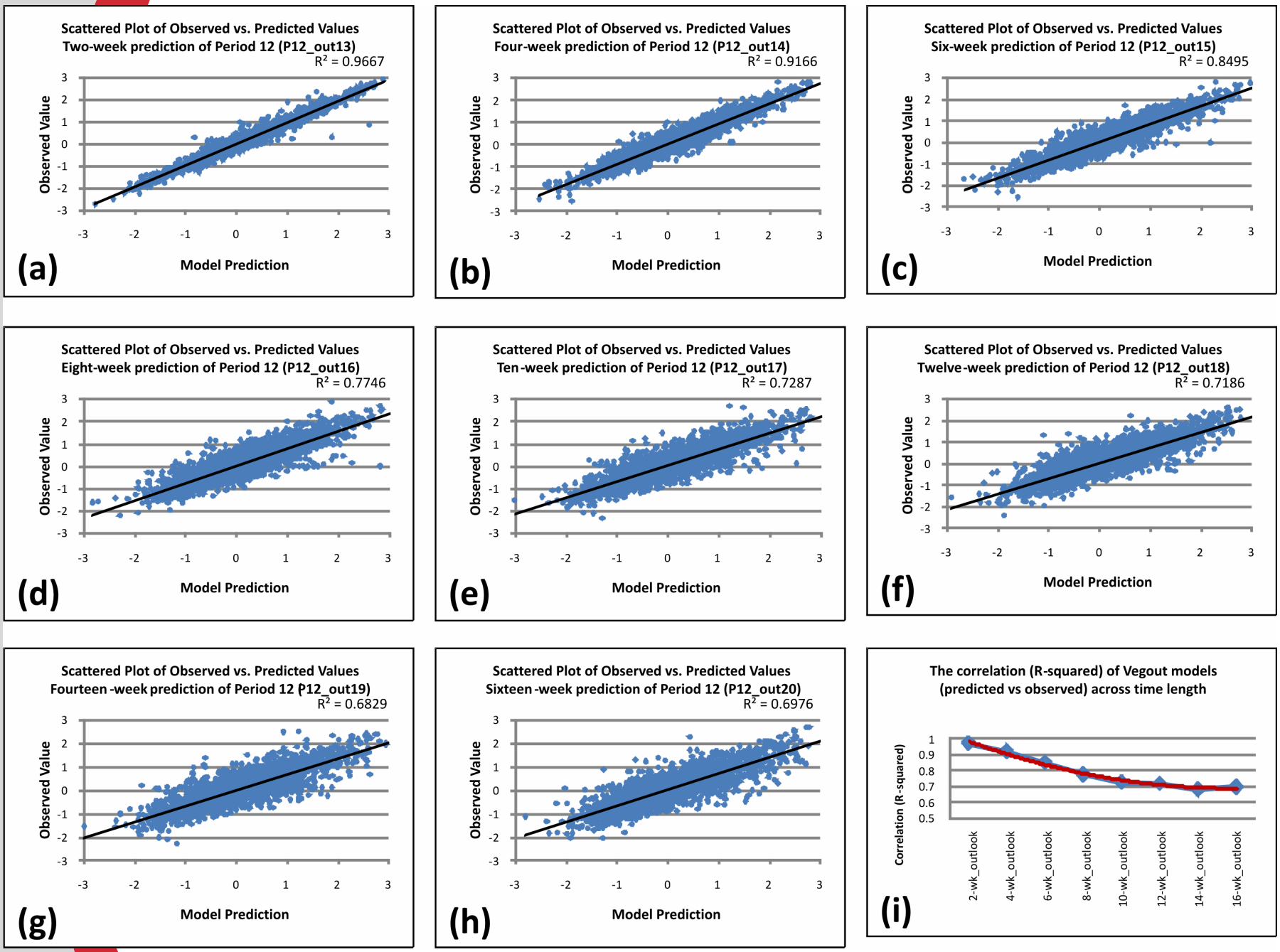


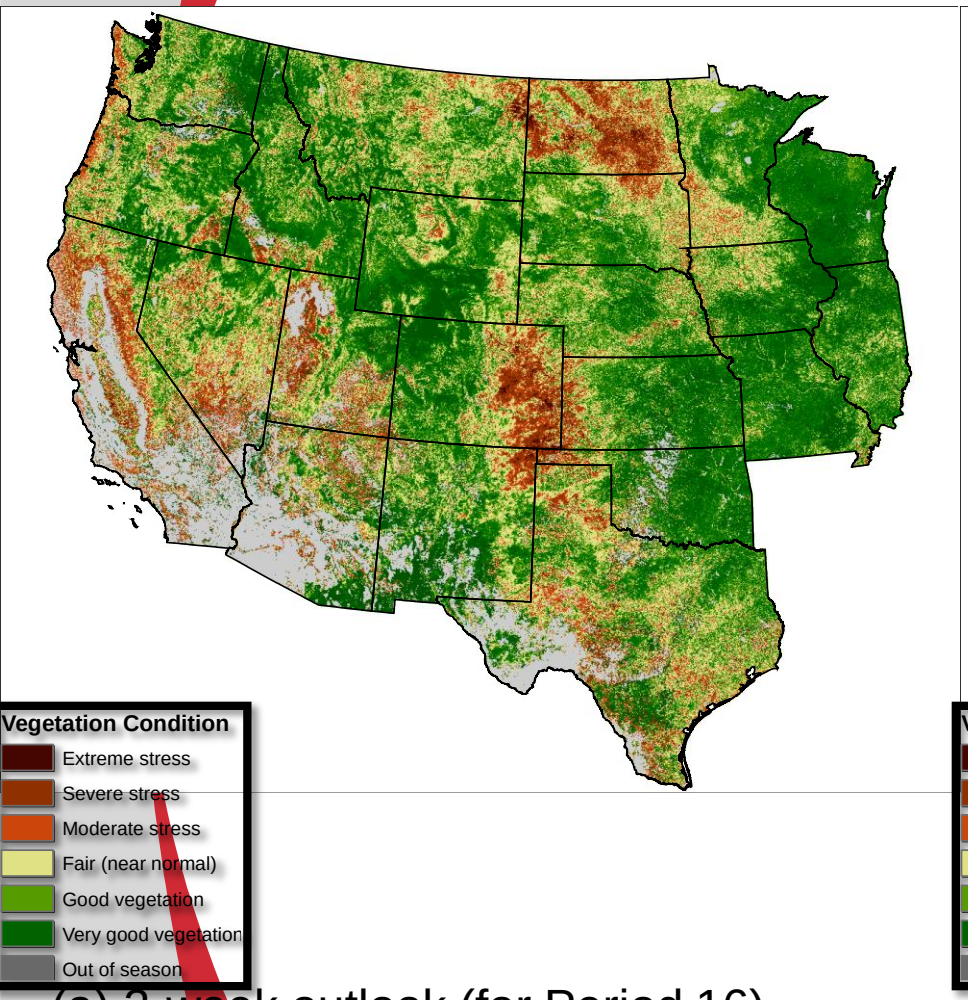
Figure 3. Scatter plots of observed and predicted SSG values for period 12 (i.e., first half of June), and coefficient of determination (R^2) showing the accuracy of the prediction across the growing season. Figures 3a, 3b, 3c, 3d, 3e, 3f, and 3h show the scatter plots of the observed and the 2-, 4-, 6-, 8-, 10-, 12-, 14-, and 16-week predicted SSG values, respectively. Figure 3i shows the R^2 across the growing season. **(After Tadesse et al., 2010, GIScience & Remote Sensing)**

	(a) 2-week outlook *(18 rules, 23940 cases)*			(b) 4-week outlook *(28 rules, 23383 cases)*			(c) 6-week outlook *(36 rules, 23021 cases)*		
Data Type	***Variable***	***Conditional Statement***	***Regression Model***	***Variable***	***Conditional Statement***	***Regression Model***	***Variable***	***Conditional Statement***	***Regression Model***
Satellite data	**SSG**	**58%**	**100%**	**SSG**	**39%**	**100%**	**SSG**	**55%**	**100%**
	SOSA	**55%**	**76%**	**SOSA**	**35%**	**81%**	**SOSA**	**62%**	**78%**
Climate	**SPI**	**<1%**	**63%**	***SPI***	**11%**	**58%**	**SPI**	**8%**	**76%**
Oceanic/ Atmospheric	**PNA**	**37%**	**72%**	**PNA**	**28%**	**69%**	**PNA**	**49%**	**37%**
	PDO	**52%**	**67%**	**PDO**	**30%**	**71%**	***PDO***	**32%**	**56%**
	NAO	**<1%**	**64%**	**NAO**	**<1%**	**72%**	**NAO**	**<1%**	**66%**
	MJO	**7%**	**43%**	***MJO***	**<1%**	**20%**	**MJO**	**13%**	**57%**
	MEI	**<1%**	**42%**	**MEI**	**8%**	**48%**	**MEI**	**8%**	**67%**
	SOI	**<1%**	**39%**	**SOI**	**57%**	**61%**	**SOI**	**46%**	**42%**
	AMO	**<1%**	**26%**	**AMO**	**<1%**	**11%**	**AMO**	**19%**	**29%**
Bio-physical	**DEM**	**7%**	**15%**	**DEM**	**7%**	**34%**	**DEM**	**<1%**	**42%**
	AWC	**<1%**	**15%**	**AWC**	**<1%**	**13%**	**AWC**	**<1%**	**21%**
	IrrAg	**<1%**	**<1%**	**IrrAg**	**<1%**	**11%**	**IrrAg**	**<1%**	**18%**
	ECO	**91%**	**<1%**	**ECO**	**86%**	**<1%**	**ECO**	**99%**	**<1%**
	LCLU	**<1%**	**<1%**	**LCLU**	**<1%**	**<1%**	**LCLU**	**<1%**	**<1%**

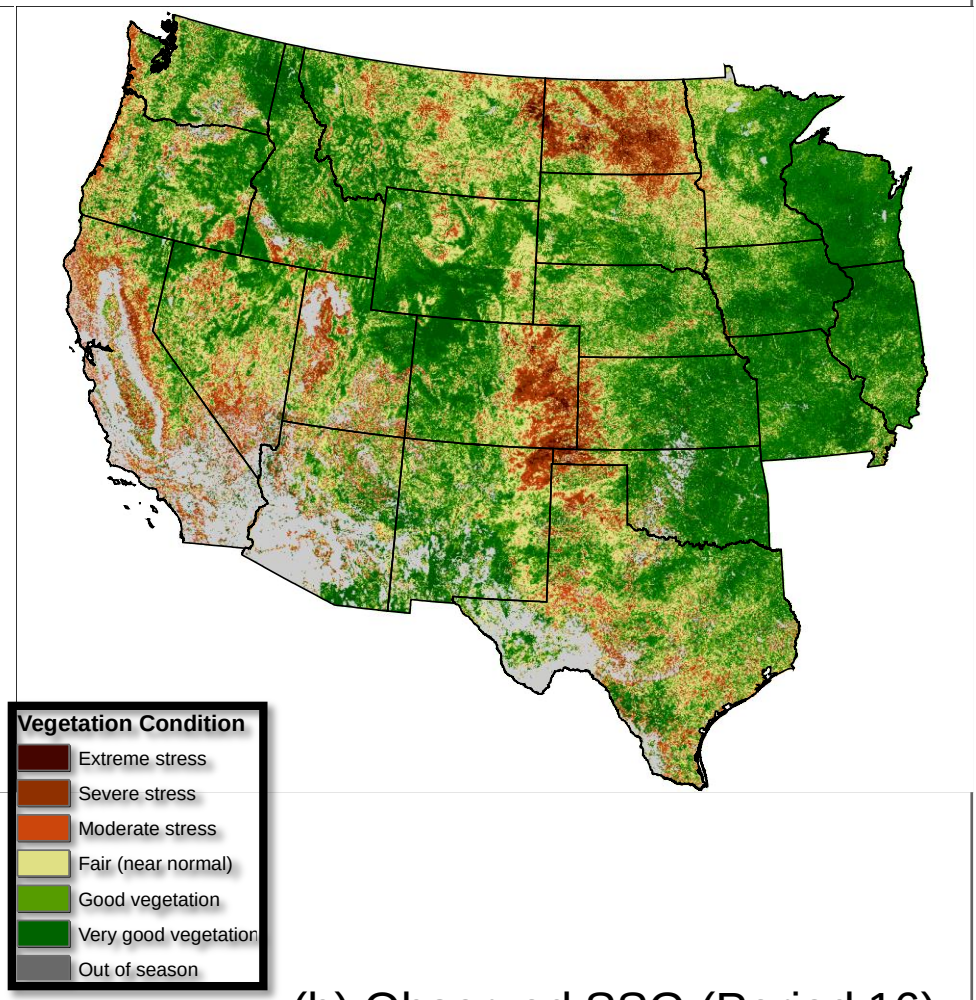
Table 3. (a), (b), and (c) show percentage contribution of individual variables (attributes) to the period 15 (July 14-28) VegOut models for 2-week, 4-week, and 6-week outlooks, respectively. At the top row of each table, the number of rules and cases for each individual model are shown. In the table, the *Conditional Statement* column shows the approximate percentage of cases for which the input variable appears in a condition of an applicable rule, and the *Regression Model* column gives the percentage of cases for which the variables appear in the model of applicable rules.

HOW ABOUT IN THE WESTERN U.S.?

Evaluation: Comparison of Two-week Outlook & Observed SSG



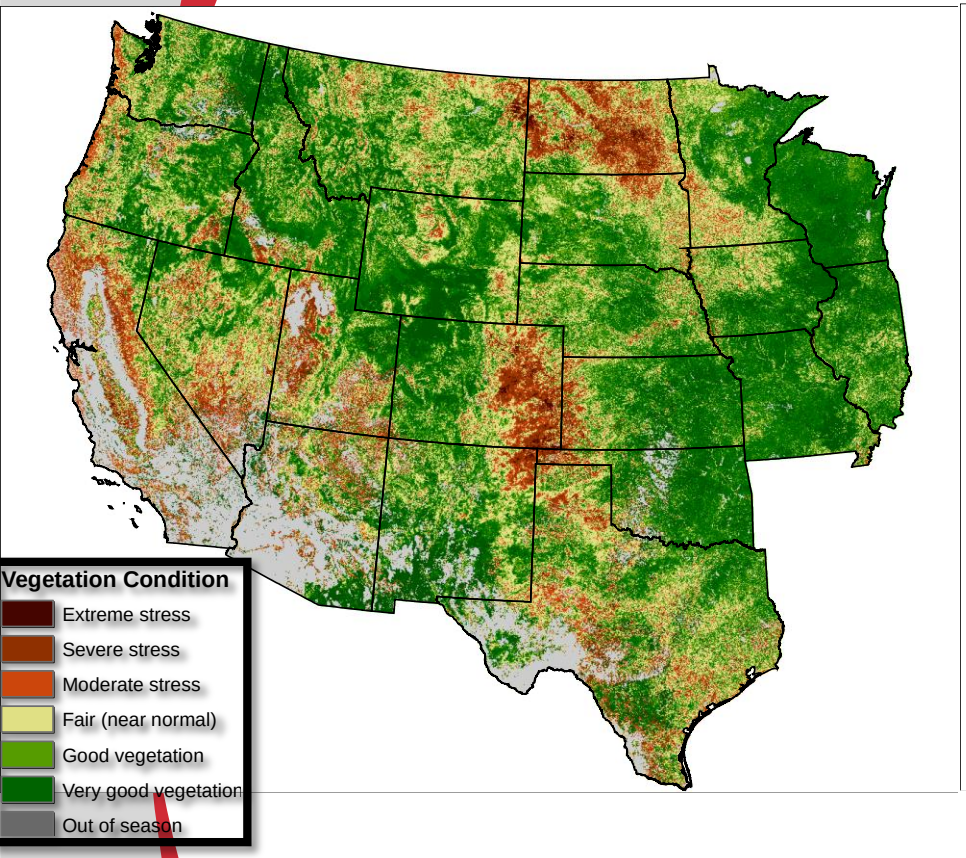
(a) 2-week outlook (for Period 16)

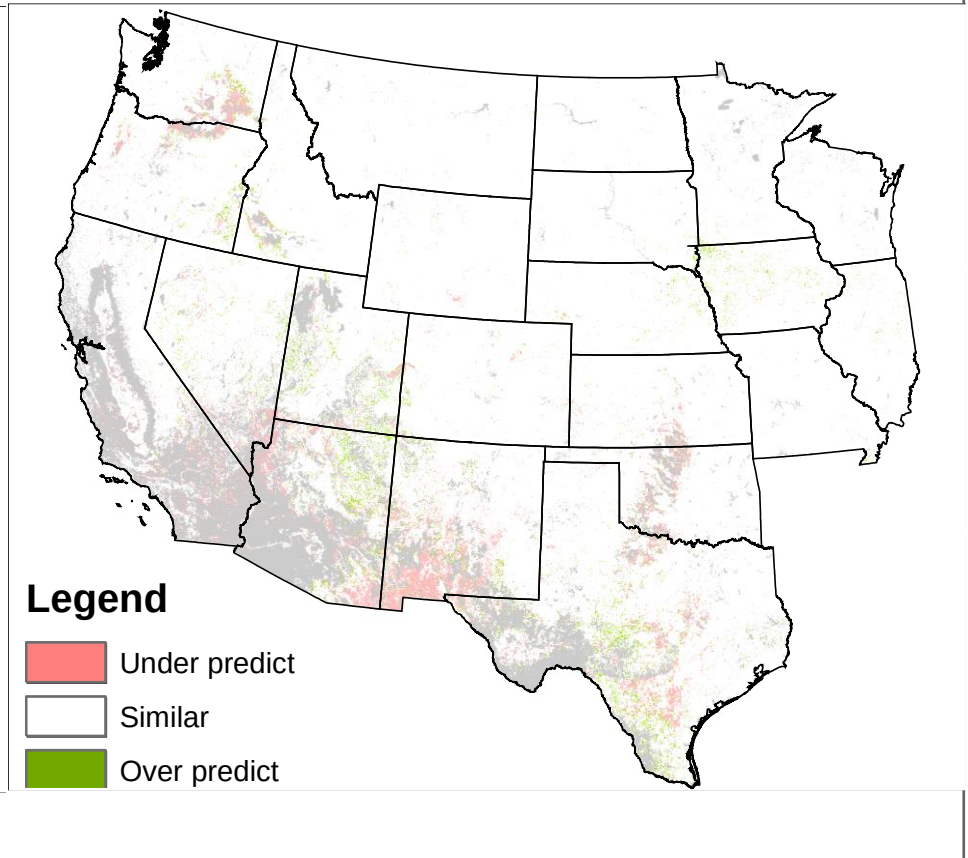


(b) Observed SSG (Period 16)

Figure 1. (a) Two-week Vegetation outlook (VegOut) map that was predicted for the period ending August 11, 2008; (b) Bi-weekly Standardized Seasonal Greenness (SSG) observed for the period ending August 11, 2008.

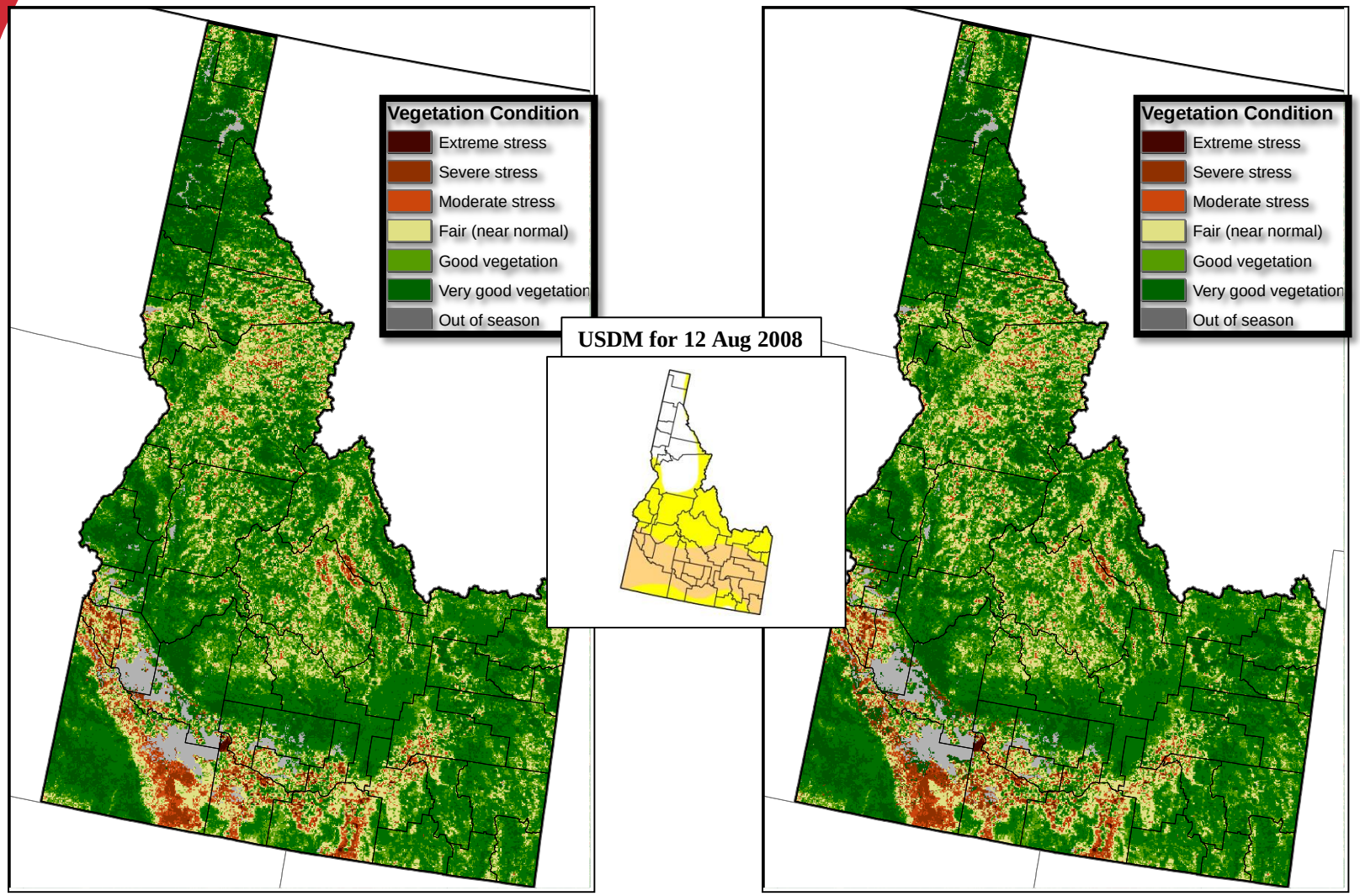
The Difference Map: Comparing two-week outlook with actual observation (VegOut minus the observed SSG)





(a) VegOUT (2-week outlook for Period 16, 11 Aug, 2008 based on 28 Jul, 2008 observed variables)
b) Difference Map (predicted minus observed) of Period 16

Evaluation: Comparison of Two-week Outlook & Observed SSG

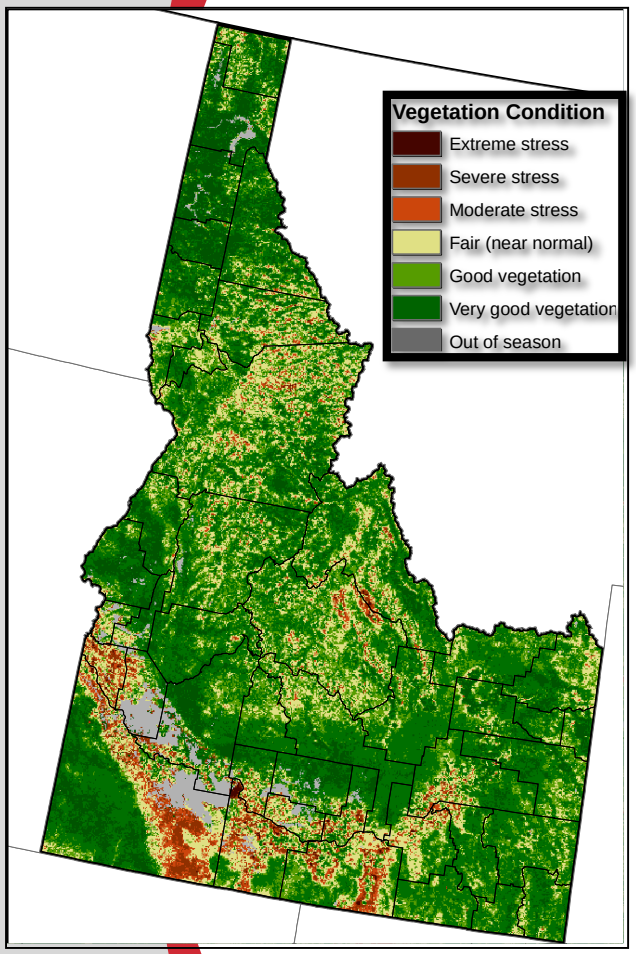


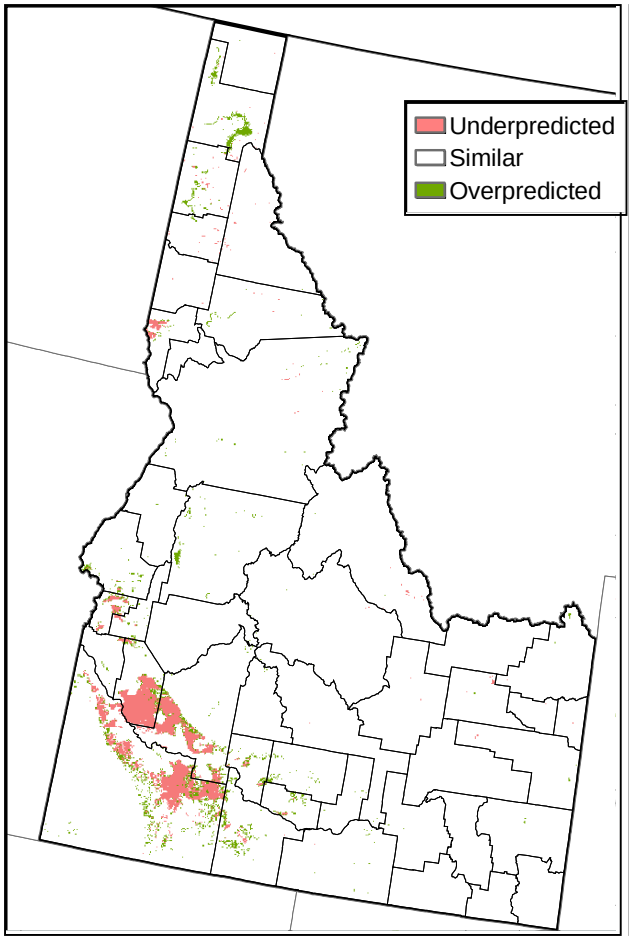
(a) 2-week outlook (for Period 16)

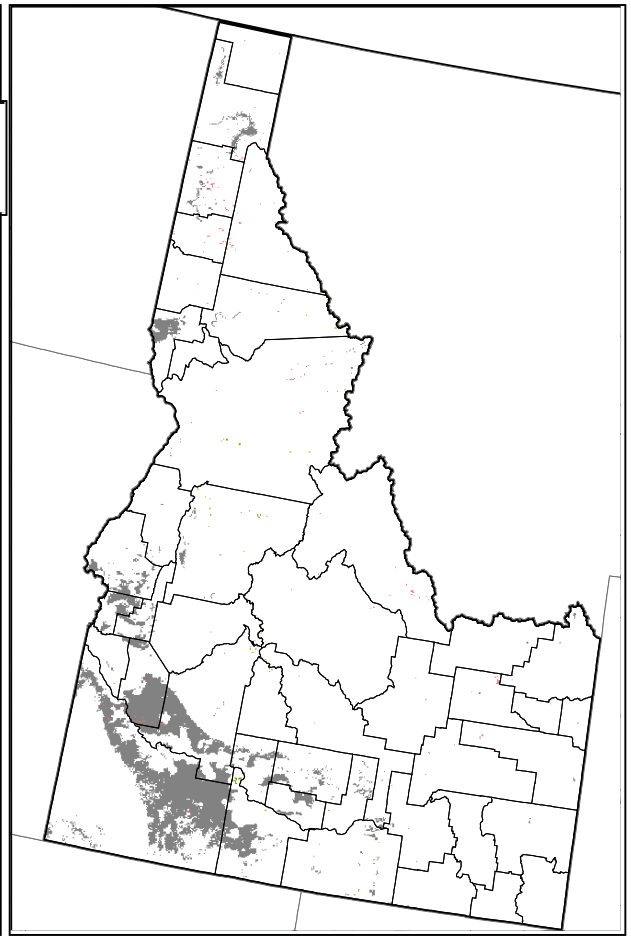
(b) Observed SSG (Period 16)

Figure 1. (a) Two-week Vegetation outlook (VegOut) map that was predicted for the period ending August 11, 2008; (b) Bi-weekly Standardized Seasonal Greenness (SSG) observed for the period ending August 11, 2008.

The Difference Map: Comparing two-week outlook with actual observation (VegOut minus the observed SSG)

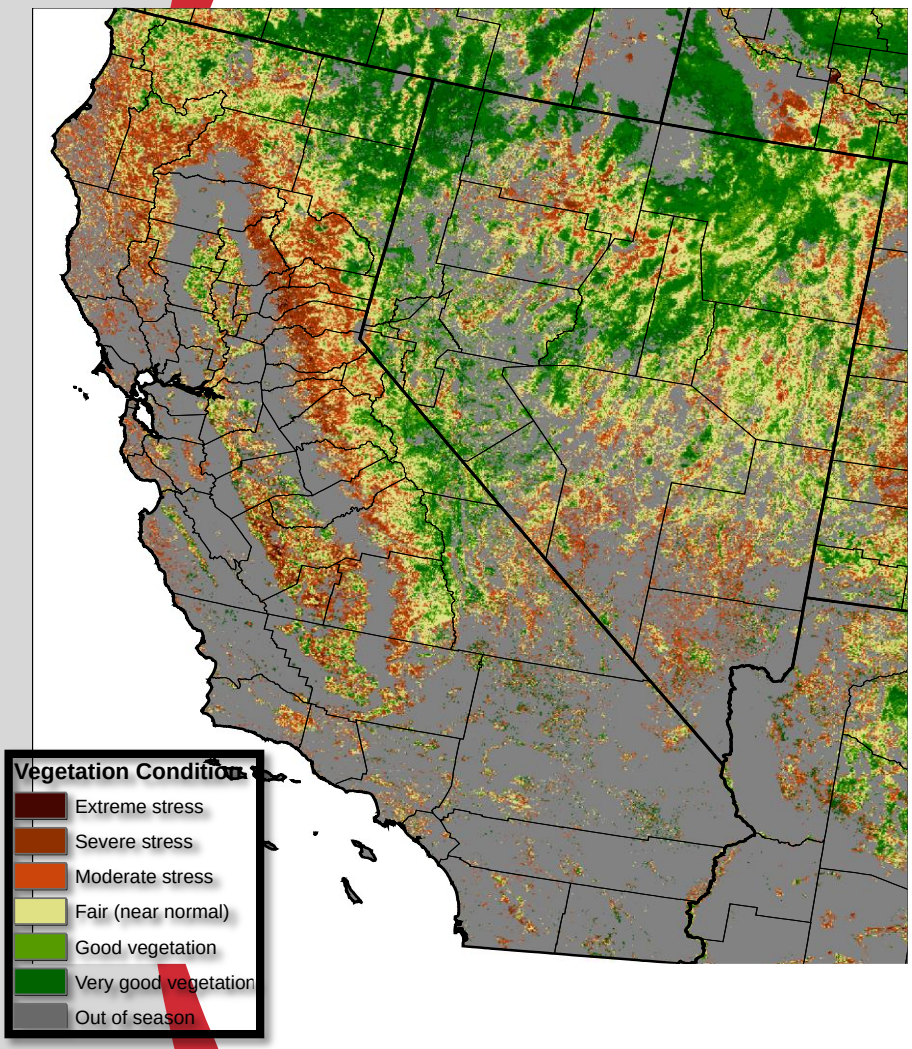


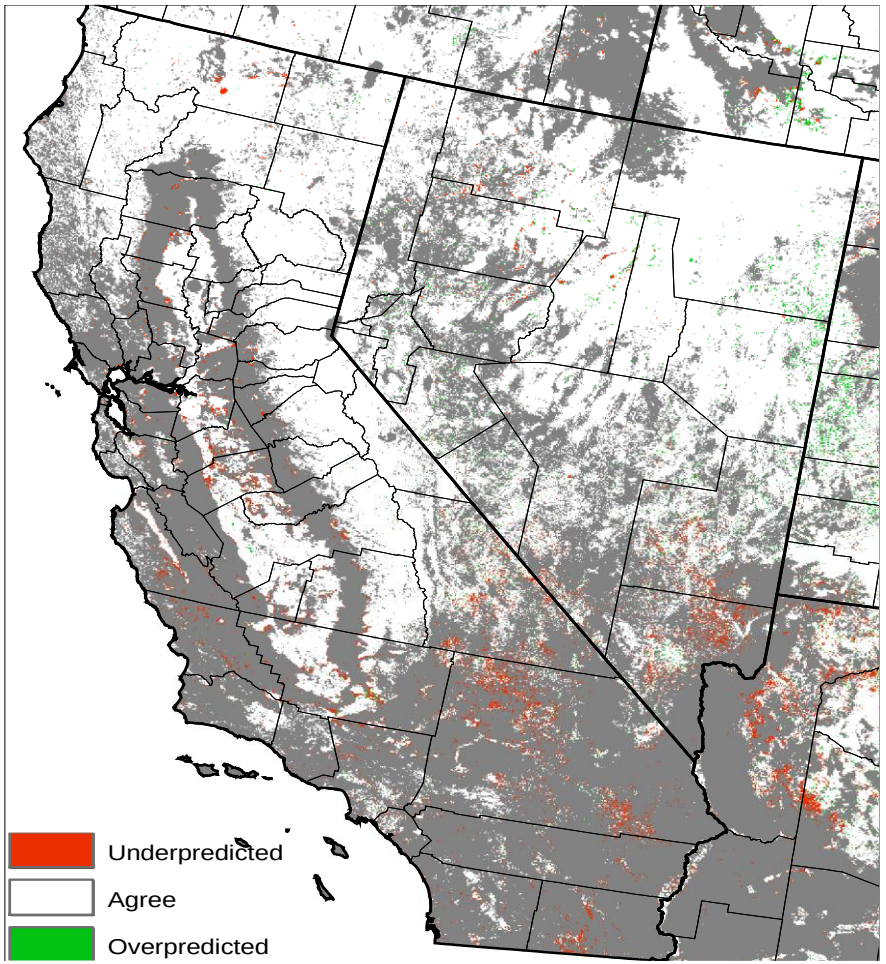




(a) VegOUT (2-week outlook for Period 16, 11 Aug, 2008 based on 28 Jul, 2008 observed variables)
b) Difference Map (predicted minus observed) of Period 16

The Difference Map: Comparing two-week outlook with actual observation (VegOut minus the observed SSG)





(a) VegOUT (2-week outlook for Period 16, 11 Aug, 2008 based on 28 Jul, 2008 observed variables)
b) Difference Map (predicted minus observed) of Period 16

VegOut- Scenario model

Model

- Method: Given the current independent variables listed, what would be the value in the following 2 week based on the dry, wet, and normal precip scenarios?

- $VegOut_{t=2\ wk} = f_{t=0}$ (SSG, MRLC, Eco_R, Per_Irrig, AWC, SoS_anom) + $f_{t=bestCorrelated}$ (MEI, MJO_RMM1, NAO, PDO, SOI, AMO, JAM, ONI, PNA) + $f(SPI_{t=2wk_scenario})$

- Where $VegOut_{t=2\ wk}$ is two-week prediction of SSG based on the historical pattern identified by the regression tree model;
- $SPI_{t=2wk_scenario}$ is:
  - **a)** **Scenario 1 (dry):** e.g., precipitation expected to be less than 50 % of normal
  - **b)** **Scenario 2 (near normal):** e.g., precipitation expected to be between 50 & 150 %
  - **c)** **Scenario 3 (wet):** e.g., precipitation expected to be more than 150 % of normal

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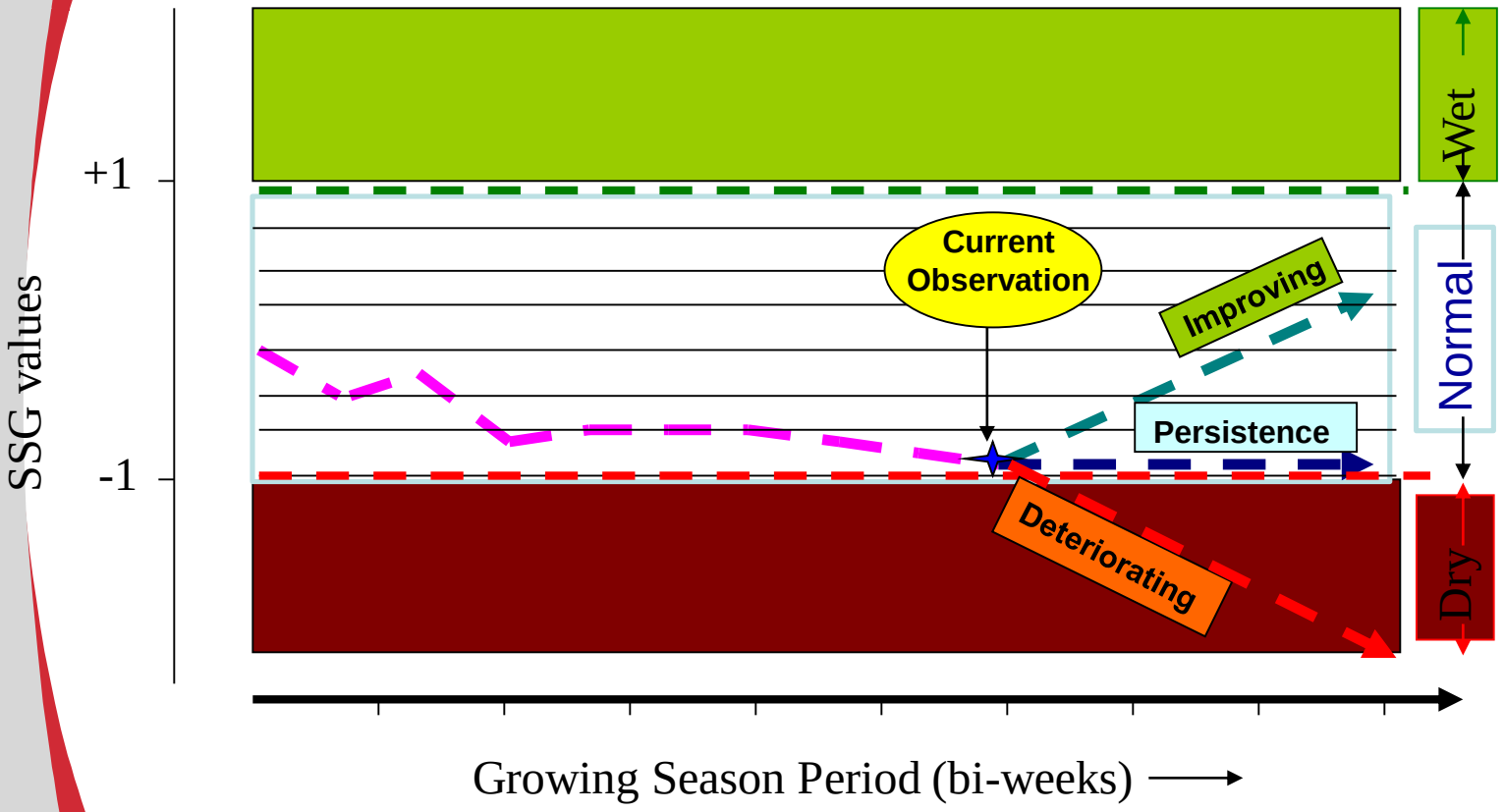
E.g., Projected Trends of Vegetation Conditions

VegOut Trends

("Whisk-broom" method)



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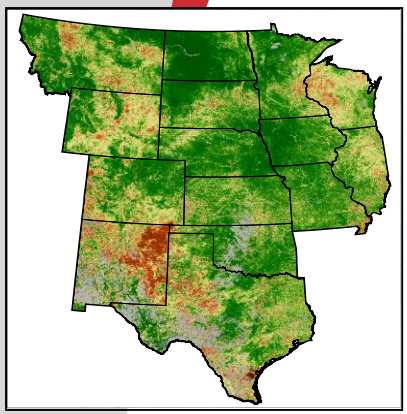
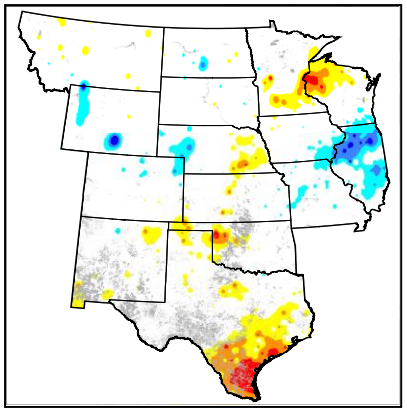
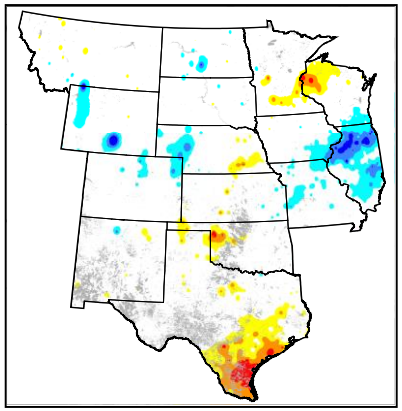
Examples of Scenario-VegOut for different episodes (i.e., dry, normal, and wet conditions)



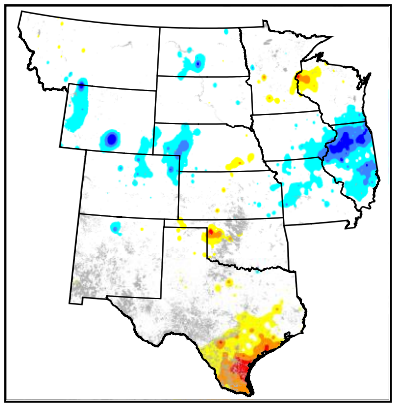
(a) SSG for 13 July 2009



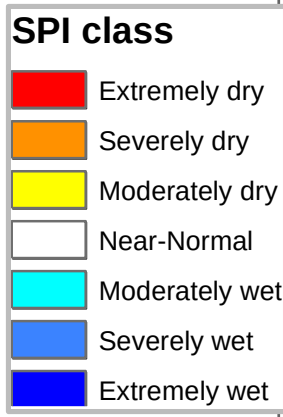
(c) Dry scenario 36-week SPI for 27 July 2009

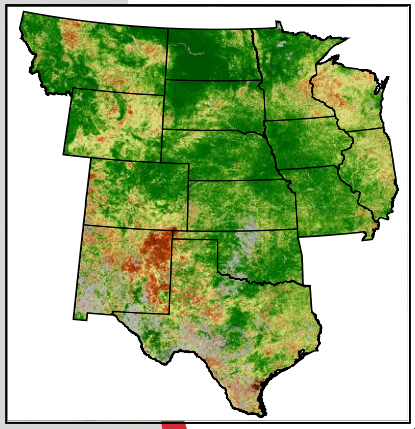


(e) Normal scenario 36-week SPI for 27 July 2009

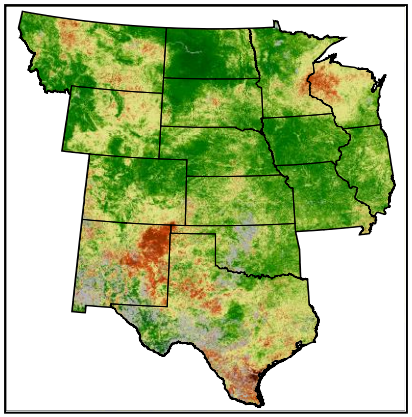


(g) Wet scenario 36-week SPI for 27 July 2009

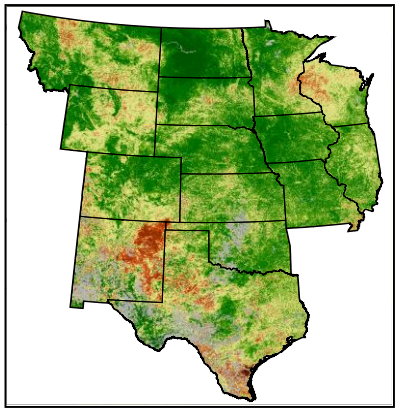




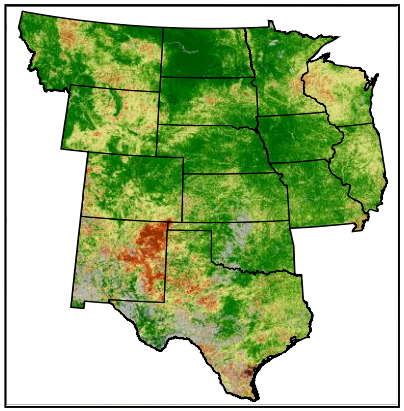
(b) SSG for 27 July 2009



d) Dry scenario-VegOut for 27 July 2009



(f) Normal scenario-VegOut for 27 July 2009



(h) Wet scenario-VegOut for 27 July 2009

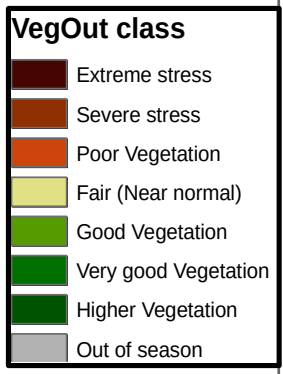


Figure 3. Observed and predicted SSG and 36-week SPI. [Figure 3a and 3b are the observed standardized seasonal greenness (SSG) for 13 and 27 Jul 2009. Figures 3c, 3e, and 3g show the predicted 50%, 100%, and 150% SPI for 27 July 2009; Figures 3d, 3f, and 3h show the corresponding vegetation outlook (S-VegOut) for each scenario, respectively.]

Climate Outlooks Resources

- Expert knowledge
- Climate Prediction Center
  - http://www.cpc.ncep.noaa.gov/index.htm
- National Drought Mitigation Center
  - http://www.drought.unl.edu/dm/forecast.html

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How do we improve the VegOut model?

- Assess temporal and spatial relationships between
  - Climate & vegetation dynamics
  - Oceanic dynamics & climate
  - Spatial variability of drought indices
- Use this relationships to determine which variables to integrate in modeling the VegOut to improve its accuracy
- Evaluation based on feedback from users & potential users (e.g., ranchers, university extention agents, and managers)

Future Activities

- Experimental maps will be posted online
- Semi-operational VegOut maps planned for the central U.S. in the 2010 growing season
- Evaluation over the central U.S. region is under progress including:
  - Expert assessments
  - Users feedback
- Expanding the areas to the western & eastern U.S.?

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Thank You!

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