Applications of NASA Data for Natural Resource Management:

SMAP soil moisture for USDA Forest Service Rangeland Monitoring

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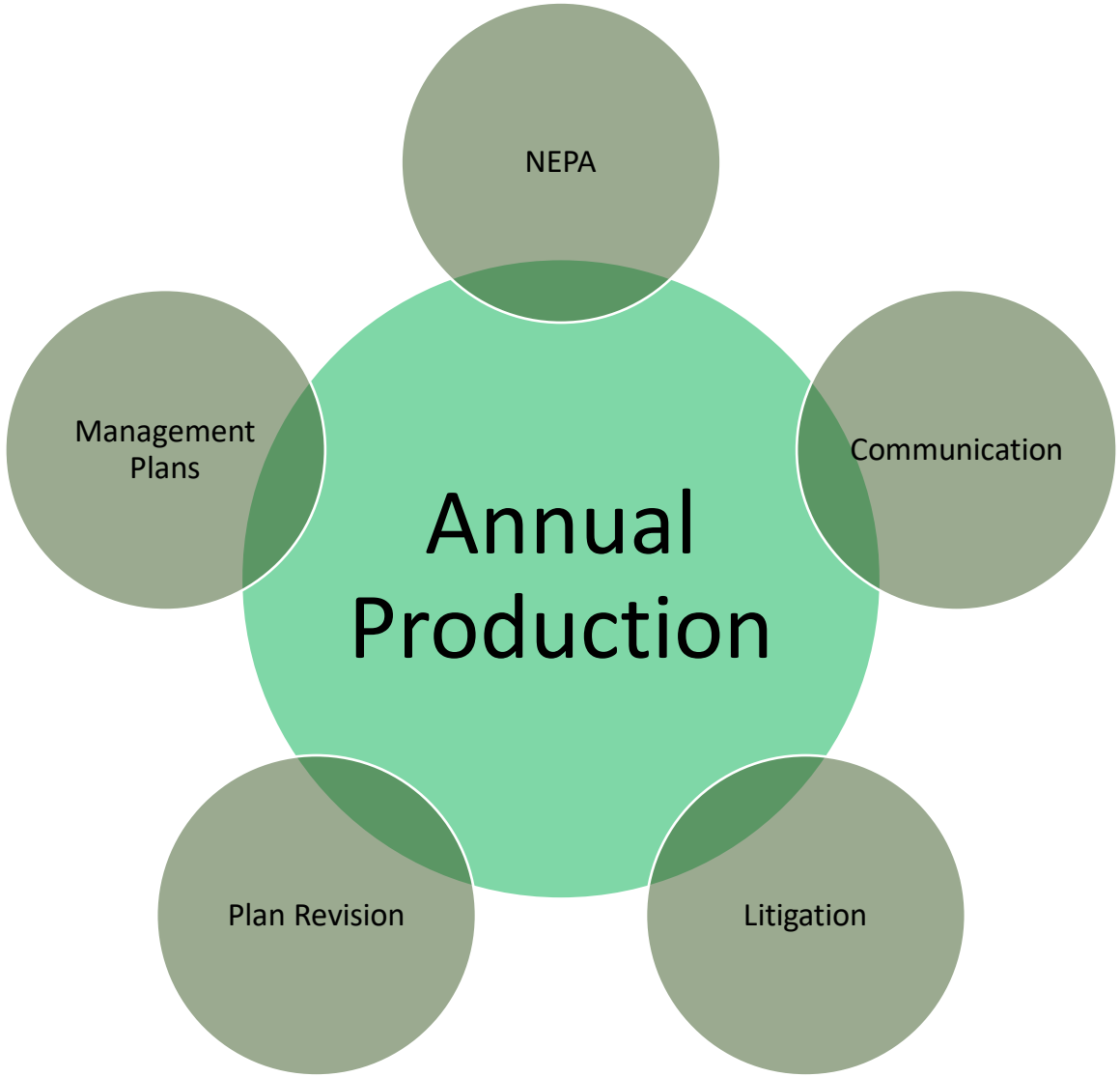
The USFS is required by law to **develop** and **adhere** to an analysis schedule for all of its **grazing allotments**.

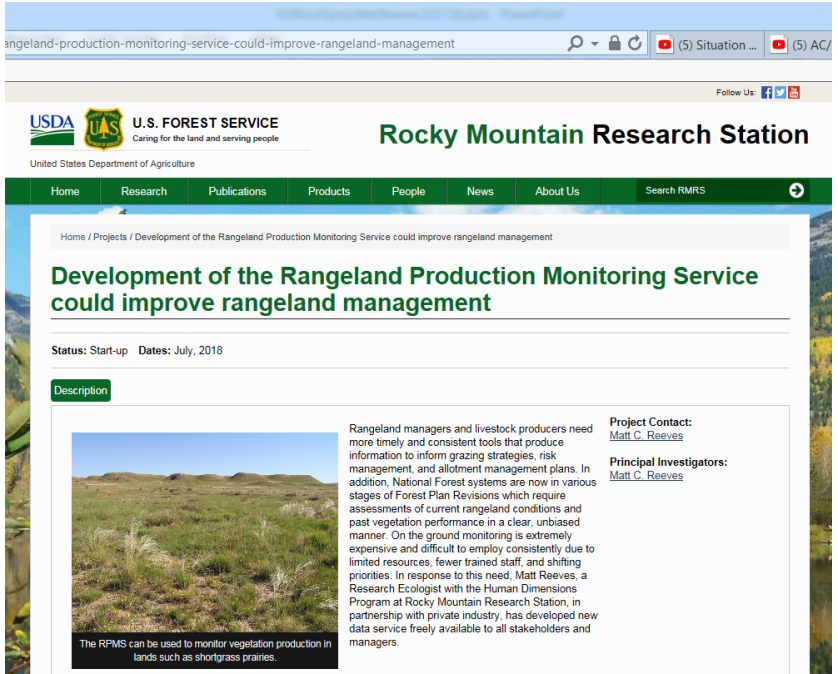
The USFS is facing **challenges** in meeting its analysis targets for numerous reasons including **cost**, **capacity issues**, and **appeals & litigation**.

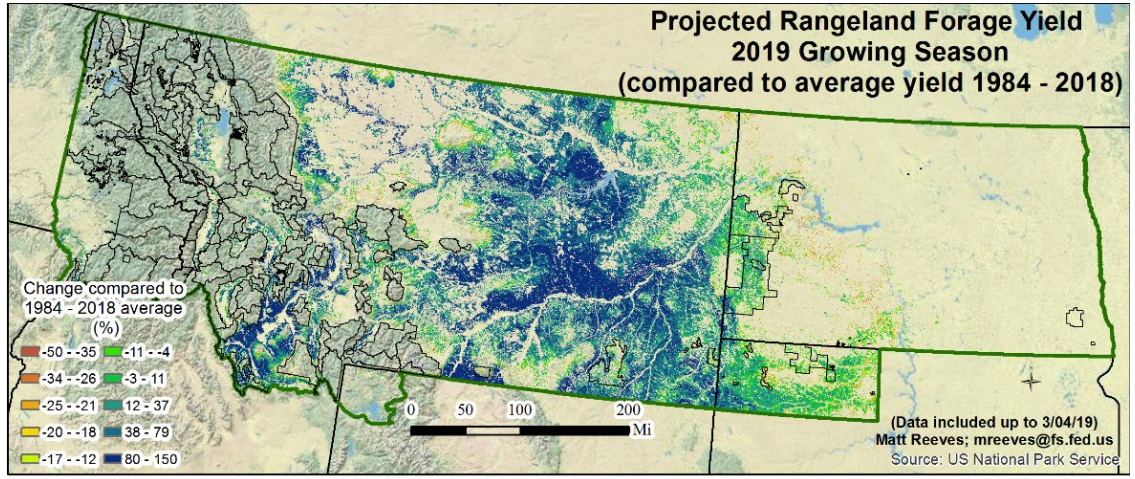
Deer on rangelands. Photo credit: Natural Resources Conservation Service


NEPA
Management Plans
Communication
Annual Production
Plan Revision
Litigation

The Rangeland Production Monitoring Service (RPMS)

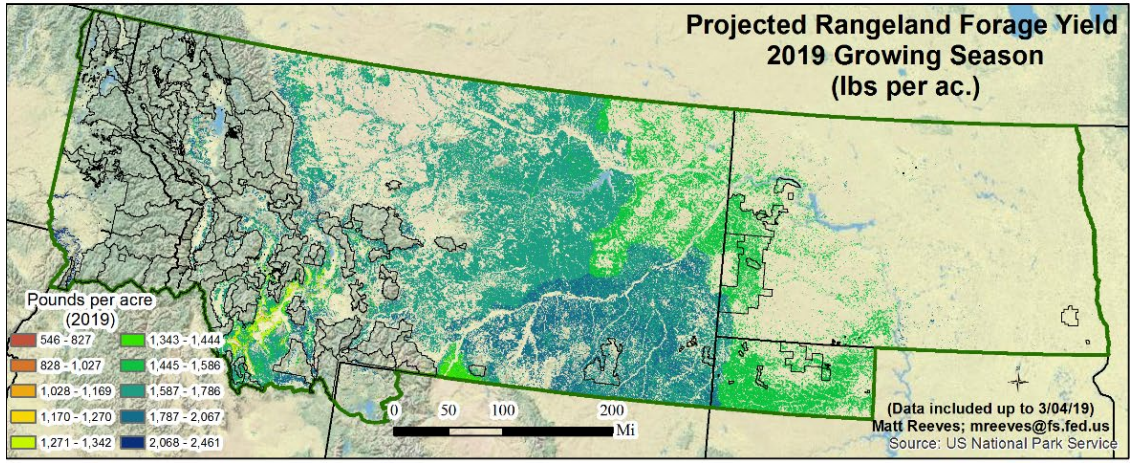
- Based on TM and MODIS satellite suites
  - Hosts 2 services:
    - *Retrospective (where have we been)?*
    - *In season, near real time forage projections*

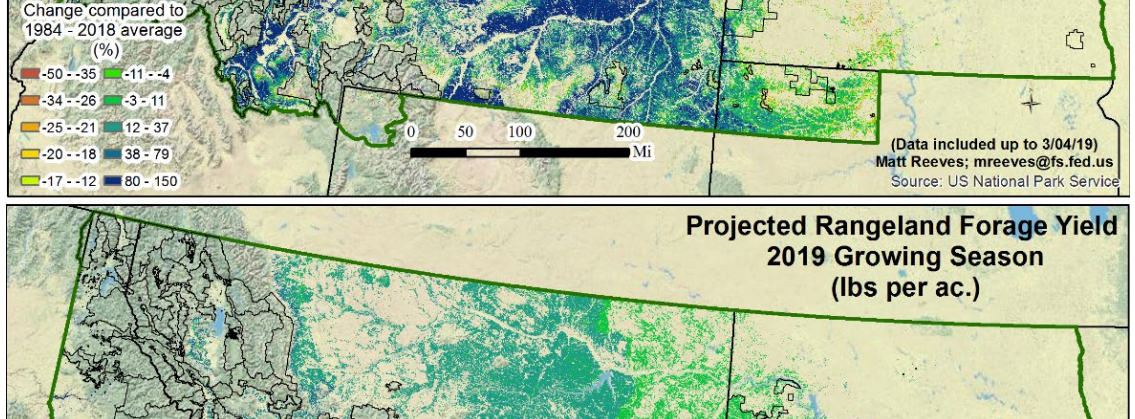




Yield compared with 35 yr average

In season, near real time forage projections

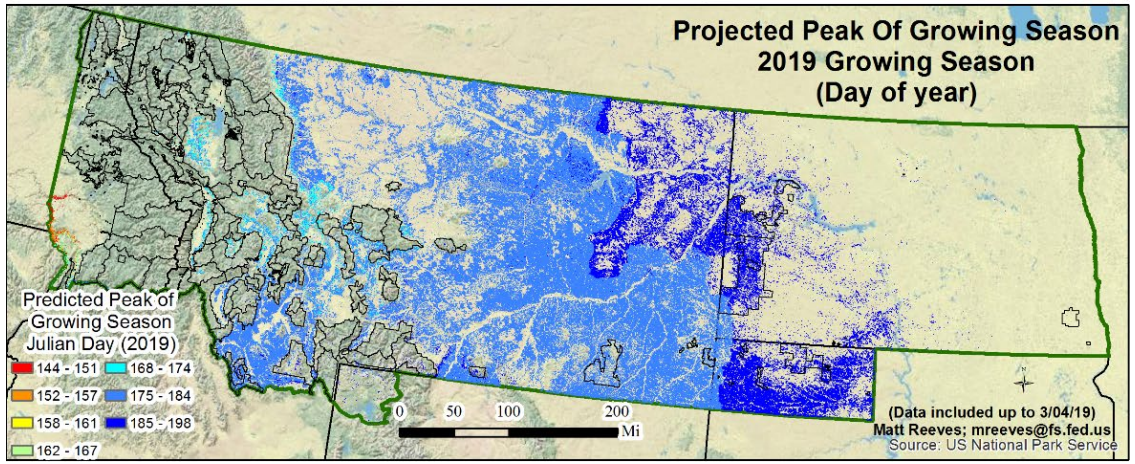




Yield pounds per acre

Begins March 1 each year!!

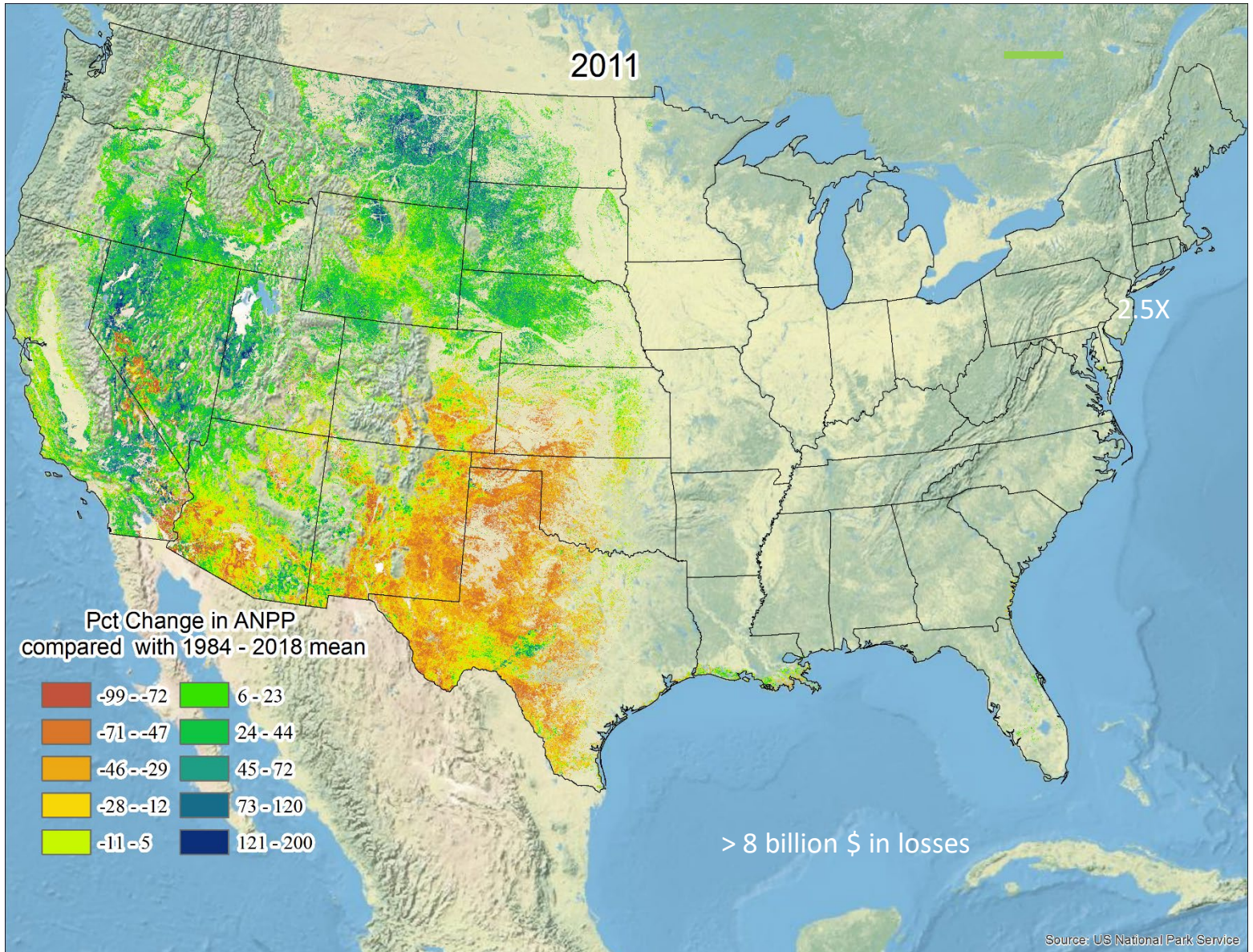
https://www.lankstonconsulting.com/data-warehouse



Peak of season

https://www.fs.fed.us/rmrs/projects/development-rangeland-production-monitoring-service-could-improve-rangeland-management

Background


2011
2.5X
Pct Change in ANPP
compared with 1984 - 2018 mean
-99 - -72
-71 - -47
-46 - -29
-28 - -12
-11 - 5
6 - 23
24 - 44
45 - 72
73 - 120
121 - 200
> 8 billion $ in losses
Source: US National Park Service

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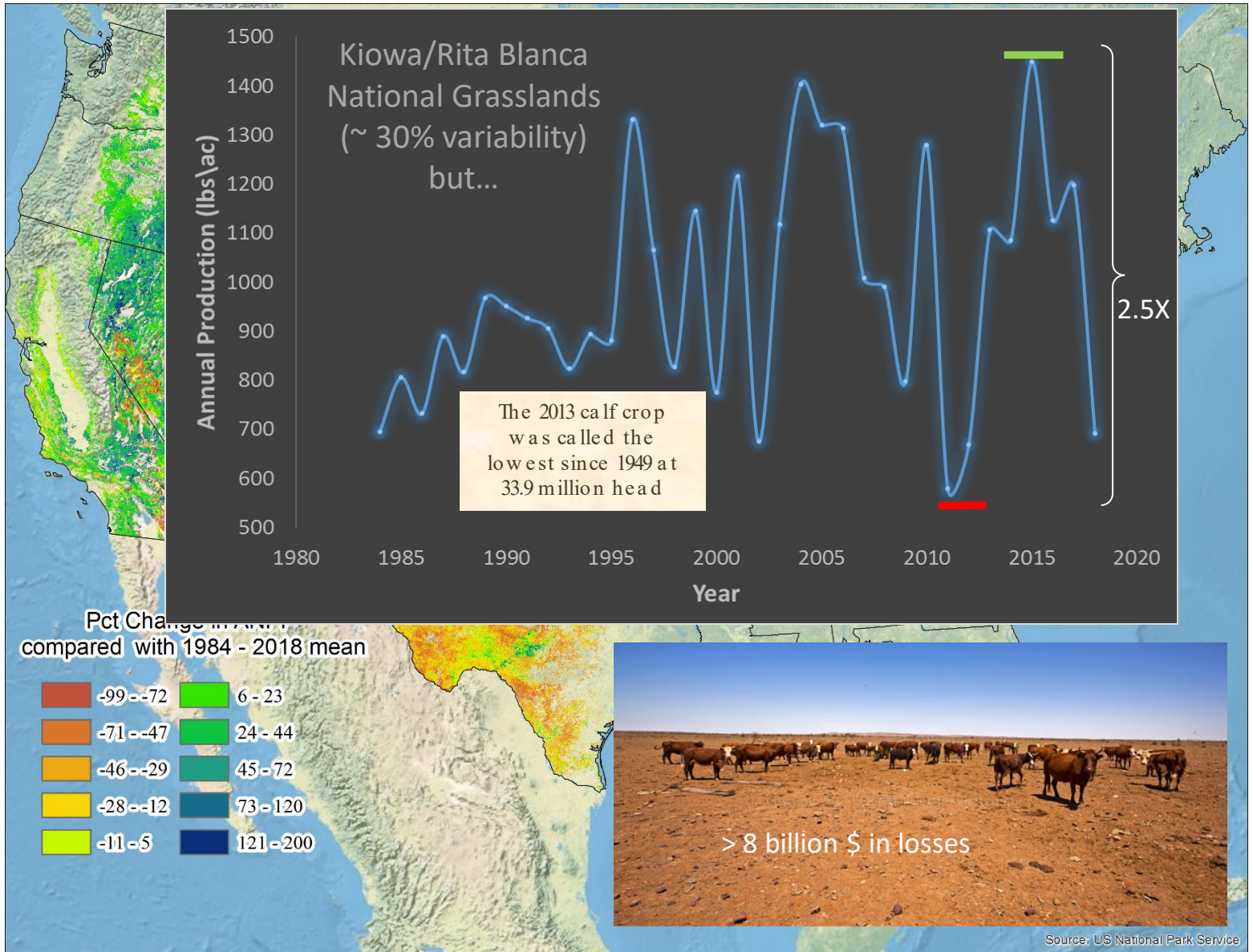
Kiowa/Rita Blanca National Grasslands (~ 30% variability) but…
Annual Production (lbs\ac)
1500
1400
1300
1200
1100
1000
900
800
700
600
500
1980
1985
1990
1995
2000
2005
2010
2015
2020
Year
2.5X
The 2013 calf crop was called the lowest since 1949 at 33.9 million head
compared with 1984 - 2018 mean
-99 - -72
-71 - -47
-46 - -29
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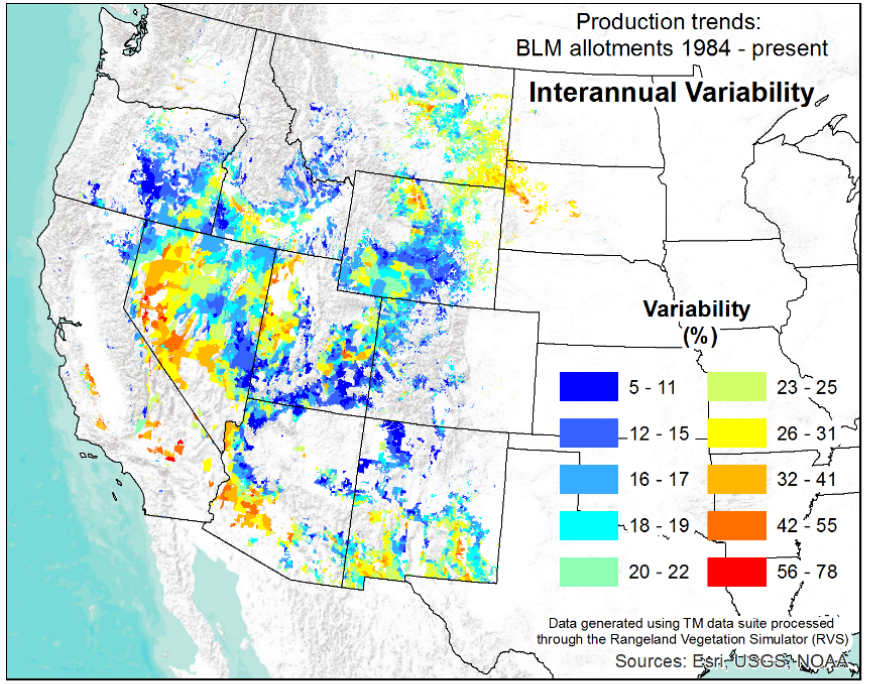
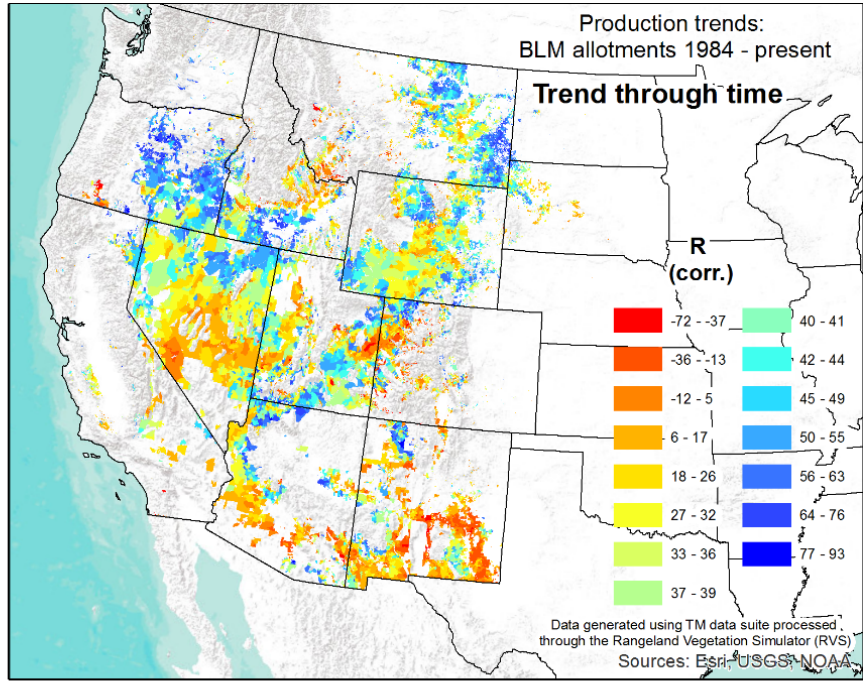

Production trends:
BLM allotments 1984 - present
Interannual Variability
Variability
(%)
5 - 11
12 - 15
16 - 17
18 - 19
20 - 22
23 - 25
26 - 31
32 - 41
42 - 55
56 - 78
Data generated using TM data suite processed through the Rangeland Vegetation Simulator (RVS)
Sources: Esri, USGS, NOAA


Production trends:
BLM allotments 1984 - present
Trend through time
R
(corr.)
-72 - -37
-36 - -13
-12 - 5
6 - 17
18 - 26
27 - 32
33 - 36
37 - 39
40 - 41
42 - 44
45 - 49
50 - 55
56 - 63
64 - 76
77 - 93
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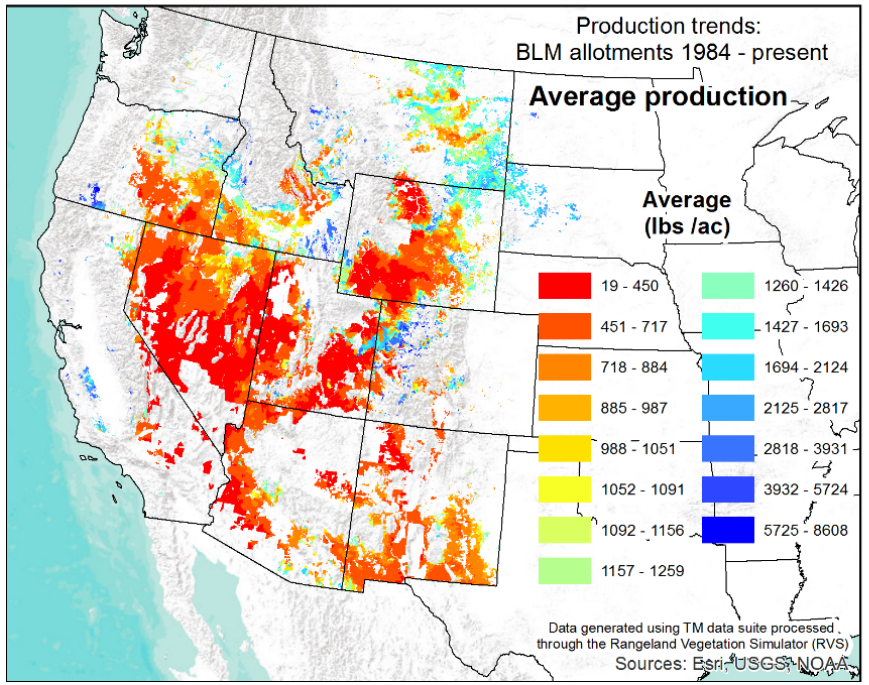
Production trends:
BLM allotments 1984 - present
Average production
Average
(lbs /ac)
19 - 450
451 - 717
718 - 884
885 - 987
988 - 1051
1052 - 1091
1092 - 1156
1157 - 1259
1260 - 1426
1427 - 1693
1694 - 2124
2125 - 2817
2818 - 3931
3932 - 5724
5725 - 8608
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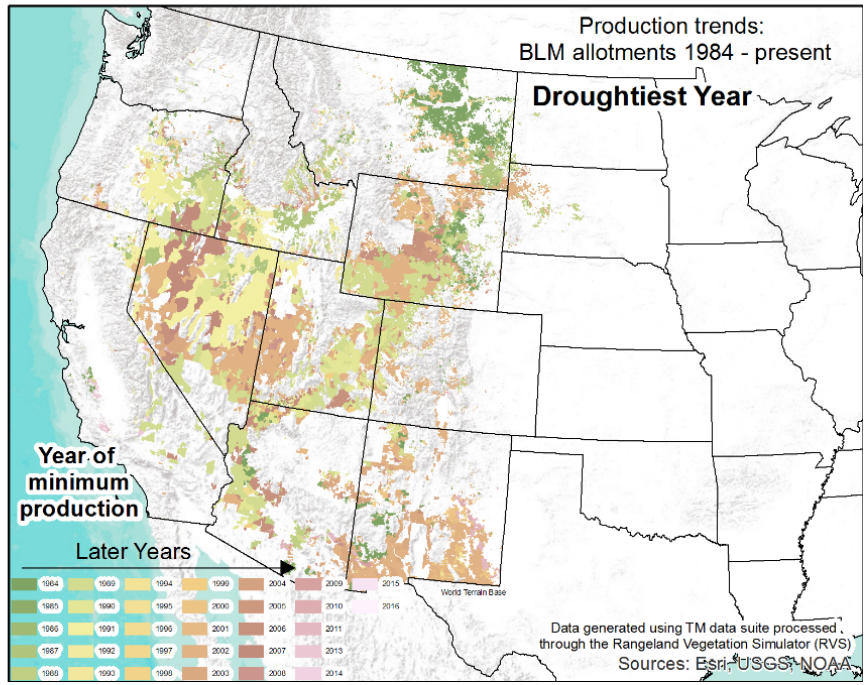
Production trends:
BLM allotments 1984 - present
Droughtiest Year
Year of
minimum
production
Later Years
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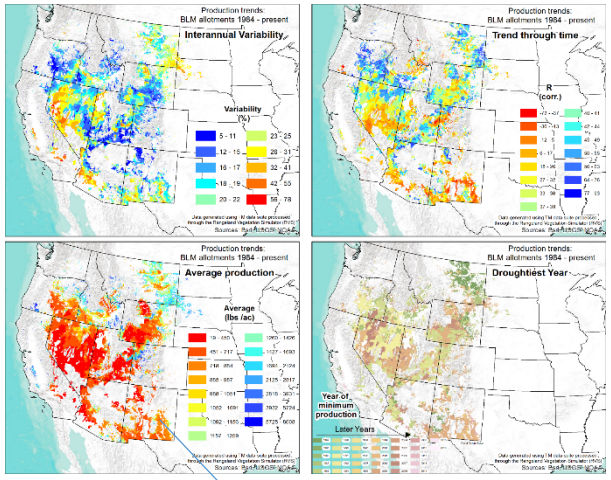
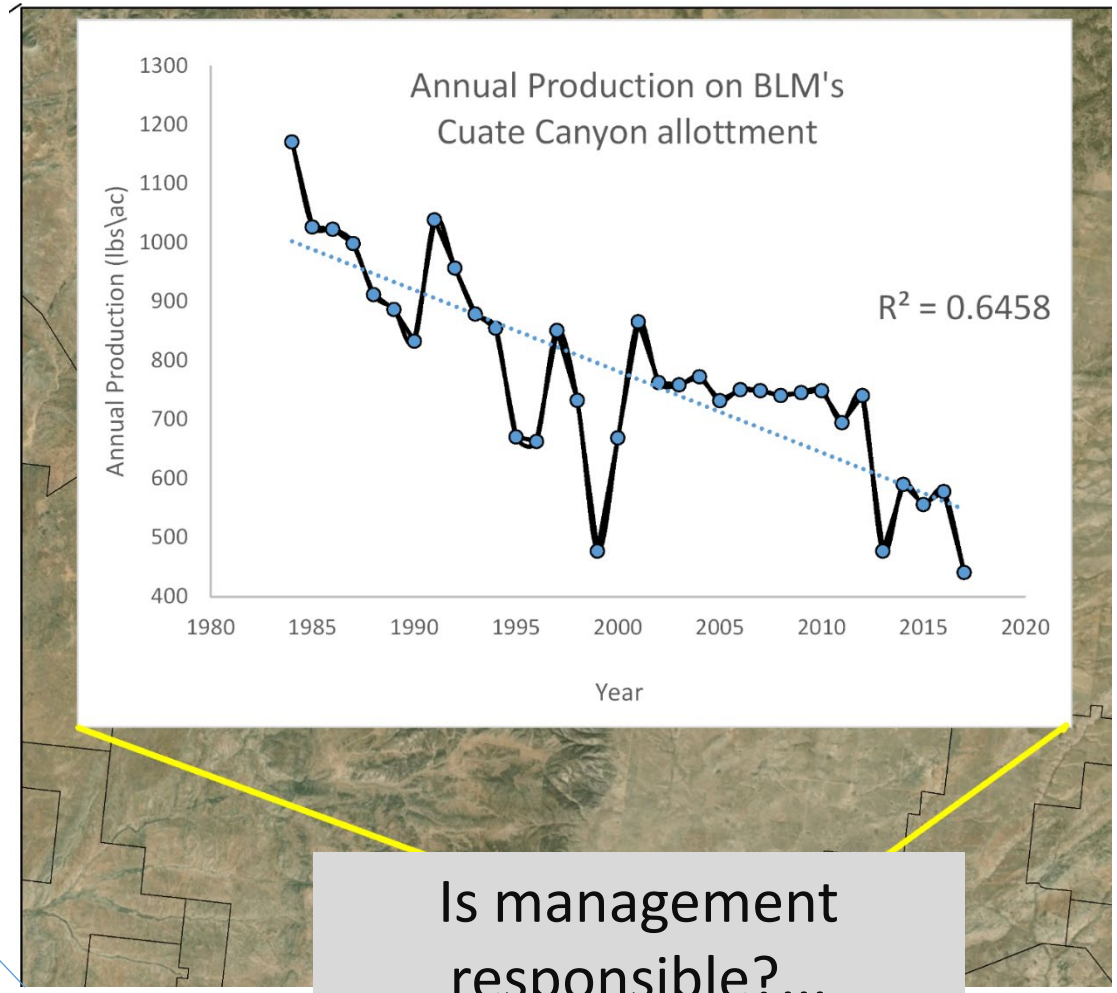
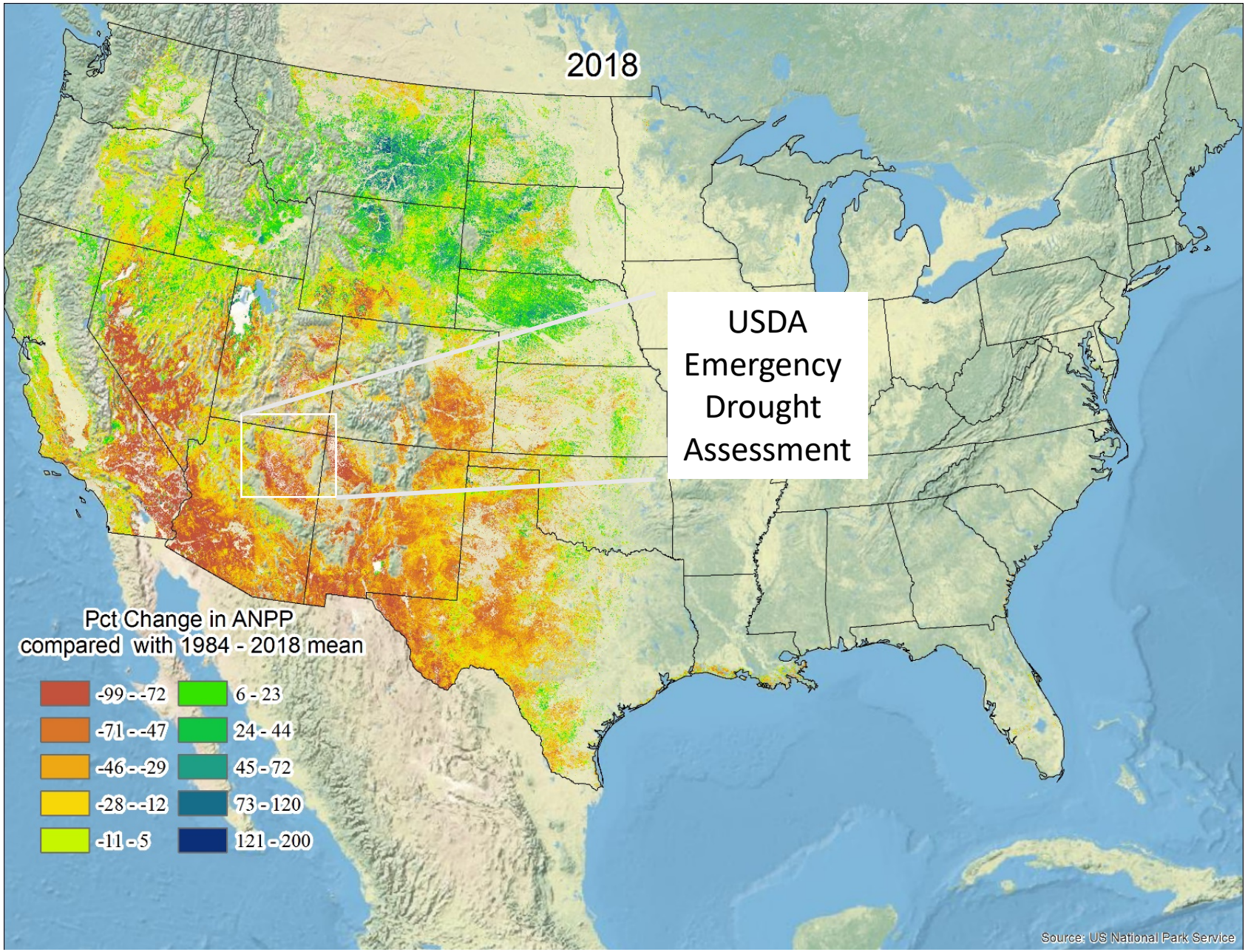




Is management responsible?... <u>probably not</u>



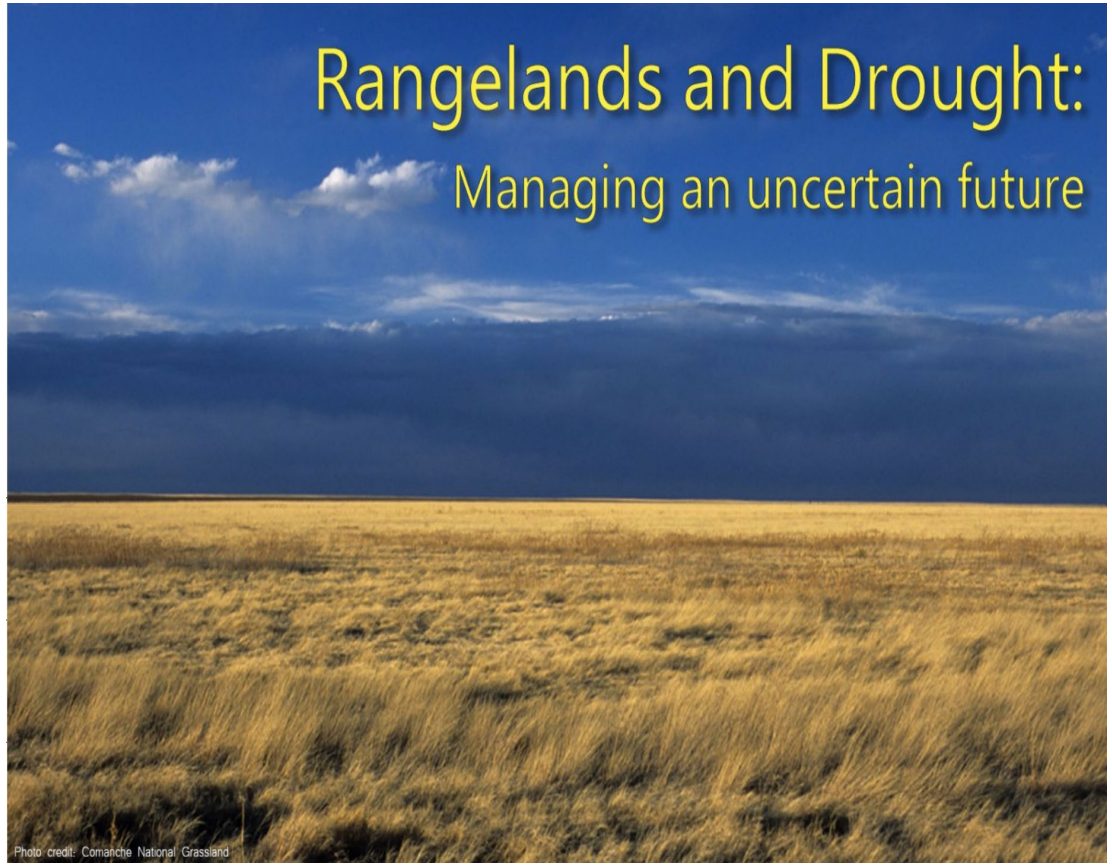
Emergency Drought Situation

>50% reduction on
~ 1 million acres

This monitor has formed basis for
~ 15 million to re-seed

How do you use NASA data product(s)?

"To make decisions about rangelands that are backed by science, the agency needs a tool that delivers easy to understand information on rangeland conditions and trends."

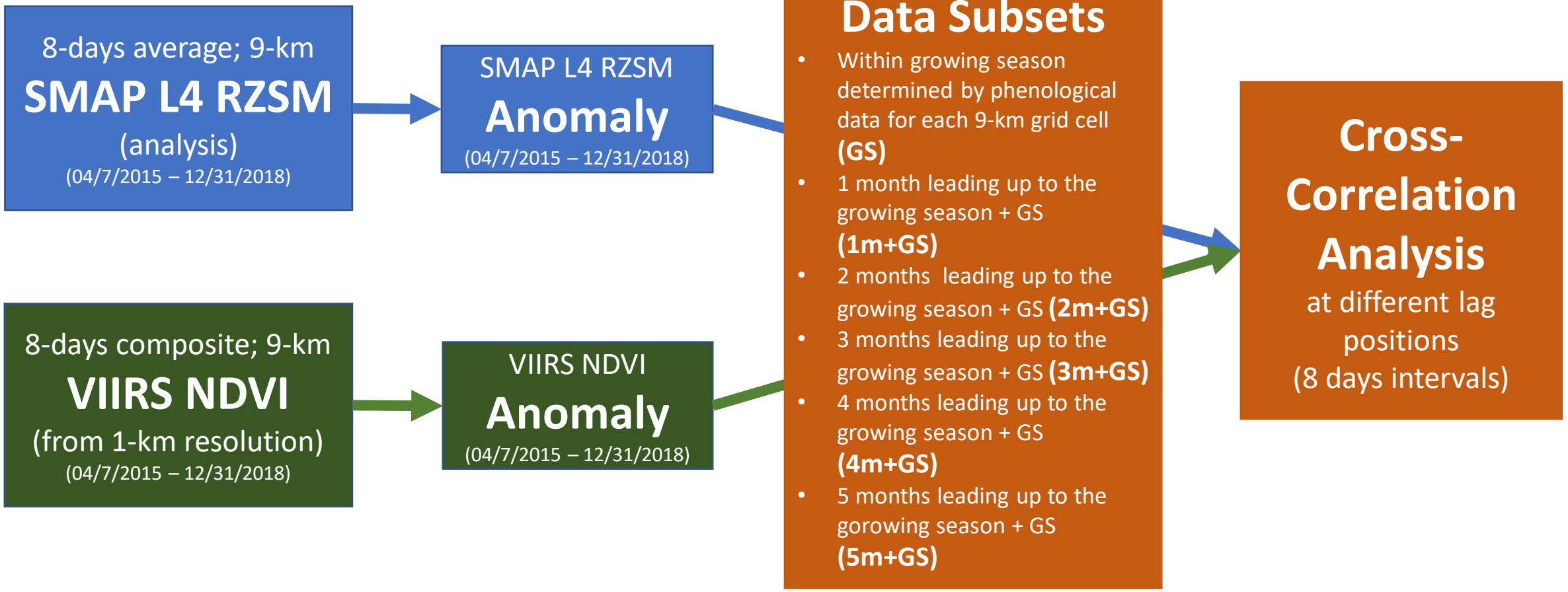


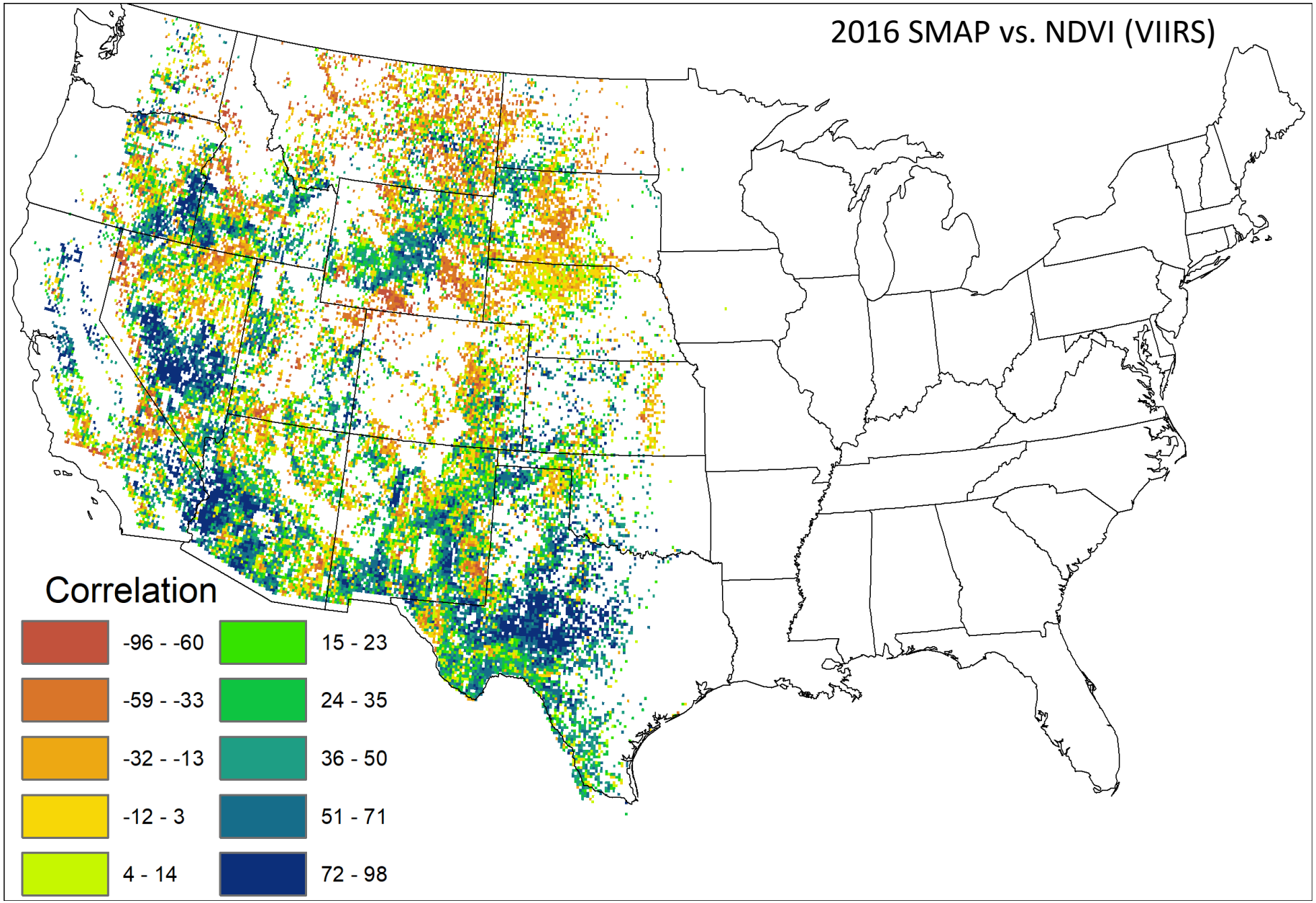
- Develop production monitors (MODIS + TM suite)
- Evaluate the relationship between rangeland production and drought monitors
- Investigate use of **SMAP** as part of this broader study

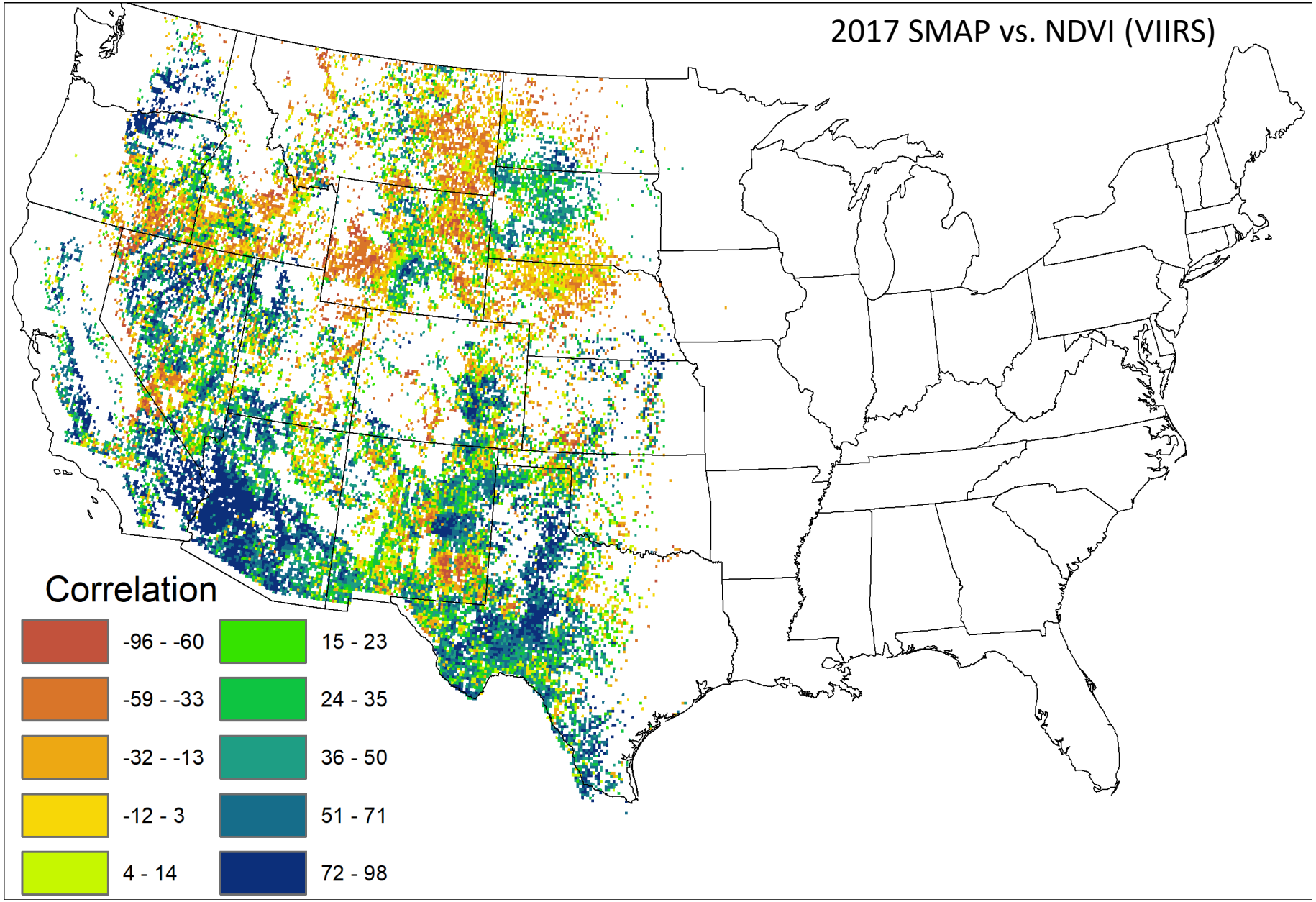
Can SMAP data product(s) help improve the USFS Rangeland Monitoring tool?

- **Does rangeland *productivity* (NDVI as a proxy) correlate with SMAP *root zone soil moisture*?**
- **Can SMAP be used as a *forward-looking indicator* for an early alert system (*where, how early*)?**

USFS Rangeland Monitoring Tool




2016 SMAP vs. NDVI (VIIRS)
Correlation
-96 - -60
-59 - -33
-32 - -13
-12 - 3
4 - 14
15 - 23
24 - 35
36 - 50
51 - 71
72 - 98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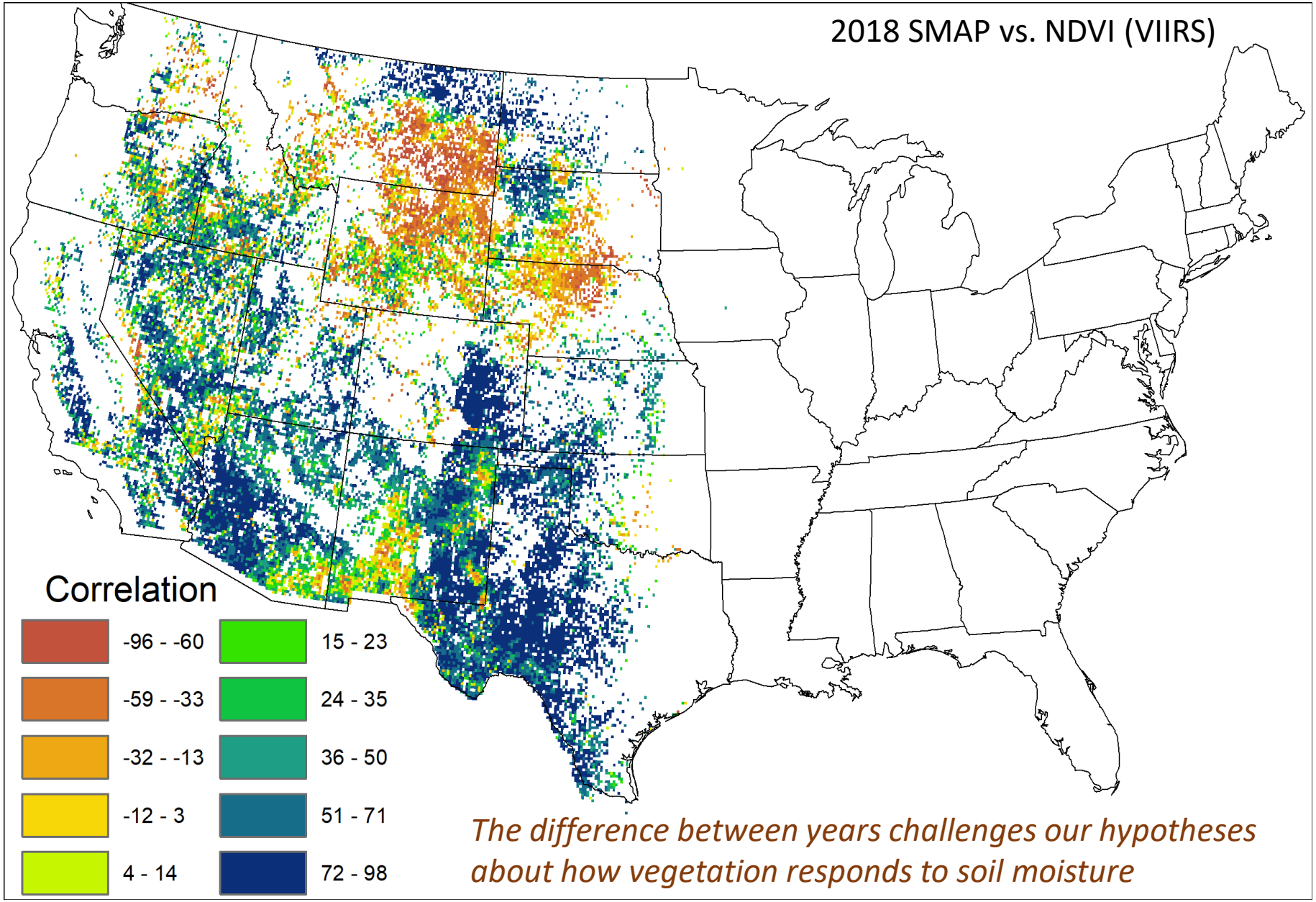
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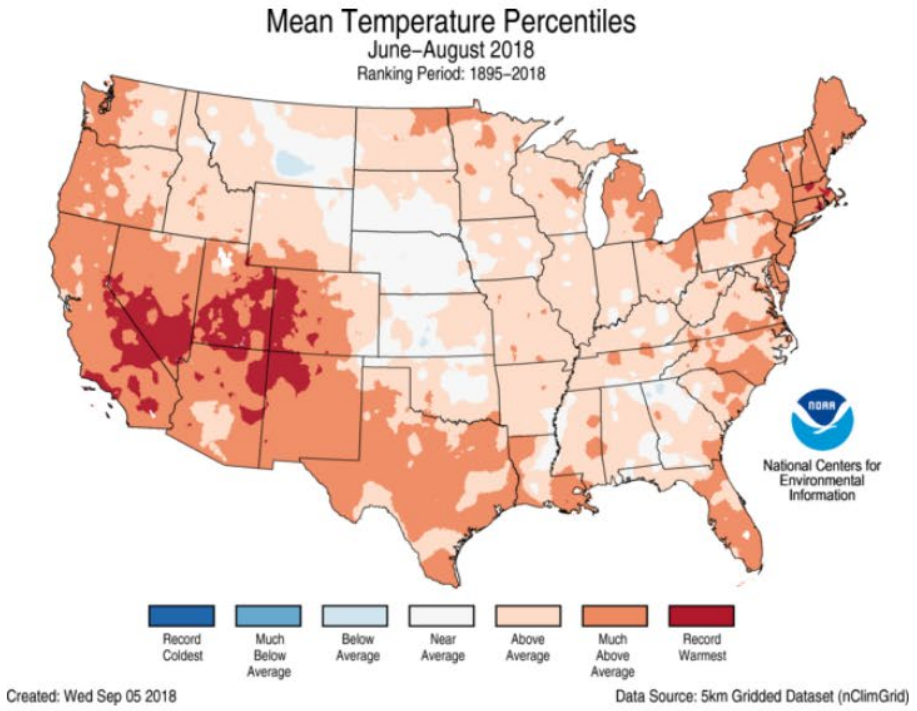
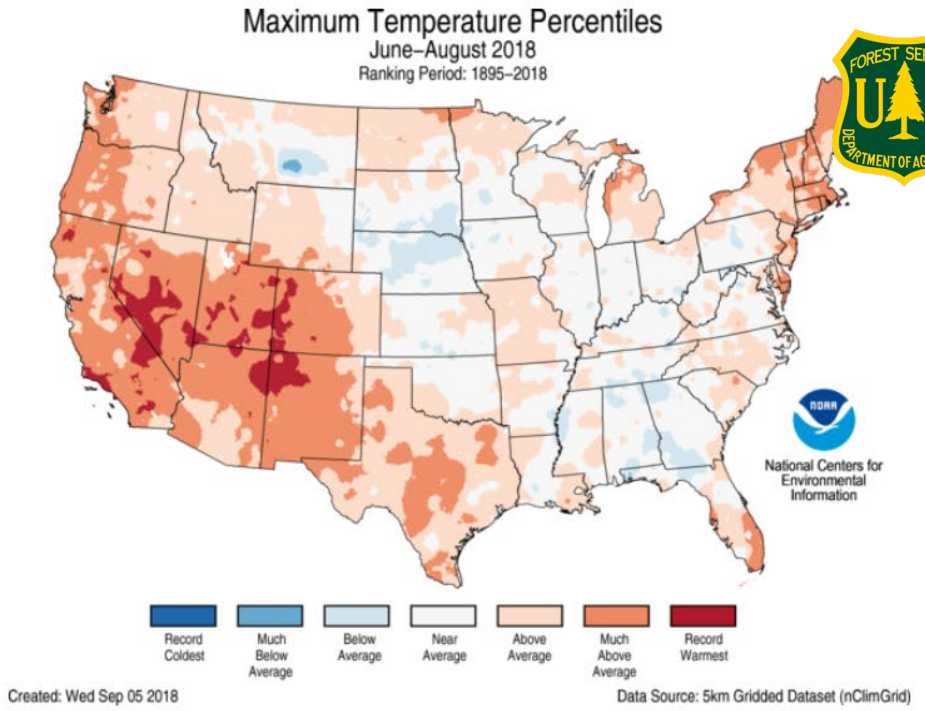
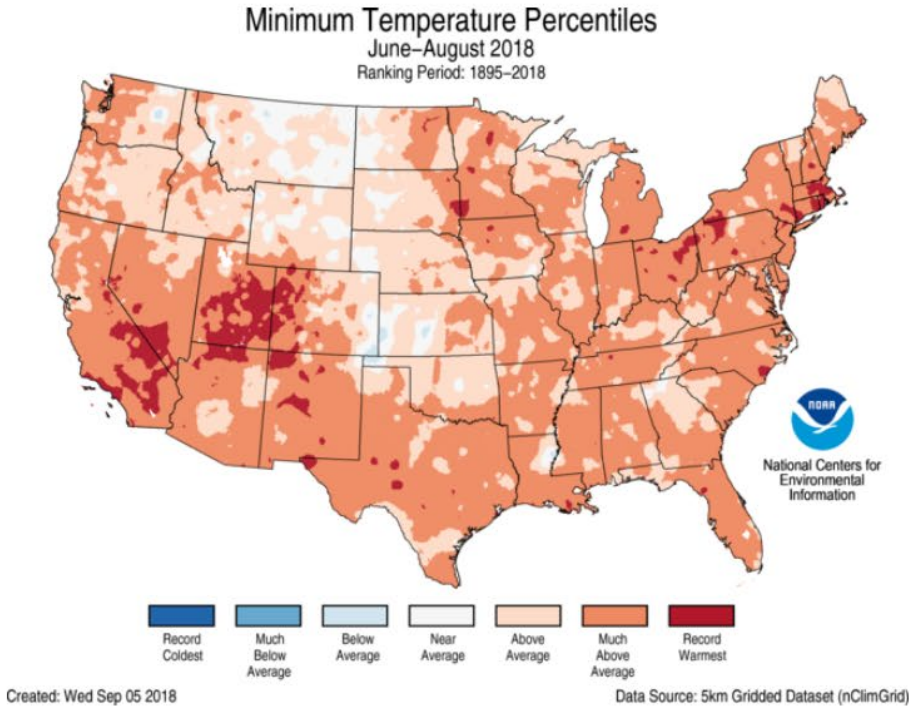
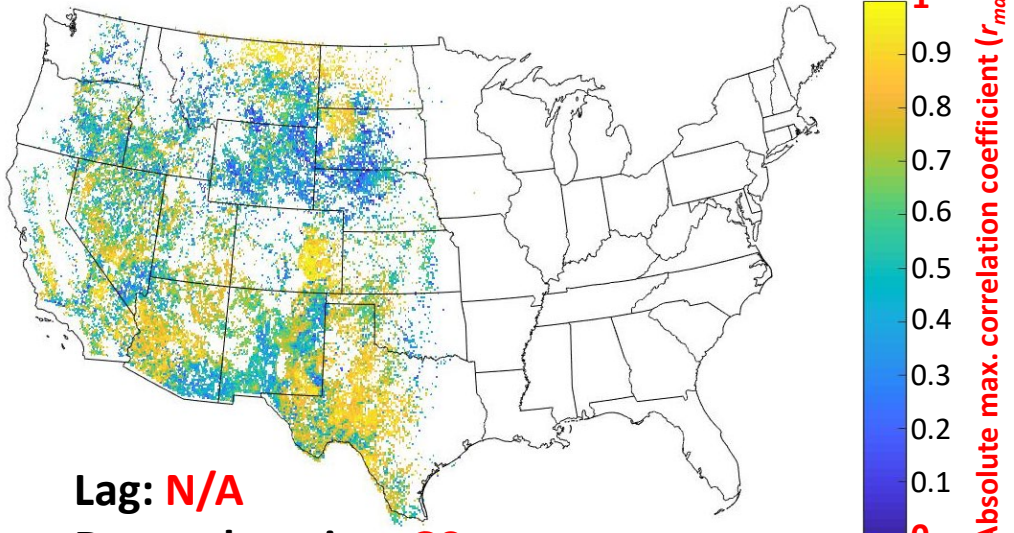
The difference between years challenges our hypotheses about how vegetation responds to soil moisture







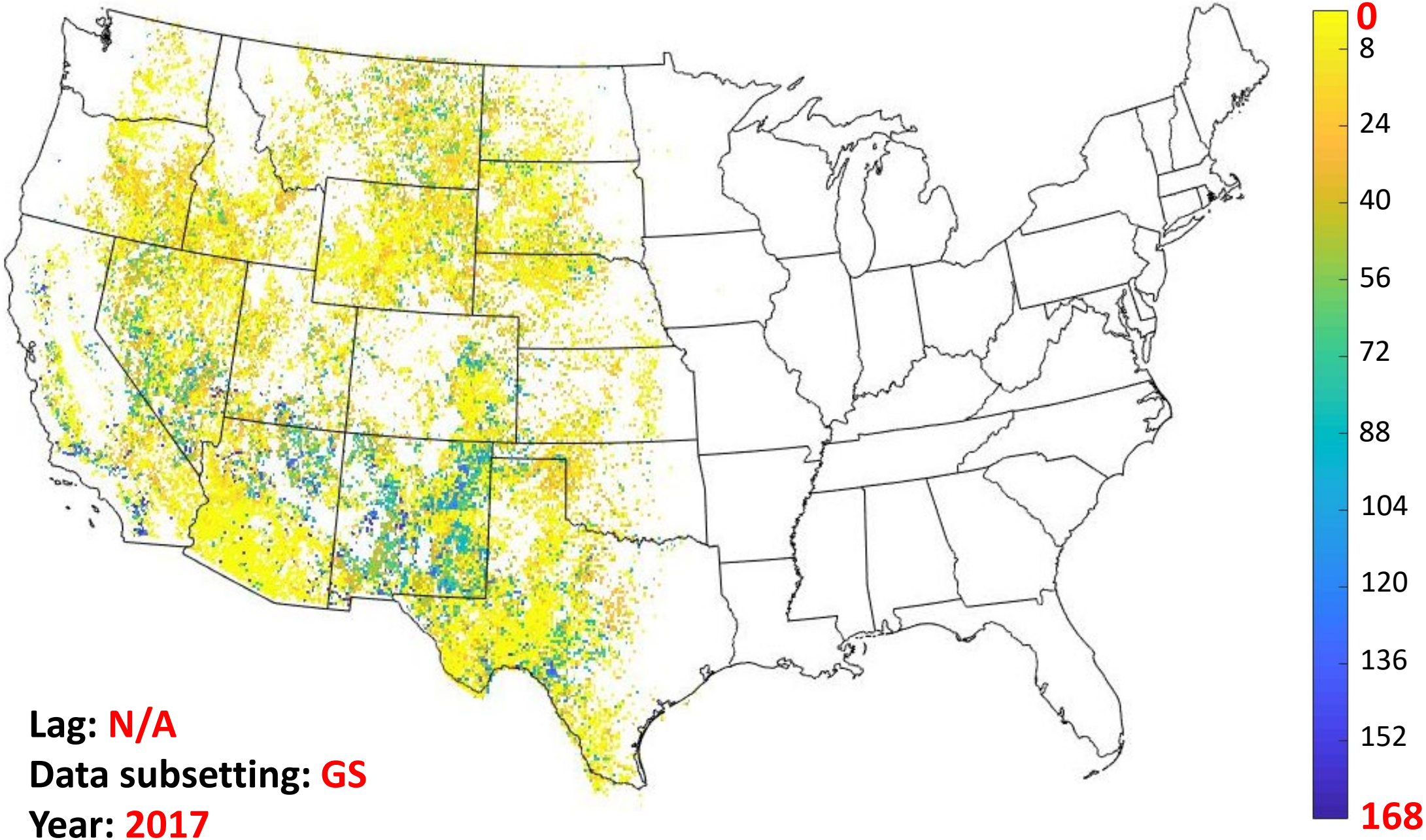


Lag: N/A

Data subsetting: GS

Year: 2018

Existing Vegetation Type	PCT of US Rangeland	2016	2017	2018
Northwestern Great Plains Mixedgrass Prairie	11	-2	11	7
Inter-Mountain Basins Big Sagebrush Shrubland	10	17	28	13
Western Great Plains Shortgrass Prairie	8	14	55	22
Inter-Mountain Basins Big Sagebrush Steppe	6	12	8	7
Western Great Plains Sand Prairie	4	1	-22	-10
Apacherian-Chihuahuan Mesquite Upland Scrub	4	39	60	37
Inter-Mountain Basins Mixed Salt Desert Scrub	3	27	45	24
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	3	35	55	54
Sonoran Paloverde-Mixed Cacti Desert Scrub	3	44	64	67
Western Great Plains Mesquite Woodland and Shrubland	3	52	76	44
Apacherian-Chihuahuan Semi-Desert Grassland and Steppe	3	26	31	24
Mojave Mid-Elevation Mixed Desert Scrub	3	27	44	34
Central Mixedgrass Prairie	2	27	60	26
Chihuahuan Mixed Desert and Thornscrub	2	35	60	31
Inter-Mountain Basins Greasewood Flat	2	26	40	21
Chihuahuan Creosotebush Desert Scrub	2	40	43	35



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- This work is an all lands approach and is fulfilling needs of multiple agencies (FSA, NRCS, BLM) as evidenced by the *emergency drought analysis*

Range Management is much like being a trial layer (Art + Science)

Make decisions based on preponderance of evidence

To be successful you need all the evidence you can get

What are lessons-learned from doing your work?

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- Relationships between SMAP and vegetation are quite different than those from drought monitors *(suggesting role of temperature)*
- The large differences between years in correlation with soil moisture is vexing. Need more study *(again possibly temperature effect)*

Conducting research and creating a publication is not enough for mangers to adopt the work!!

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Quite different than performance of most drought monitors

In what way will your future work support USFS management needs?

- Mostly will be in systems integration rather than basic research
- Retrospective monitoring working well but we need to continue to development of forward looking indicators
- Looking to streamline NEPA using some of these data
- Developing the next generation grazing suitability calculator with state of the art data elements
  - SMAP
  - RPMS
  - USGS cover data
  - Etc.

Thank you!

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