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Mapping interannual cheatgrass production and dieoff using remote sensing and ecological models

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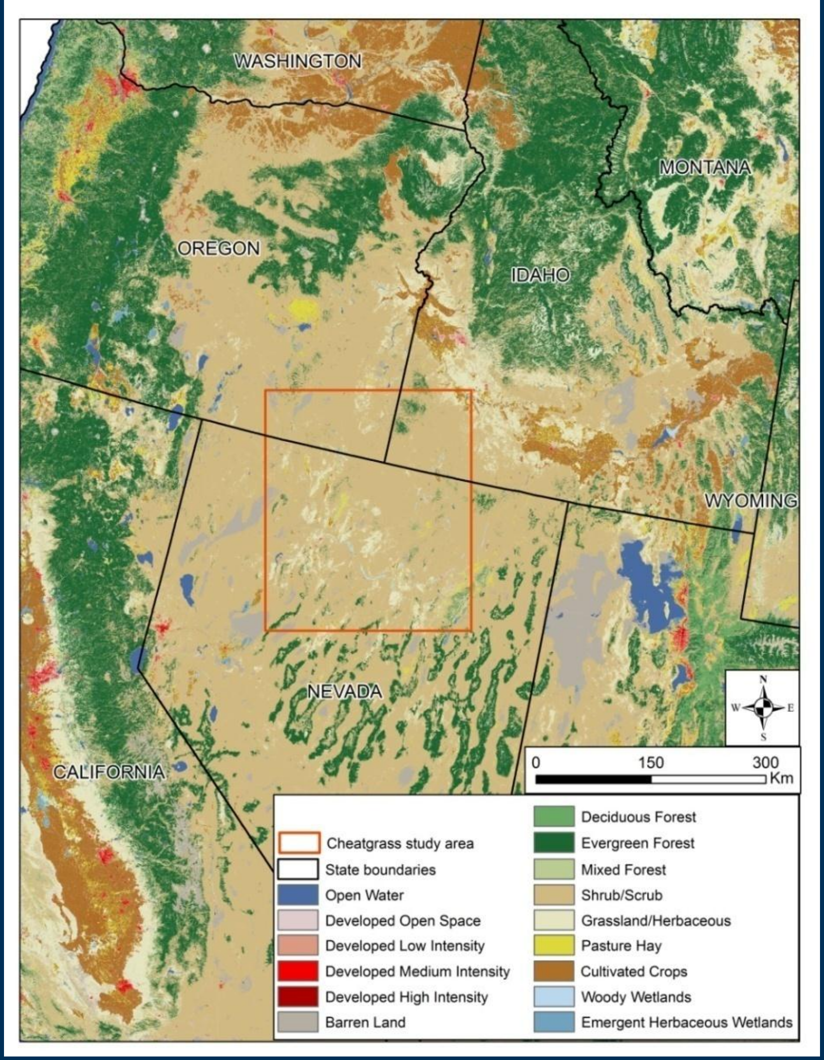
U.S. Department of the Interior
U.S. Geological Survey

Objectives

1. Track cheatgrass abundance and extents spatially and temporally
2. Identify cheatgrass dieoff areas
3. Develop a dieoff probability map



2001 NLCD

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eMODIS NDVI

- expedited Moderate Resolution Imaging Spectroradiometer 250 m is a 7-day composite available in weekly time steps
- NDVI = (NIR - Red)/(NIR + Red)
- NDVI has been used
  - As proxy for vegetation dynamics (Jia et al. 2002)
  - To map biomass (Prince et al. 1991)
  - As proxy for net primary production (Knapp and Smith 2001)

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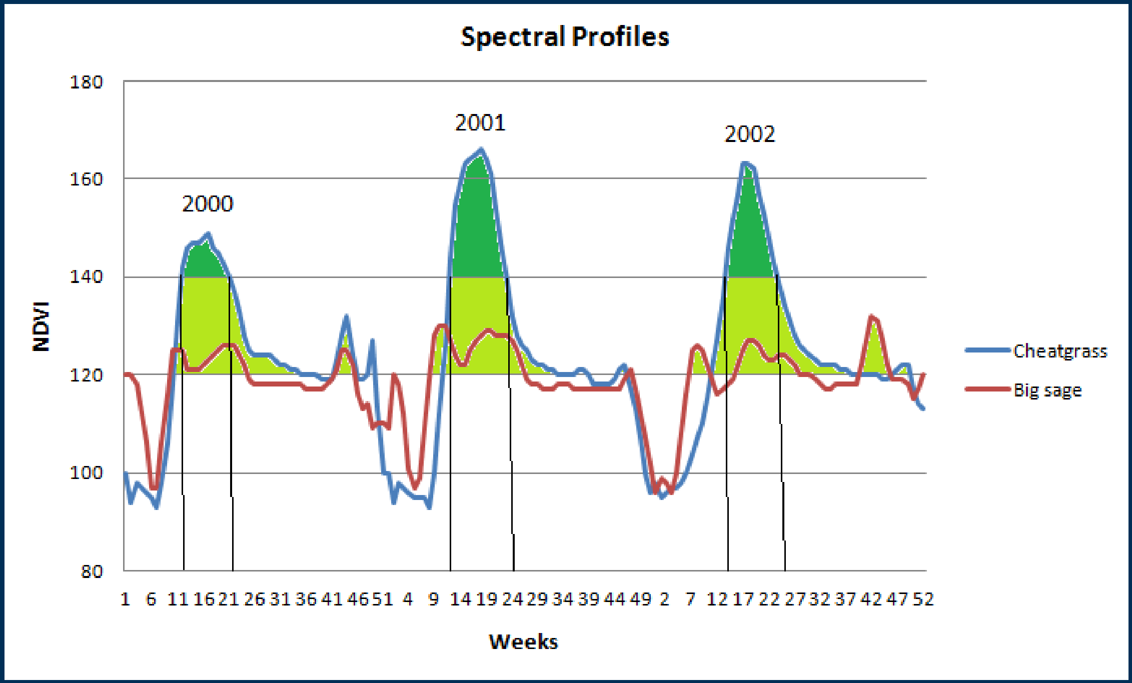
eMODIS NDVI Profiles

Early spring phenology of cheatgrass produces a spectral profile distinguishable from other vegetation types.



Two pixels in close proximity show distinctly different profiles during early spring.

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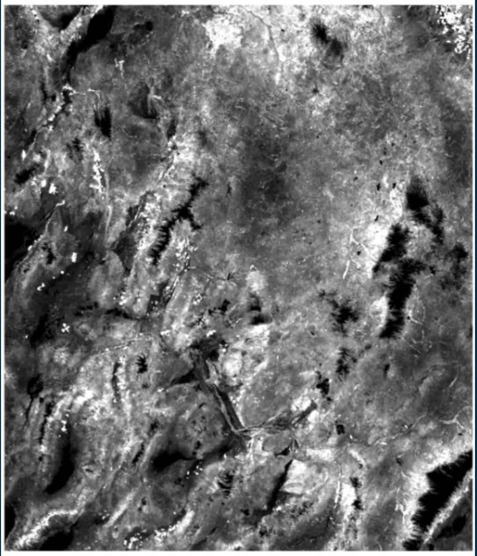
Time periods & index

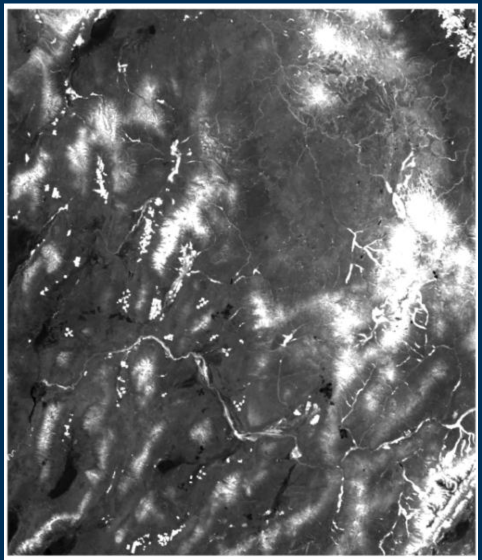
We selected cheatgrass growing season period for spring and a period for cheatgrass senesce. We created an index to contrast spring and summer spectral differences.

Index (Spring – Summer) / (Spring + Summer)

Spring period image



Summer period image



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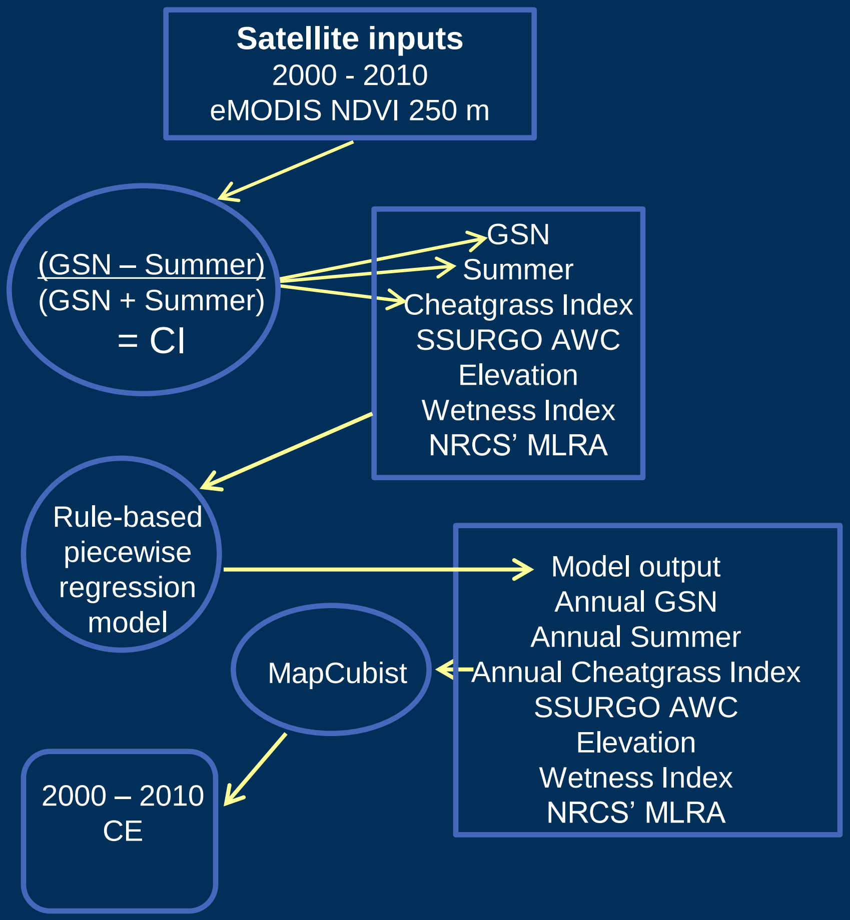
Cheatgrass model



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Model details

Multiple-regression Prediction	Utilization Stratification	Data Set
85%	52%	Spring period
84%	86%	Elevation
79%	29%	Summer period
66%	84%	Cheatgrass Index (CI)
55%	20%	CTI
30%	16%	AWC
	45%	MLRA

Training data (8953 cases) R^2 = 0.77. Test data (994 cases) R^2 = 0.71.

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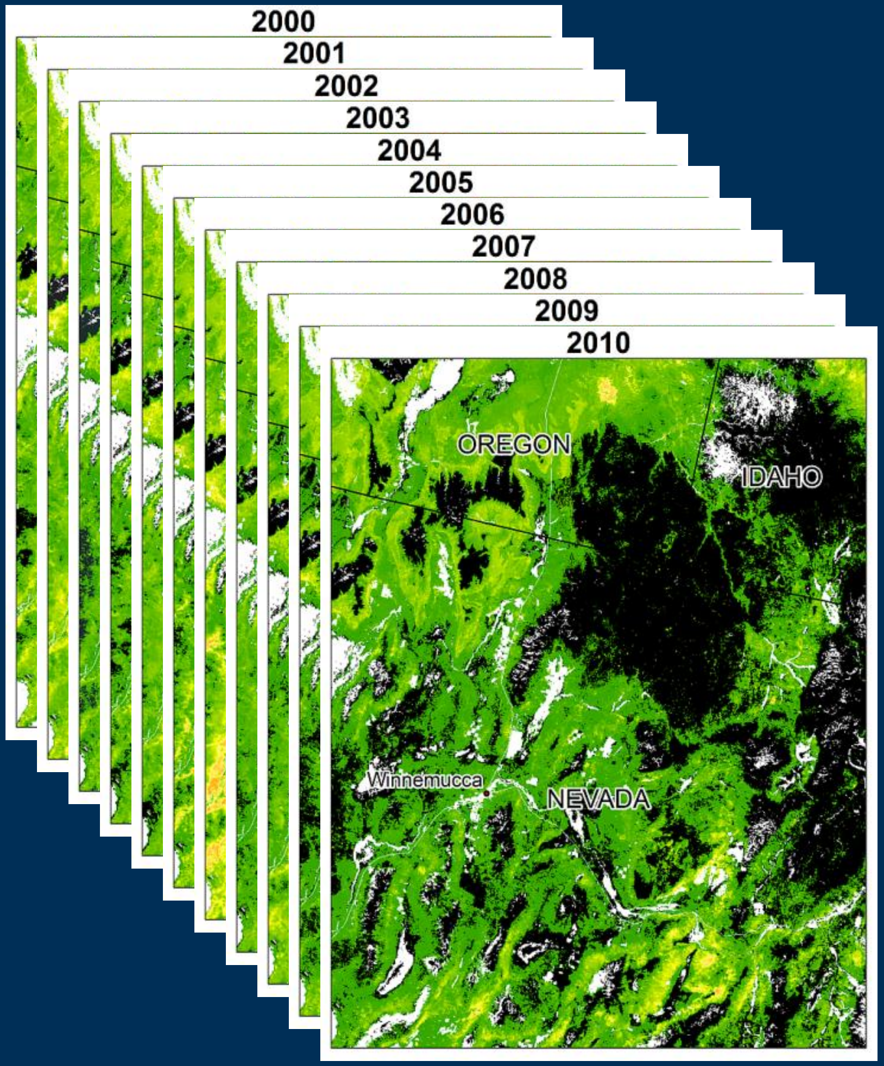
Cheatgrass maps

Maps have been developed for 2000 to 2010 using the cheatgrass model, geophysical data, and Peterson’s cheatgrass data.



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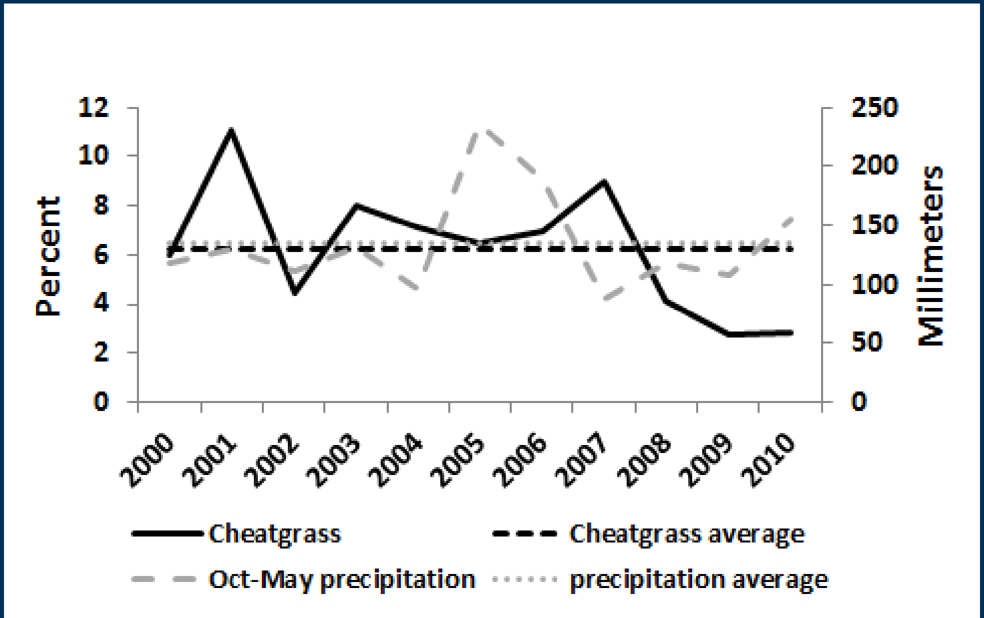
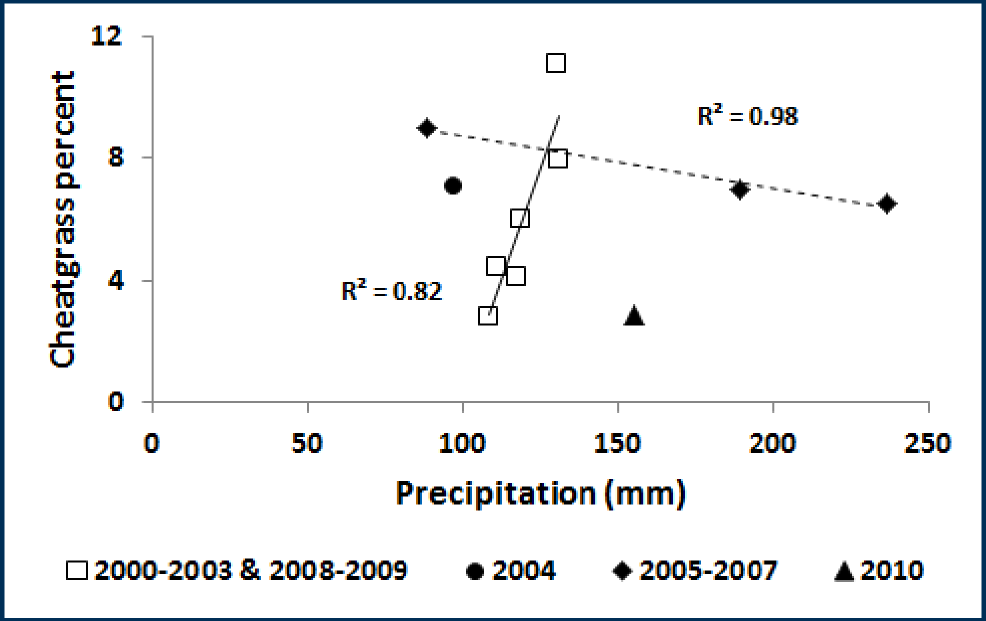
Cheatgrass production and precipitation



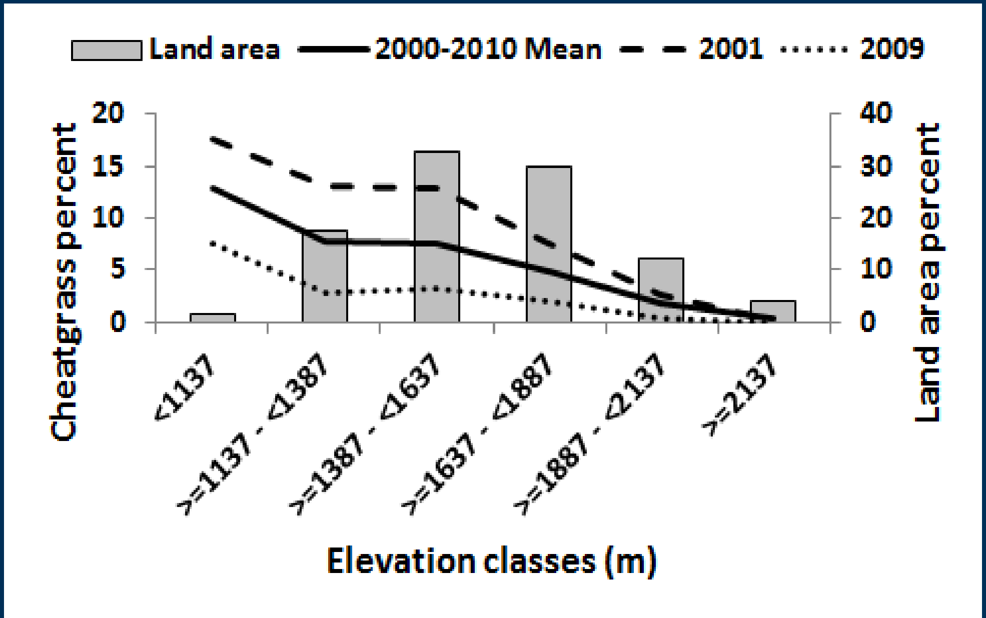
Boyte et al. submitted to *Ecosystems*

Cheatgrass production and precipitation



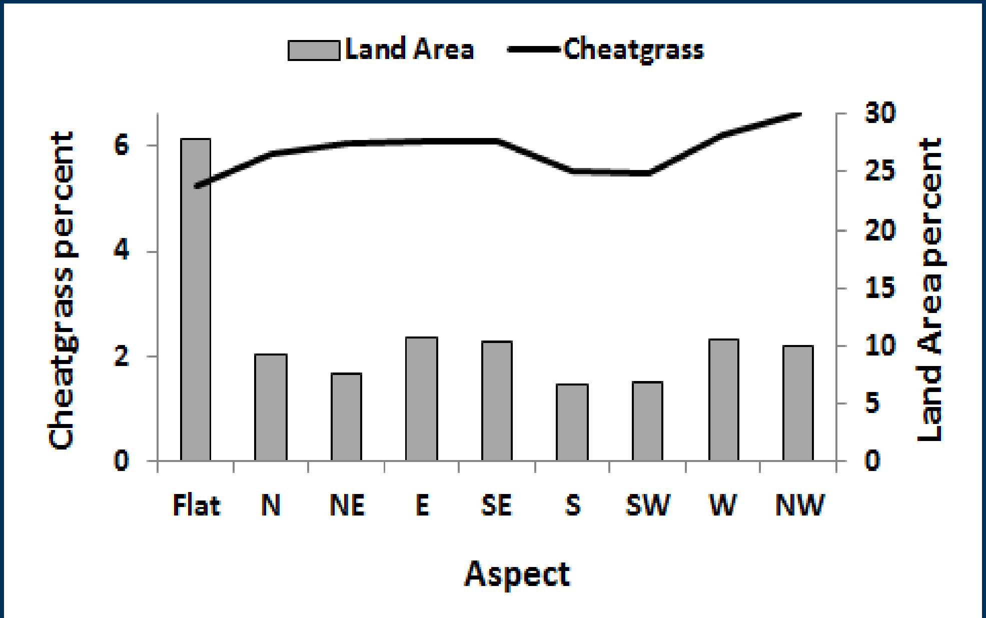
Boyte et al. submitted to *Ecosystems*

Cheatgrass production and elevation



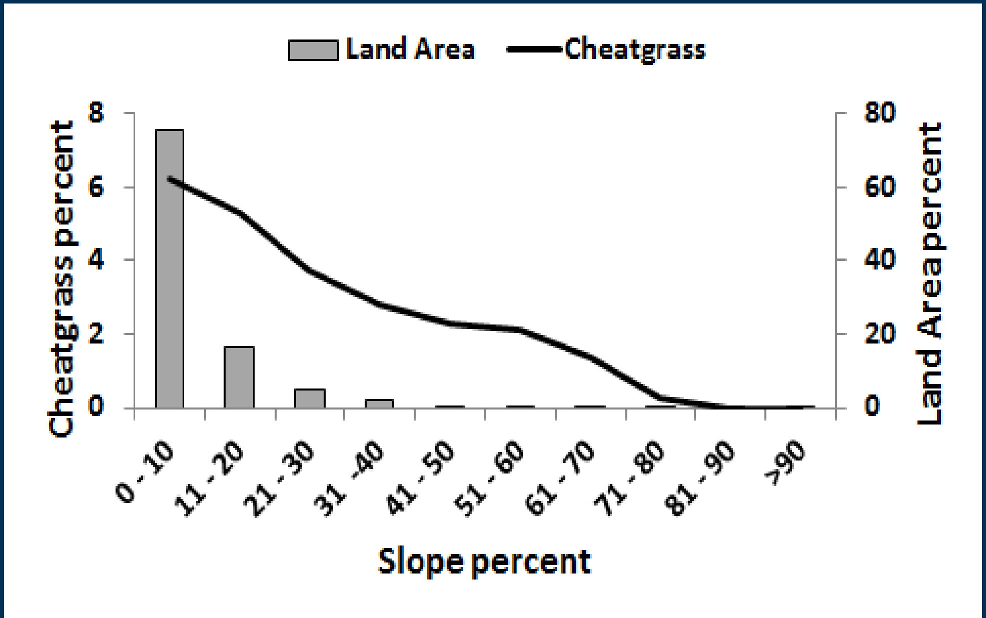
Boyte et al. submitted to *Ecosystems*

Cheatgrass production and aspect



Boyte et al. submitted to *Ecosystems*

Cheatgrass production and % slope



Boyte et al. submitted to *Ecosystems*

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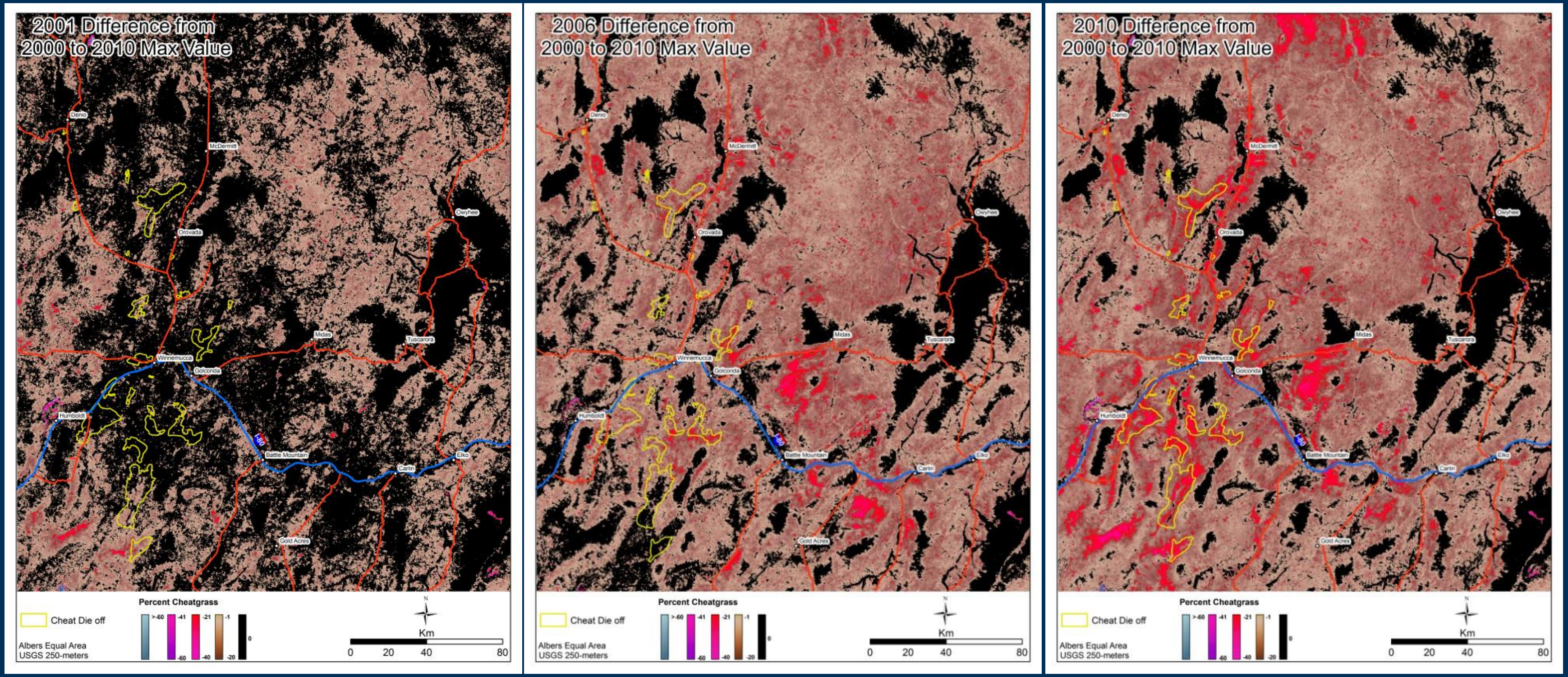
Difference Maps



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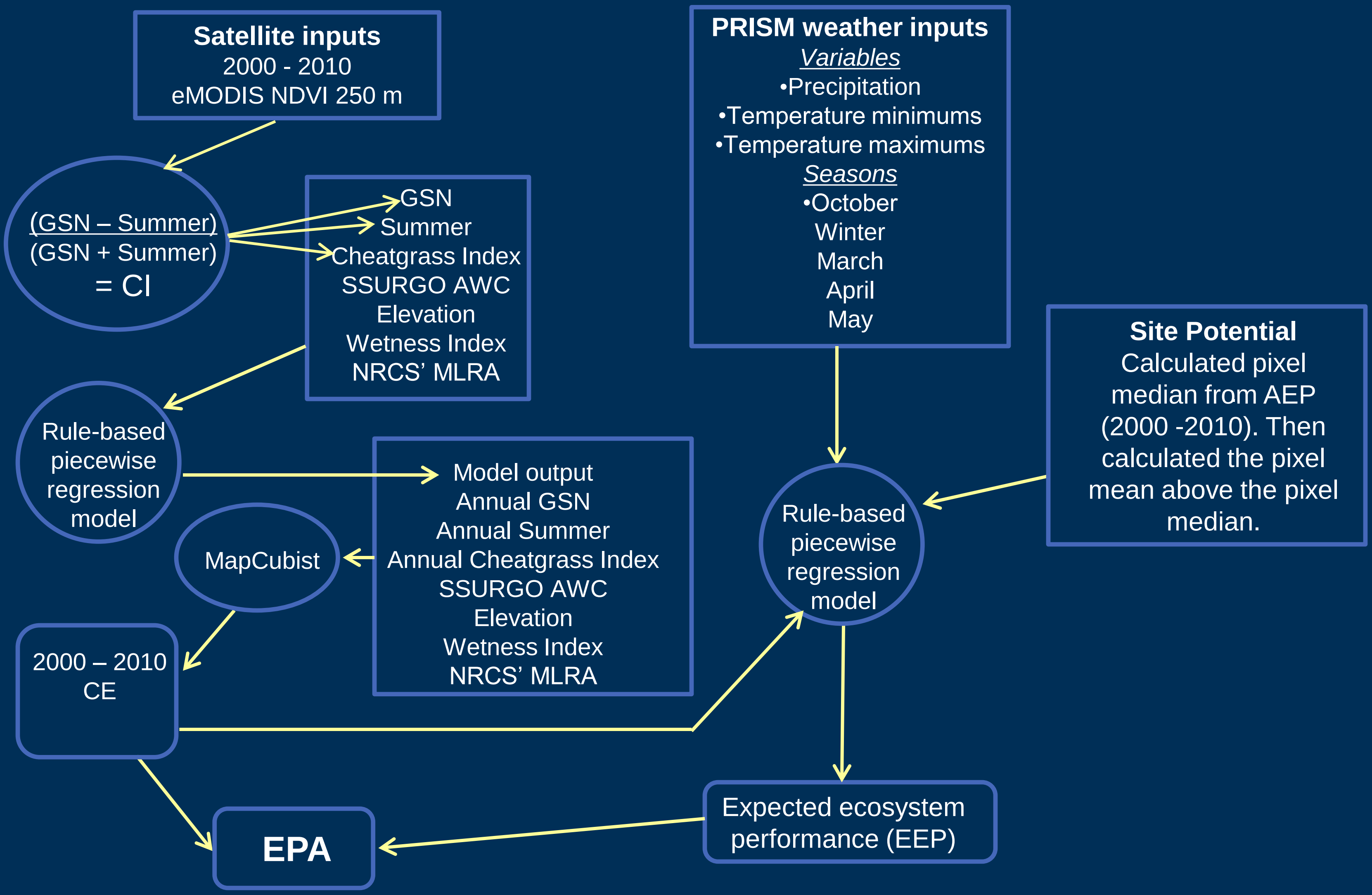
Improving the output

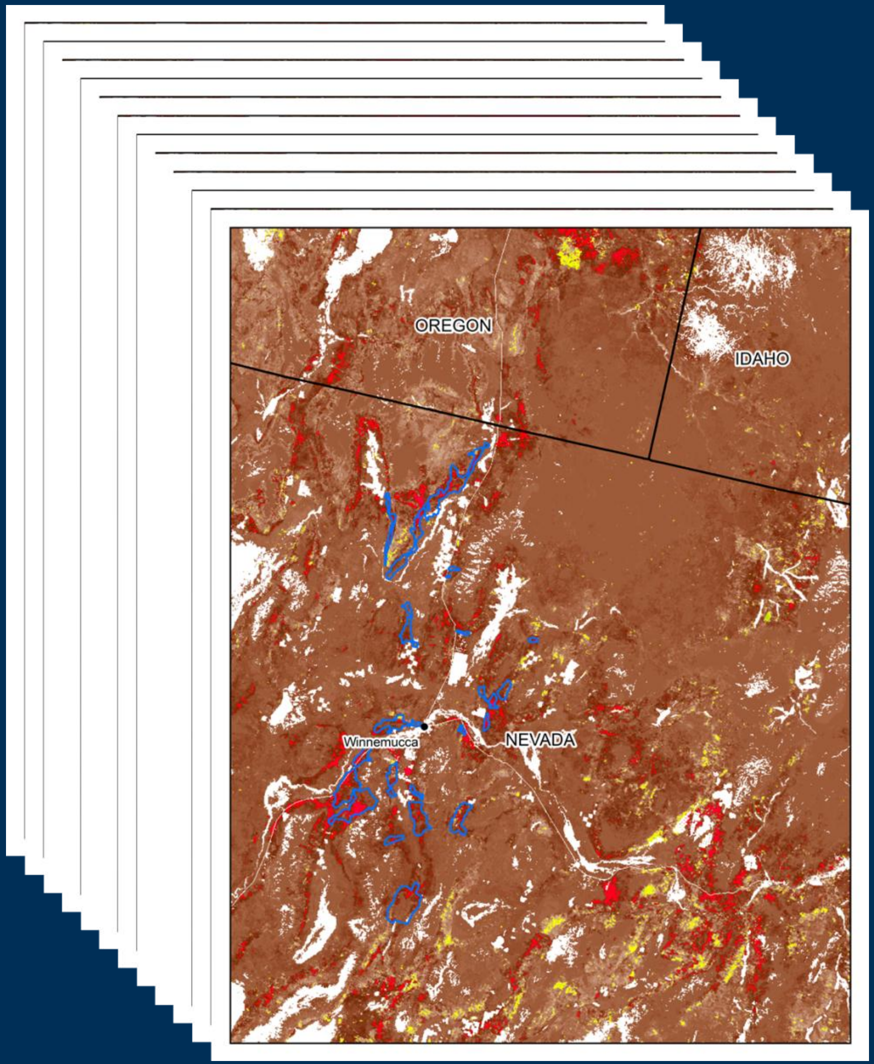
- Improving on the Difference maps so the data is more meaningful
  - Developing production maps that have been normalized for annual weather
  - Highlights ecosystem performance anomalies


Satellite inputs
2000 - 2010
eMODIS NDVI 250 m
(GSN – Summer)
(GSN + Summer)
= CI
GSN
Summer
Cheatgrass Index
SSURGO AWC
Elevation
Wetness Index
NRCS' MLRA
Rule-based piecewise regression model
Model output
Annual GSN
Annual Summer
Annual Cheatgrass Index
SSURGO AWC
Elevation
Wetness Index
NRCS' MLRA
MapCubist
2000 – 2010 CE
EPA
PRISM weather inputs
Variables
•Precipitation
•Temperature minimums
•Temperature maximums
Seasons
•October
Winter
March
April
May
Site Potential
Calculated pixel median from AEP (2000 -2010). Then calculated the pixel mean above the pixel median.
Rule-based piecewise regression model
Expected ecosystem performance (EEP)

Cheatgrass dieoff maps

Maps have been developed for 2000 to 2010 using cheatgrass production datasets, site potential, and annual weather data.

2000 - 2010



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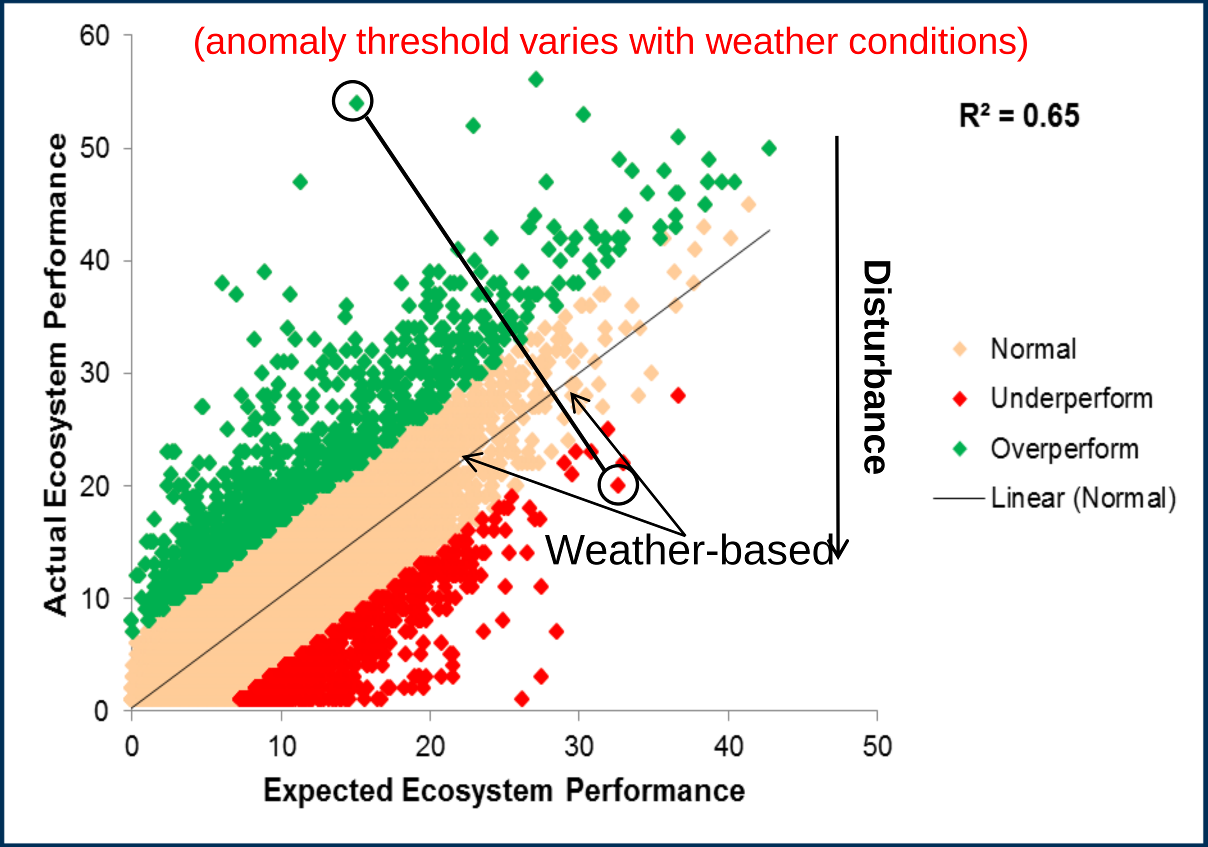
Separating weather and non-weather dynamics (2000 – 2010)



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Cheatgrass response to precipitation

Annual relationships between average cheatgrass cover and average October – May precipitation (ppt) sums for rangelands below 1887 m (6190 ft) elevation. 2005 was average year for cheatgrass production but above average year for precipitation.

Year	Cheatgrass mean (%)	Cheatgrass standard deviation	Coefficient of variation	Ppt mean (mm)	Ppt standard deviation	Coefficient of variation	Ppt/cheatgrass disparity
2000	5.97	4.99	0.84	118.4	27.12	0.23	19.83
2001	11.06	8.85	0.80	130.04	37.88	0.29	11.76
2002	4.45	4.76	1.07	110.67	35.28	0.32	24.87
2003	7.98	7.11	0.89	130.8	36.87	0.28	16.39
2004	7.08	6.08	0.86	96.75	37.69	0.39	13.67
2005	**6.5**	**7.98**	**1.23**	**236.6**	**50.84**	**0.21**	**36.4**
2006	6.98	8.21	1.18	189.24	40.87	0.22	27.11
2007	8.98	6.69	0.75	88.24	26.67	0.30	9.83
2008	4.14	5.84	1.41	117.36	45.0	0.38	28.35
2009	2.78	4.13	1.49	108.12	34.86	0.32	38.89
2010	2.87	4.29	1.49	155.42	39.5	0.25	54.15

Average cheatgrass cover = 6.25% (<1887 m elevation)
Average precipitation = 135 mm (Oct – May sums; <1887m elevation)

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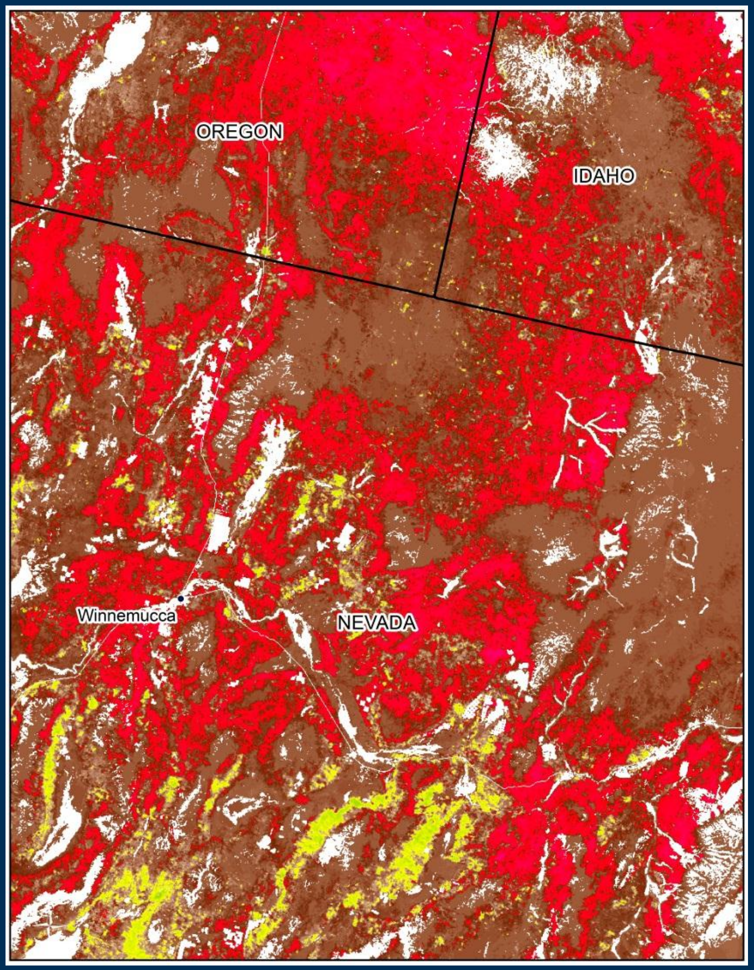
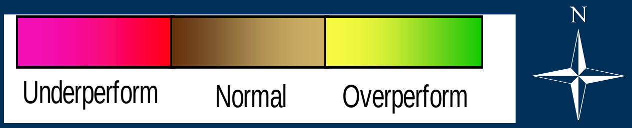
2005 Dieoff Map

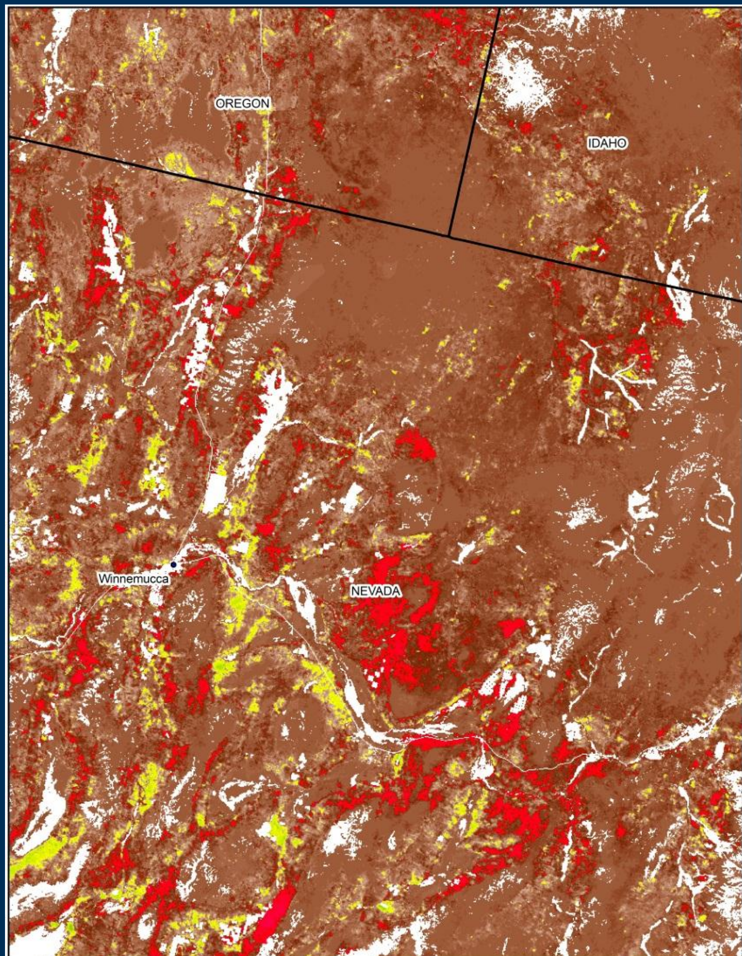


Red indicates dieoff areas. Model was normalized for weather. (26% dieoff)

Peterson (2006) field observations validate our 2005 results. 8.5% reduction in mean cover annual grasses over 2002 - 2003.

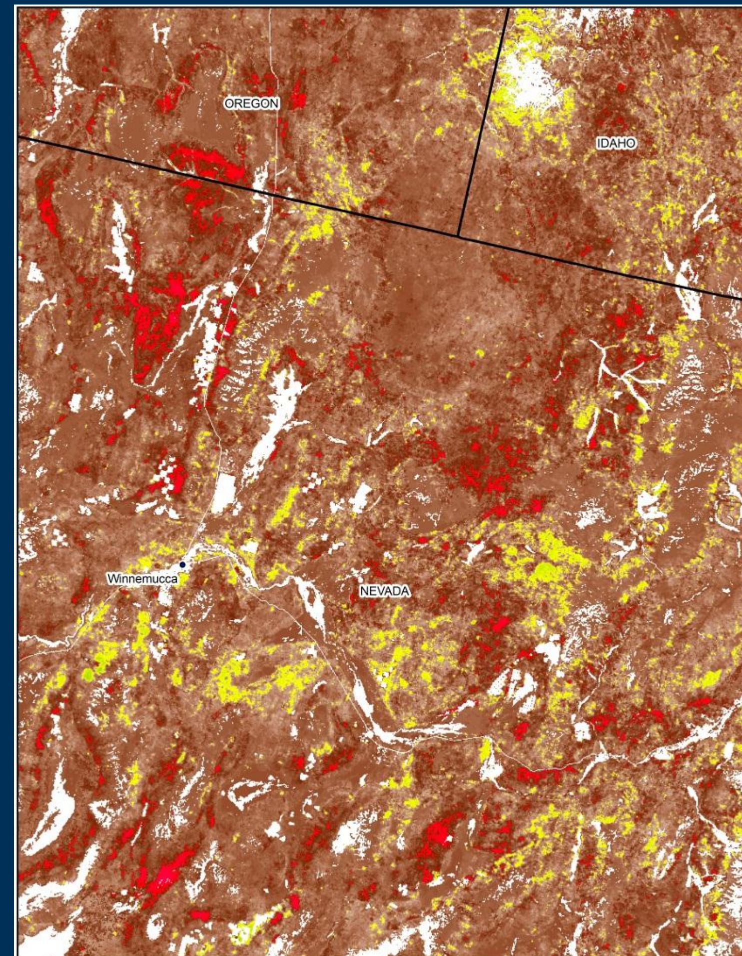


2006 Dieoff Map

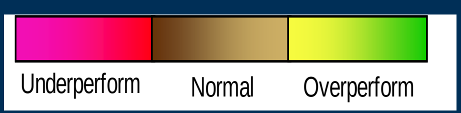


(4% dieoff)

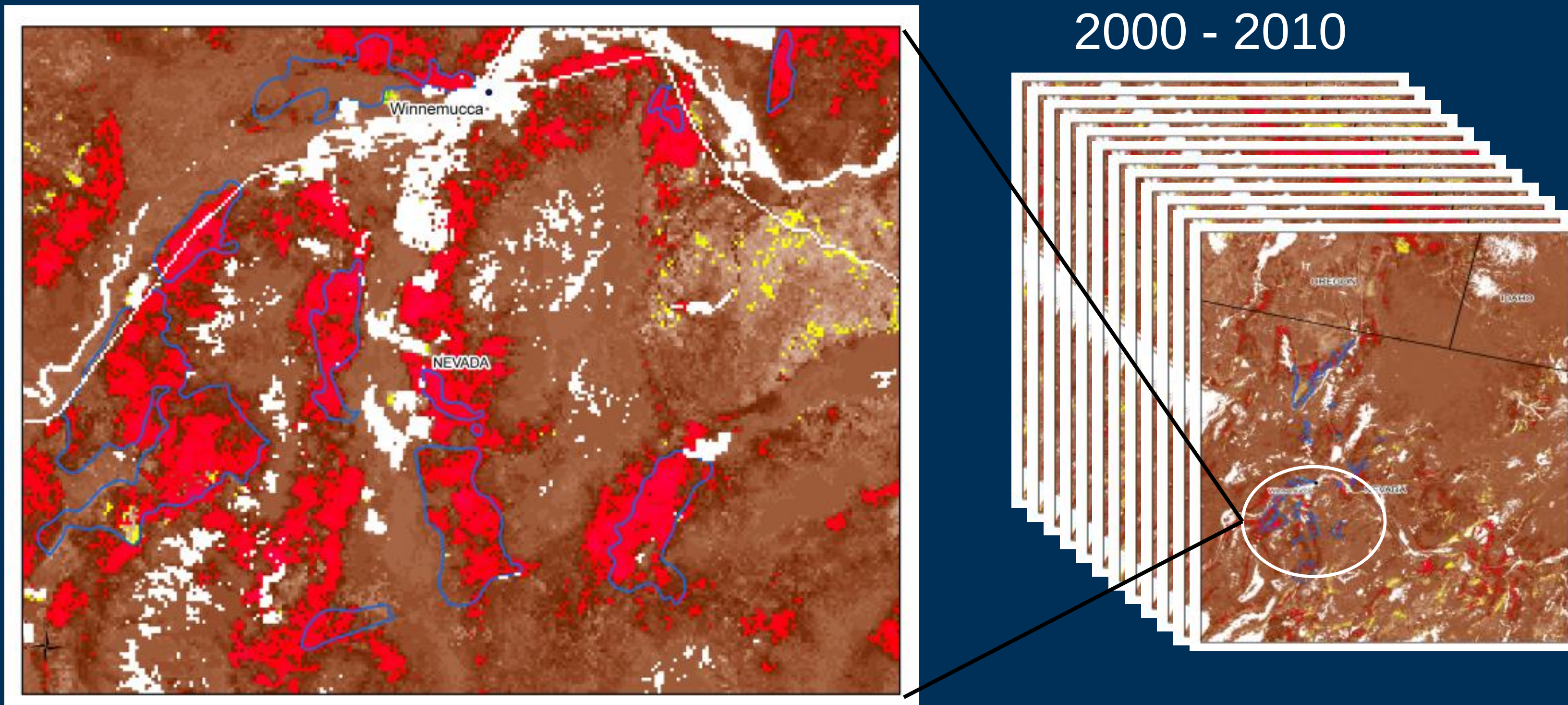
2007 Dieoff Map



(3% dieoff)



Matching BLM dieoff polygons with modeled dieoff areas



2010 dieoff polygons and 2009 estimated die off areas matched 59% of the time. Extents and performance anomalies maps were created from 2000 – 2010.

Classifying Dieoff Probability

Evaluation on training data (9009 cases):

Trial	Decision Tree Size	Errors
0	67	1120(12.4%)
1	45	1324(14.7%)
2	61	1409(15.6%)
3	66	1429(15.9%)
4	74	1394(15.5%)
5	85	1500(16.7%)
6	109	1508(16.7%)
7	13	1467(16.3%)
8	91	1461(16.2%)
9	39	1440(16.0%)
boost		1098(12.2%)

Evaluation on test data (901 cases):

Trial	Decision Tree Size	Errors
0	67	129(14.3%)
1	45	152(16.9%)
2	61	184(20.4%)
3	66	161(17.9%)
4	74	153(17.0%)
5	85	189(21.0%)
6	109	197(21.9%)
7	13	162(18.0%)
8	91	163(18.1%)
9	39	158(17.5%)
boost		128(14.2%)

Attribute usage:

100%	tmax
100%	ppt
100%	awc
100%	elev
100%	nlcd
100%	latmap
100%	cti
91%	tmin
84%	lfesp
81%	soc
79%	nslp
74%	mlra
33%	sslp

training			
Predicted class			
No dieoff	dieoff		
7567	63	Nodieoff	Actual
1035	344	dieoff	class
0.88	0.85		
test			
Predicted class			
nodie	dieoff		
756	11	Nodieoff	Actual
117	17	dieoff	class
0.87	0.61		

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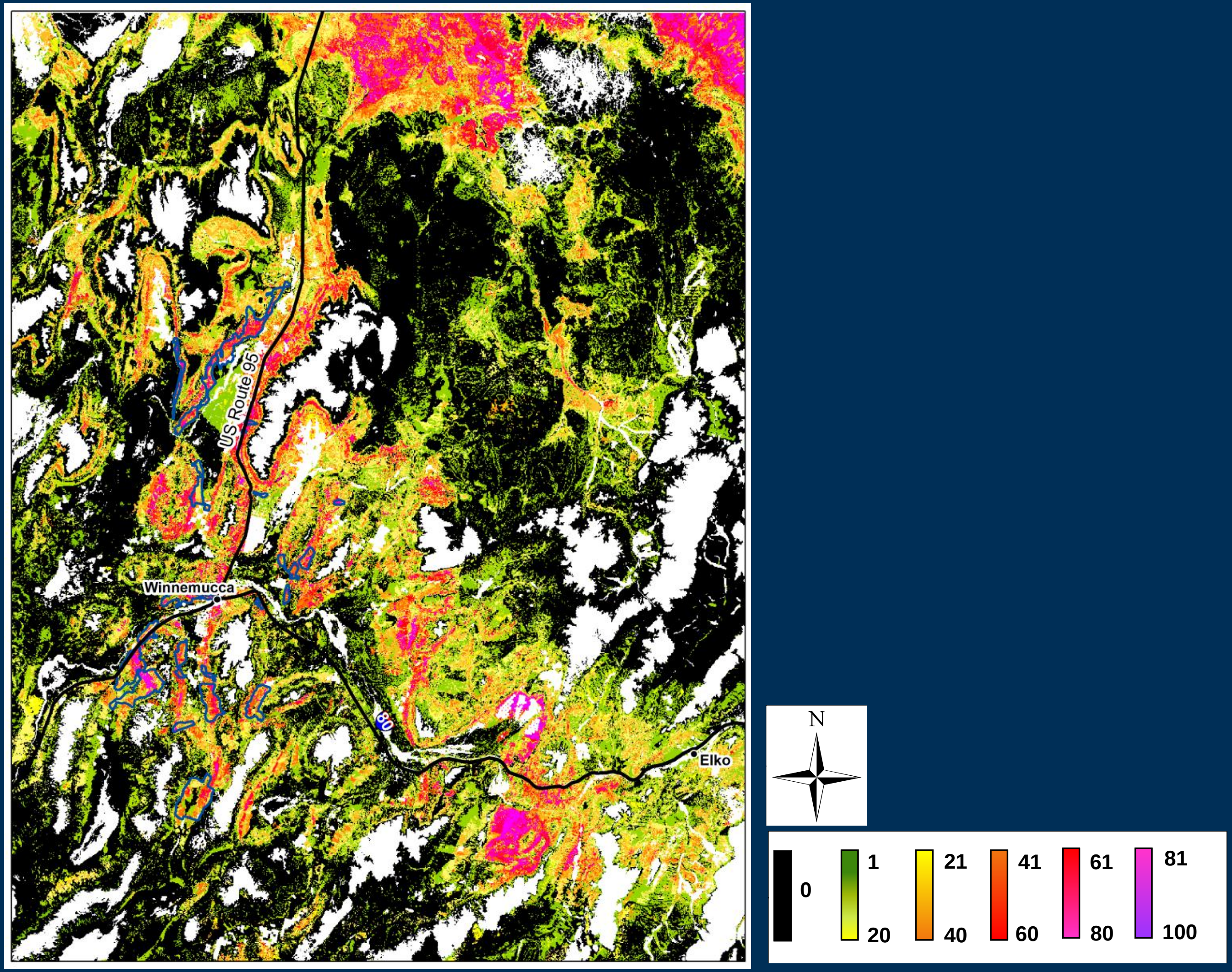
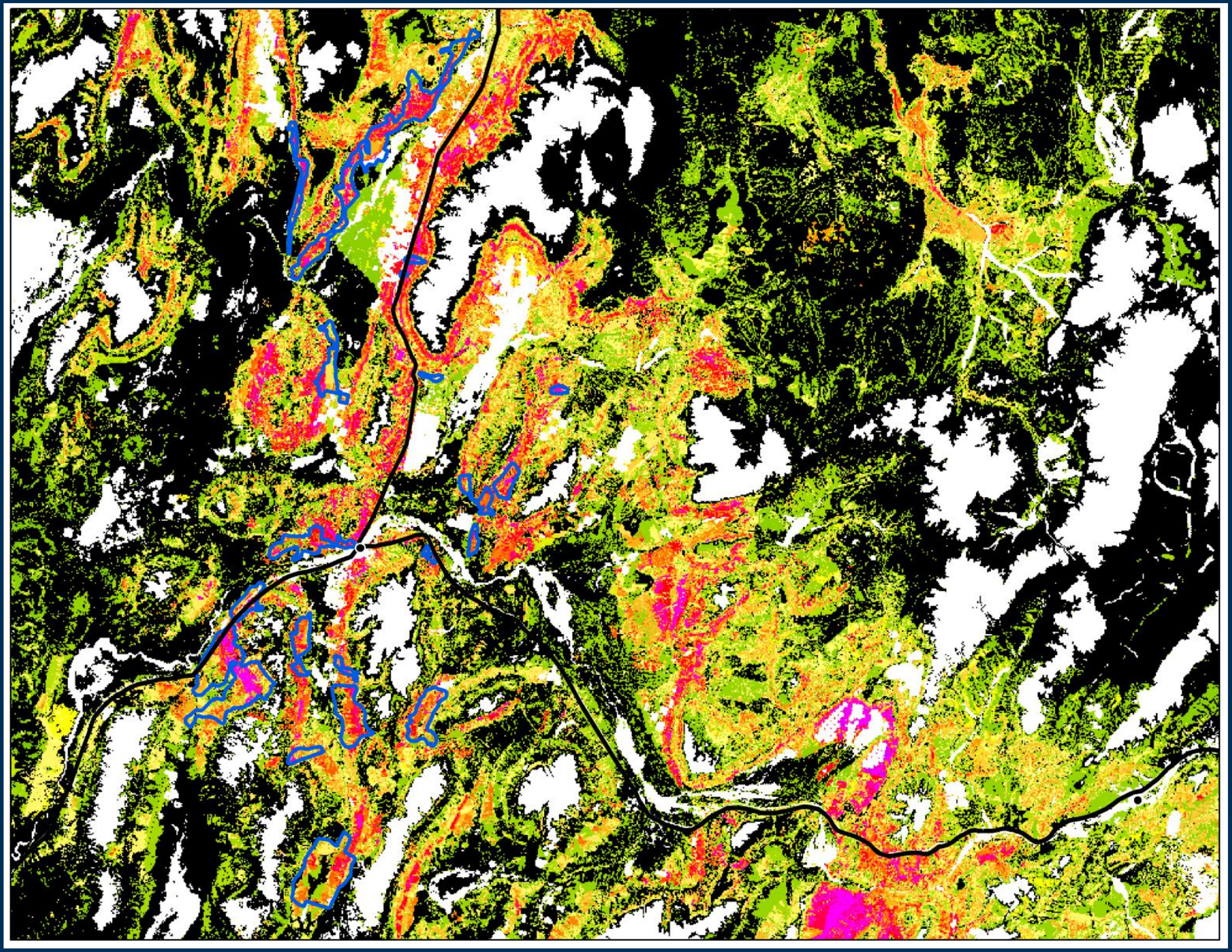
Dieoff Probability Map



Dieoff Probability Zoomed



Next Steps

- Complete development of cheatgrass production and dieoff datasets for the northern Great Basin
- Apply future climate data to the dieoff probability model to predict the probability of future dieoff areas
- Compare the time series of cheatgrass production maps with MTBS fire data
- Compare dieoff areas to topographic and edaphic data sets

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