Range-wide Hierarchical population monitoring and modeling to inform greater sage-grouse management

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Project Objectives

1) Create centralized lek database

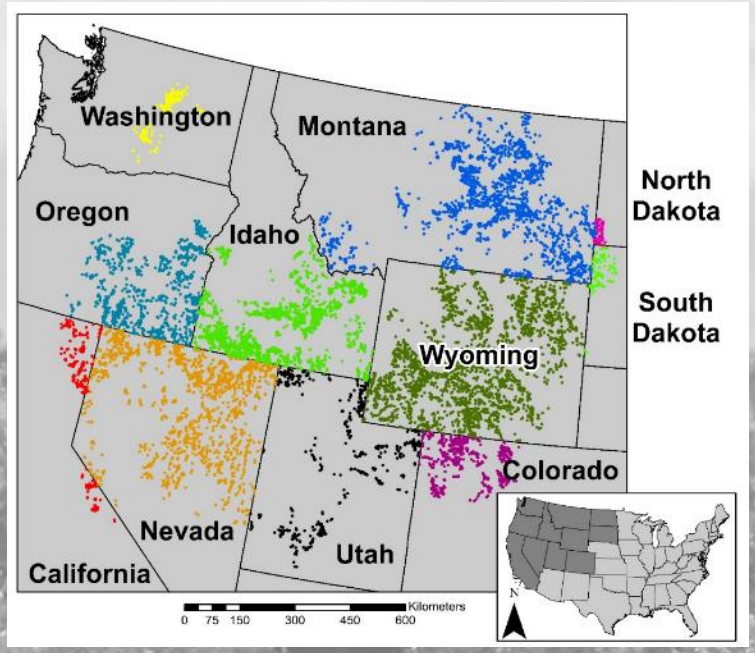
2) Develop population clusters across the range

3) Estimates of trends and abundances at different spatiotemporal scales

4) Targeted annual warning system for targeted management

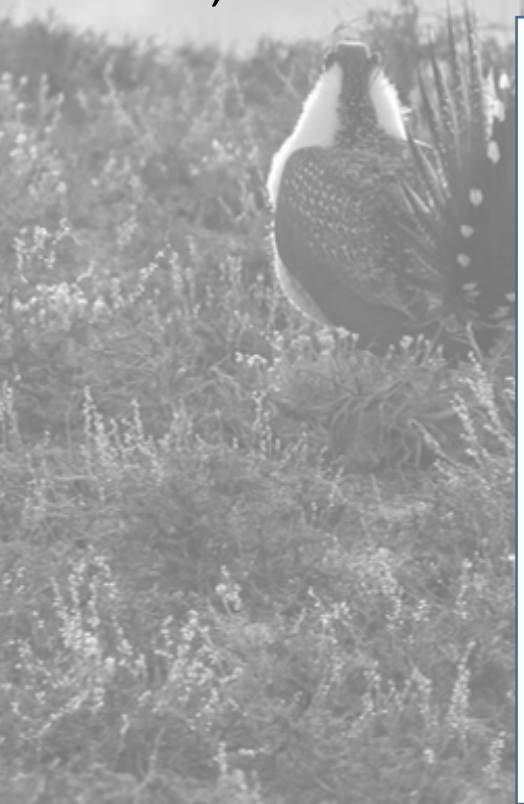
Database and Population Clusters

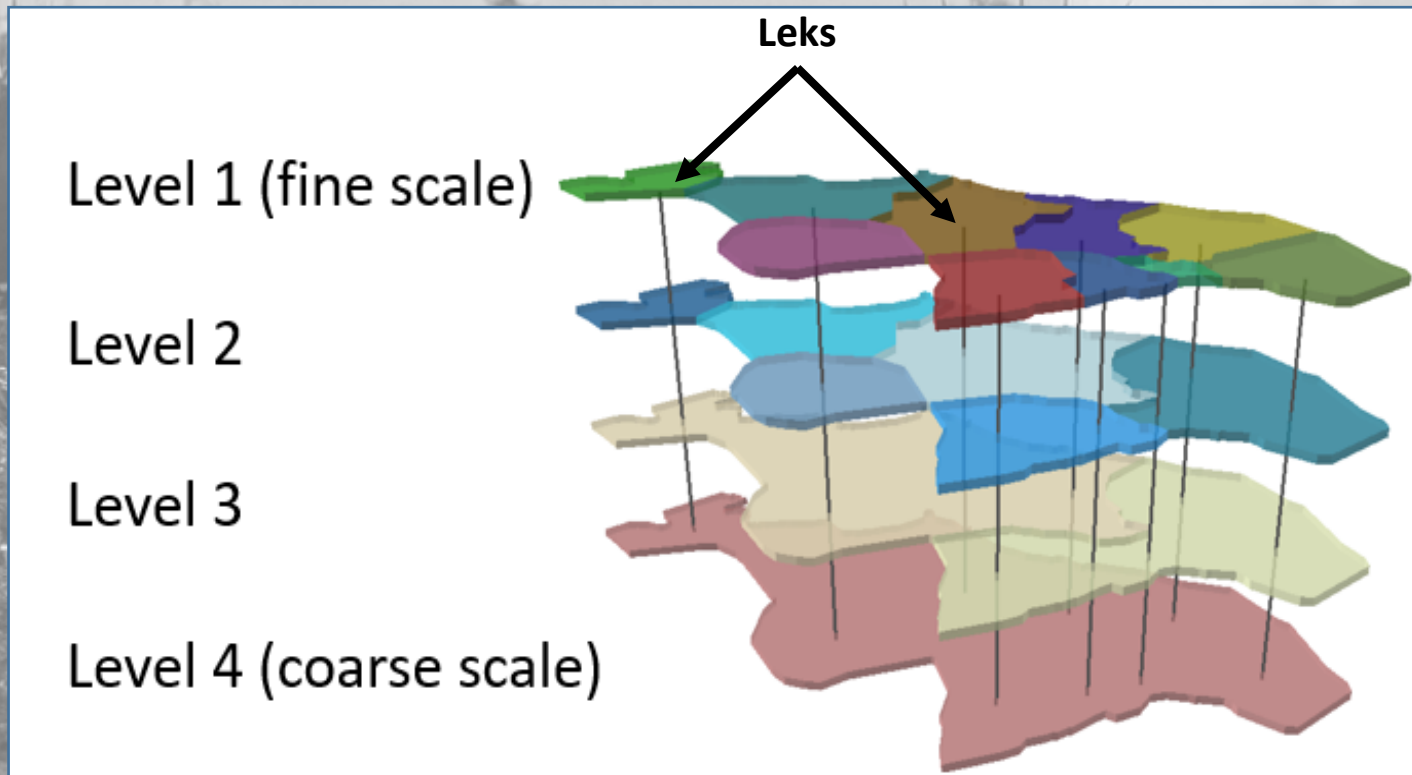
- Statistical and repeatable approach
- Consider *Biological Structure*
- Cluster leks located in similar habitat
- Minimize movement between clusters and consider landscape barriers
- Regionalize the landscape while capturing sage-grouse connectivity
- Support a hierarchical population monitoring framework



Range-wide Lek Database Reduction to Support *Clusters Process only*

- Generated range-wide cluster levels 1-13
  - Considered Active and Pending New leks (5,832 leks from original numbers of leks 8,421)
- Final cleaned dataset
  - 262,744 lek observations with male counts (all leks) for Trend Modeling





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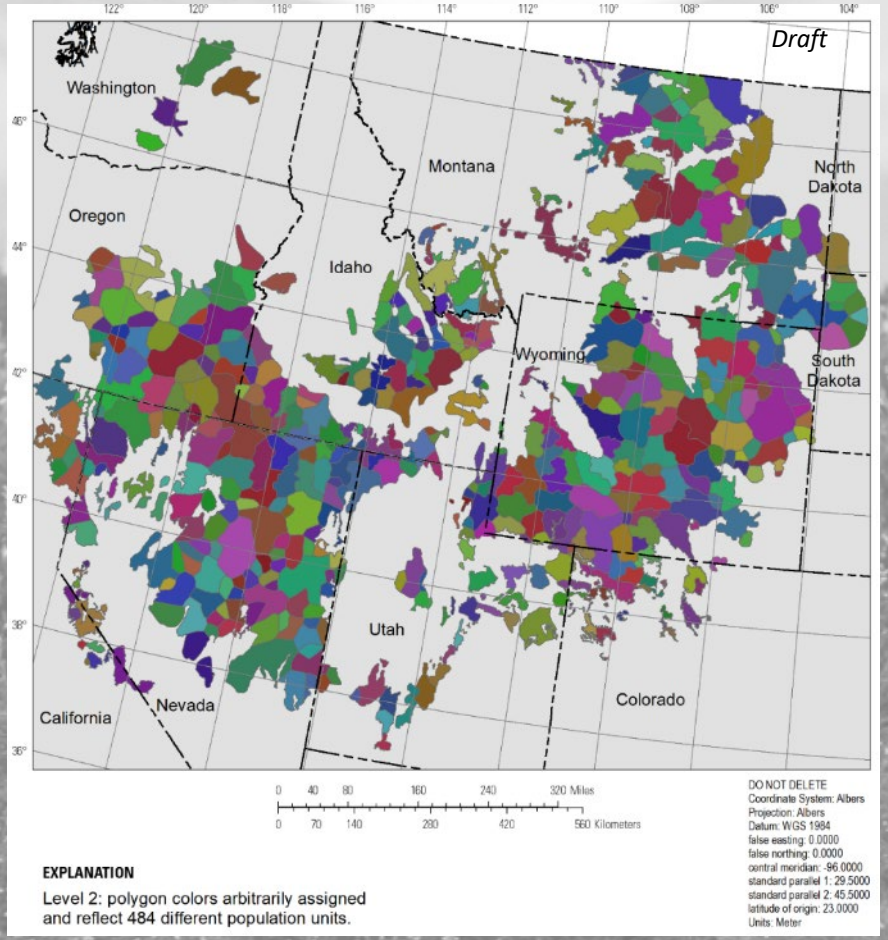
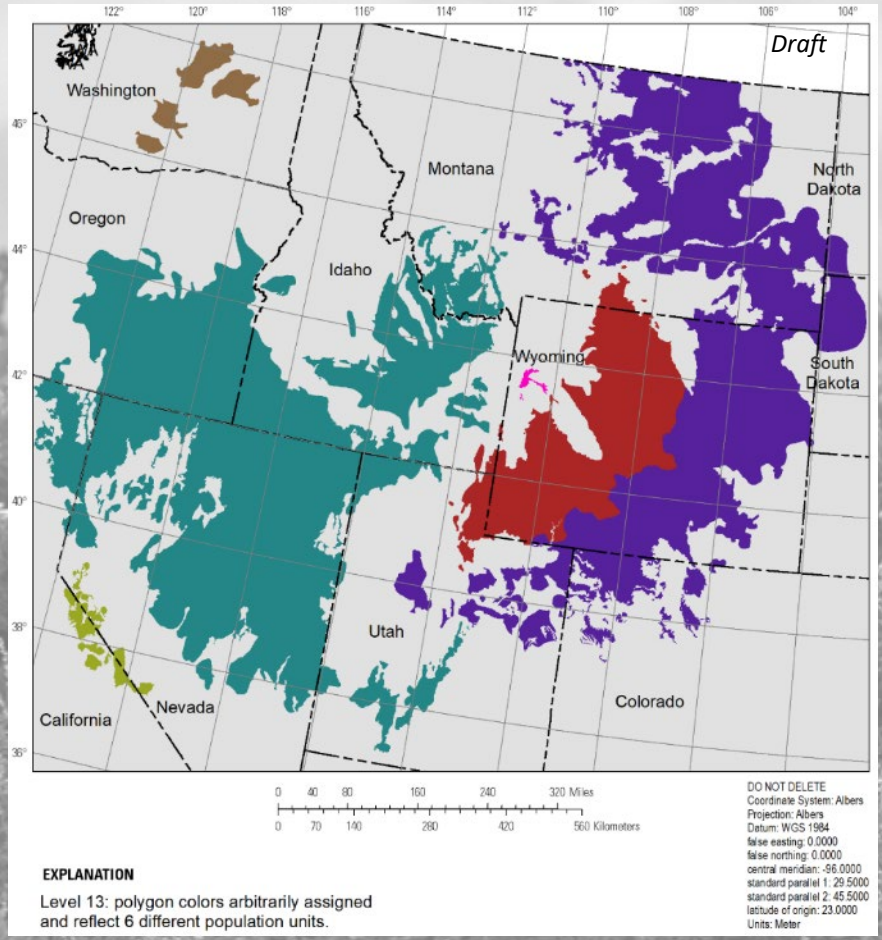
Neighborhood and Climate Clusters

Neighborhood Cluster

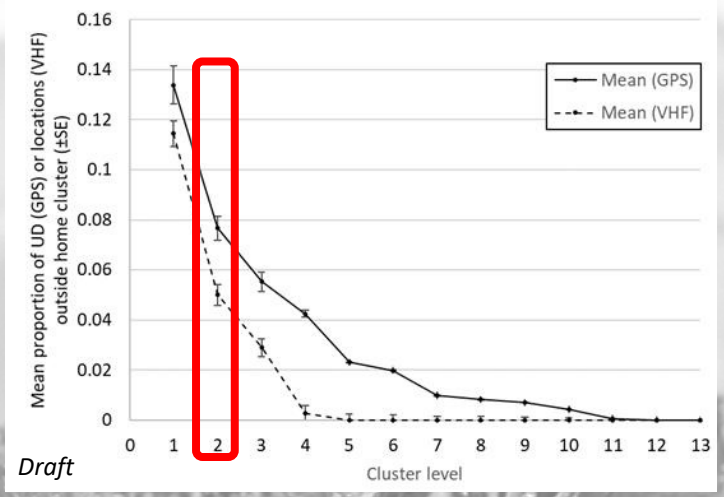


Climate Cluster

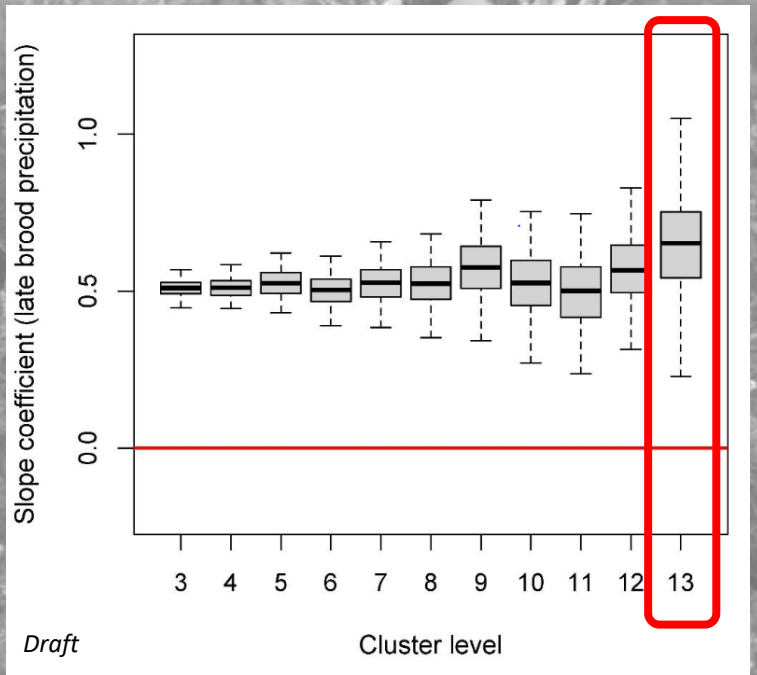


Range-wide Population Clusters Level Selection

- Neighborhood cluster selection justifications (approx. closed populations)
  - GPS & VHF data evaluation
  - Appropriate number of leks for management



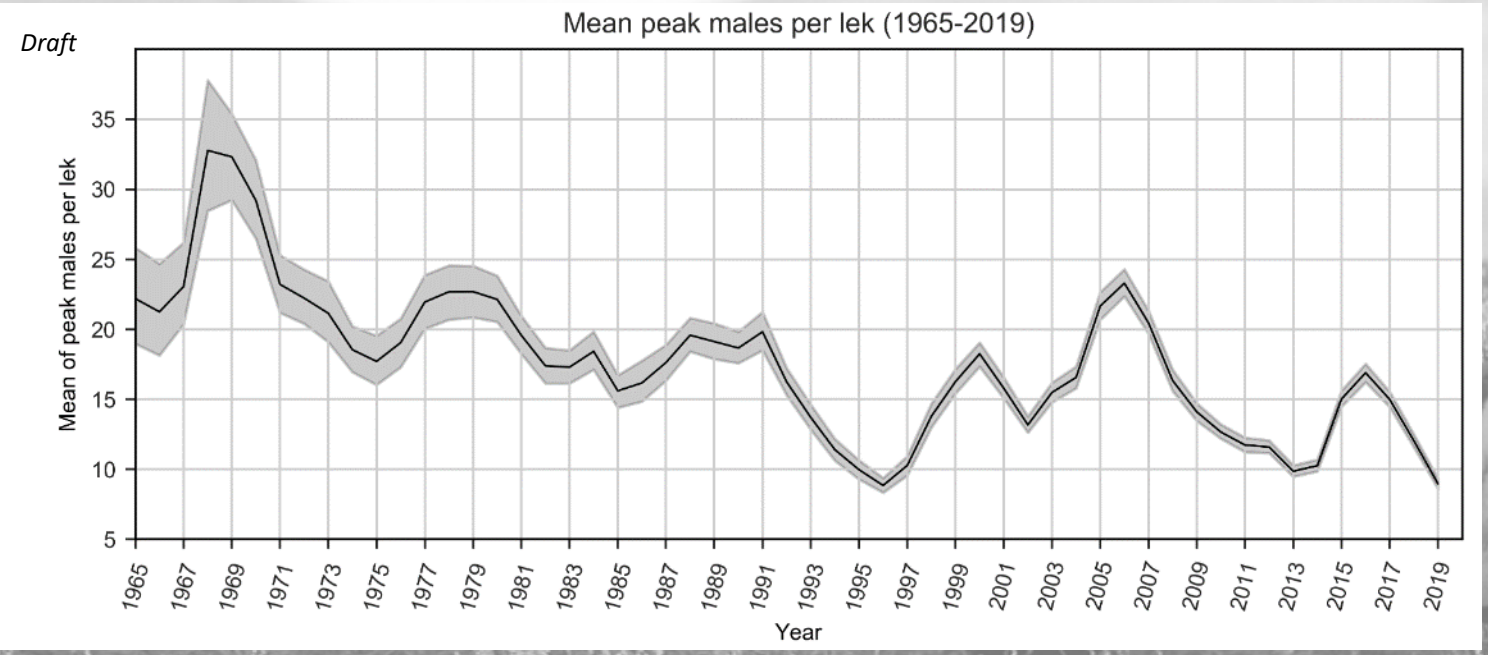
- Climate cluster selection:
  - Assessed relationship between precipitation (late brood period) and population rate of change



Range-wide Data Products – Going Forward

Product	Input Dates	Potential Update Frequency	Management Tool
Standardized lek Database	State data	Annual	Software standardization
Clusters	Last 20-years	None planned	Multi-scale PVA, dual frame monitoring, habitat model partitions, management units, etc.
Population trends	1960-2019	5-to-9 years, requires multiple nadir-to-nadir Oscillations ($\bar{x}$=9.4 yr)	Long-term monitoring, population assessment
Targeted Annual Warning System (TAWS)	1990-2019	Annual; requires enough data (e.g., Oscillations) to inform today's signals	Adaptive (annual) management

Population Monitoring Framework: Accounting for Sage-Grouse Population Oscillations



Population Monitoring Framework: Accounting for Sage-Grouse Population Oscillations

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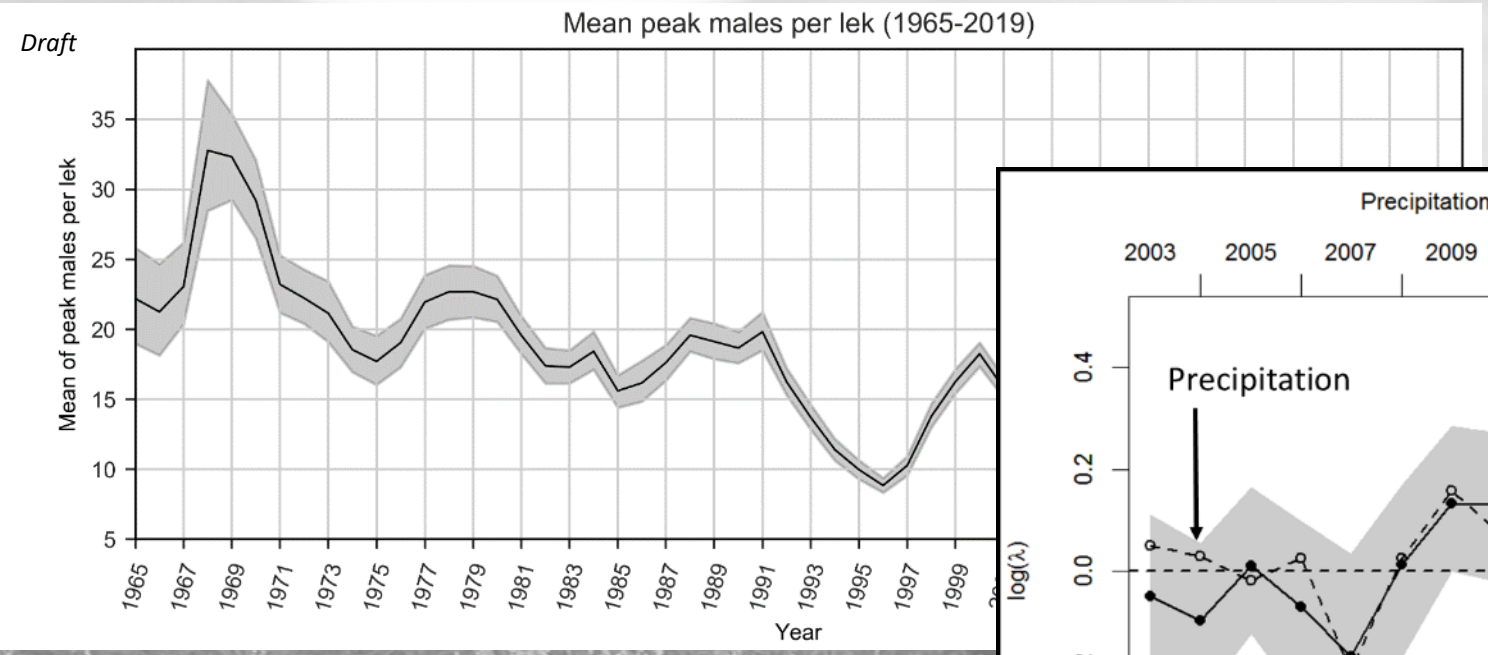

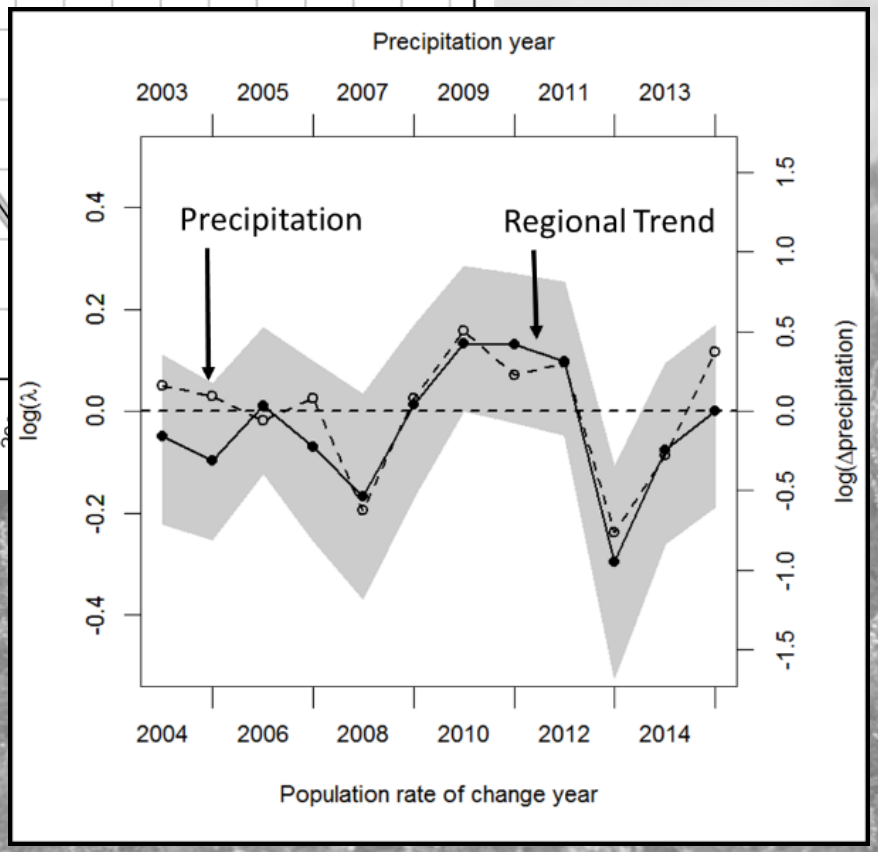

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RESEARCH ARTICLE

The relative importance of intrinsic and extrinsic drivers to population growth vary among local populations of Greater Sage-Grouse: An integrated population modeling approach

Peter S. Coates,[1]* Brian G. Prochazka,[1] Mark A. Ricca,[1] Brian J. Halstead,[1] Michael L. Casazza,[1] Erik J. Blomberg,[2] Brianne E. Brussee,[1] Lief Wiechman,[3] Joel Tebbenkamp,[4] Scott C. Gardner,[5] and Kerry P. Reese[4]

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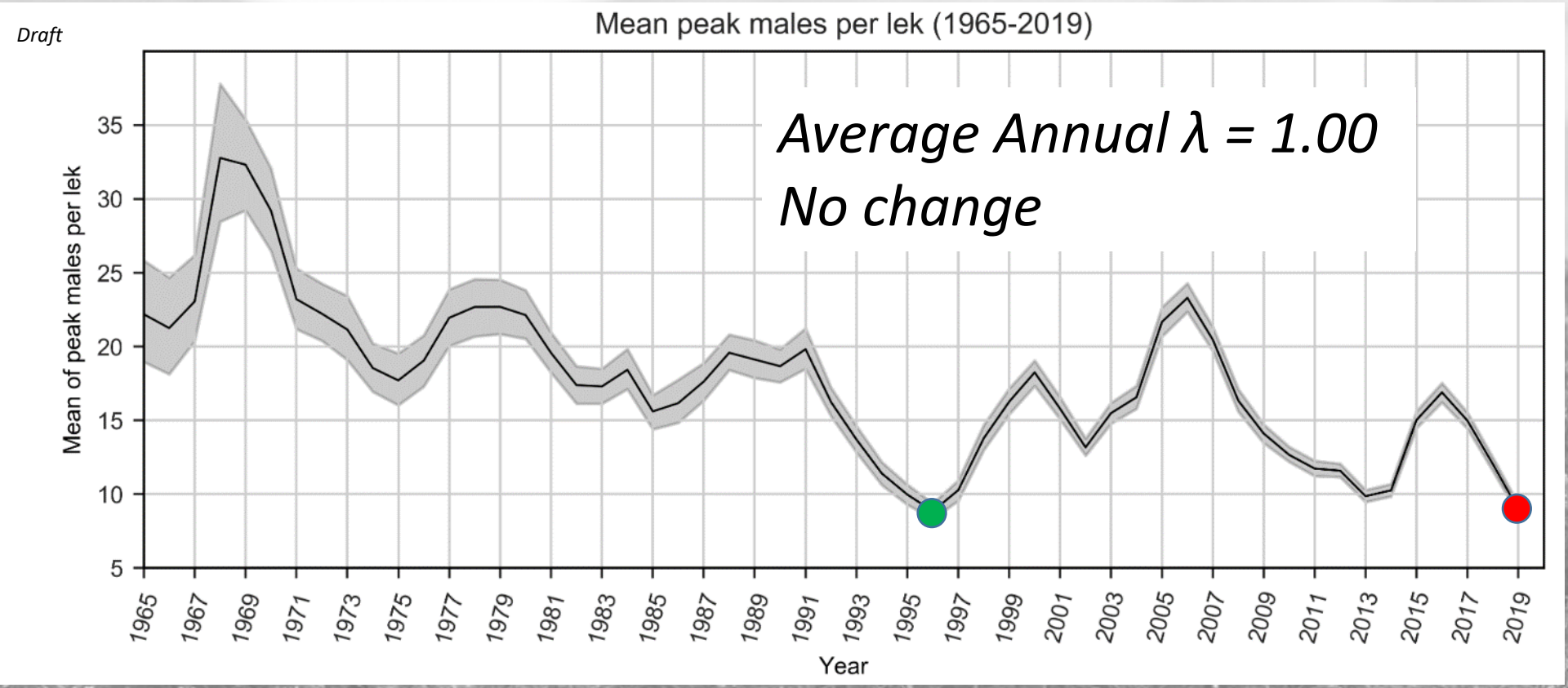

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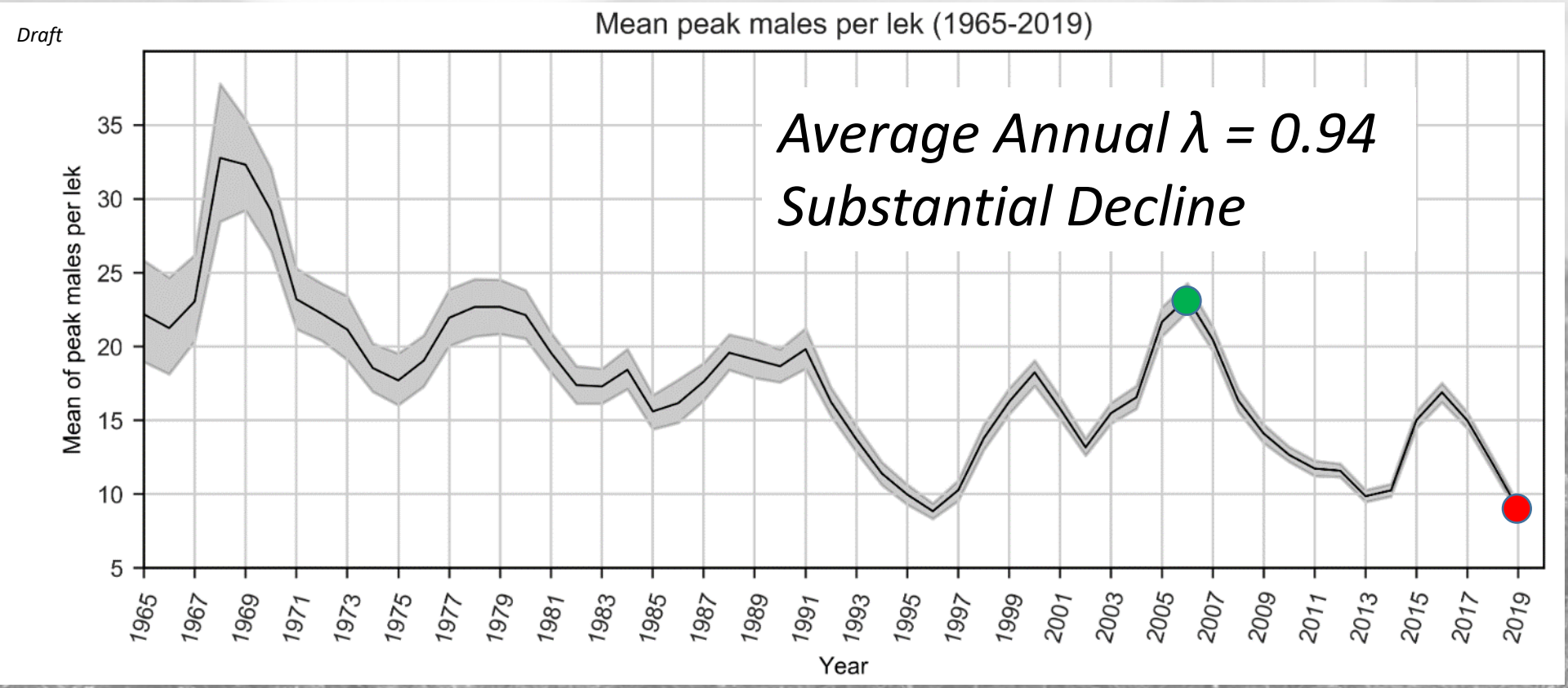

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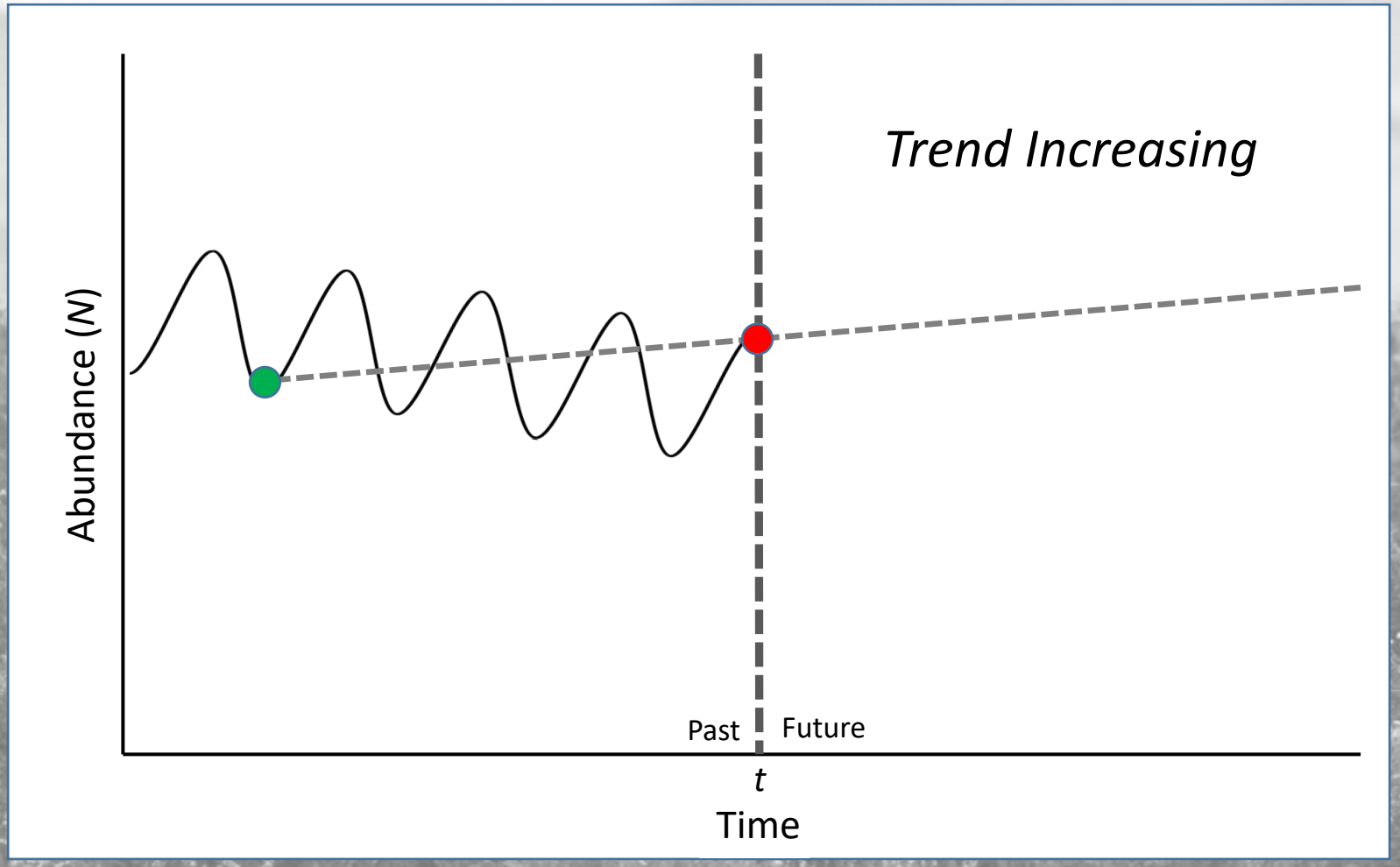

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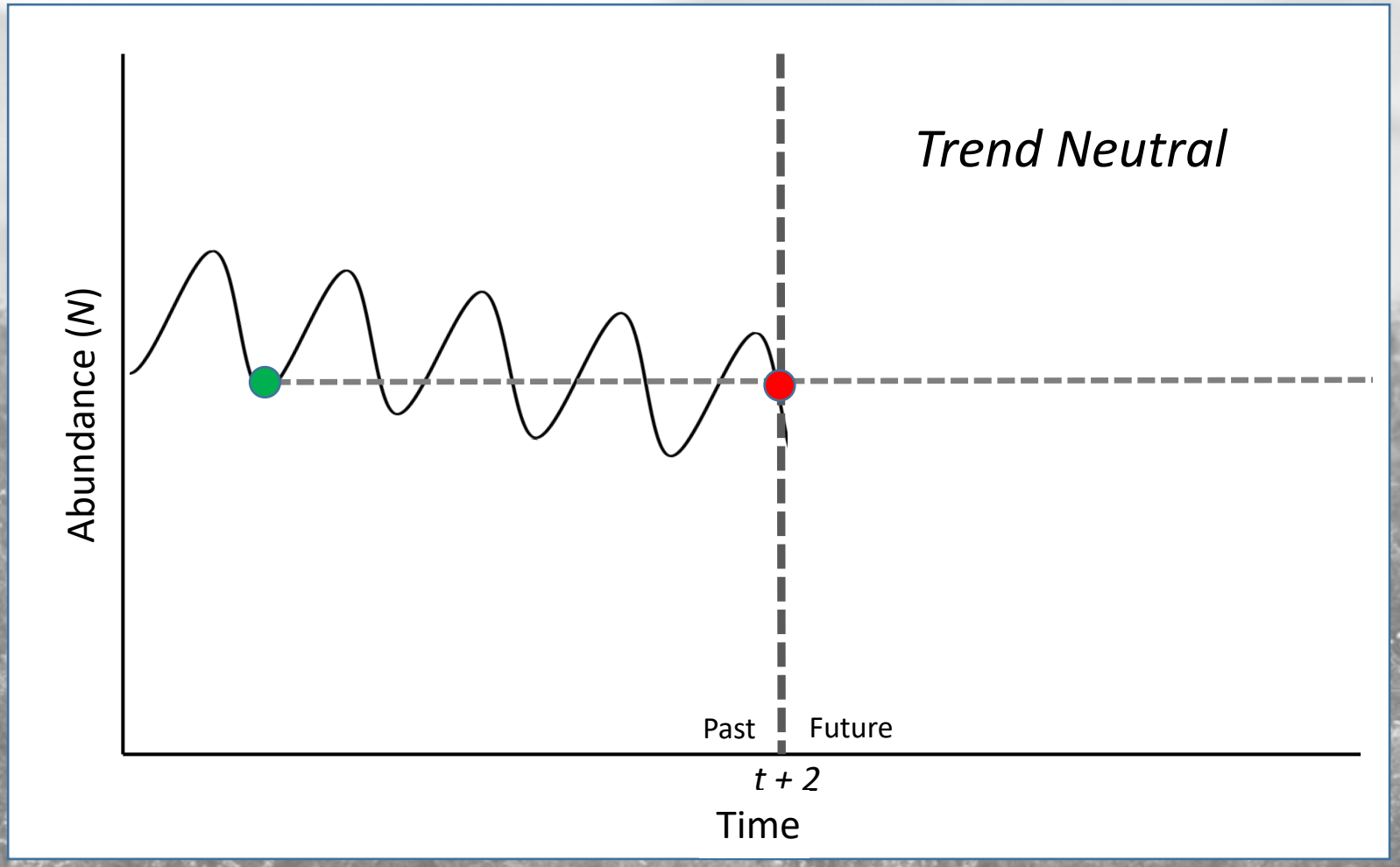

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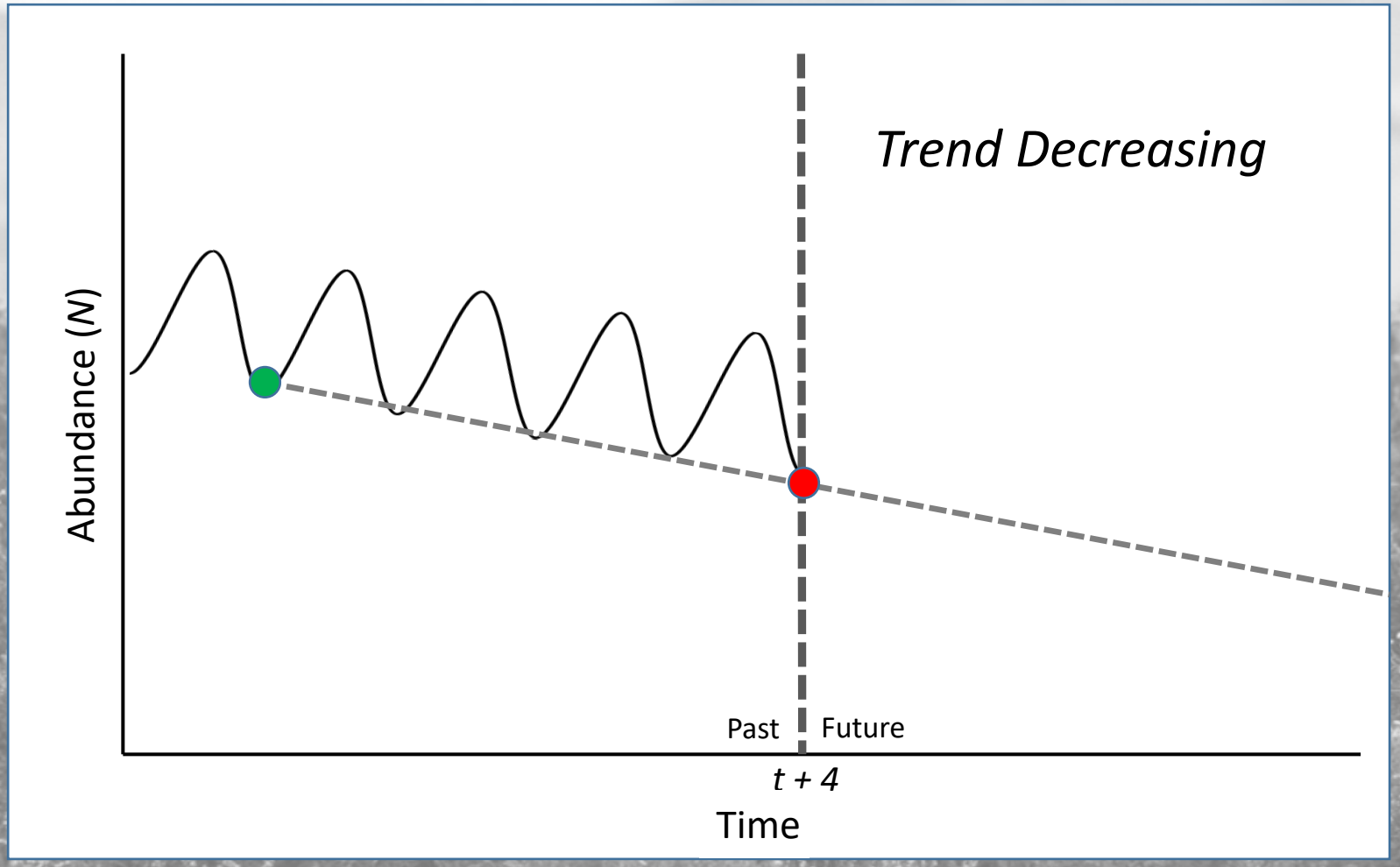

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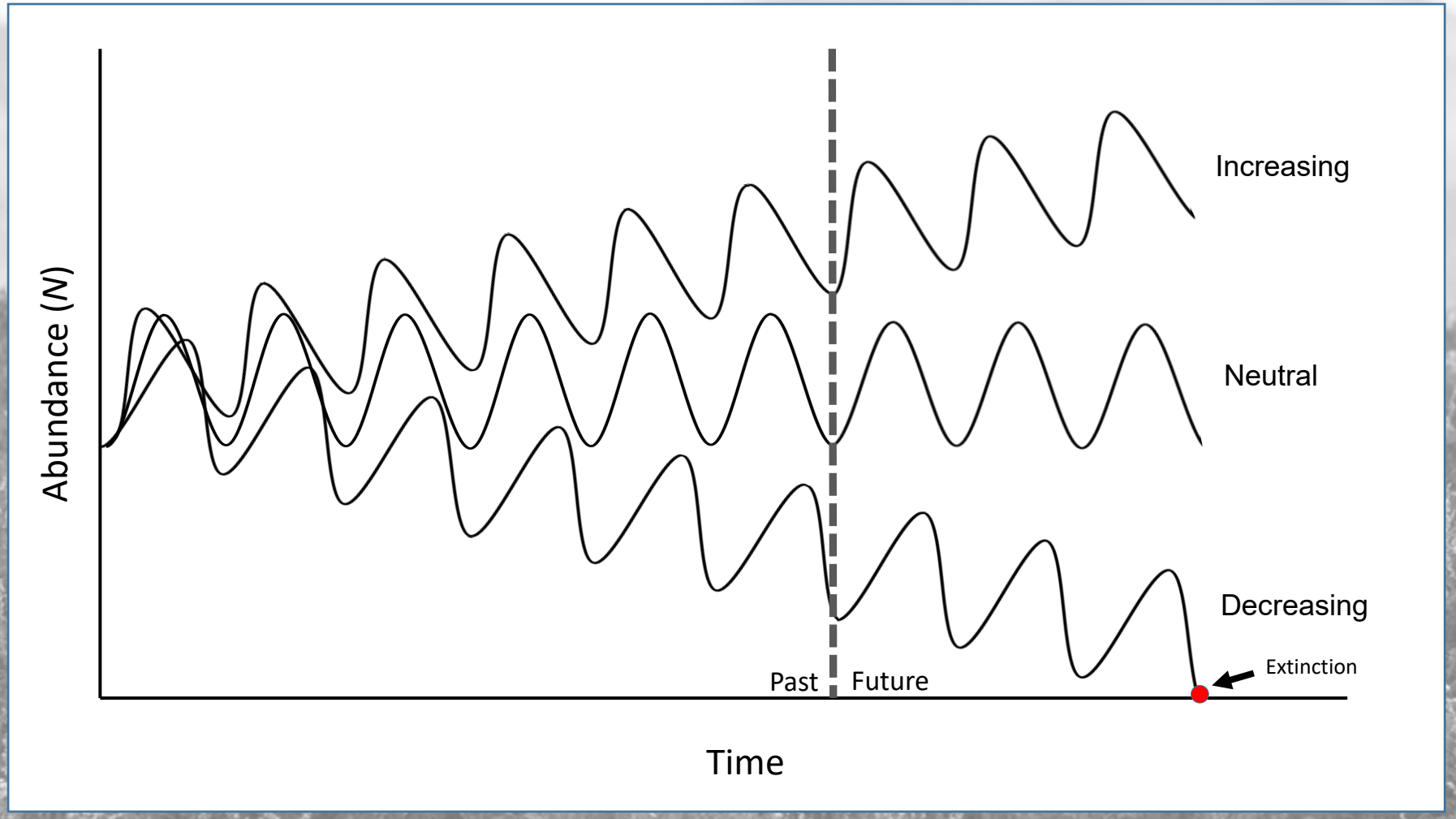
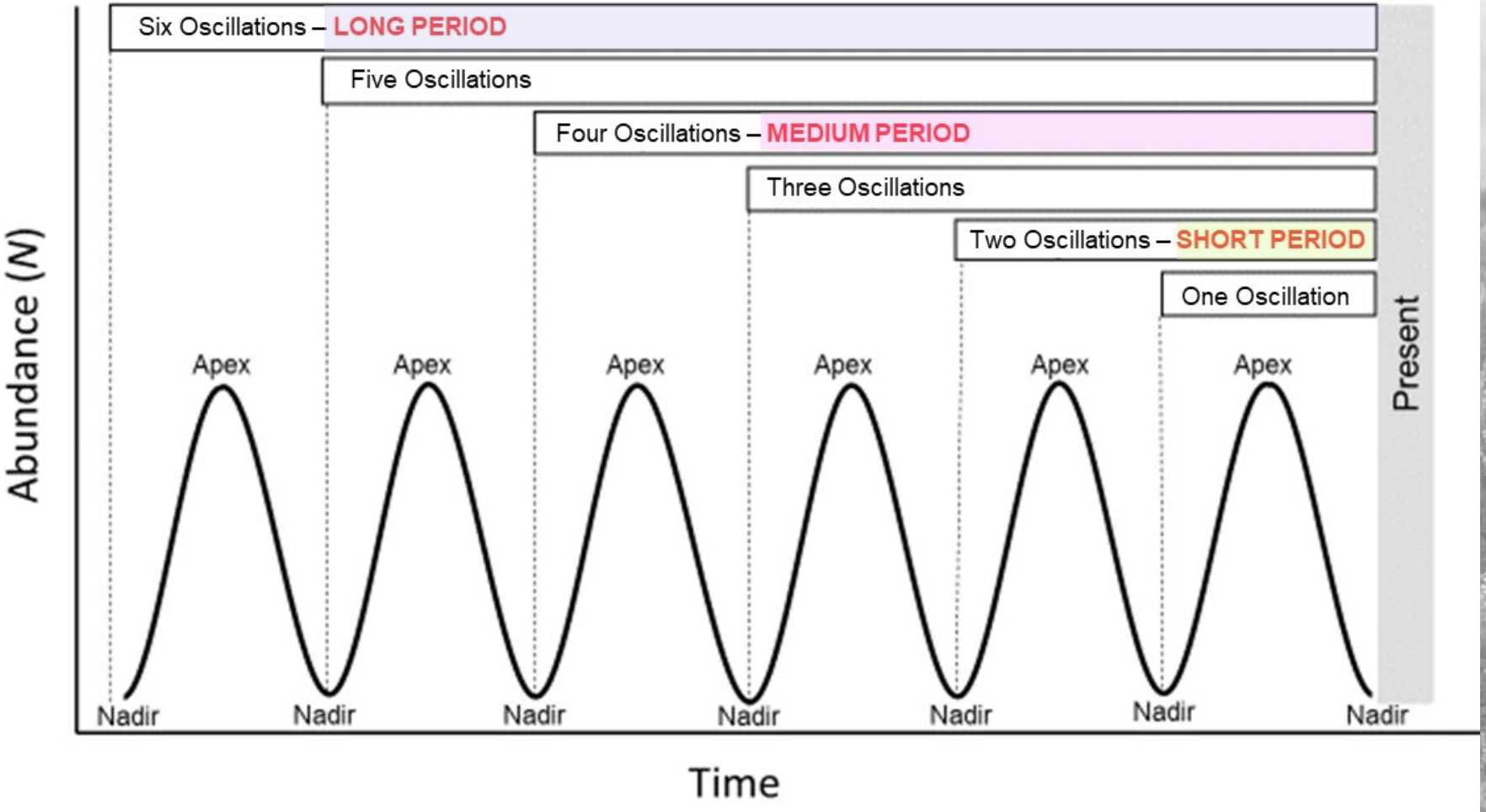
Population Monitoring Framework: Accounting for Sage-Grouse Population Oscillations



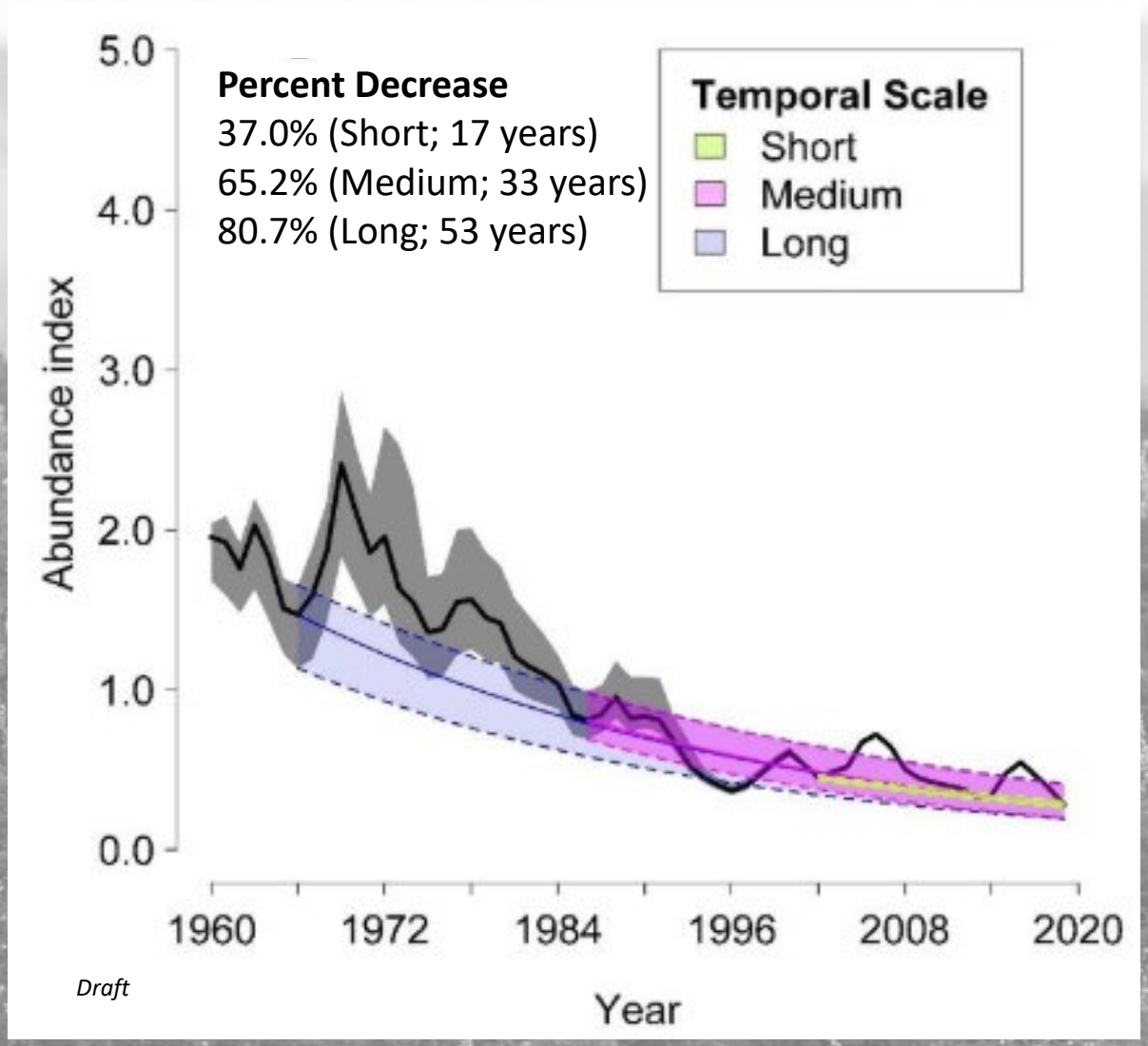
Population Monitoring Framework: Accounting for Sage-Grouse Population Oscillations

Bayesian State-Space Model Framework

- Partitions process from observation variance
- Accounts for nested structure (lek, neighborhood, climate)



Temporal Variation in Trends at the Range-Wide Scale



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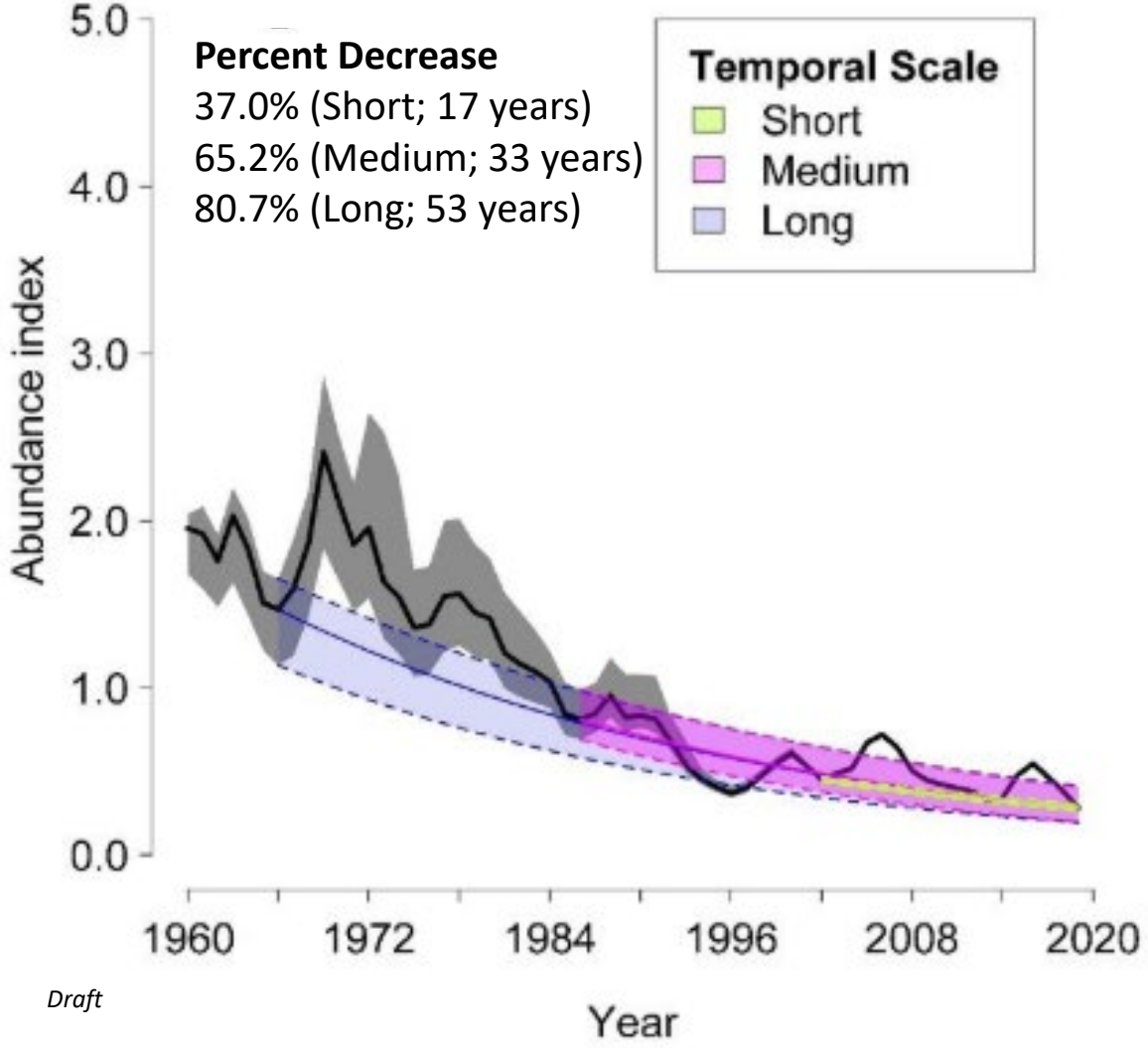

Comparison with similar large-scale studies

Study	Reported (λ)	Nadir-to-Nadir (λ)
Nielson et al. (2015) 50 years	0.979	**0.969**
Garton et al. (2015) 6 years	0.872	**0.973**
Coates et al. (2015) Bi-State 23 years	1.018	**0.995**
Montana 2020 Unpbl. Report 18 years	0.998	**0.966**

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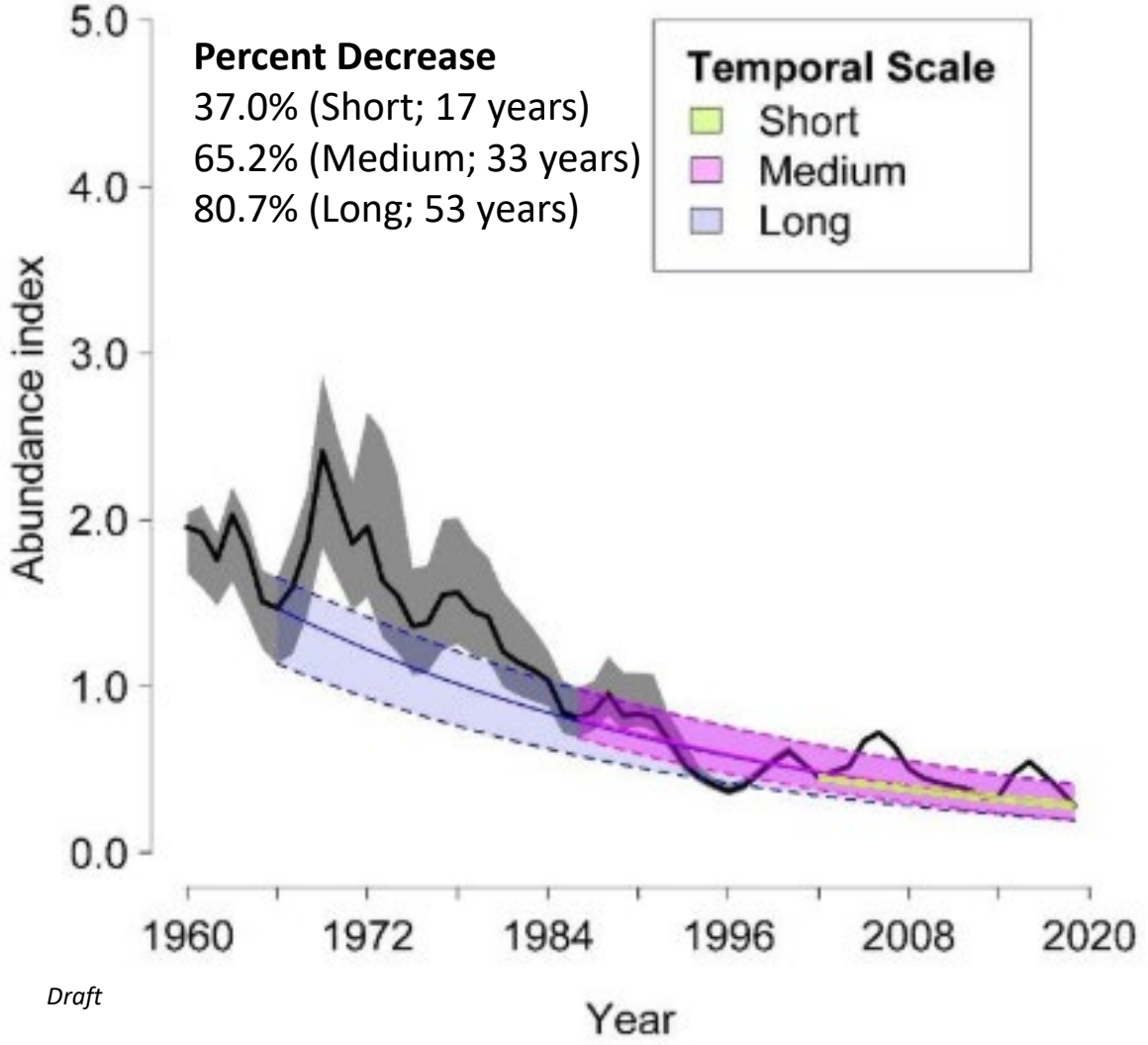

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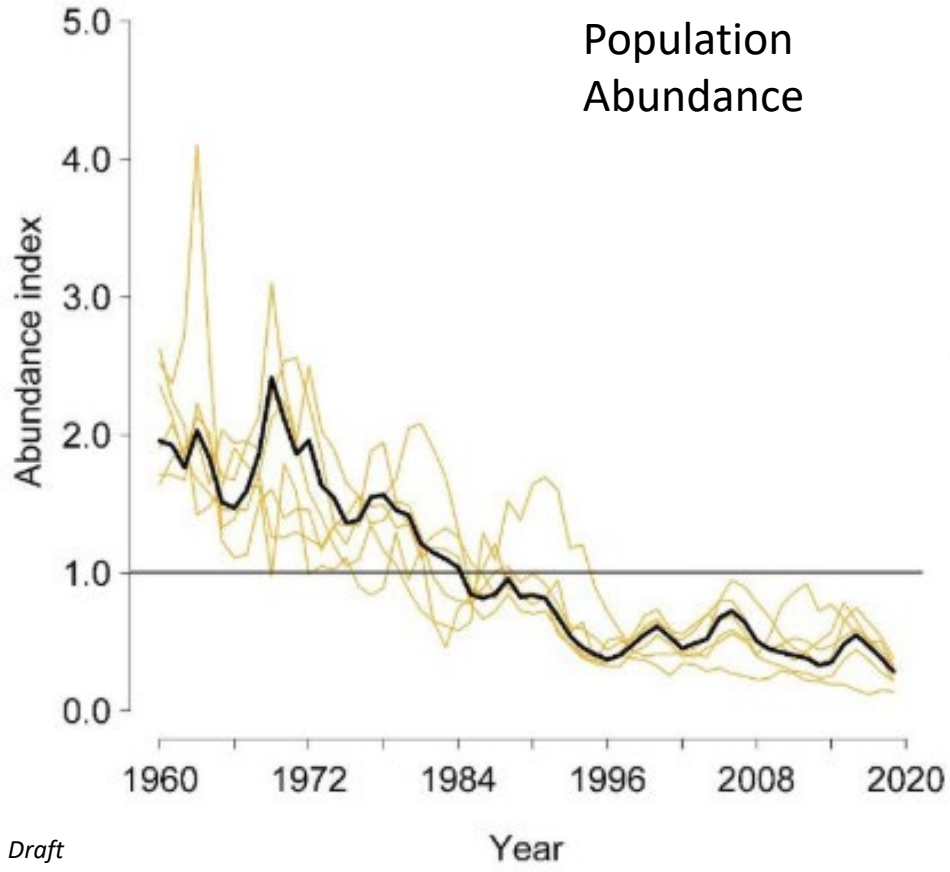
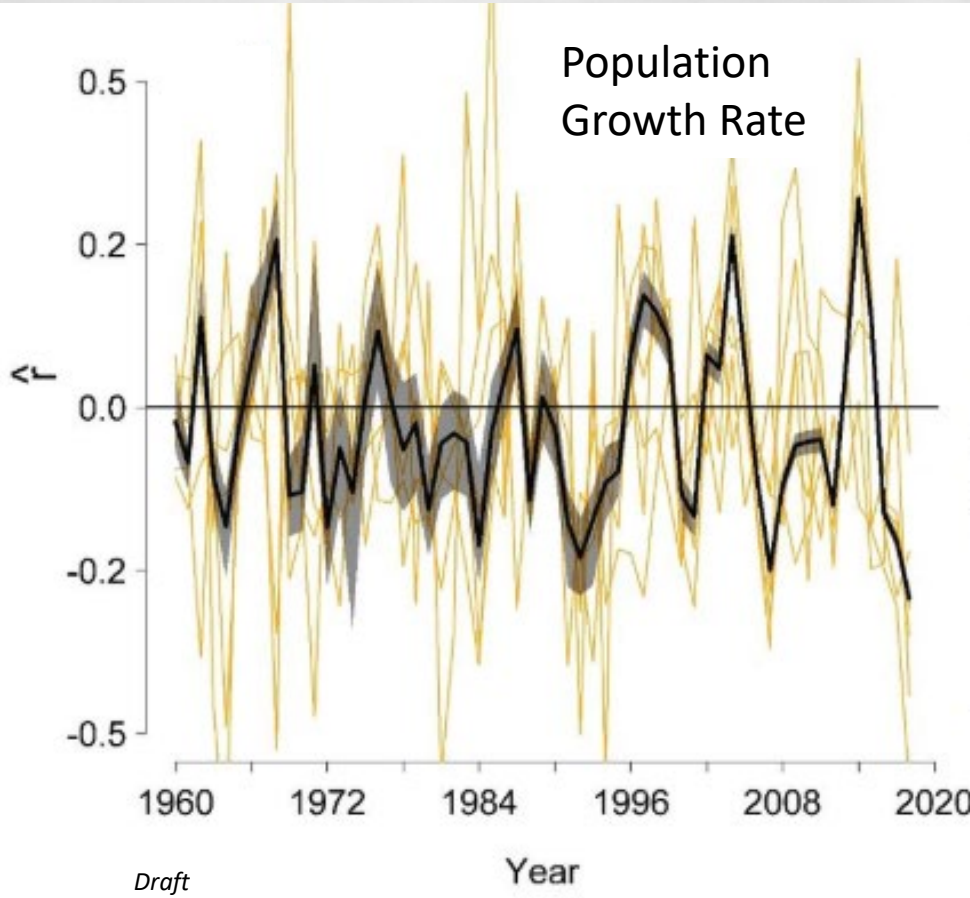
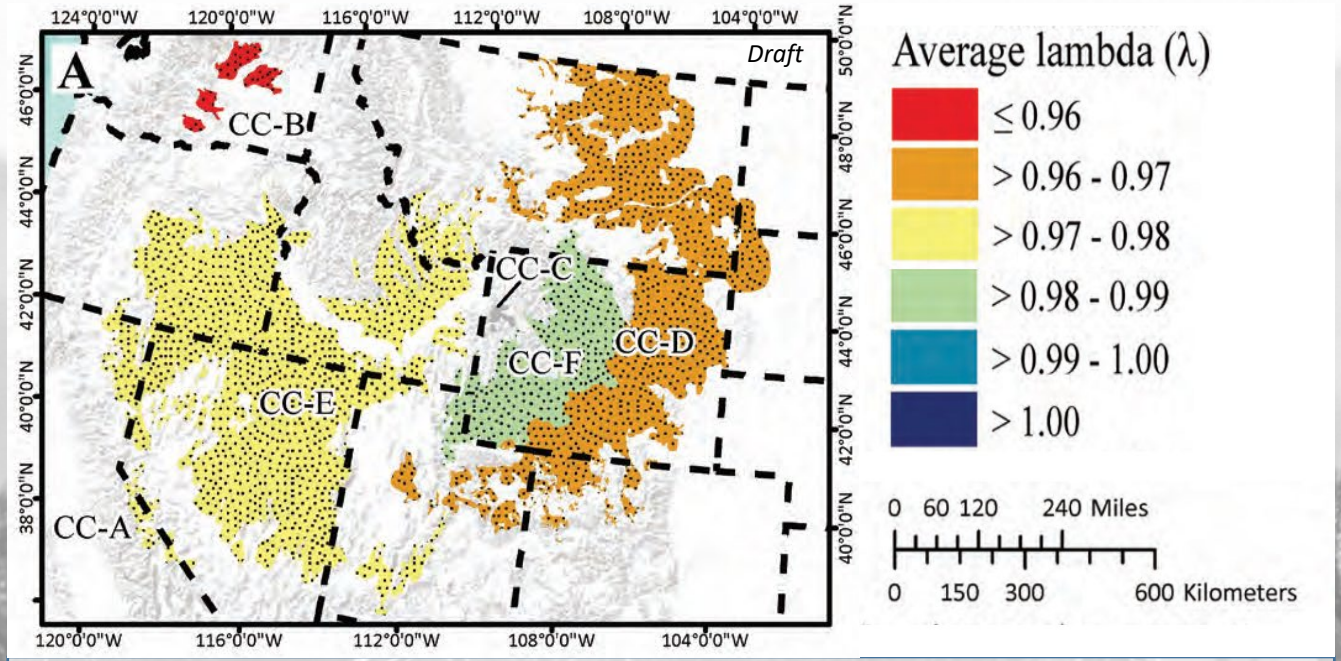




Spatial Variation in Trends at the Climate Cluster Scale



Averaged Annual Rate of Change (λ)

Range-wide	**0.970**	**(0.967 – 0.980)**
Bi-State Area (CC-A)	0.978	(0.964 – 0.987)
Washington Area (CC-B)	0.954	(0.943 – 0.969)
Jackson Hole WY Area (CC-C)	NA	NA
Eastern Area (CC-D)	0.963	(0.960 – 0.980)
Great Basin Area (CC-E)	0.971	(0.967 – 0.976)
Western WY Area (CC-F)	0.980	(0.975 – 0.987)

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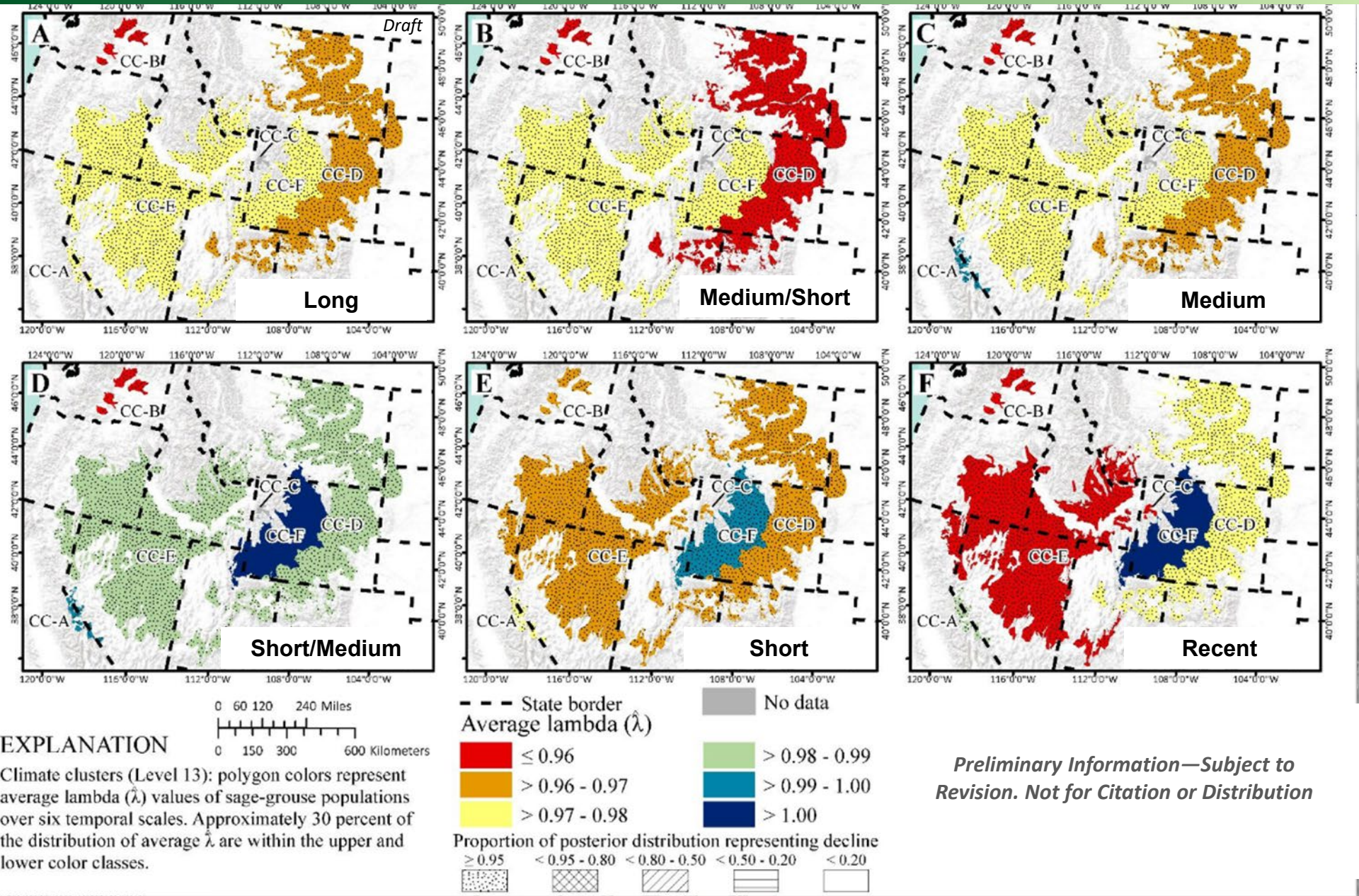
Spatiotemporal Variation in Trends at the Climate Cluster Scale



Preliminary Information—Subject to Revision. Not for Citation or Distribution

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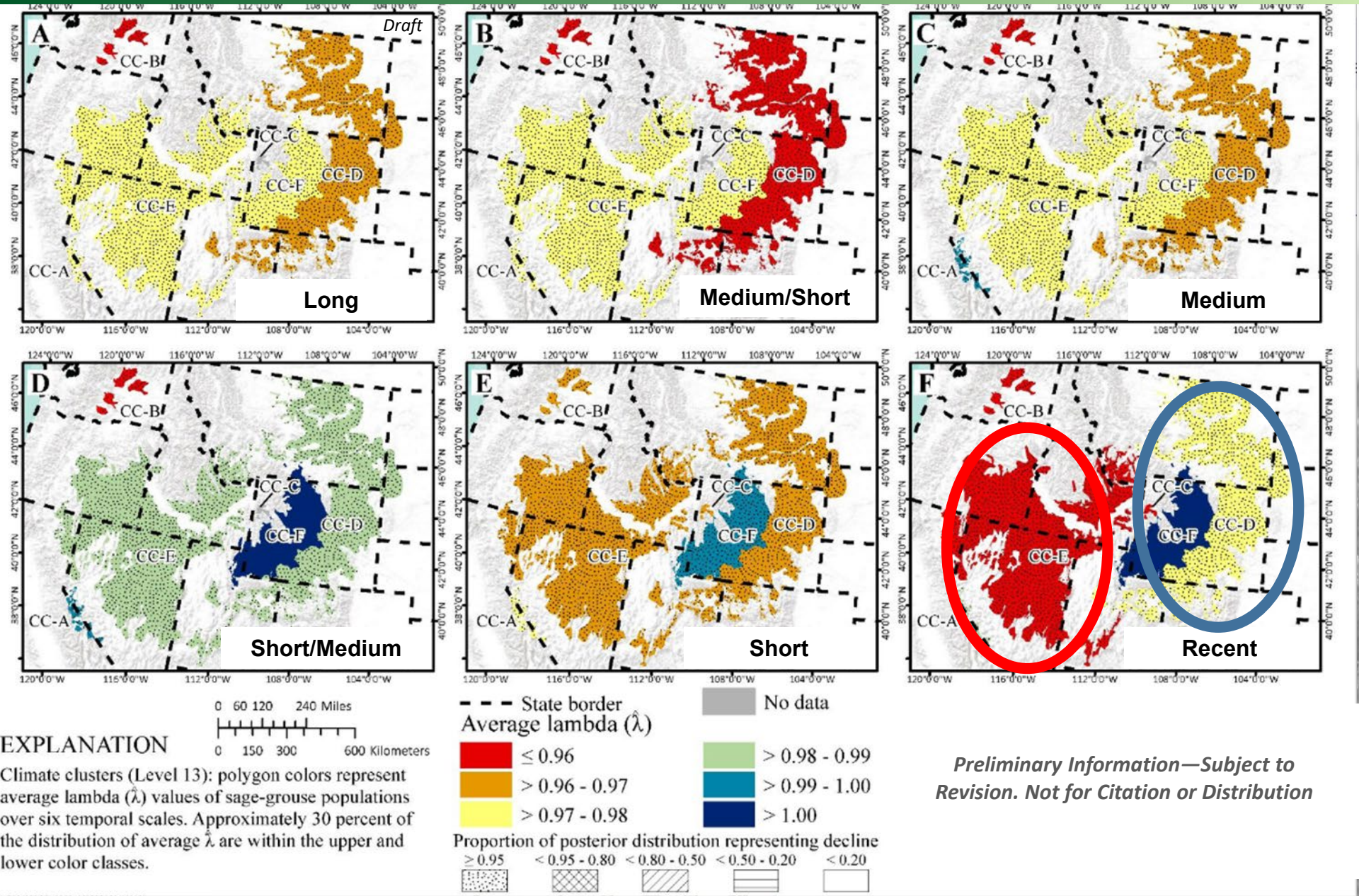

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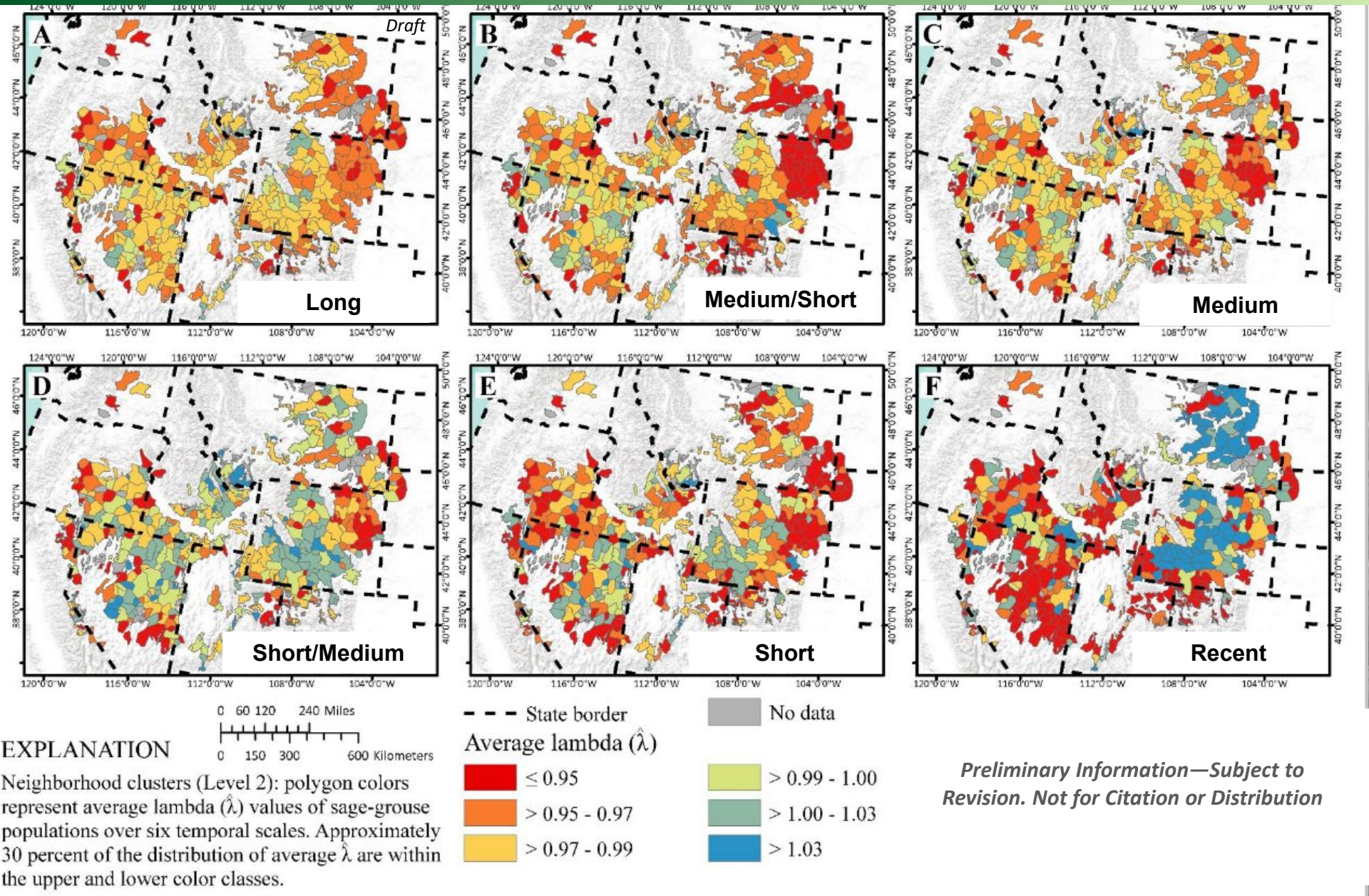
Spatiotemporal Variation in Trends at the Neighborhood Cluster Scale



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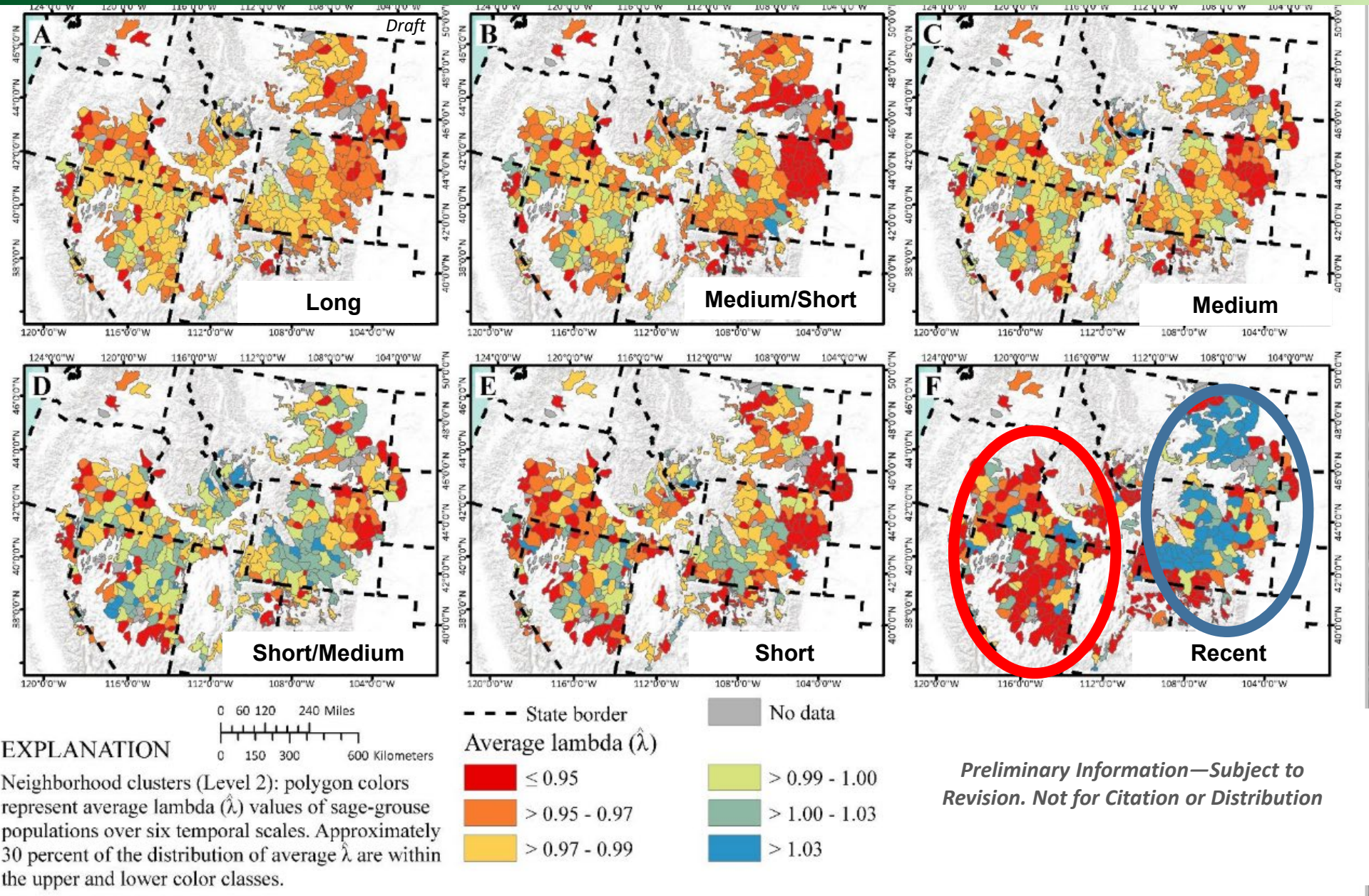

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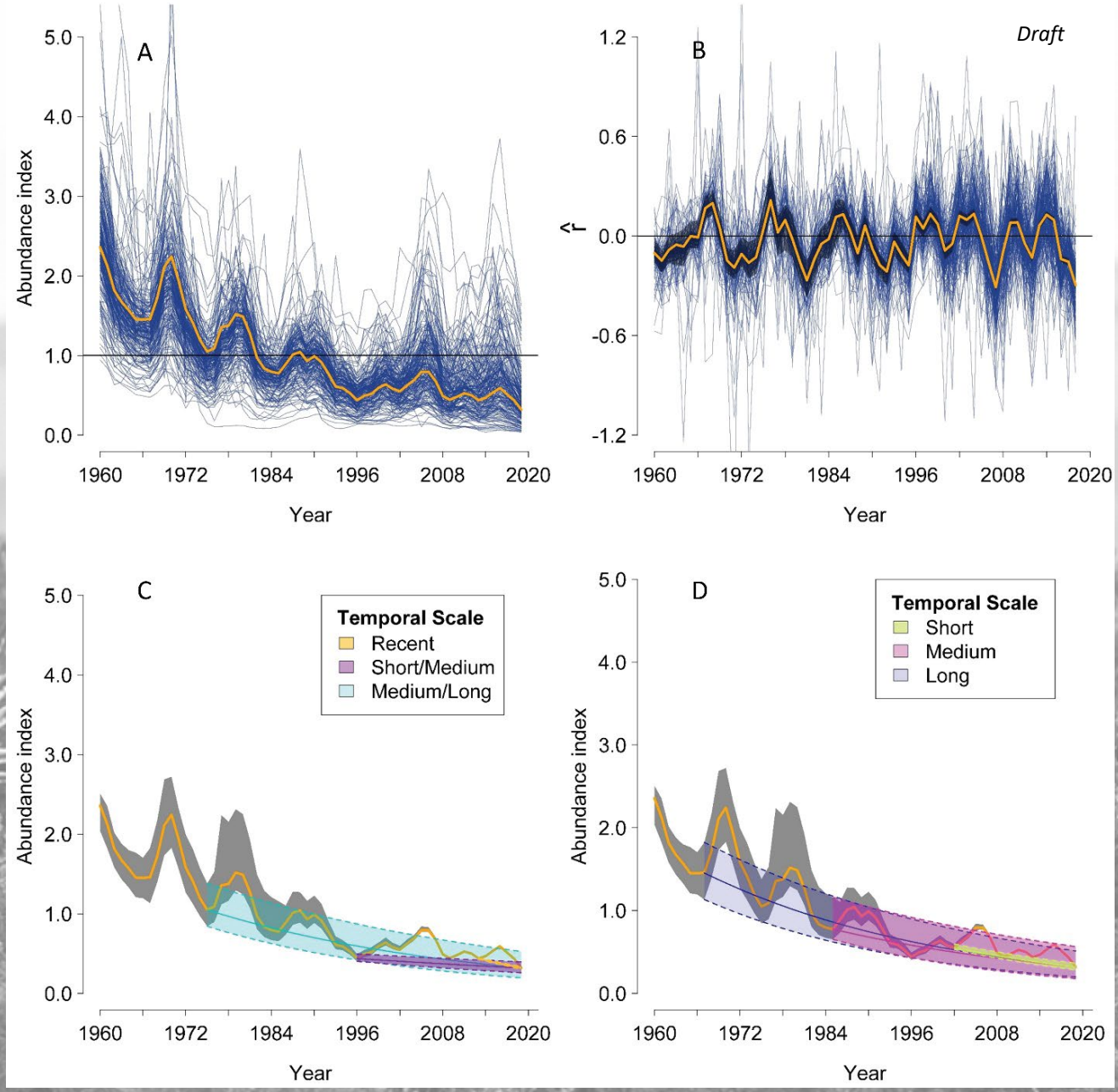
Cycle	GR	CRI
6	0.971	(0.967–0.976)
5	0.973	(0.967–0.978)
4	0.974	(0.963–0.979)
3	0.986	(0.981–0.990)
2	0.968	(0.964–0.971)
1	0.949	(0.944–0.955)



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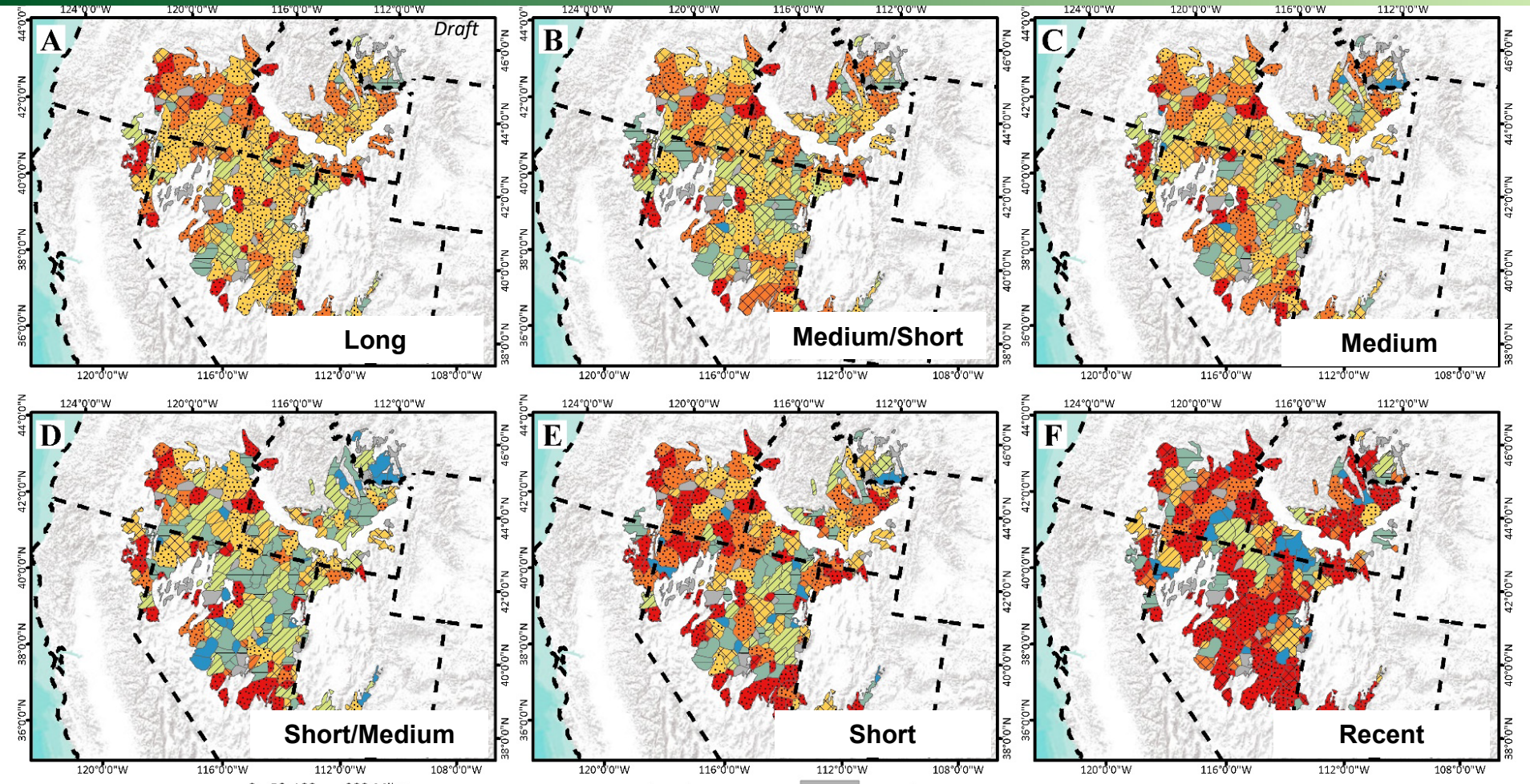

EXPLANATION

Neighborhood clusters (Level 2) within the Great Basin area (climate cluster E): polygon colors represent average lambda values ($\hat{\lambda}$) for sage-grouse populations over six temporal scales. Approximately 30 percent of the distribution of average $\hat{\lambda}$ are within the upper and lower color classes. ymbols are based on a range-wide distribution of values and all may not be represented here.

State border

No data

Average lambda ($\hat{\lambda}$)

- ≤ 0.95
- > 0.95 - 0.97
- > 0.97 - 0.99
- > 0.99 - 1.00
- > 1.00 - 1.03
- > 1.03

Proportion of posterior distribution representing decline

≥ 0.95 | < 0.95 - 0.80 | < 0.80 - 0.50 | < 0.50 - 0.20 | < 0.20

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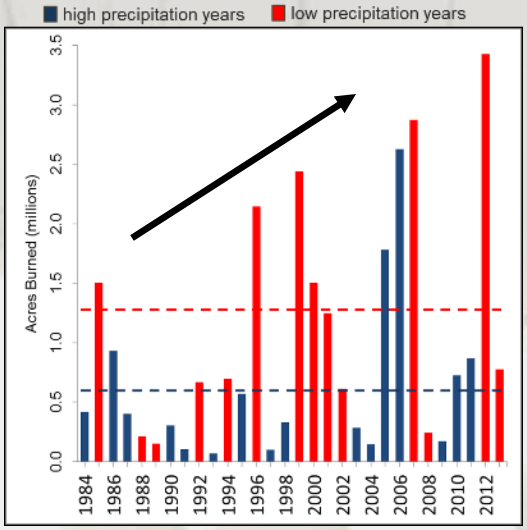
Explanations: Wildfire and Invasive Grass



Coates et al. 2016. Proceedings of National Academy of Science 113: 12745–12750

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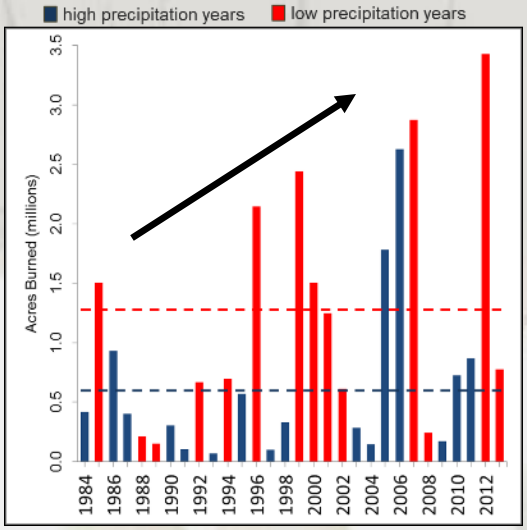

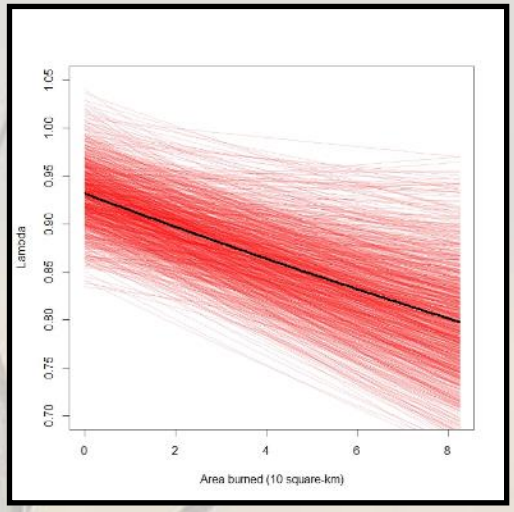

A 10-km^2 increase in burned area decreased lambda by approximately **2.1%**

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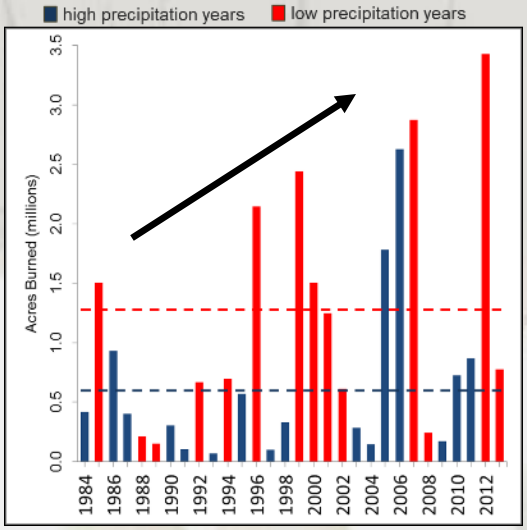

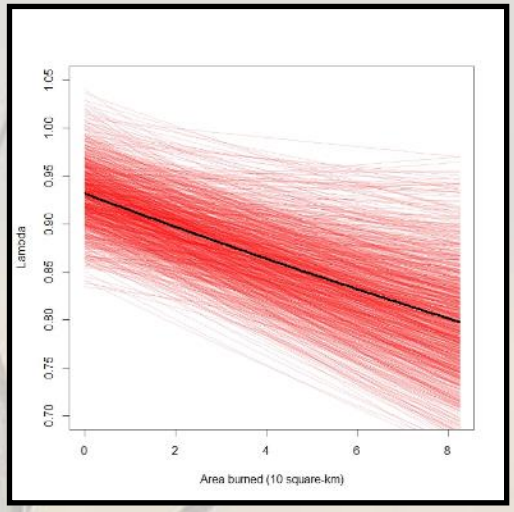

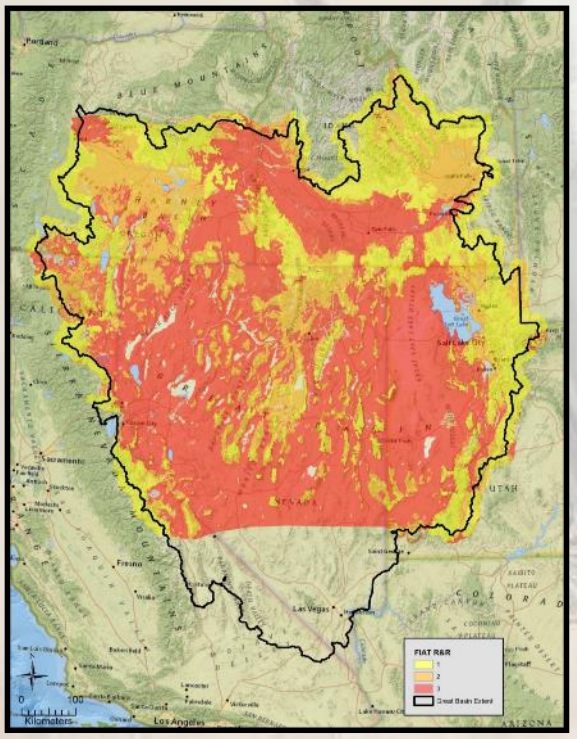

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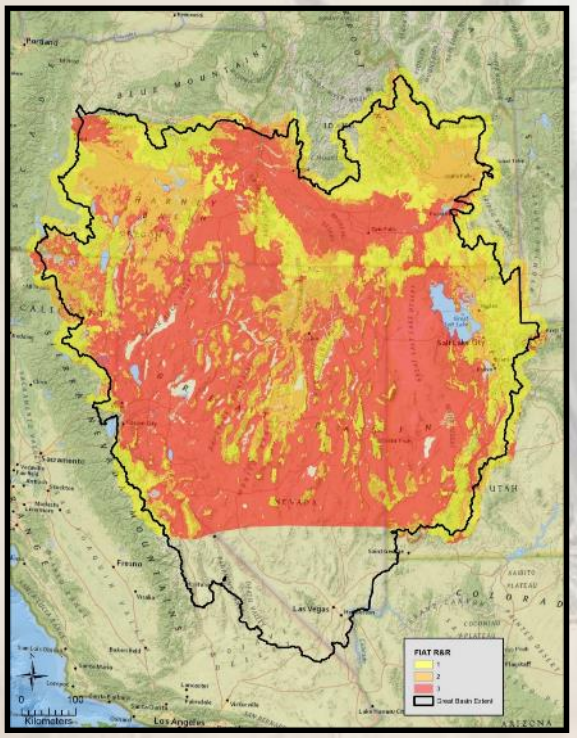

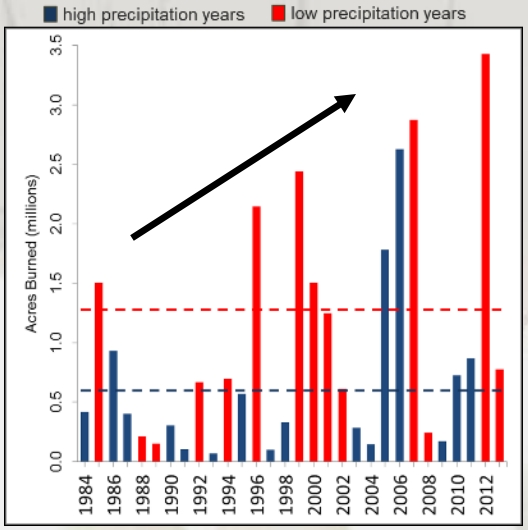

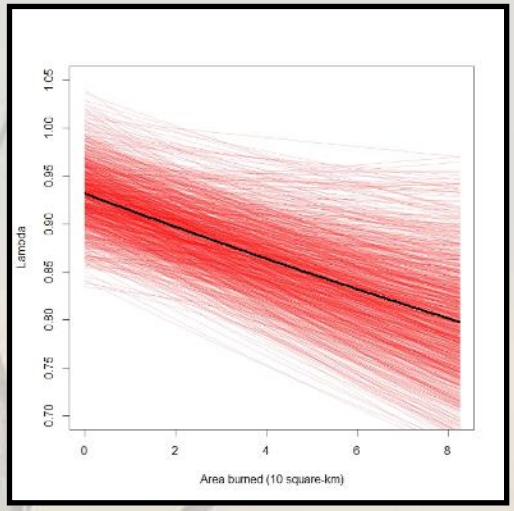

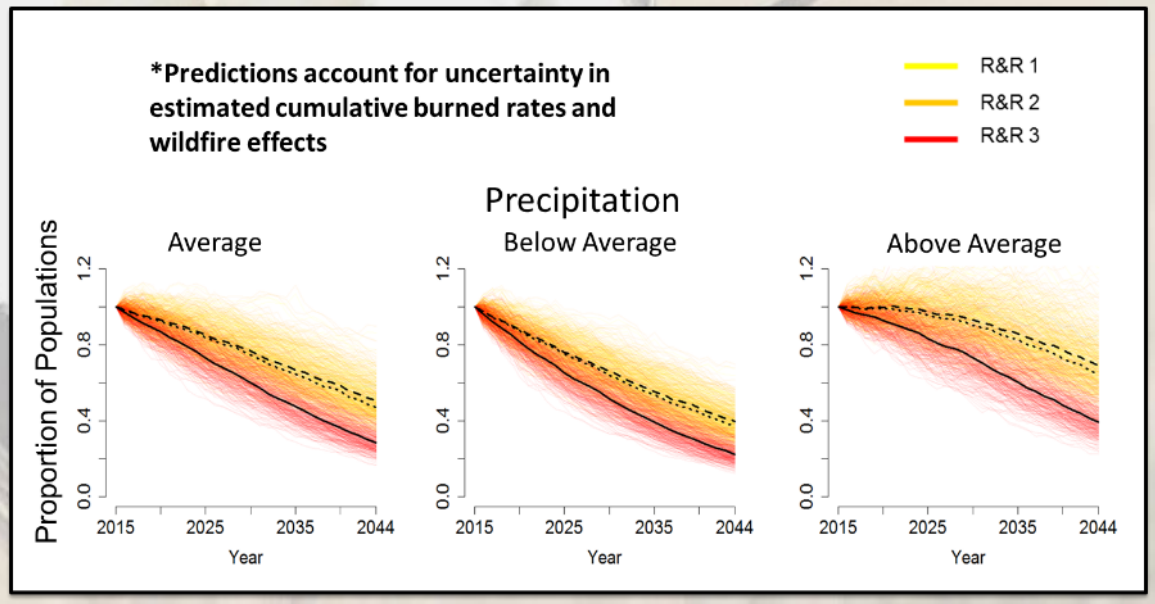

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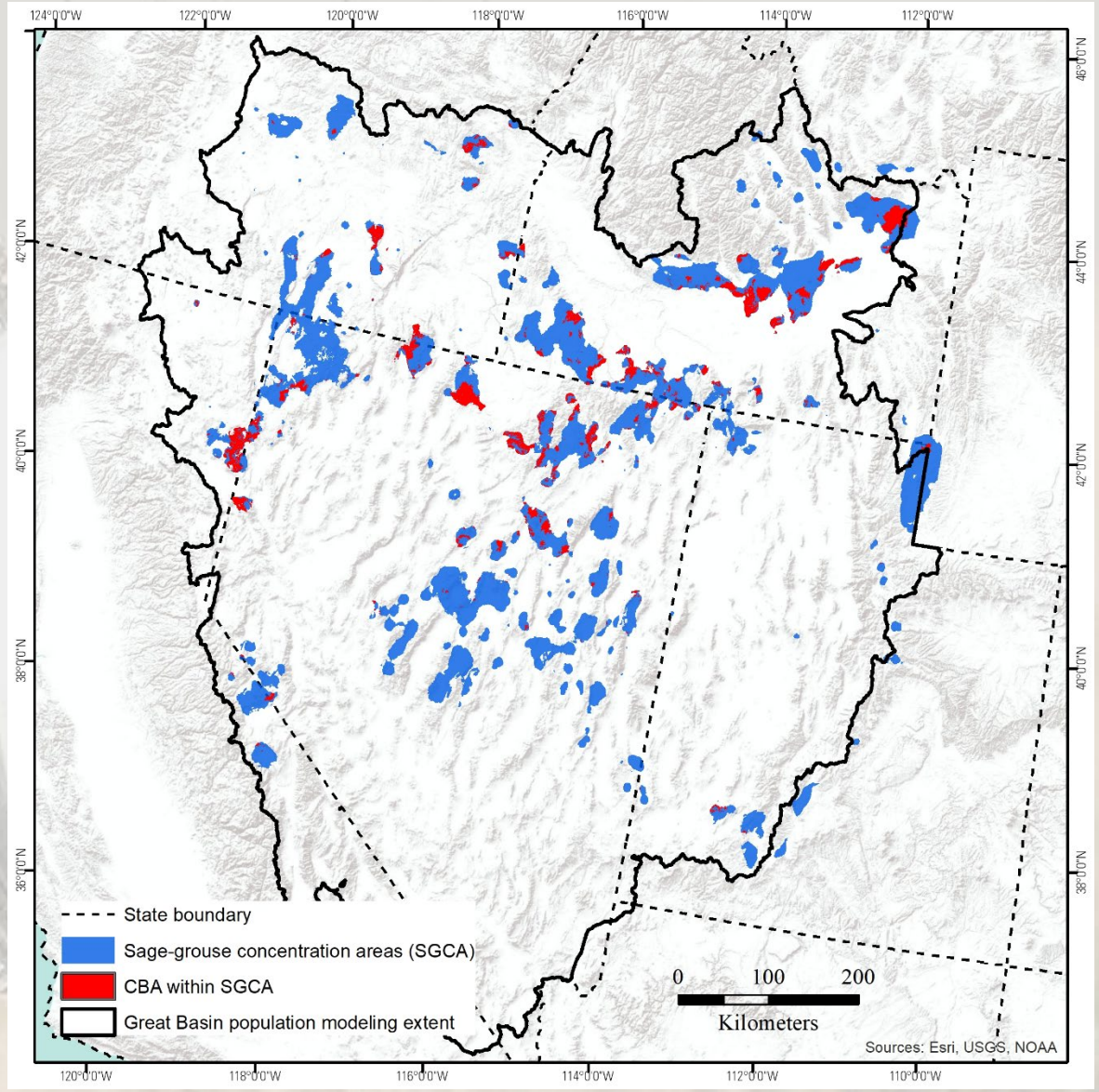

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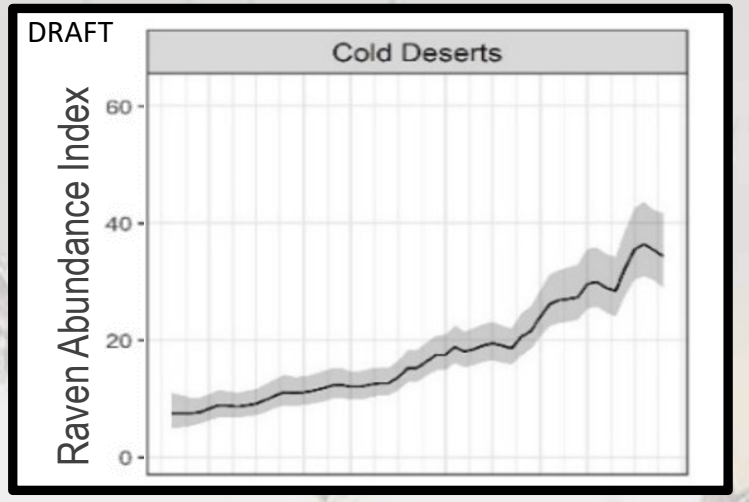
Explanations: Increasing Raven Populations



Ravens have experienced population increases by ~350% since 1970s

BBS Data; Sauer et al. 2019

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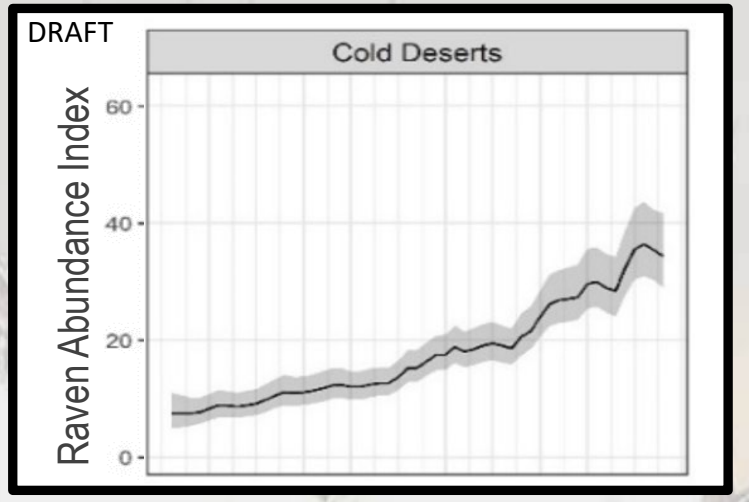
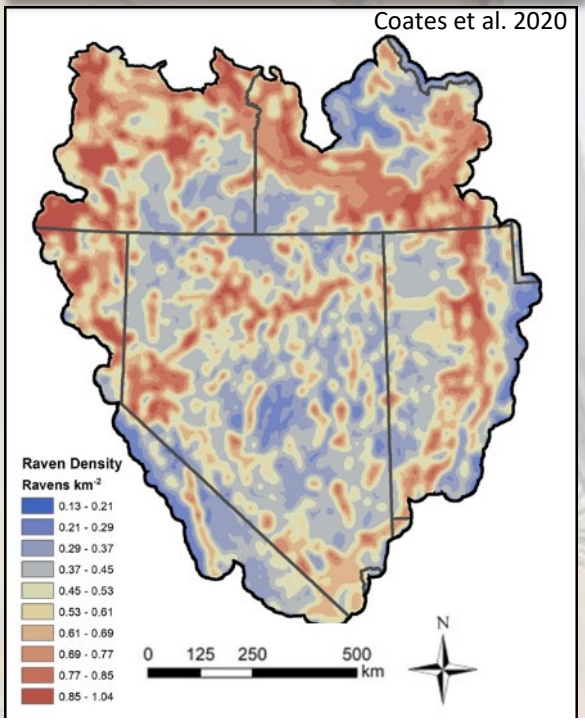


Coates et al. 2020



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Coates et al. 2020. Biological Conservation 243: 108409

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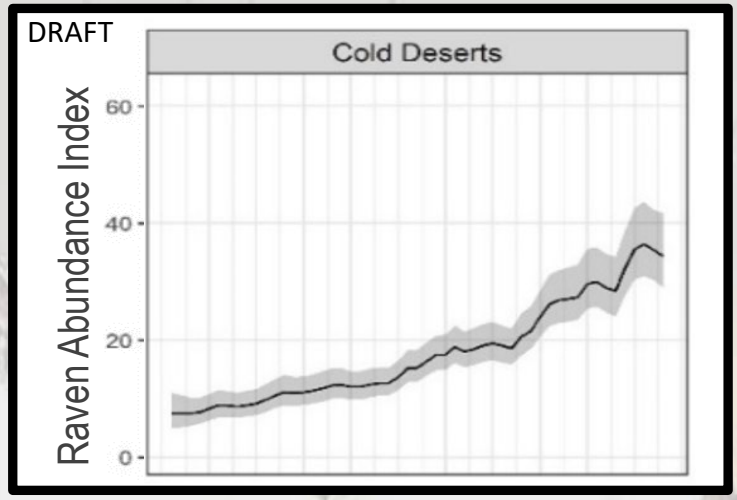
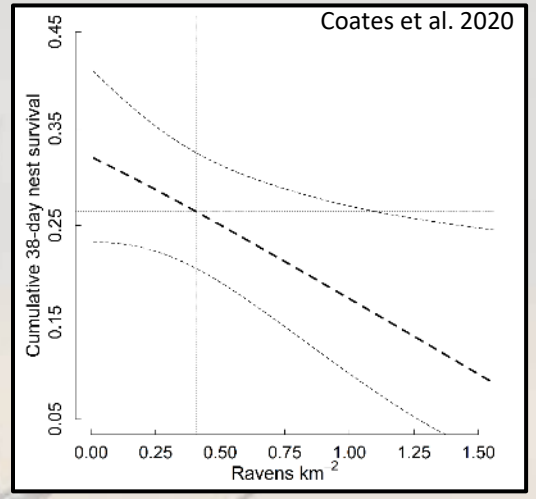
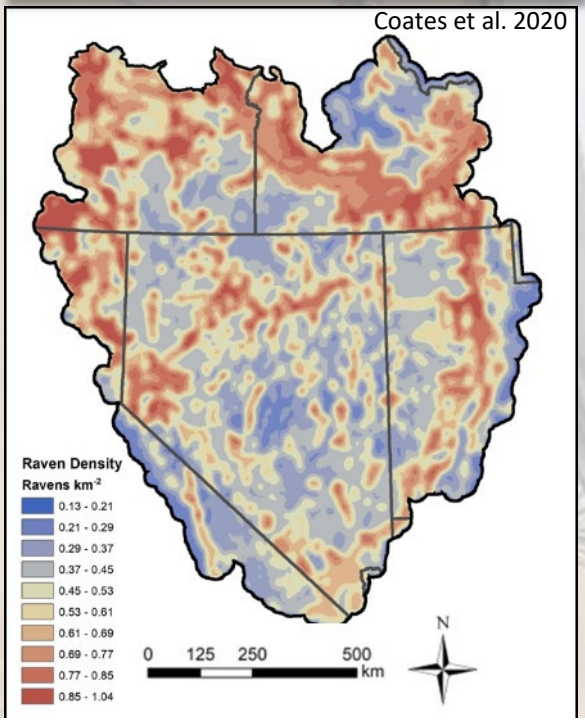




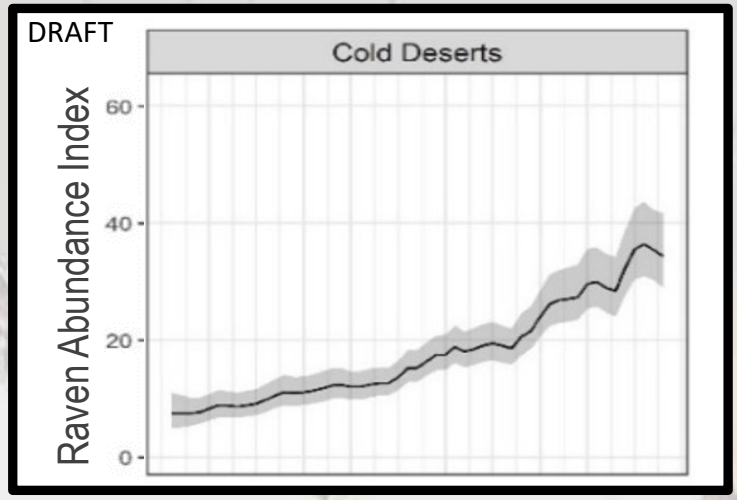


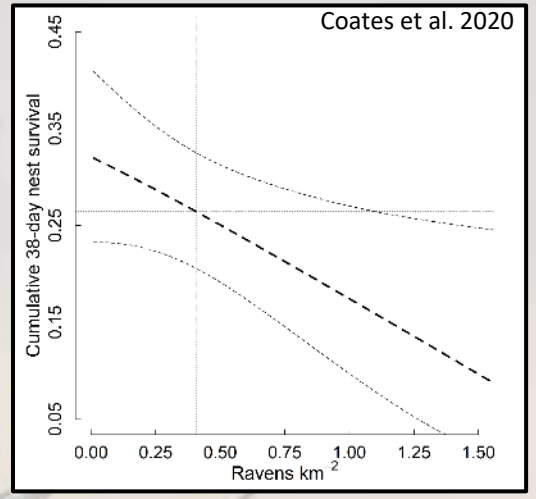
Ravens have experienced population increases by ~350% since 1970s

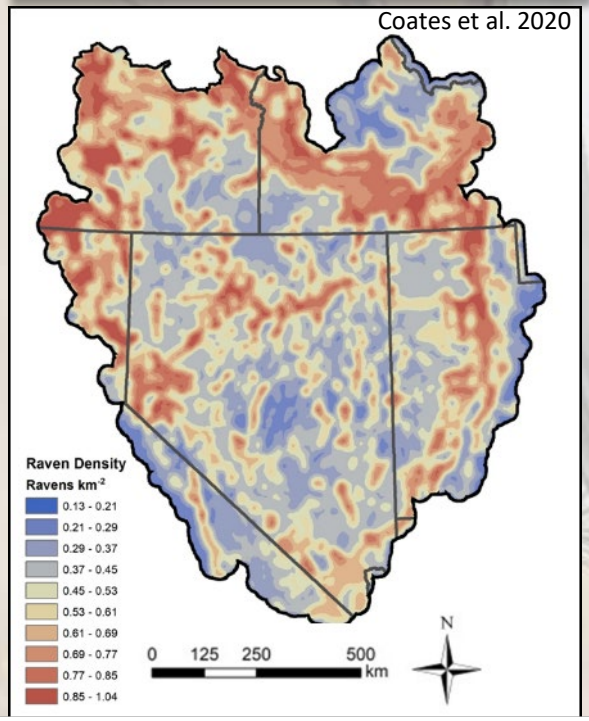
Ecological threshold ~0.4 ravens km^{-2}

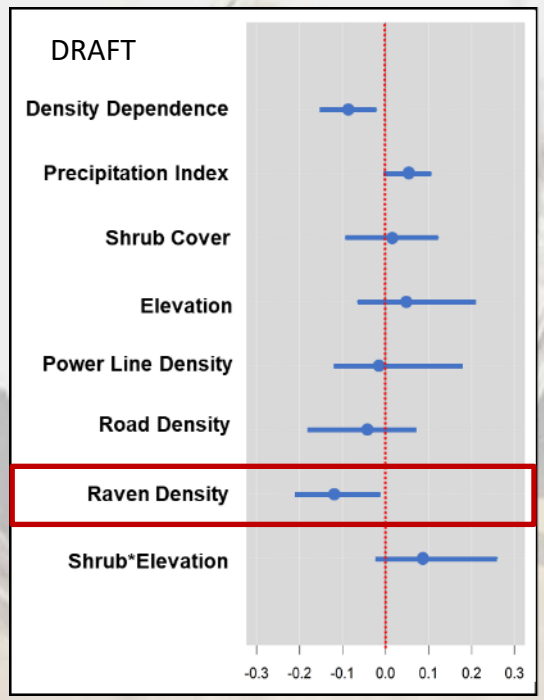
Coates et al. 2020. Biological Conservation 243: 108409

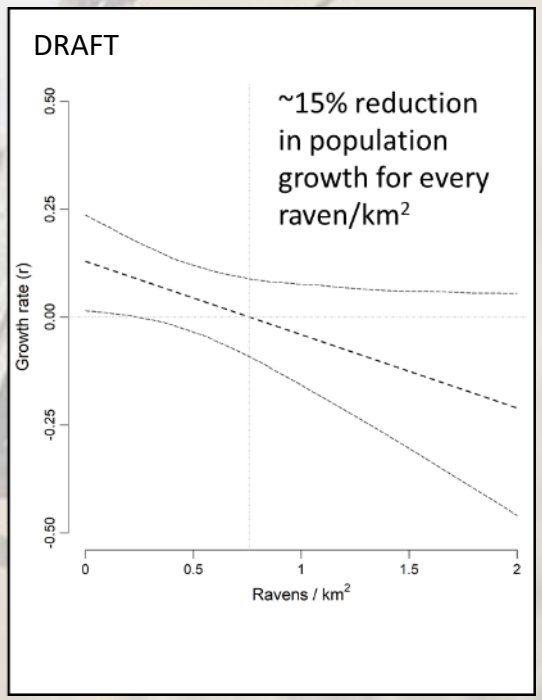
Explanations: Increasing Raven Populations







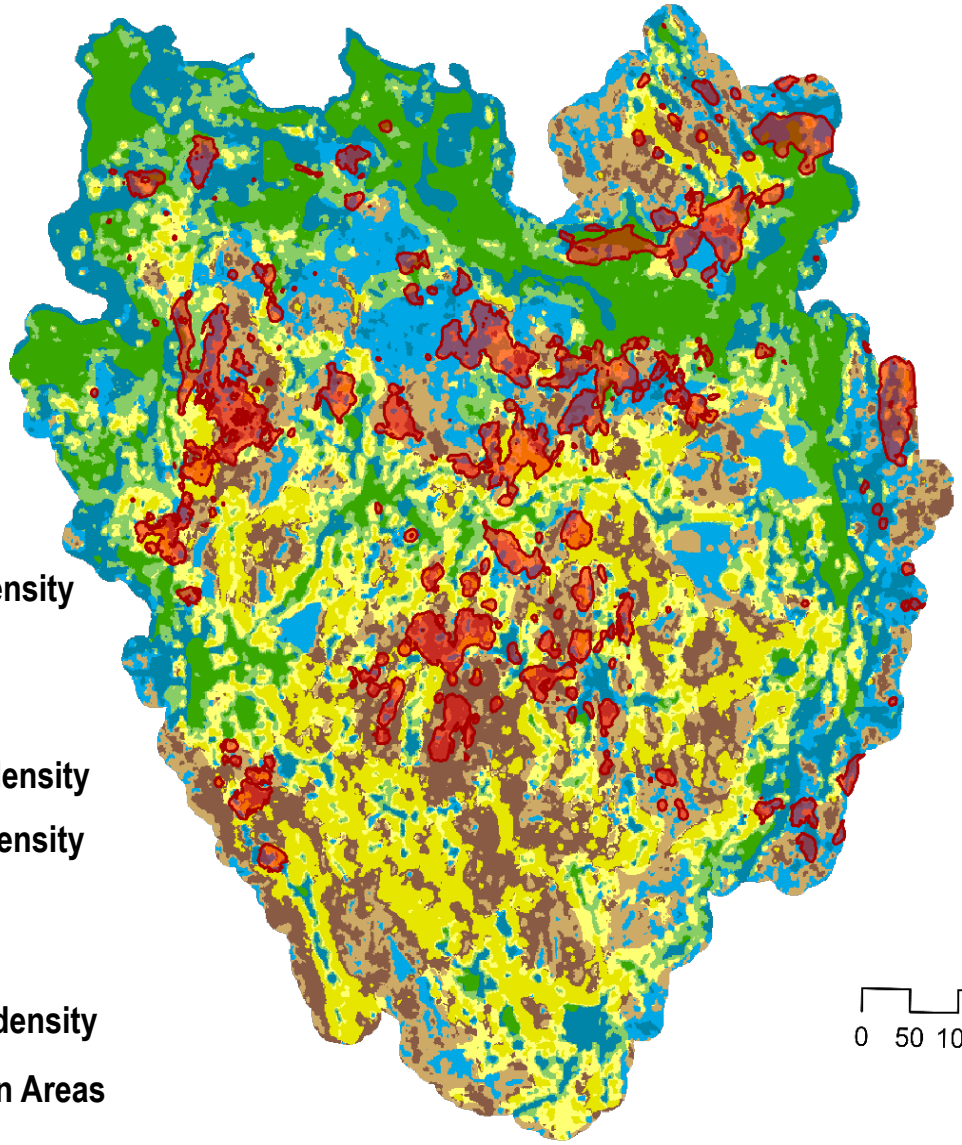




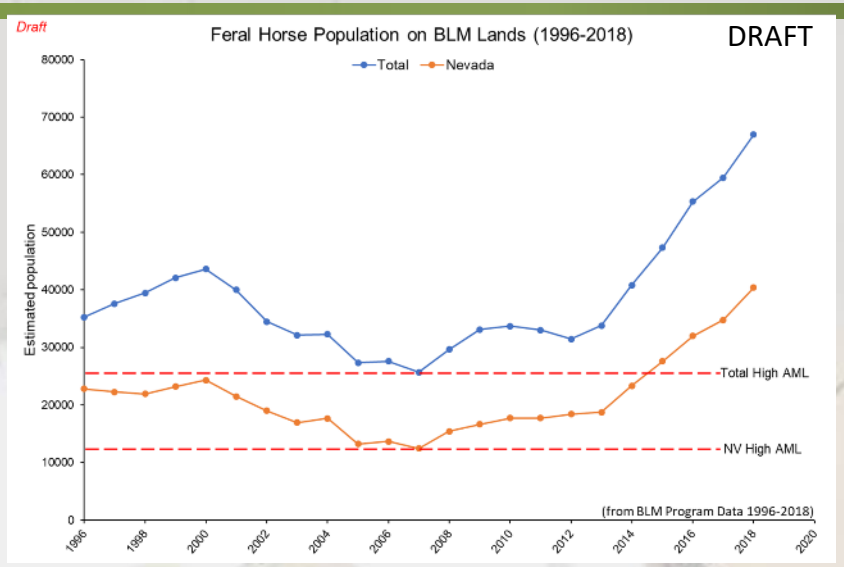
Preliminary Information—Subject to Revision. Not for Citation or Distribution

Explanations: Increasing Raven Populations

DRAFT

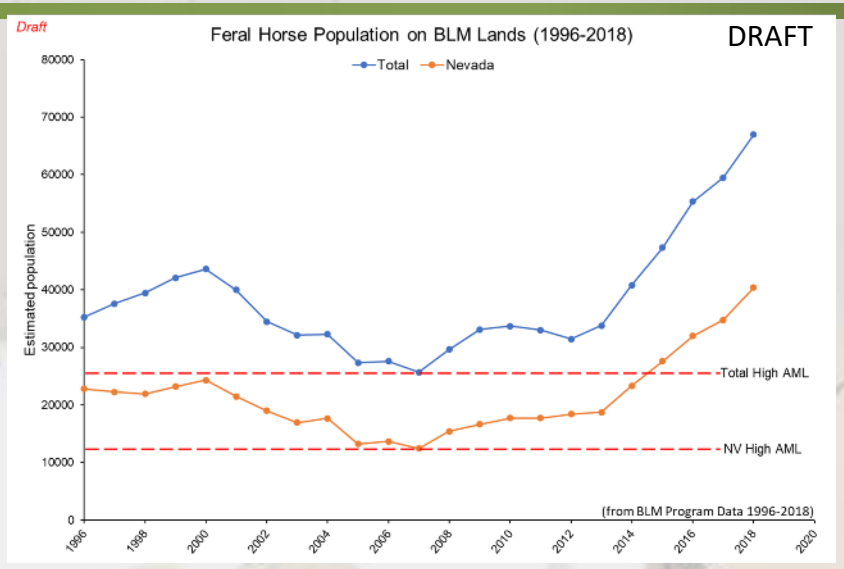


Explanations: Increasing Raven Populations



Feral horse populations are currently >4 times over max AML in NV

Explanations: Increasing Raven Populations



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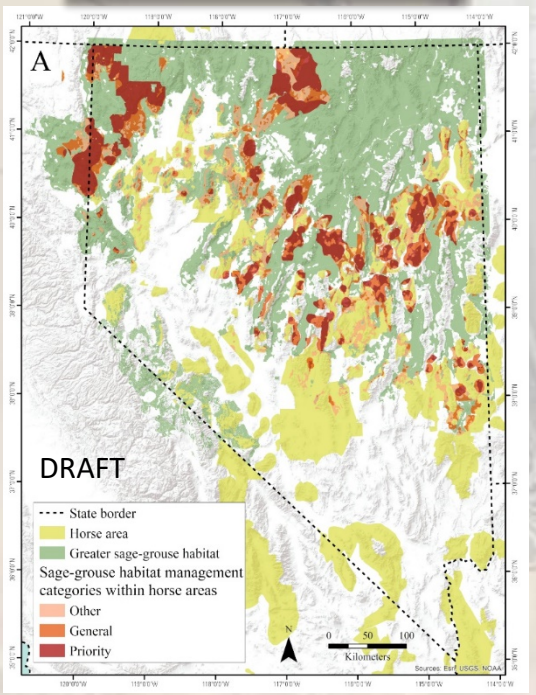
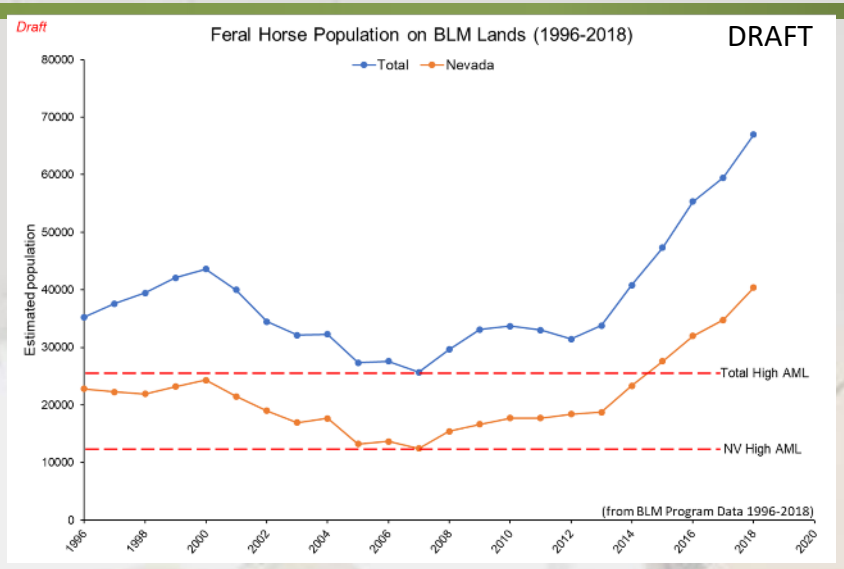
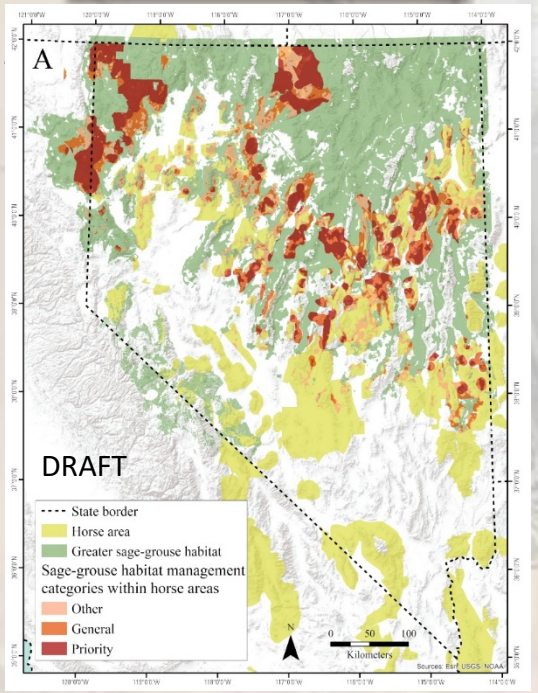
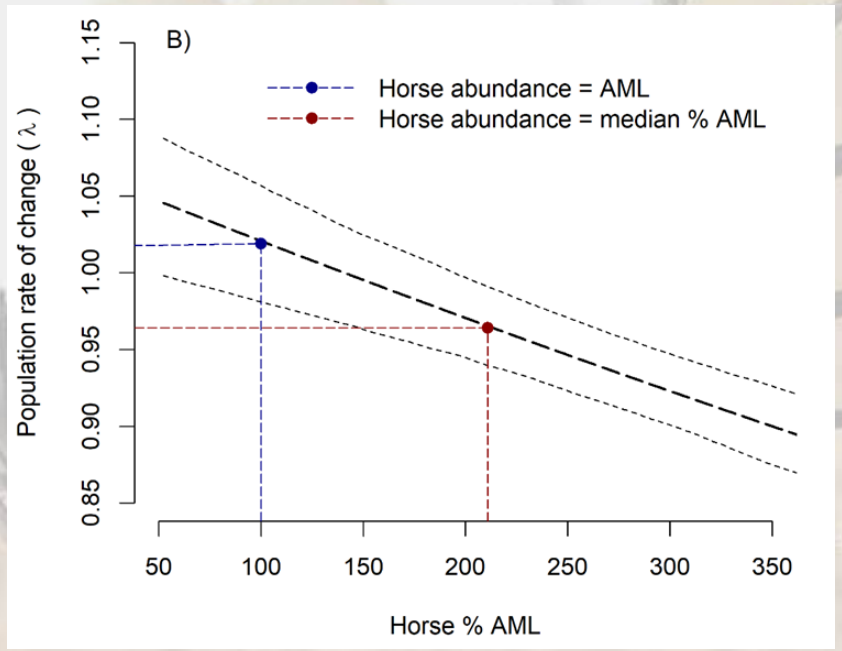


Explanations: Increasing Feral Horse Populations



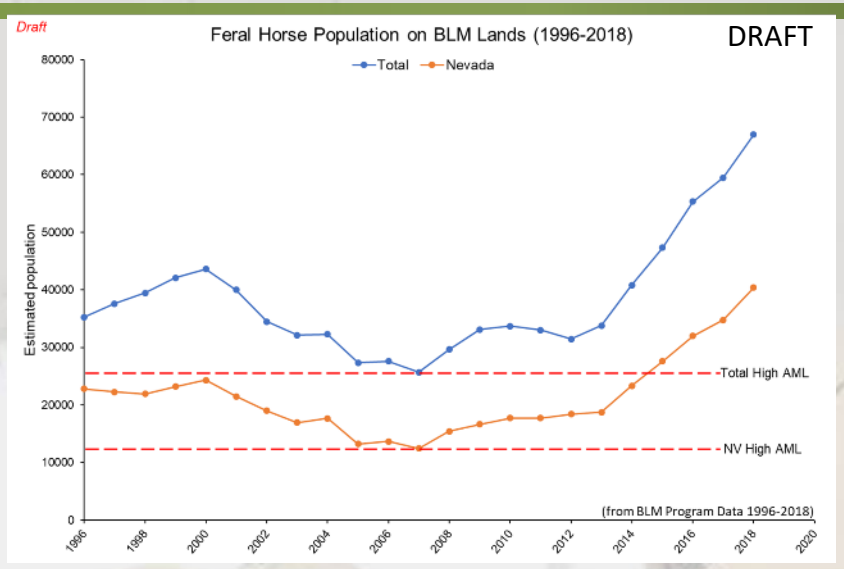
Feral horse populations are currently >4 times over max AML in NV



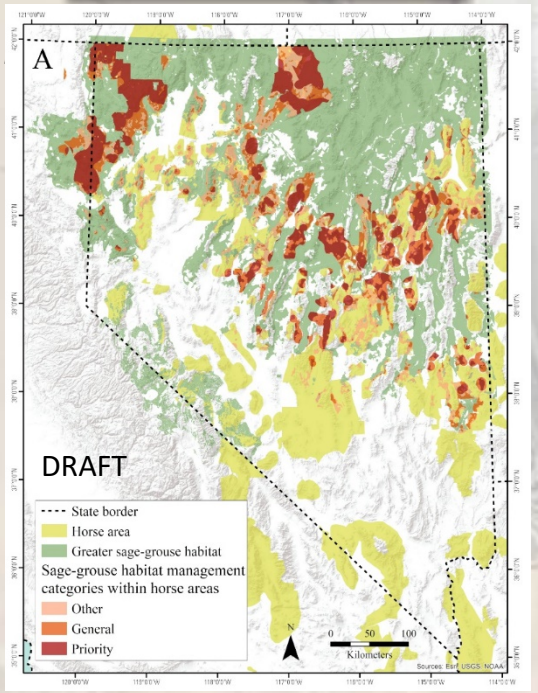


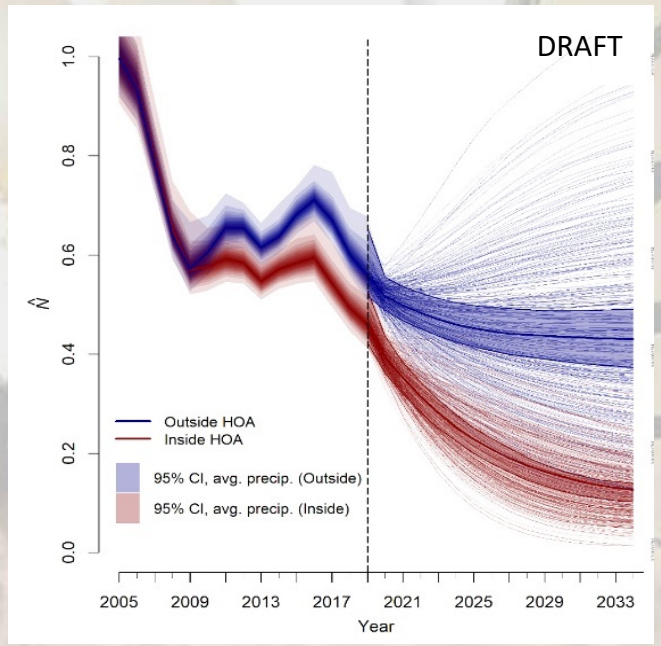
For every 50% increase in horse abundance over AML, model predicts an annual decline in sage-grouse abundance by **2.6%.**

Explanations: Increasing Feral Horse Populations



Feral horse populations are currently >4 times over max AML in NV

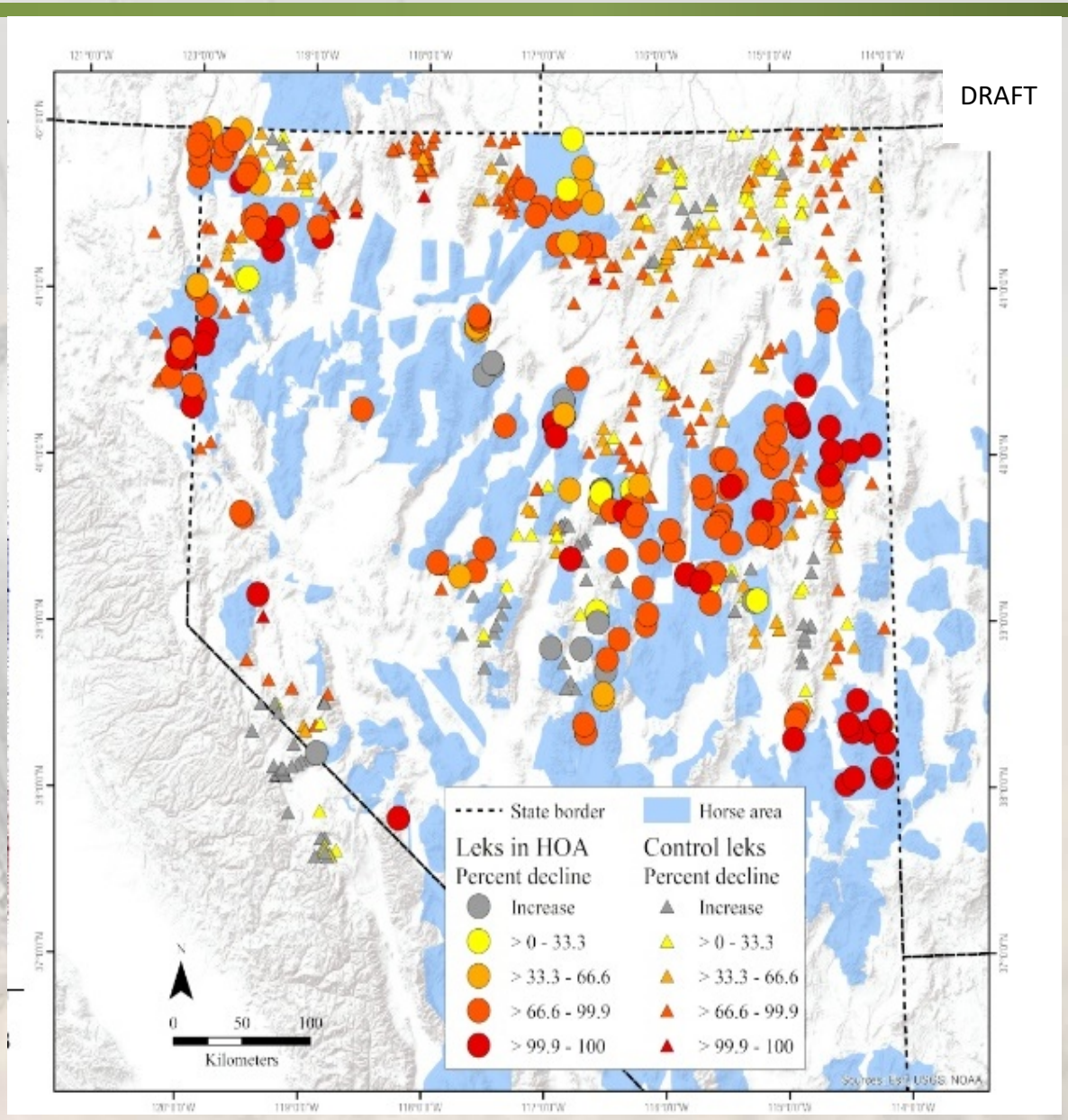




Within horse occupied areas, models predict declines of ~70% over 15 years if horse populations continue to grow unabated

Explanations: Increasing Feral Horse Populations

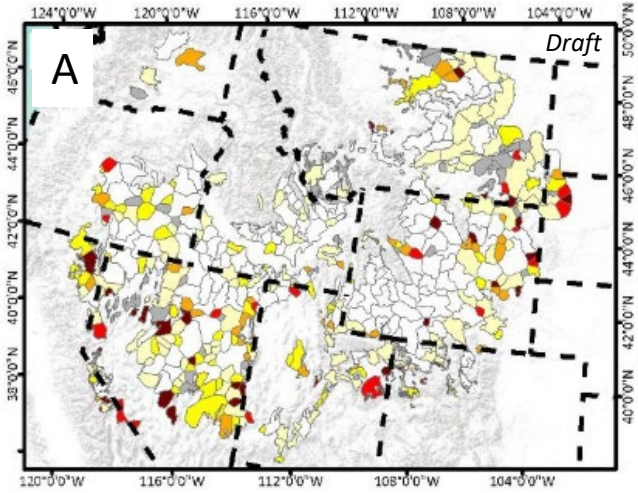
DRAFT



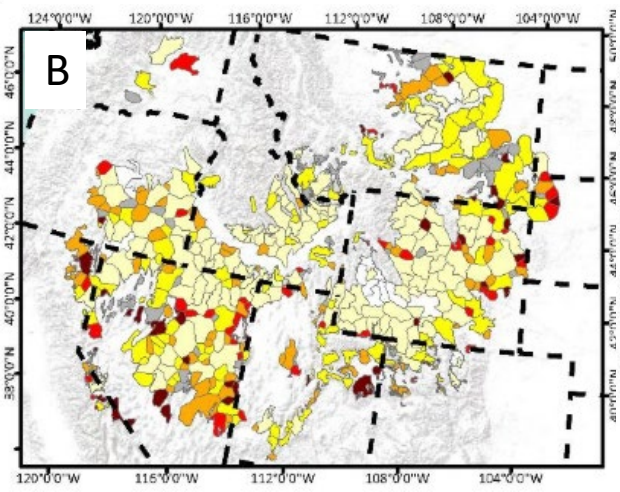
Preliminary Information—Subject to Revision. Not for Citation or Distribution

Extirpation Probabilities at the Neighborhood Cluster Scale

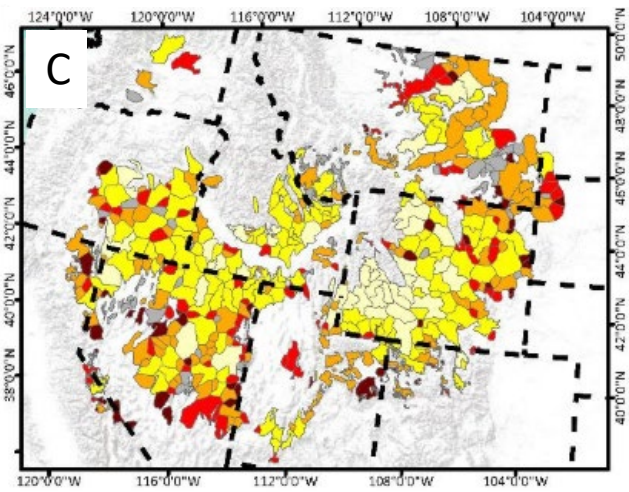
PROJECTED SHORT



PROJECTED MEDIUM



PROJECTED LONG



State border

No data

Probability of extirpation

> 0 - 0.25

> 0.25 - 0.50

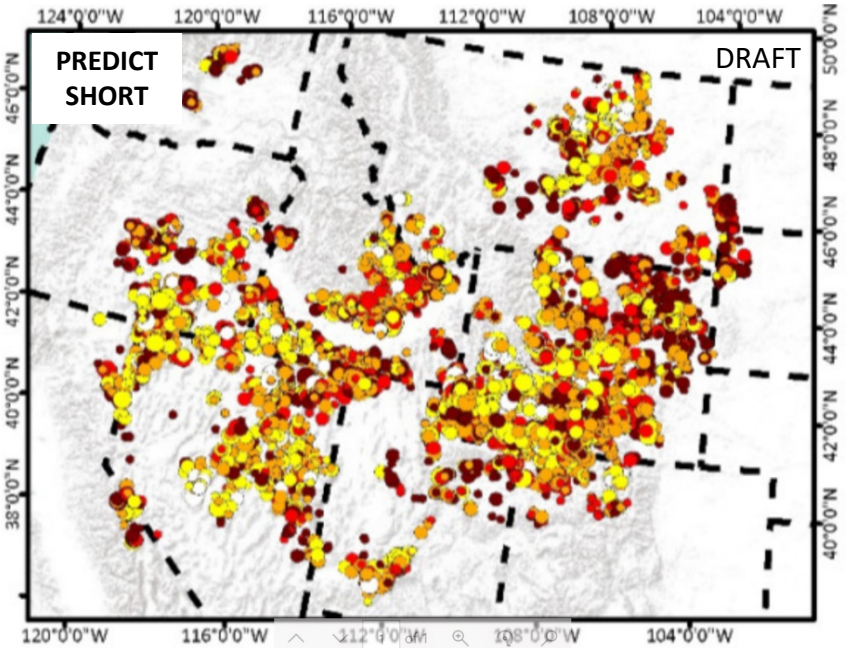
> 0.50 - 0.75

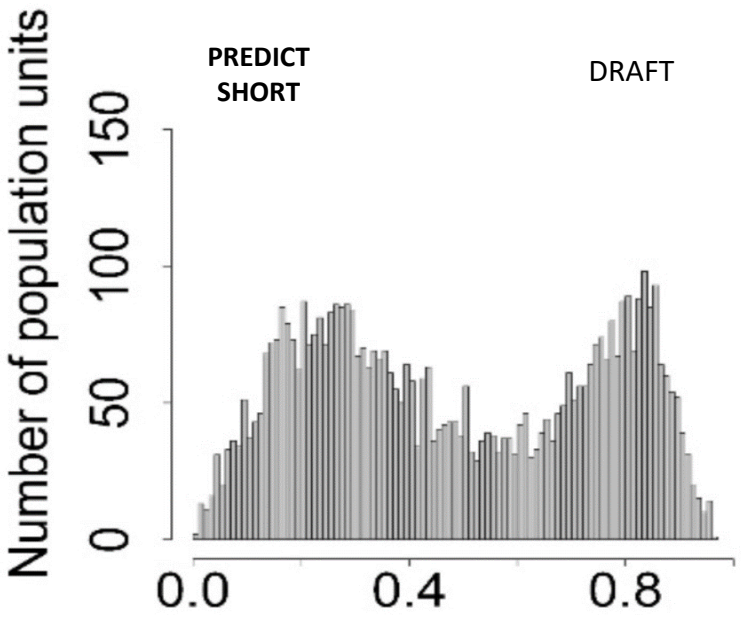
> 0.75 - 0.97

Percent of neighborhood clusters (NC) with >50% Probability of Extirpation

- 12.3% of NCs (Short; 19 years)
- 19.2% of NCs (Medium; 38 years)
- 29.6% of NCs (Long; 56 years)

Extirpation Probabilities at the Neighborhood Cluster Scale





Probability of extirpation

- 0 - 0.10
- > 0.10 - 0.25
- > 0.25 - 0.50
- > 0.50 - 0.75
- > 0.75

Percent of leks with >50% Probability of Extirpation

- 45.7% of leks (Short; 19 years)
- 60.1% of leks (Medium; 38 years)
- 78.0% of leks (Long; 56 years)

Targeted Annual Warning System

Estimated Growth Rates (Multi-Scale)

↓

Signal

Spatial Thresholds
(Declining and Decoupling)

↓

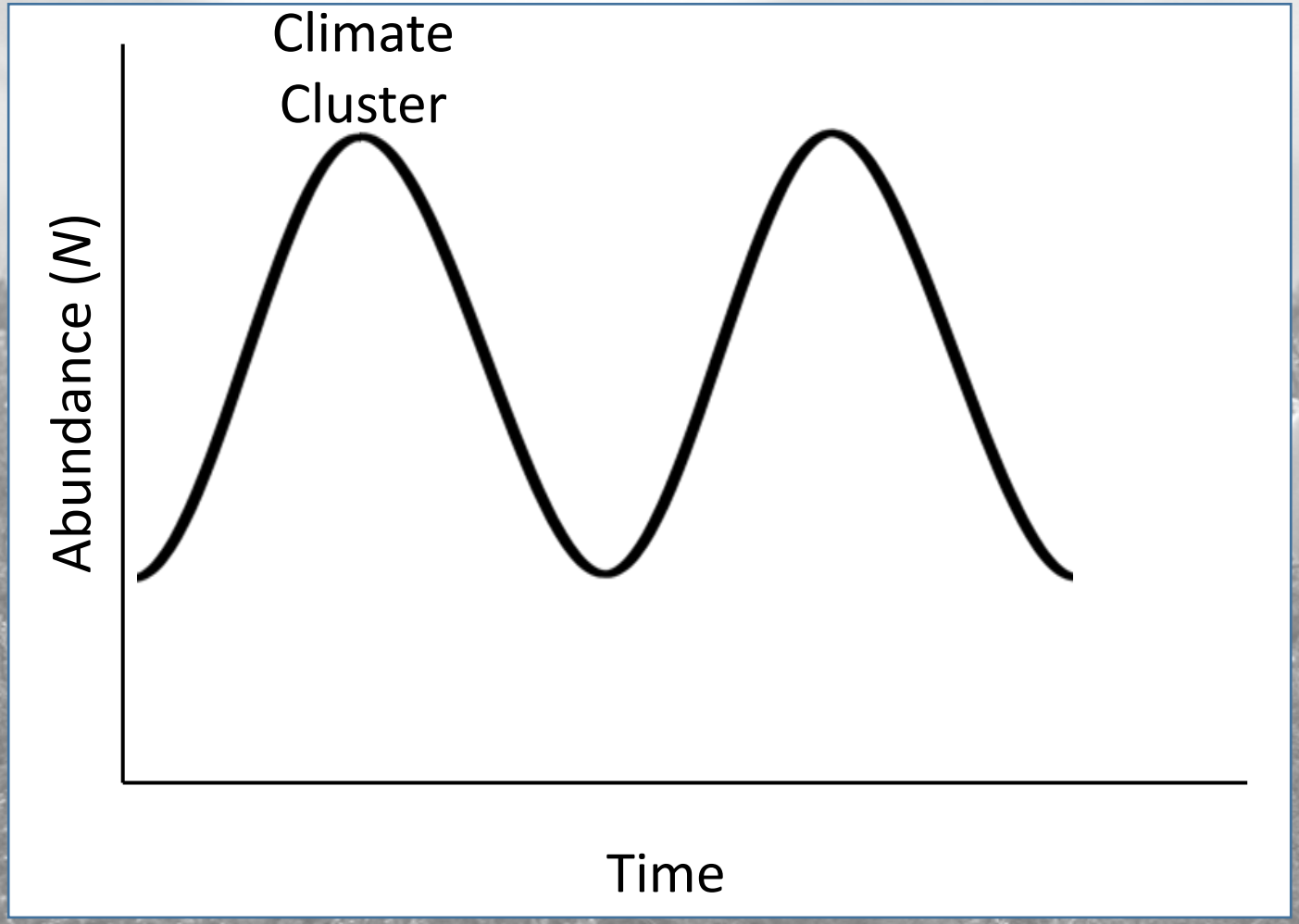
Watch

Temporal Thresholds
(Time Series Alerts)

↓

WARNING

Population Monitoring Framework: Targeted Annual Warning System



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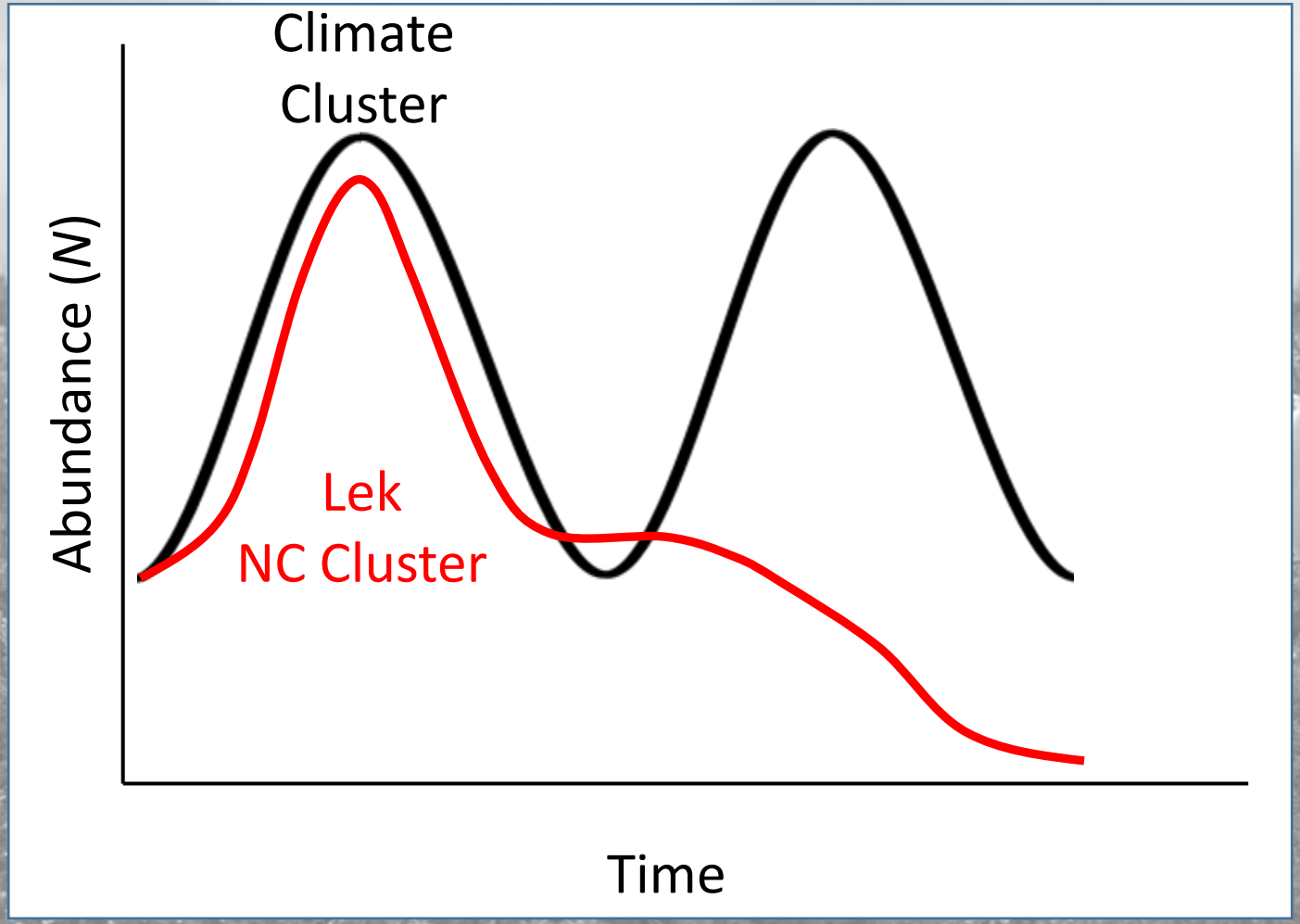

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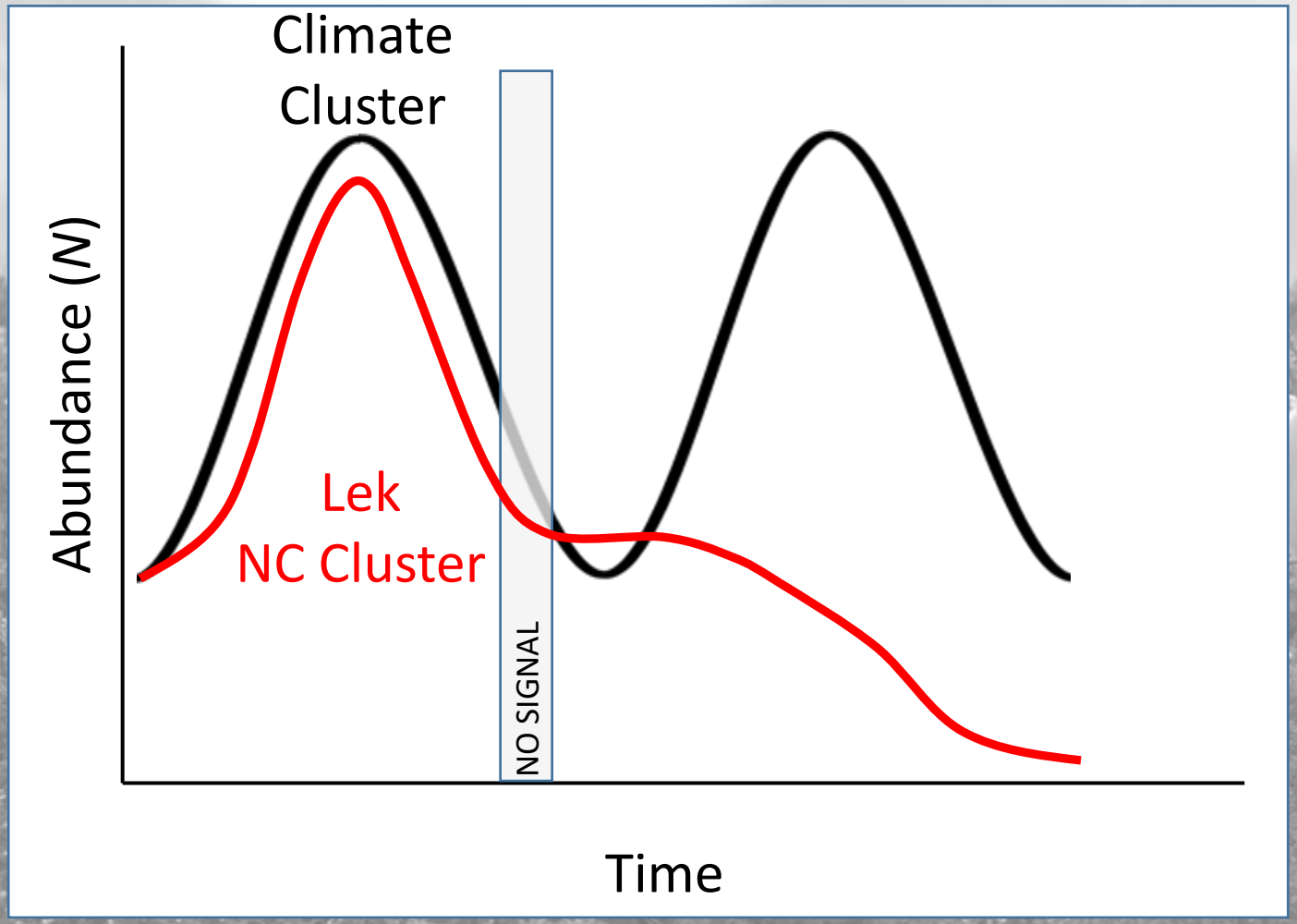

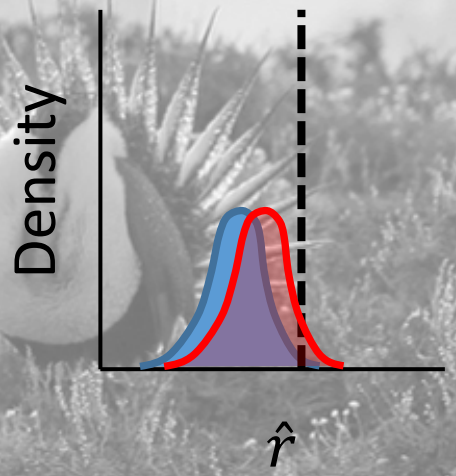

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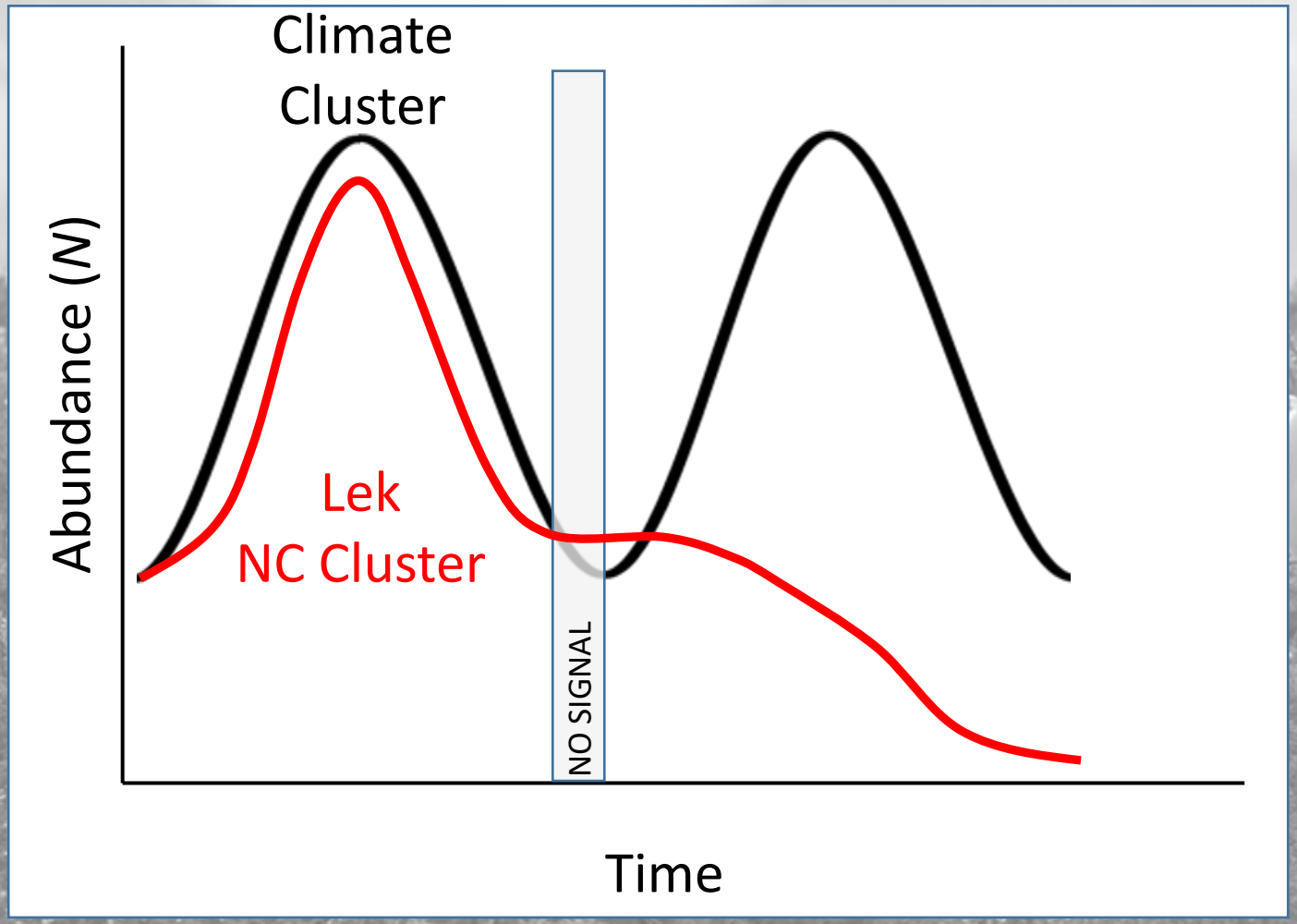
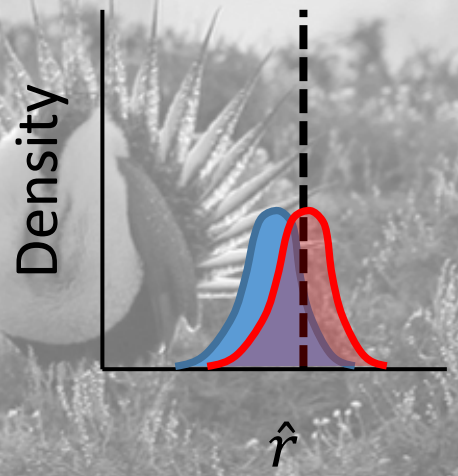
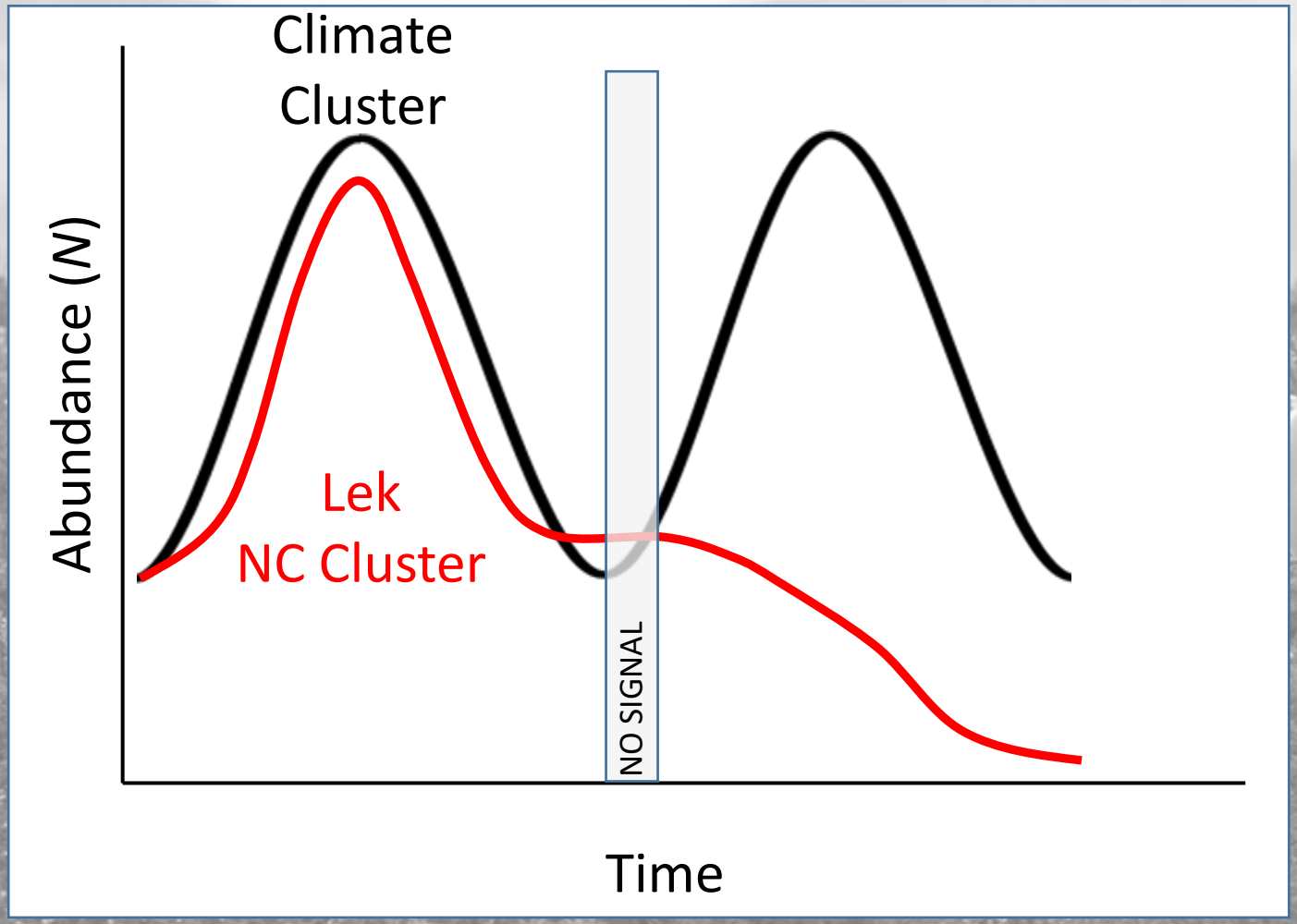
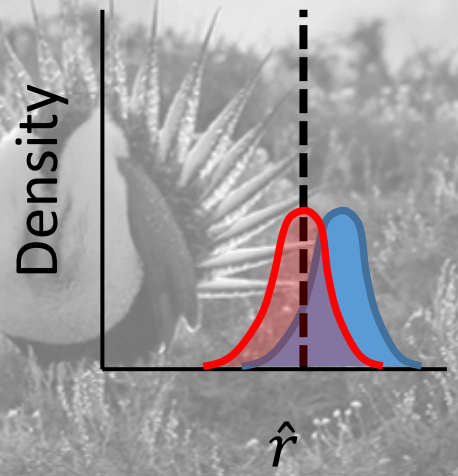


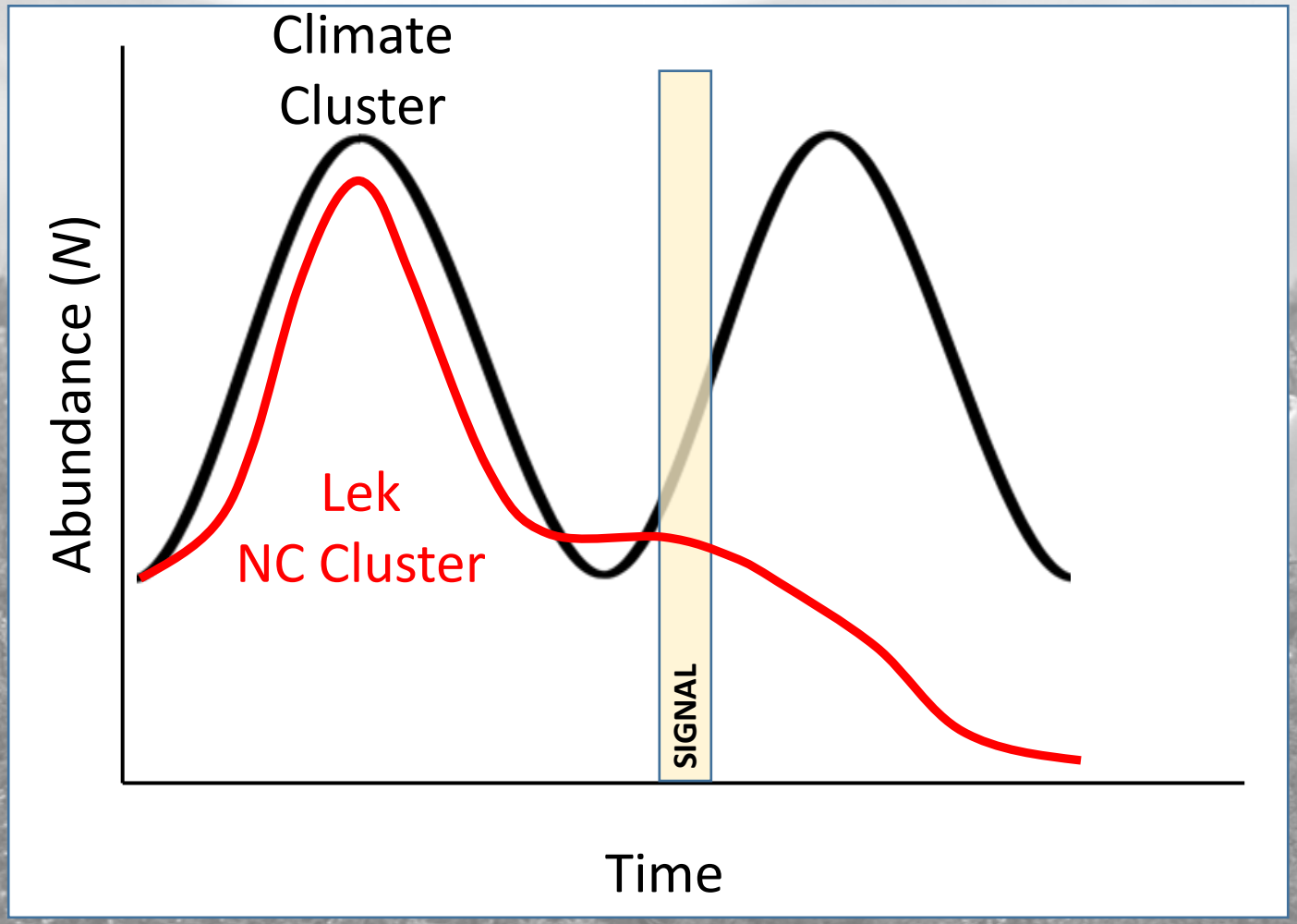


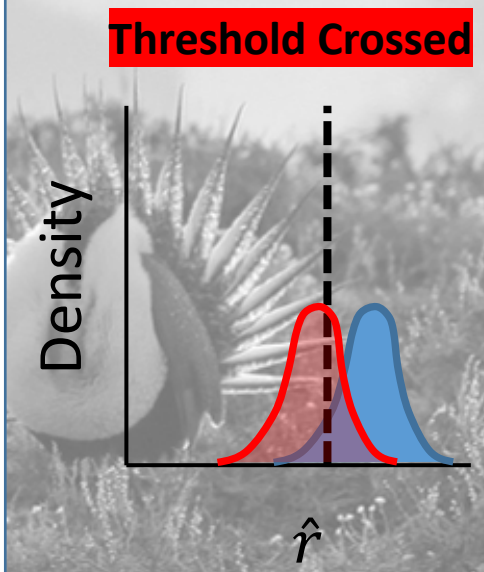
Population Monitoring Framework: Targeted Annual Warning System





Population Monitoring Framework: Targeted Annual Warning System





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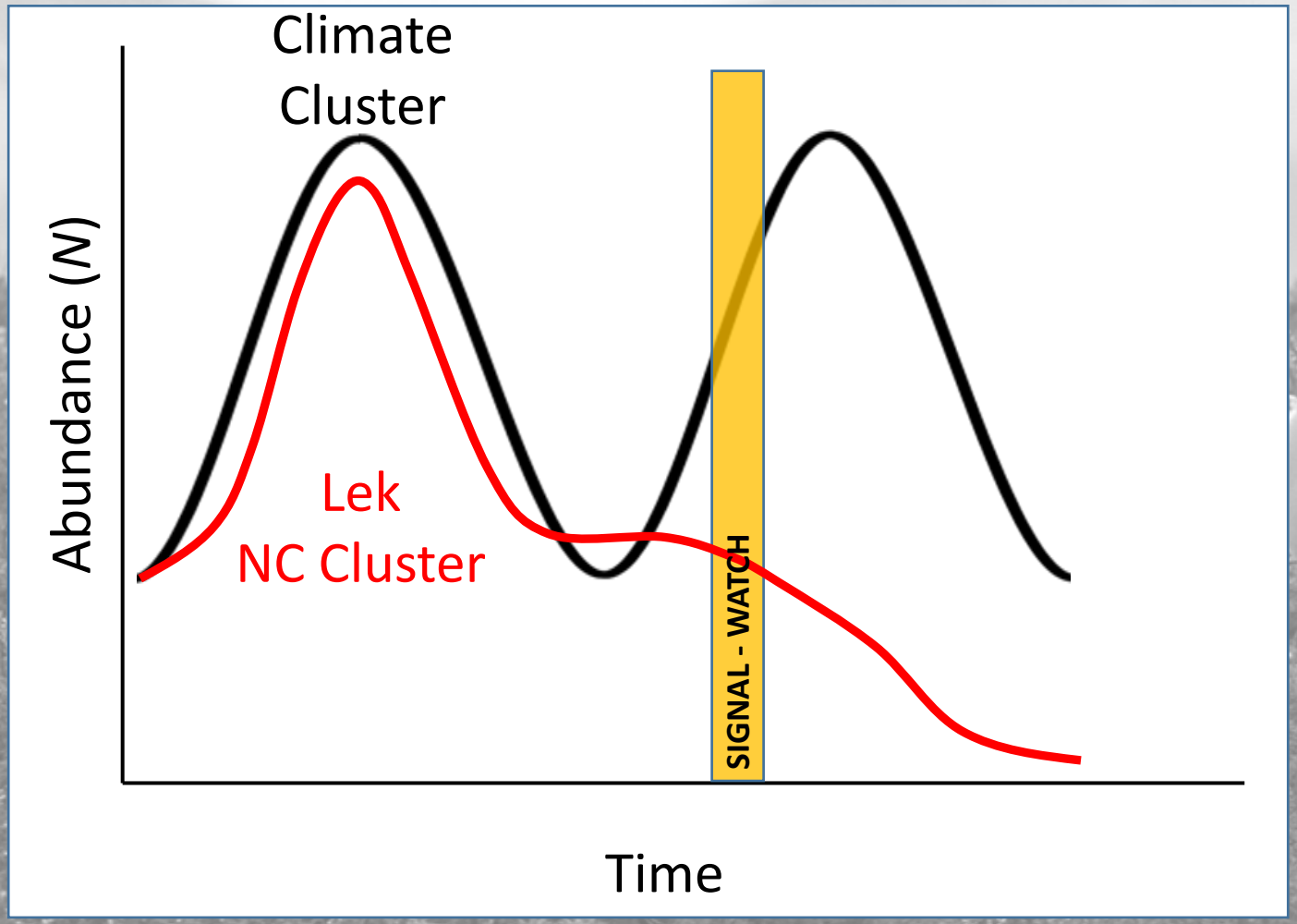

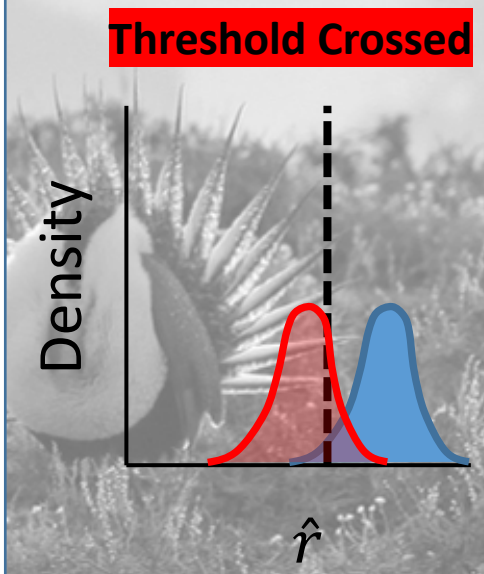

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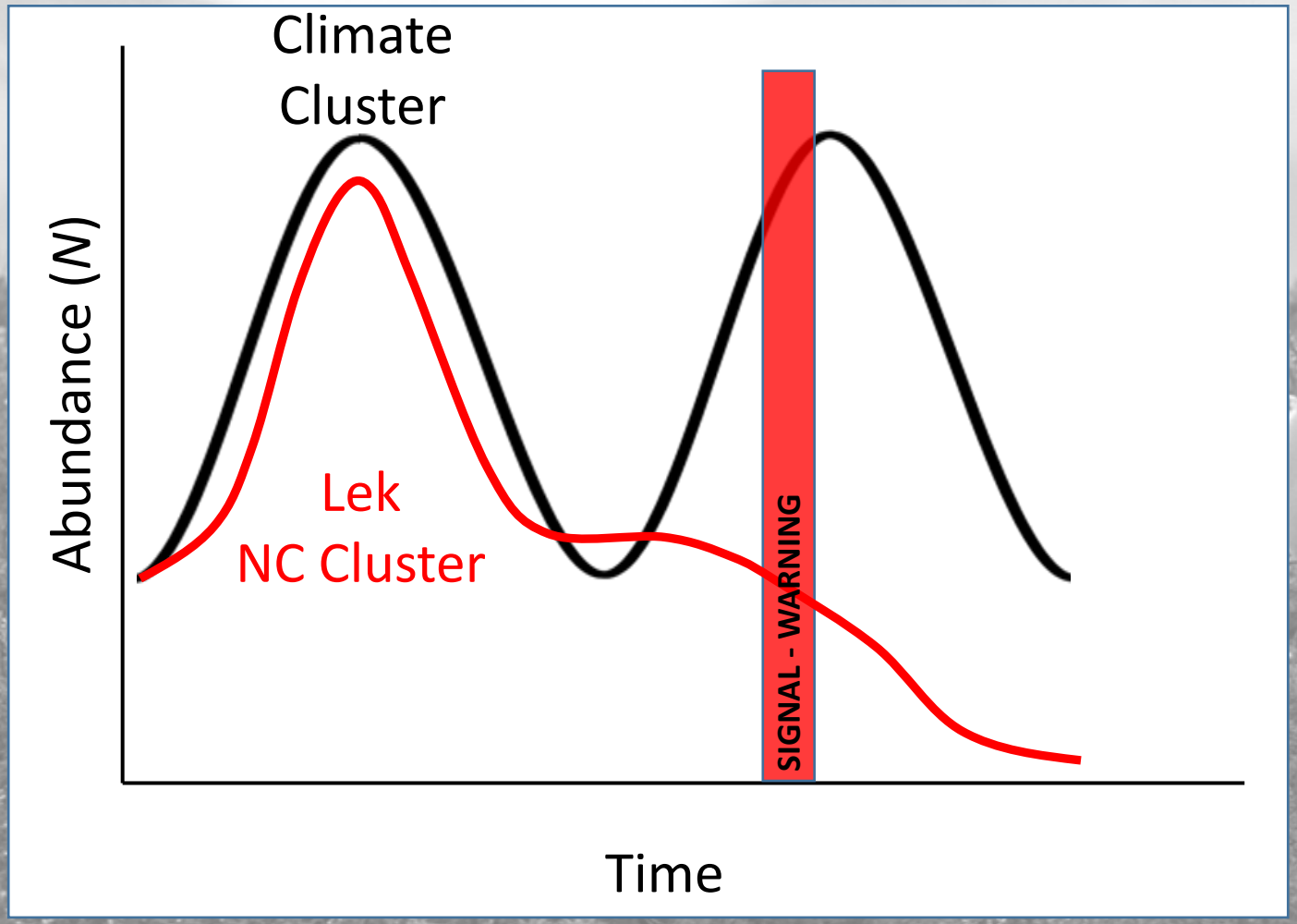

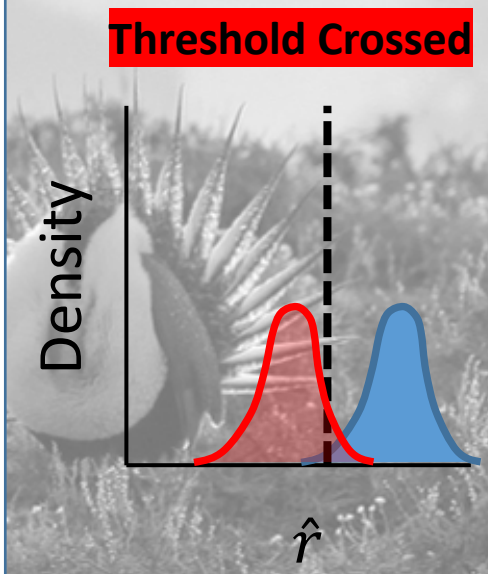

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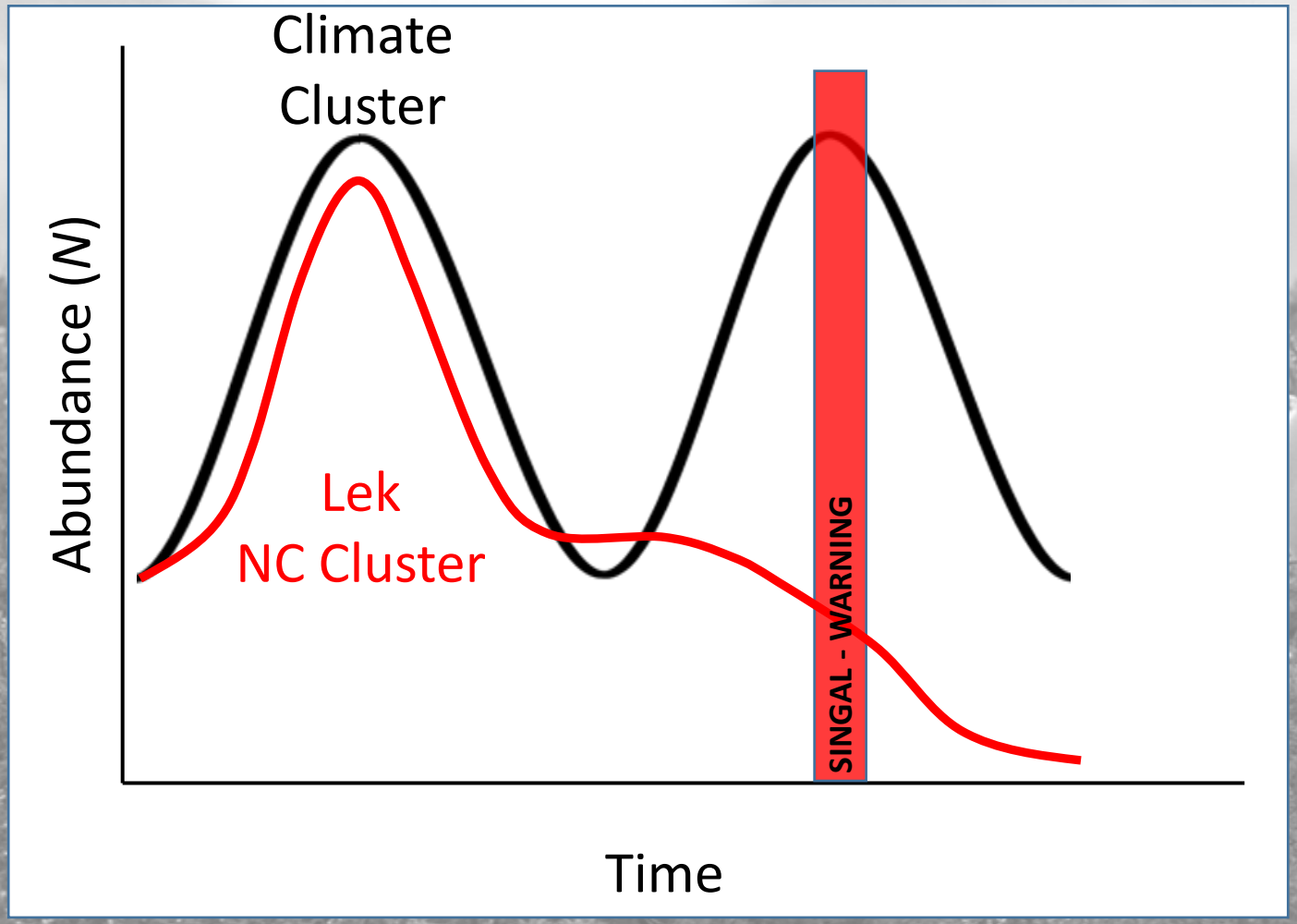

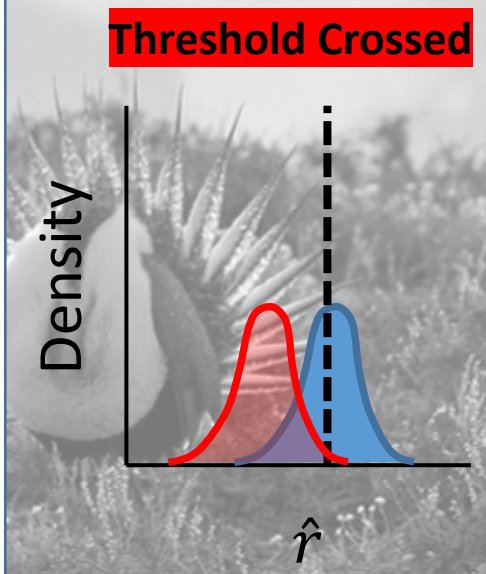

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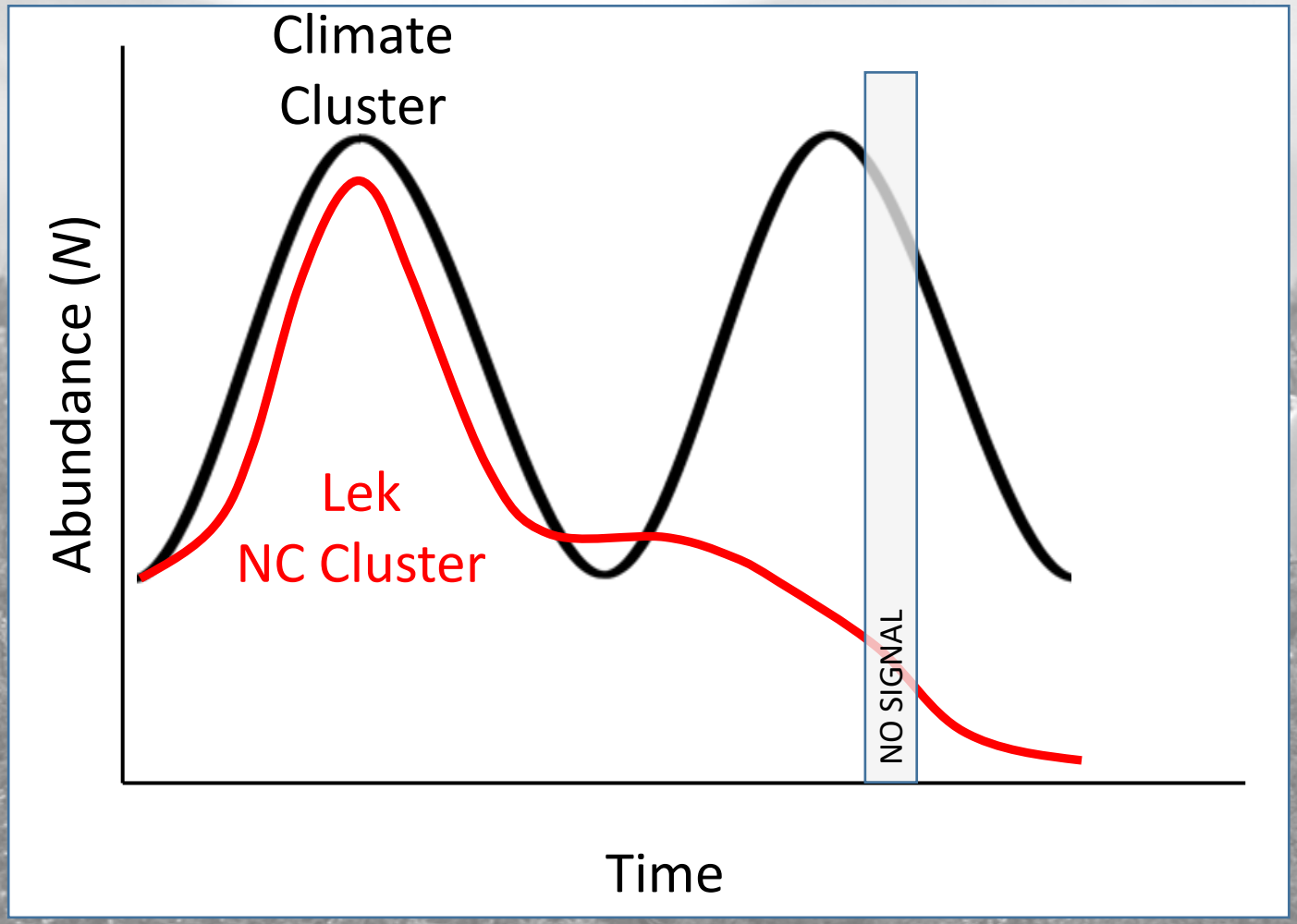

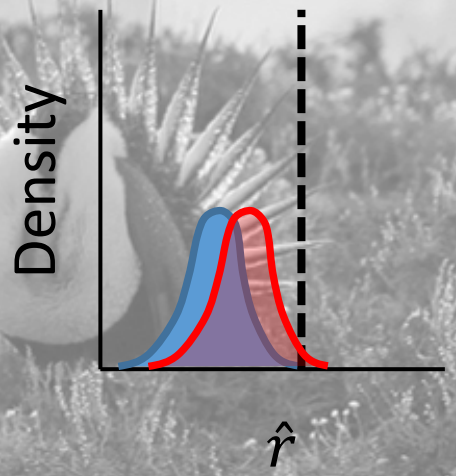

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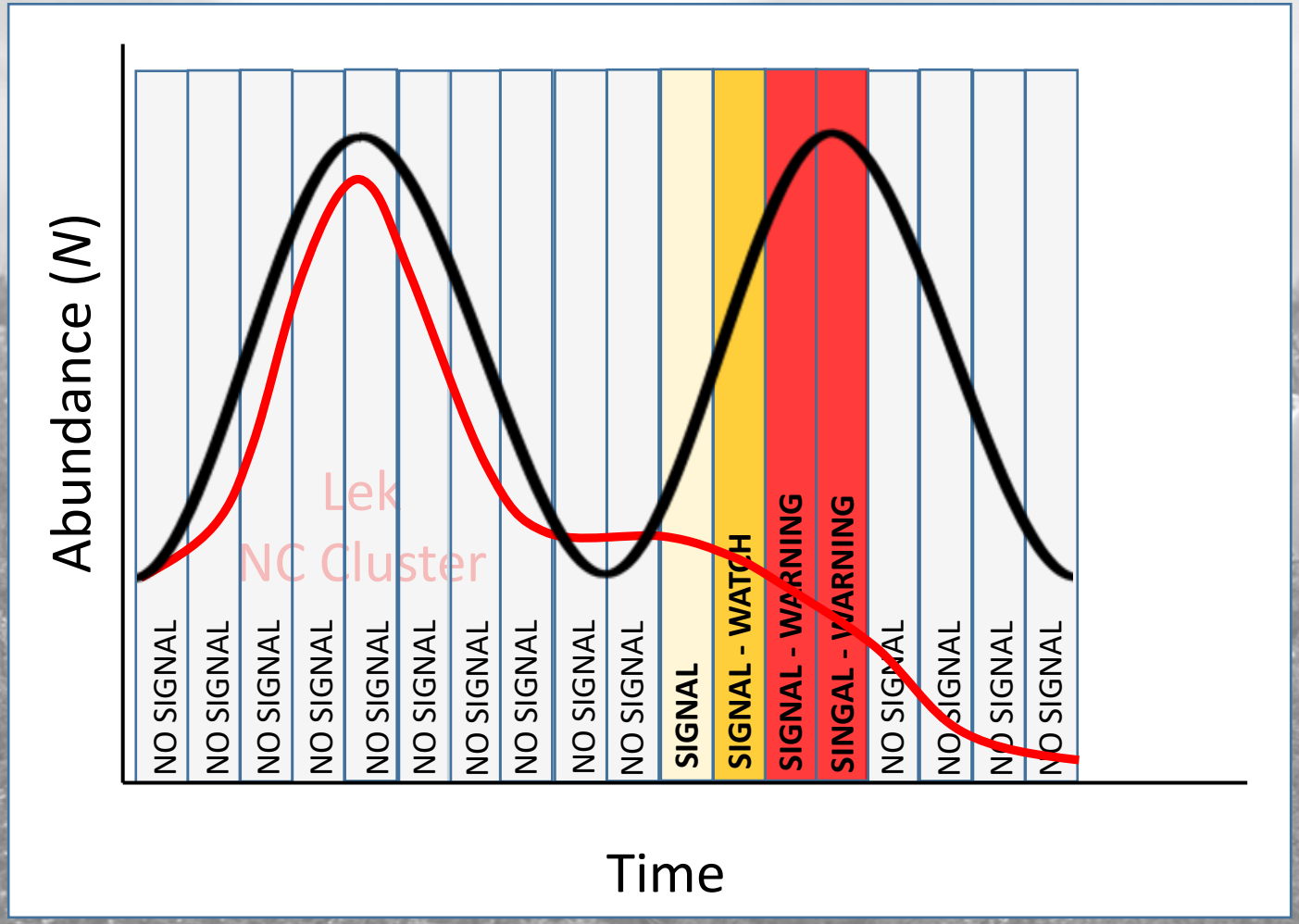

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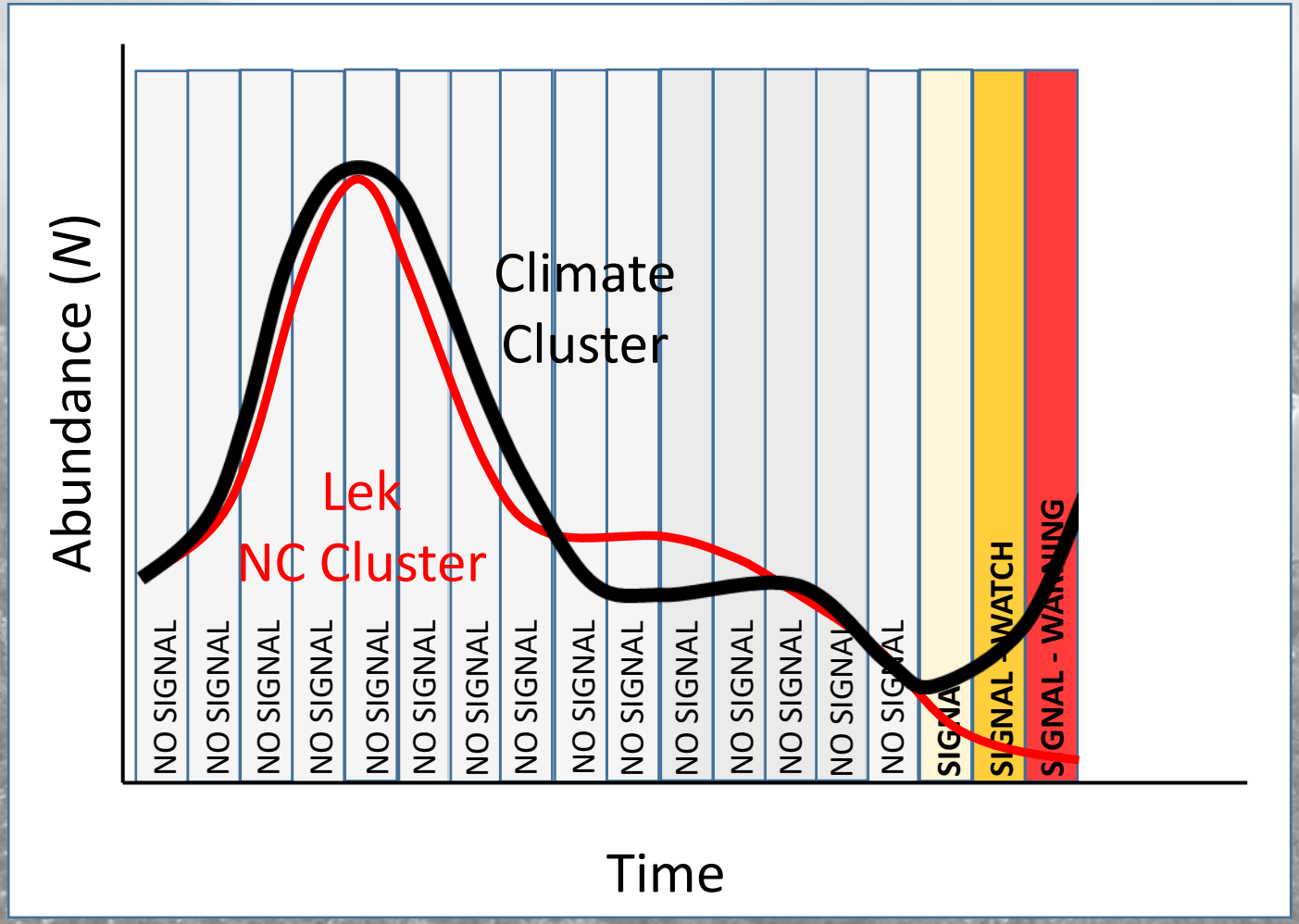
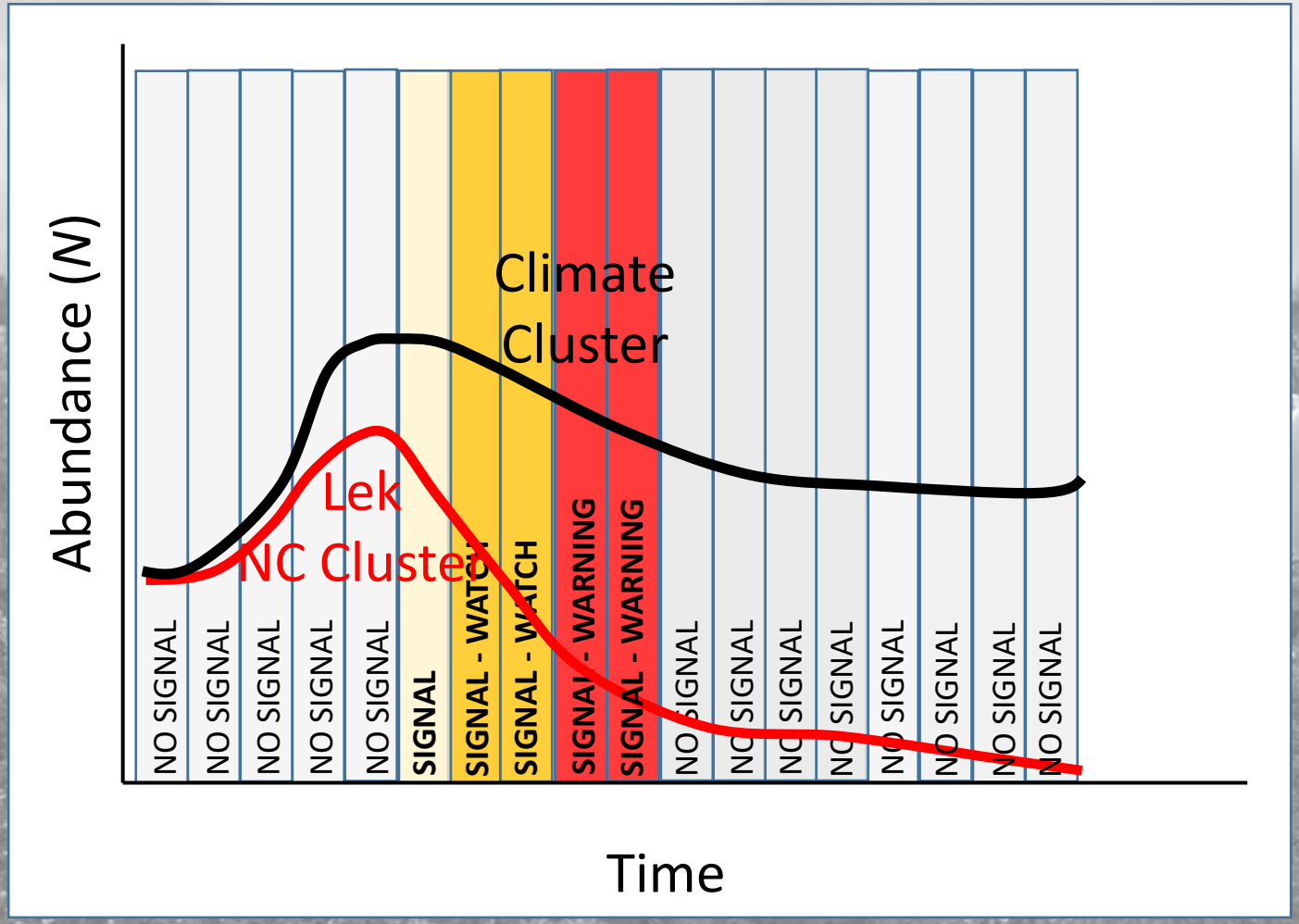
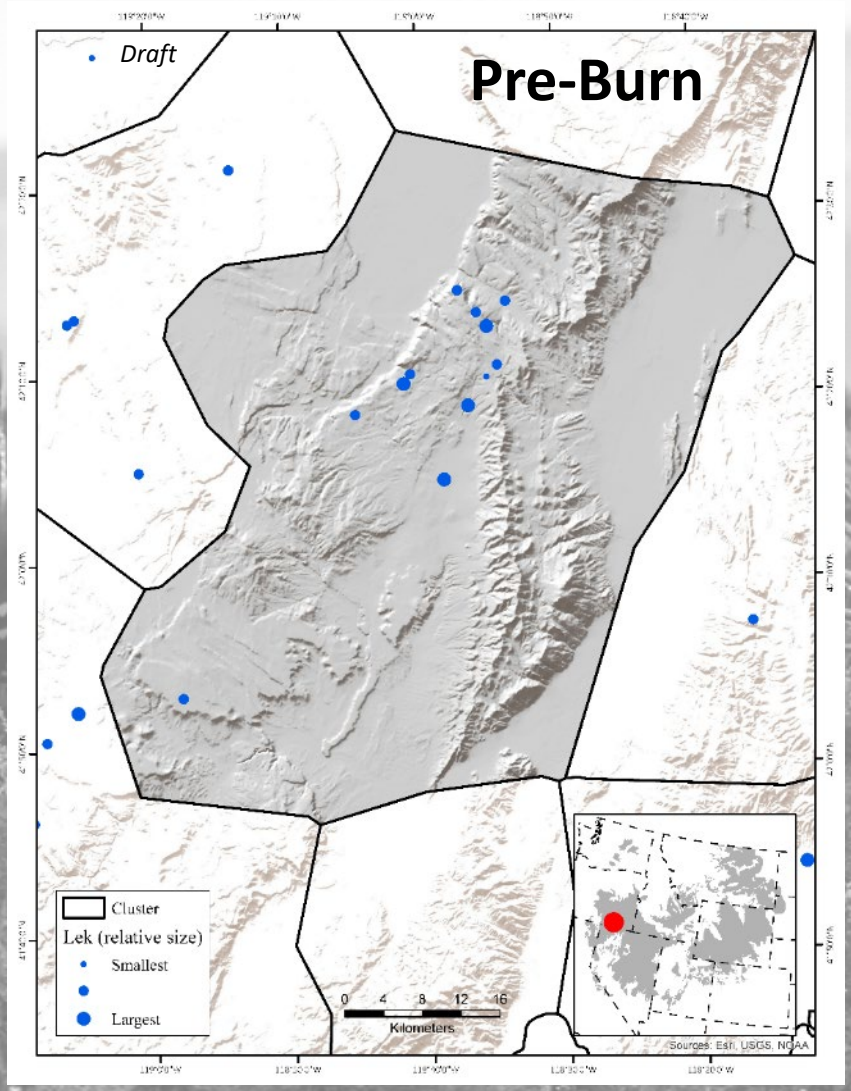


Population Monitoring Framework: Targeted Annual Warning System



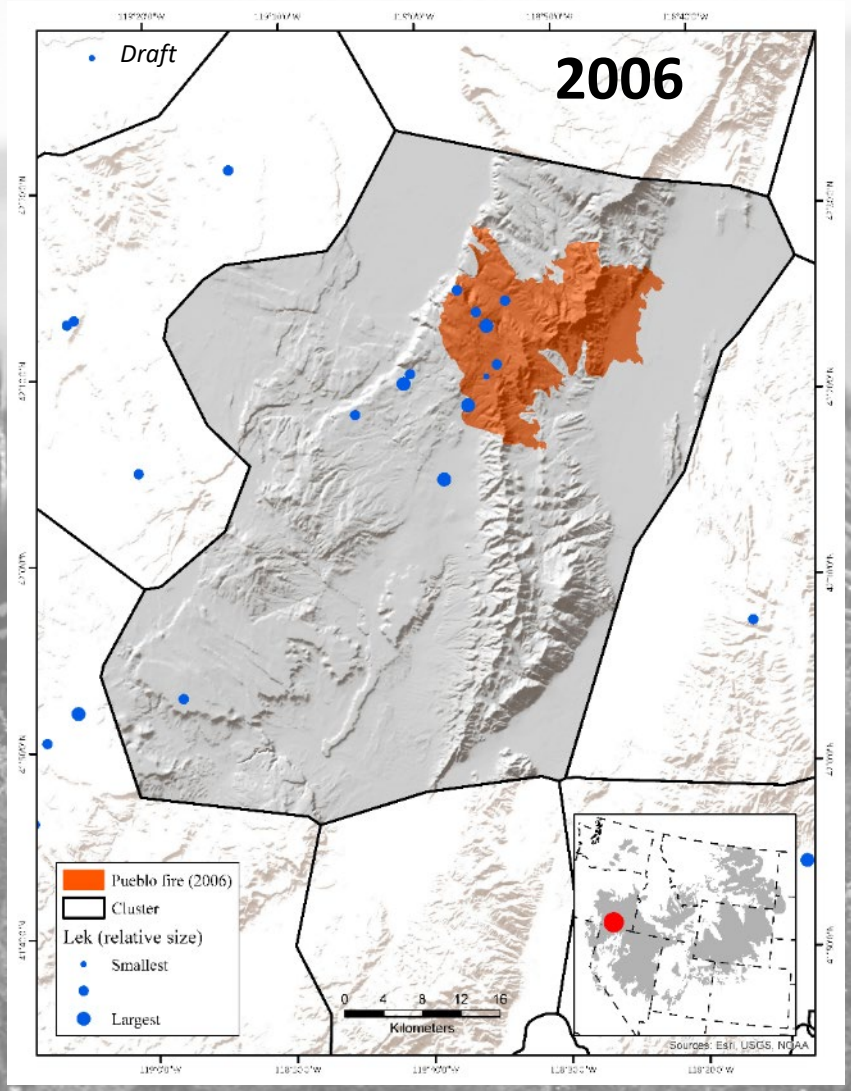
TAWS Example
Wildfire Effects (Pueblo Fire)



Preliminary Information—Subject to Revision. Not for Citation or Distribution

USGS
science for a changing world

TAWS Example
Wildfire Effects (Rush Fire and Pueblo Fire)



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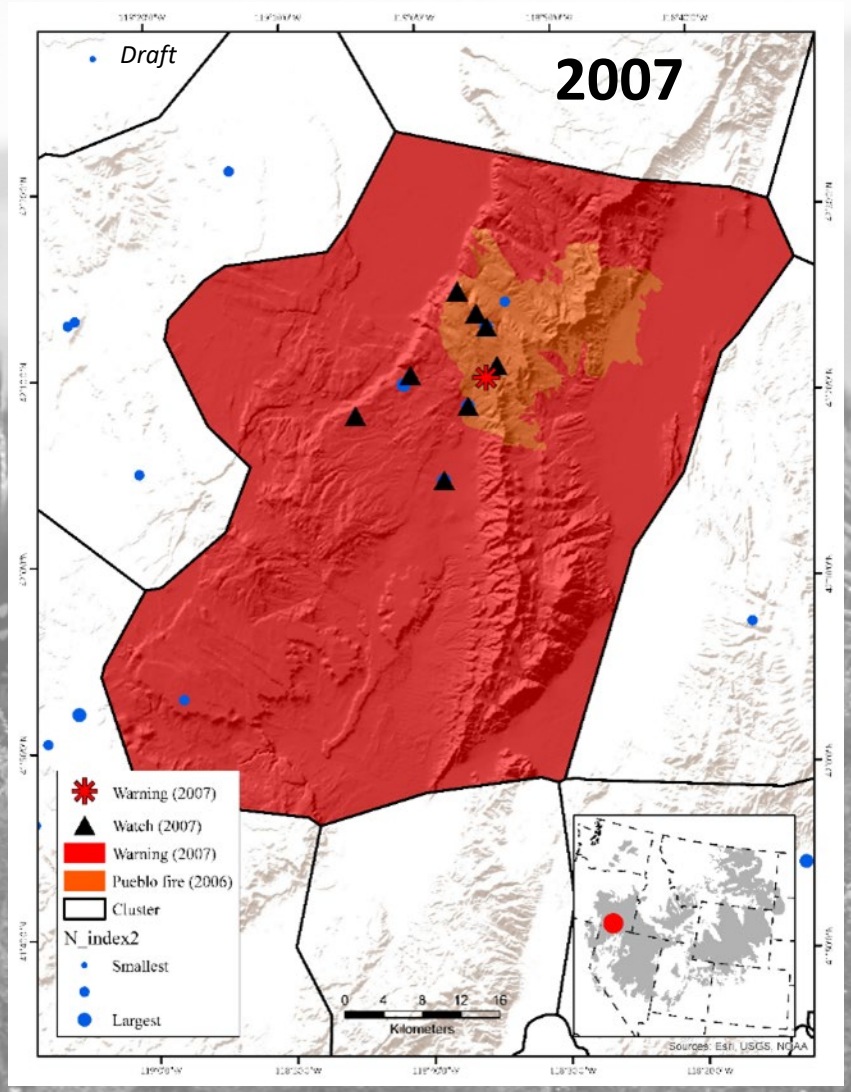

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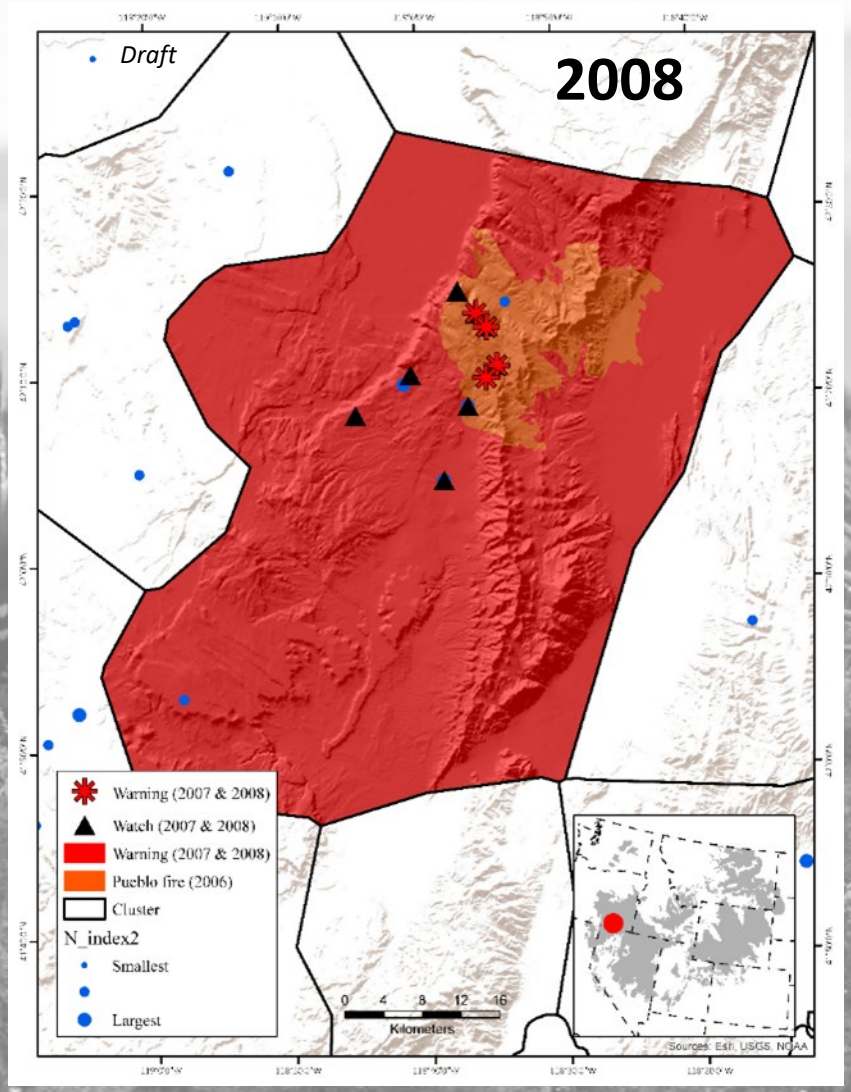
Wildfire Effects (Rush Fire and Pueblo Fire)



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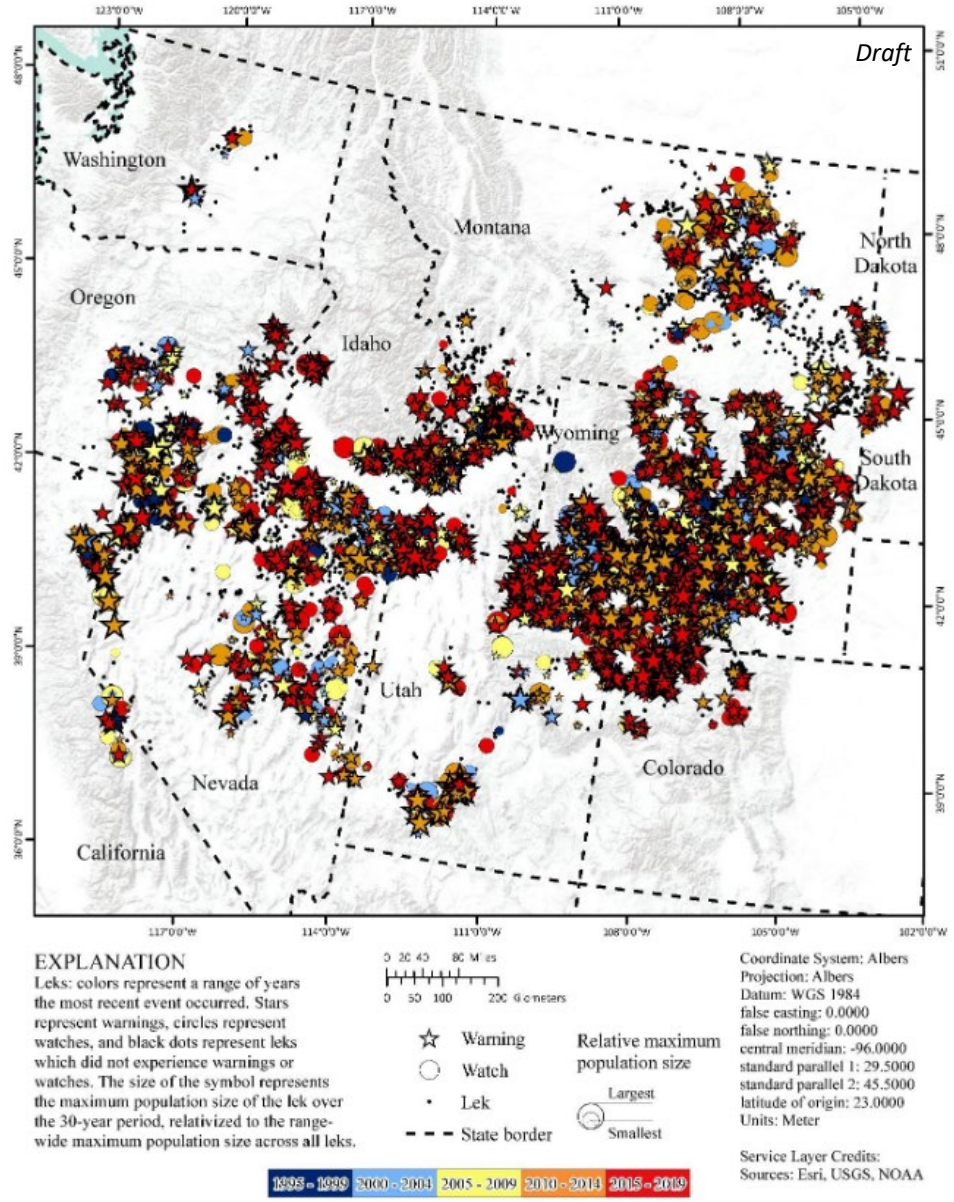
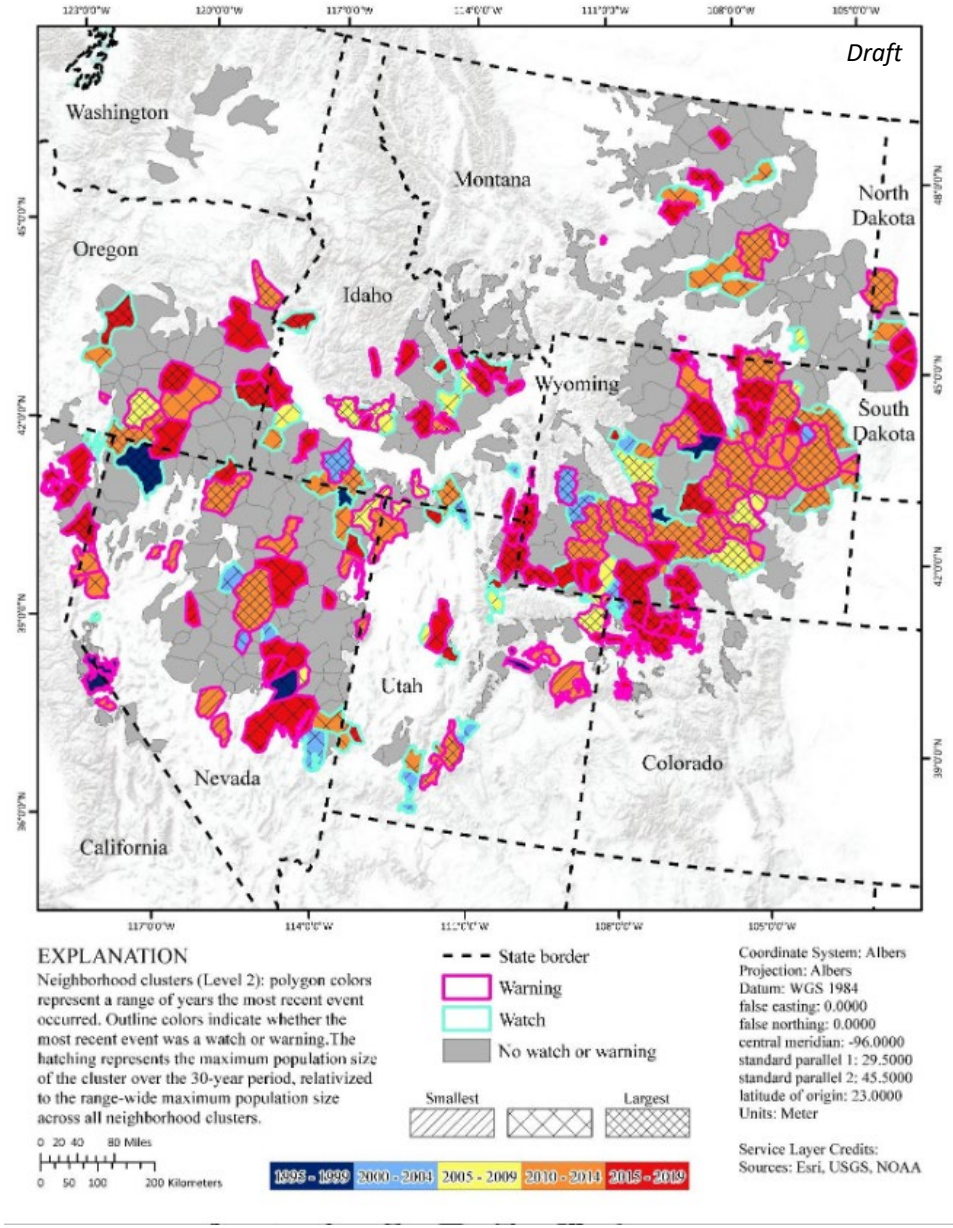
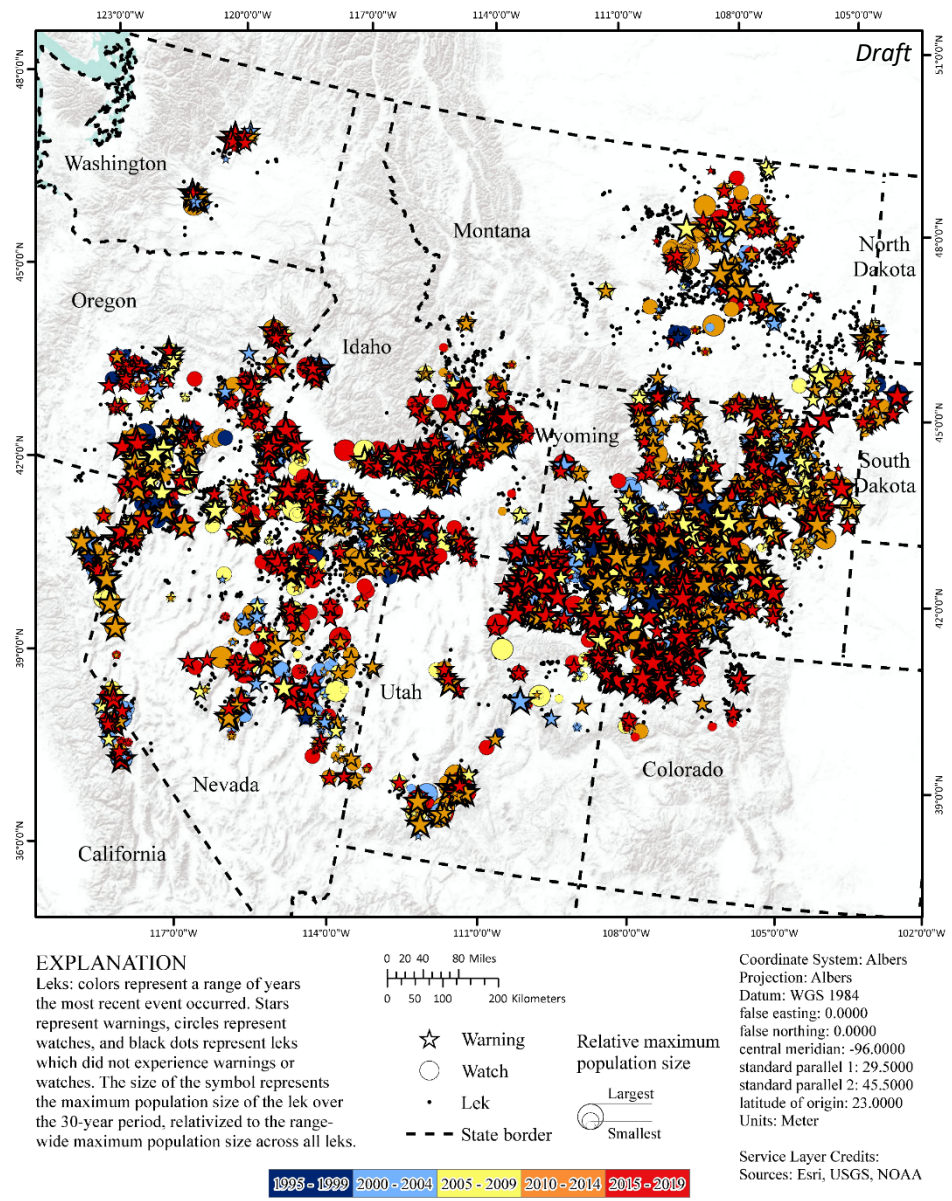
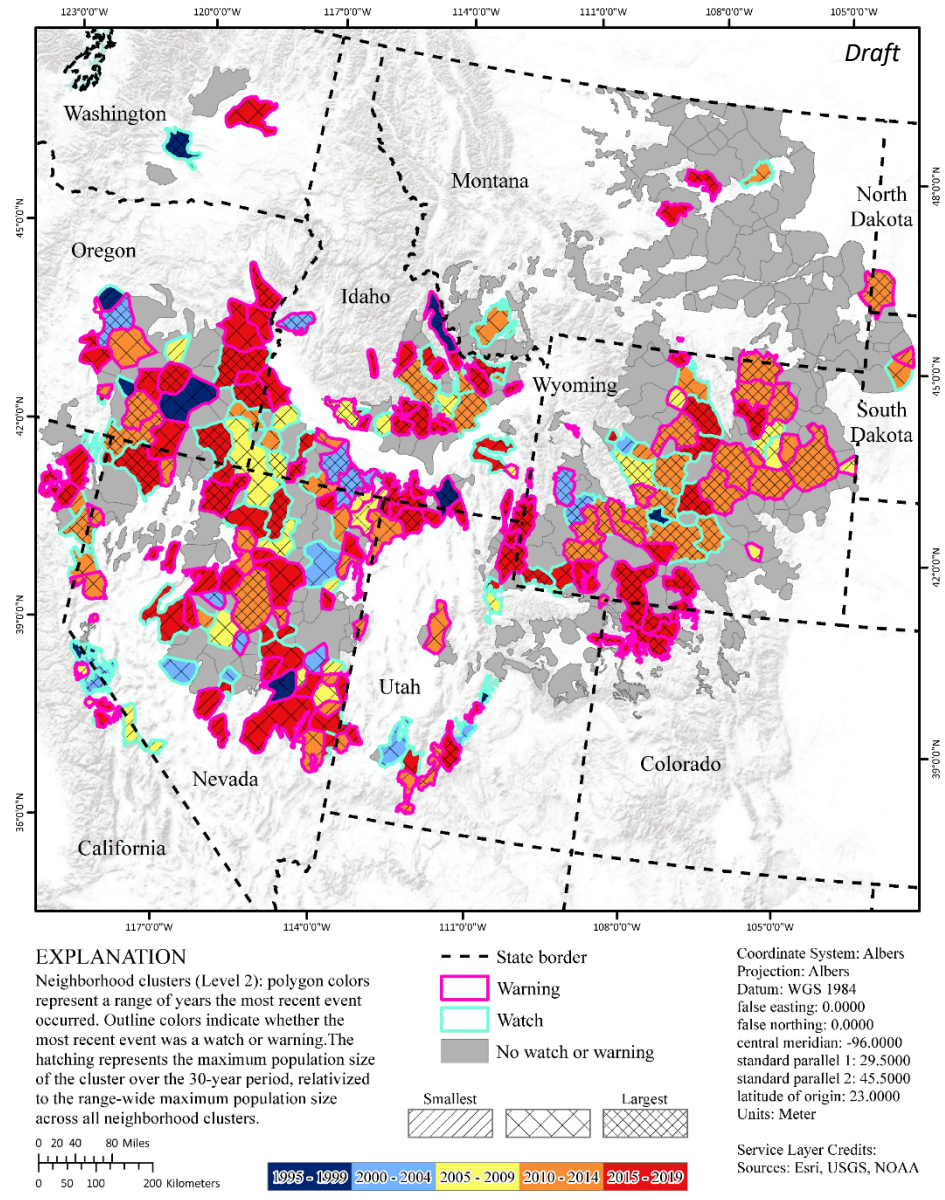
TAWS Results 1990 – 2019 (Range-wide Stability)





TAWS Results 1990 – 2019 (CC Stability)





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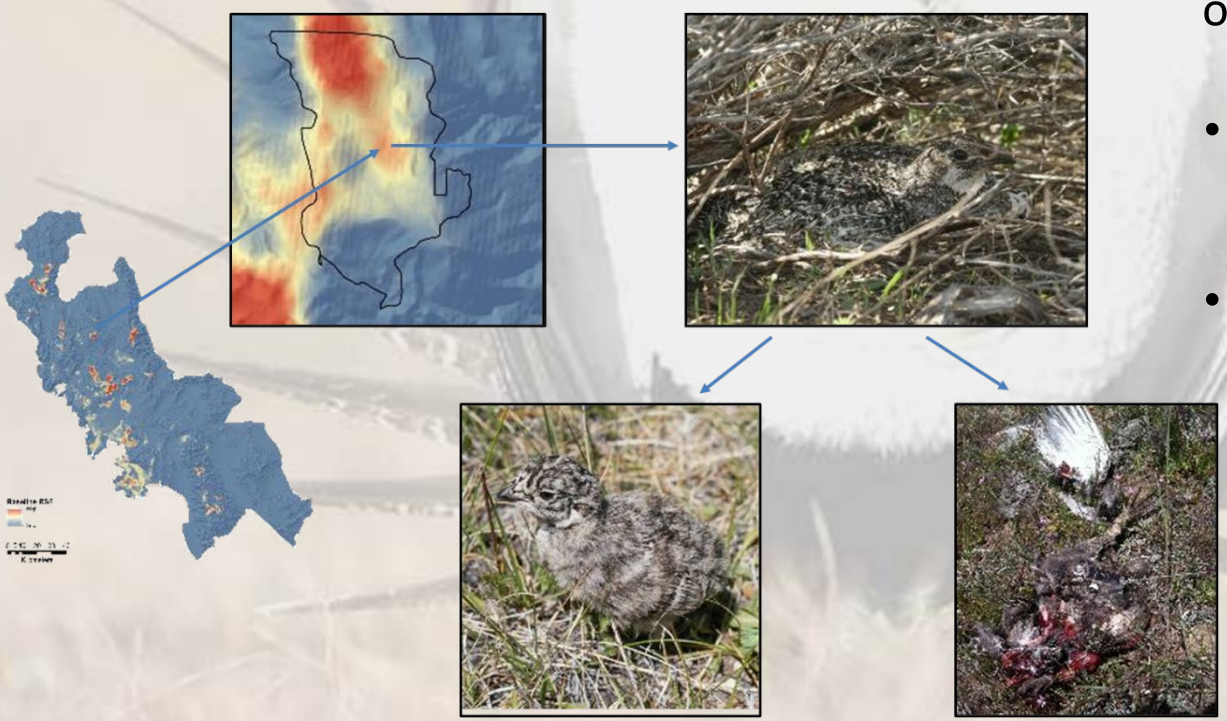
Conservation Planning Tool

Ecological Applications, 28(4), 2018, pp. 878–896

A conservation planning tool for Greater Sage-grouse using indices of species distribution, resilience, and resistance

Mark A. Ricca,[1,8] Peter S. Coates,[1] K. Benjamin Gustafson,[1] Brianne E. Brussee,[1] Jeanne C. Chambers,[2] Shawn P. Espinosa,[3] Scott C. Gardner,[4] Sherri Lisius,[5] Pilar Ziegler,[6] David J. Delehanty,[7] and Michael L. Casazza[1]

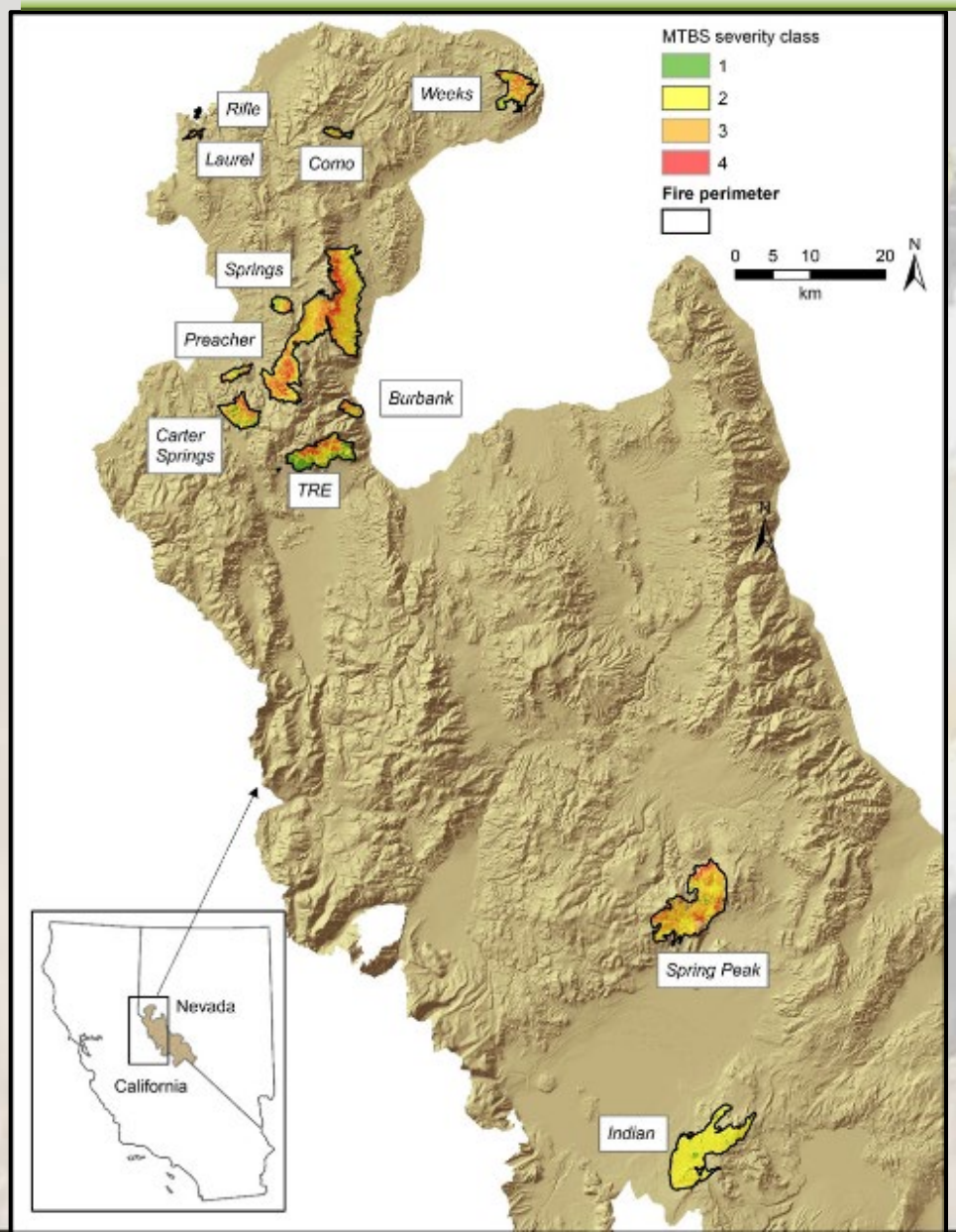


A data-driven decision support tool

- Spatially-explicit simulated management
- Measures predicted ecological benefits to sage-grouse (or other species)
  - Habitat suitability or linked survival
  - Abundance and space use patterns of sage-grouse

Post-fire conservation planning tools

Decision Tree Model: Identifying the 'best' burns to restore



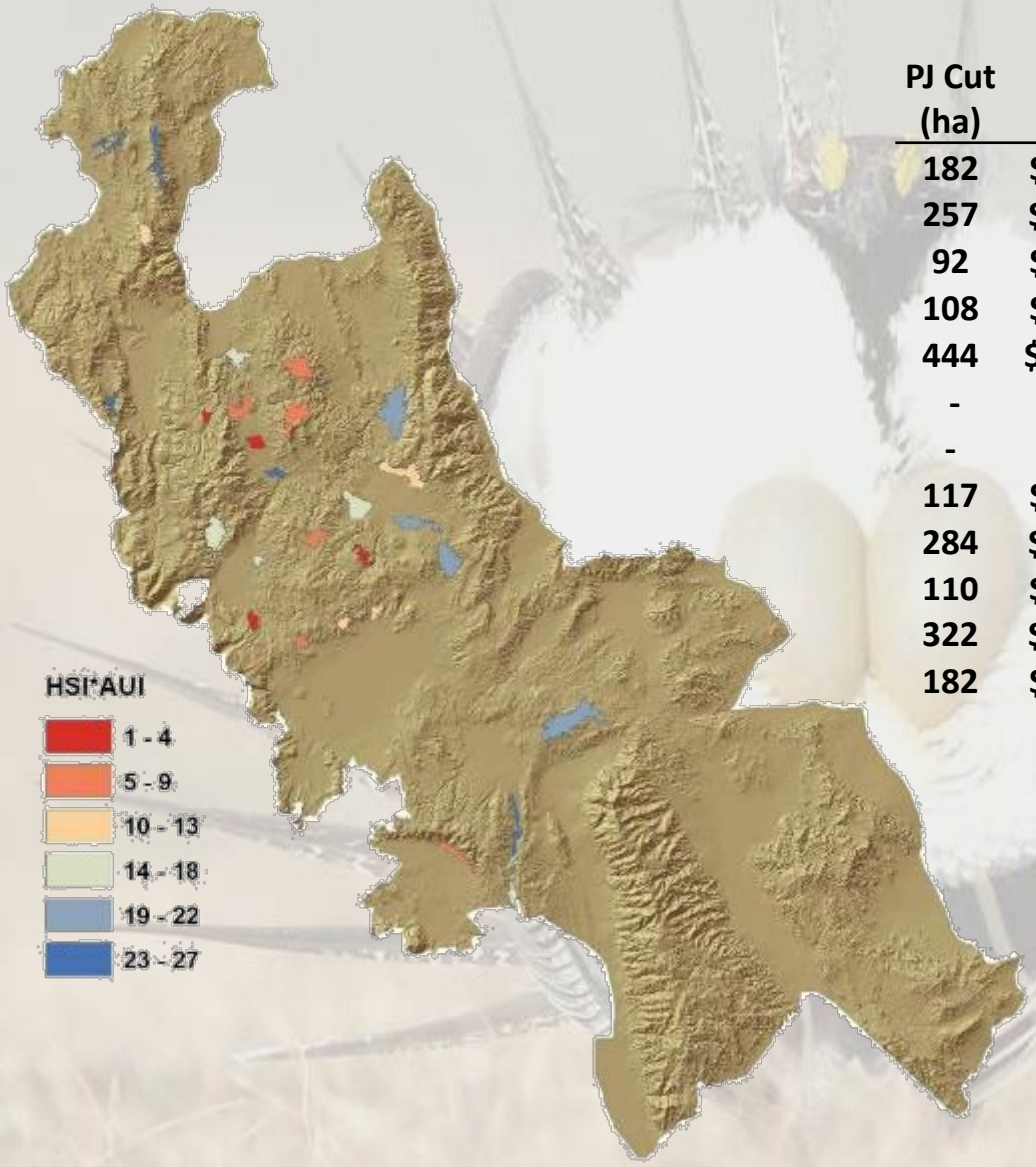
Predicted Benefit to Sage-grouse

Fire	Area burned (ha)	Average ΔGBI / ha	Cumulative ΔGBI / ha	rank [a]
Spring Peak	5759	25.49	0.61	1 (1,1)
TRE	2471	8.75	0.81	2 (2,3)
Indian	5089	5.16	0.94	3 (3,2)
Como	311	0.96	0.96	4 (4,6)
Bison	9657	0.66	0.98	5 (5,4)
Carter Springs	1400	0.65	0.99	6 (6,5)
Burbank	450	0.19	1.00	7 (7,7)
Preacher	435	0.09	1.00	8 (8,8)
Springs	483	0.07	1.00	9 (9,9)
Laurel	130	0.00	1.00	10 (10,10)
Rifle	50	0.00	1.00	11 (11,11)
Weeks	1563	0.00	1.00	12 (12,12)

Ricca et al. 2018. Ecological Applications 28: 878–896

Conservation Planning Tool – Conifer Treatment

Predicted Benefit to Sage-grouse



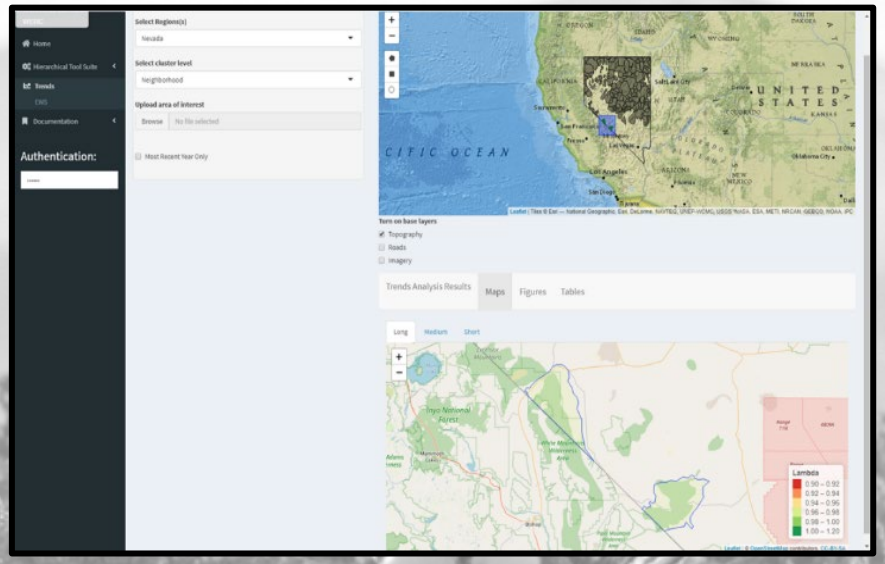
PJ Cut (ha)	Σ Cost	Rank (HSI* AUI)	GBI (HSI*AUI)	Total
182	$ 78,890	1	4.832	35%
257	$ 110,999	2	1.452	45%
92	$ 39,854	3	1.252	54%
108	$ 46,859	4	1.248	63%
444	$ 192,147	5	1.151	71%
-	-	-	-	-
-	-	-	-	-
117	$ 50,635	23	0.011	100%
284	$ 122,675	24	0.006	100%
110	$ 47,560	25	0.003	100%
322	$ 139,099	26	0.000	100%
182	$ 78,618	27	0.000	100%

Ricca et al. 2018. Ecological Applications 28: 878–896

Next Steps

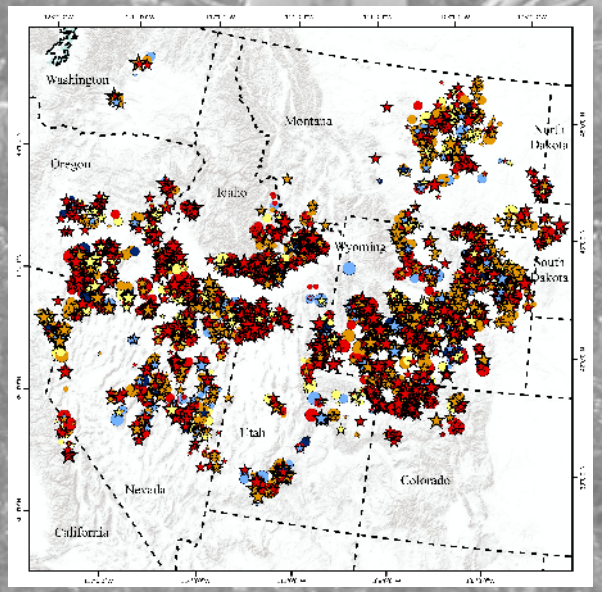
Phase I

- Open File Report – March 2021
- Continue developing web-based, user-friendly application (Shiny)
  - Interactive interface for managers
  - Input – data and options
  - Output – maps and tables



Phase II – Initiate FY2021 (Partial Funds)

- Begin assessing population change mechanisms
  - climate, sagebrush, development, grazing, etc. -- over time
- Update Database with 2020 Lek data
- Effectiveness of conservation efforts



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Thank You

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