Greater Sage-Grouse Population Dynamics and Probability of Persistence: 1965-2013

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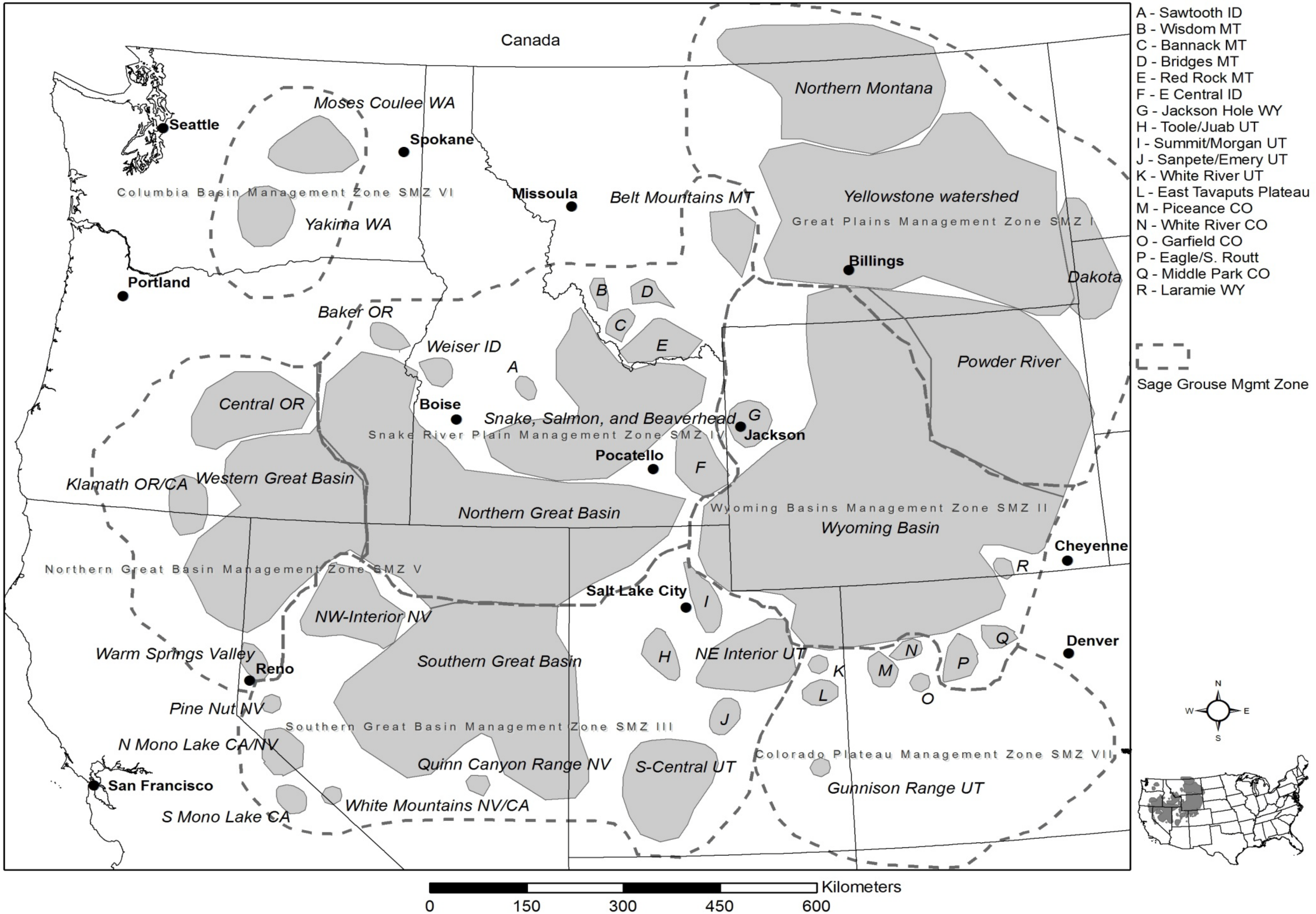
Overview

- Background: Endangered Species Act decision for Sage-grouse
- Challenge 1: Assessing abundance for a widely distributed species that must be secretive to survive in wild, undeveloped sagebrush country.
- Challenge 2: How to describe or model dynamics well and use the best model(s) to assess the species probability of persistence when it faces a large variety of threats?
- Solution:
  - 1. Clever survey sampling stats.
  - 2. Information theoretic approach to select, estimate and model dynamics.
  - 3. Use models to forecast probability of extinction.
- Questions

USFWS : "Warranted but precluded" under ESA

- USFWS petitioned repeatedly through 2005
- 2005 decision "not warranted" invalidated by suit in 2008
- Large cadre of biologists reconsidered status including a new population analysis (our work)
- *Studies in Avian Biology* 2011
- Warranted but precluded in 2009
- 2015 FWS must re-evaluate

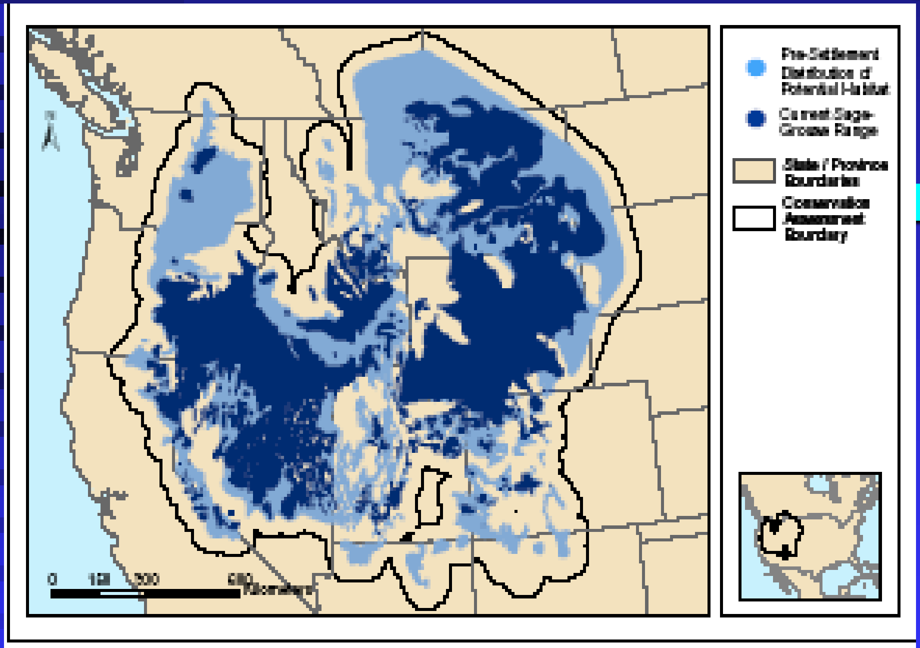
42 Populations & 7 Management Zones Delineated



ESA Listing Decision: Depends on Probability of Persistence and Threats

- Short term probability: 30 years
- Long-term: 100 years
- Presence of inverse (negative) density dependence dramatically improves probability of persistence.
- Threats increasing

Current Distribution of Sage-Grouse and Pre-Settlement Distribution of Potential Habitat



- Habitat decline: 1.2 M km^2 to 0.6 M km^2
- Threats: Fire, exotic plants, diseases, grazing?, agricultural/ urban/ surburban/energy development

Count-based Models for PVA

- Lek counts of males
  - 89,749 estimates at 10,060 leks 1965-2013
  - Index to minimum number of breeding males
  - Counting/estimating females preferable but impractical because it requires mark-resight of cryptically colored birds hiding from predators
  - Graham Caughley (1984) made a persuasive argument that such indices should be used for population management.

Lek counts of males

- 44,297 male sage-grouse counted on 5,154 leks in 2013 without Colorado data.
- Probable real total is 48,641 with Colorado.
- Protocol of using maximum of 3+ counts at a lek spread across attendance period produces high precision (repeatability)
- We improved their value by treating males attending leks as replicate cluster samples producing a precise index of population size and rates of change for population reconstruction.

Population Reconstruction Based on Ratio Estimators

- Use paired counts at leks counted in both current and previous year to estimate finite rate of increase ($\lambda(t)$) between years or relative size of population in previous year ($\theta(t)$) :

$$\lambda(t) = \frac{\sum_{i=1}^{n} M_i(t+1)}{\sum_{i=1}^{n} M_i(t)}$$

$$\theta(t) = \frac{\sum_{i=1}^{n} M_i(t)}{\sum_{i=1}^{n} M_i(t+1)}$$

Weighted Means of $\lambda(t)$ and $\theta(t)$ at individual leks

Population Reconstruction

- With variance (Scheafer, Mendenhall and Ott, 1996:200):

$$Var(\lambda_t) = \frac{fpc}{n\overline{M}(t)^2} \frac{\sum_{i=1}^{n} [M_i(t+1) - \lambda(t) M(t)]^2}{n-1}$$

$$Var(\theta_t) = \frac{fpc}{n\overline{M}(t+1)^2} \frac{\sum_{i=1}^{n} [M_i(t) - \theta_t M_i(t+1)]^2}{n-1}$$

- where fpc is conservatively assumed = 1.0

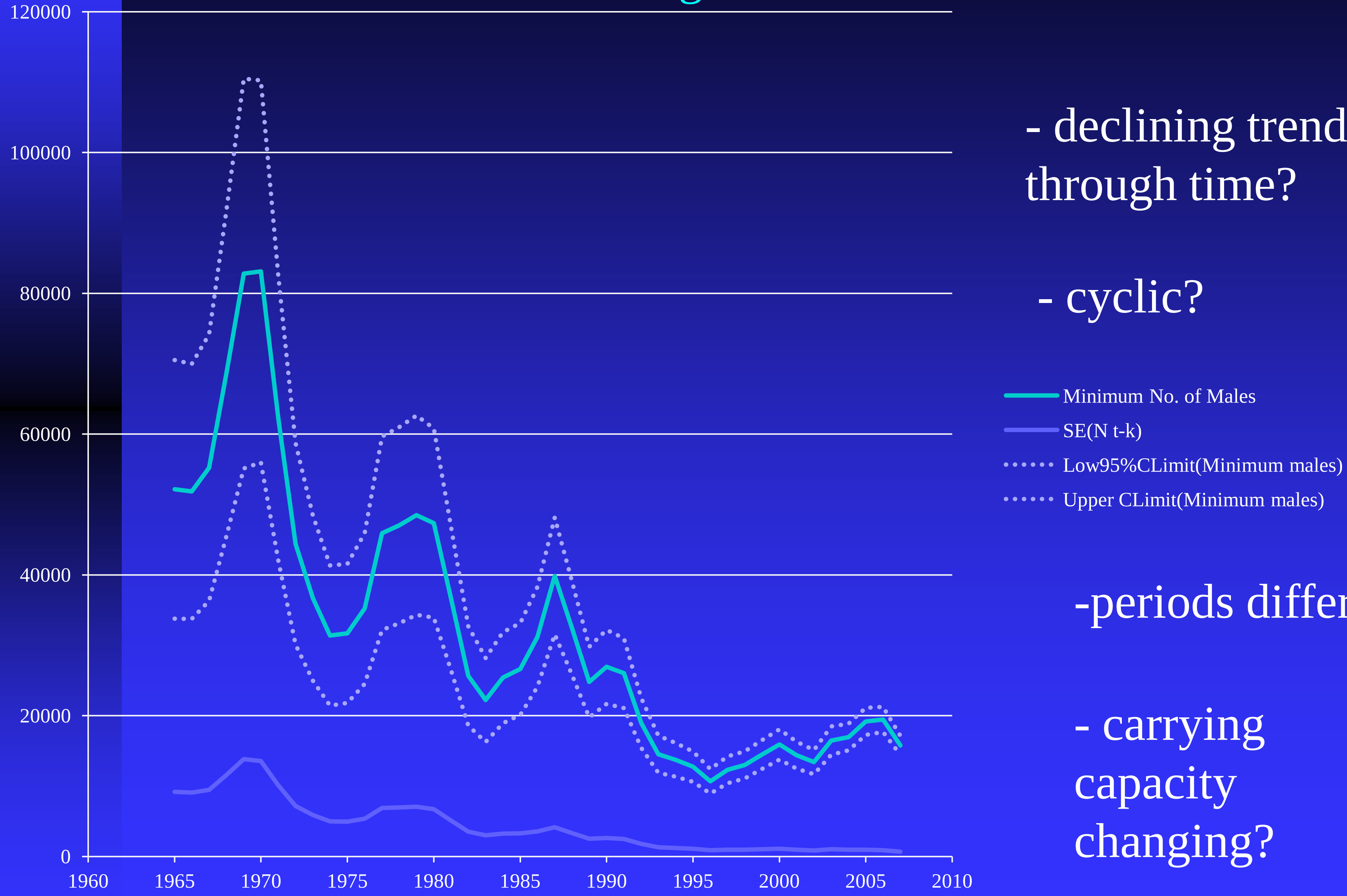
Population Reconstruction

- Variance of reconstructed population size using estimated $Var(\theta_t)$s (Goodman 1962):

$$V\hat{a}r(\prod_{i=1}^{k}\hat{\theta}_i) = \prod_{i=1}^{k}(V\hat{a}r(\hat{\theta}_i) + \hat{\theta}_i^{\,2}) - \prod_{i=1}^{k}\hat{\theta}_i^{\,2}$$

- where k is number of years prior to 2013.

Estimated Minimum Males from Population Reconstruction for Snake River Plain Management Zone IV



- declining trend through time?

- cyclic?

-periods differ?

- carrying capacity changing?

Sage-Grouse Population Changes 2007-2013

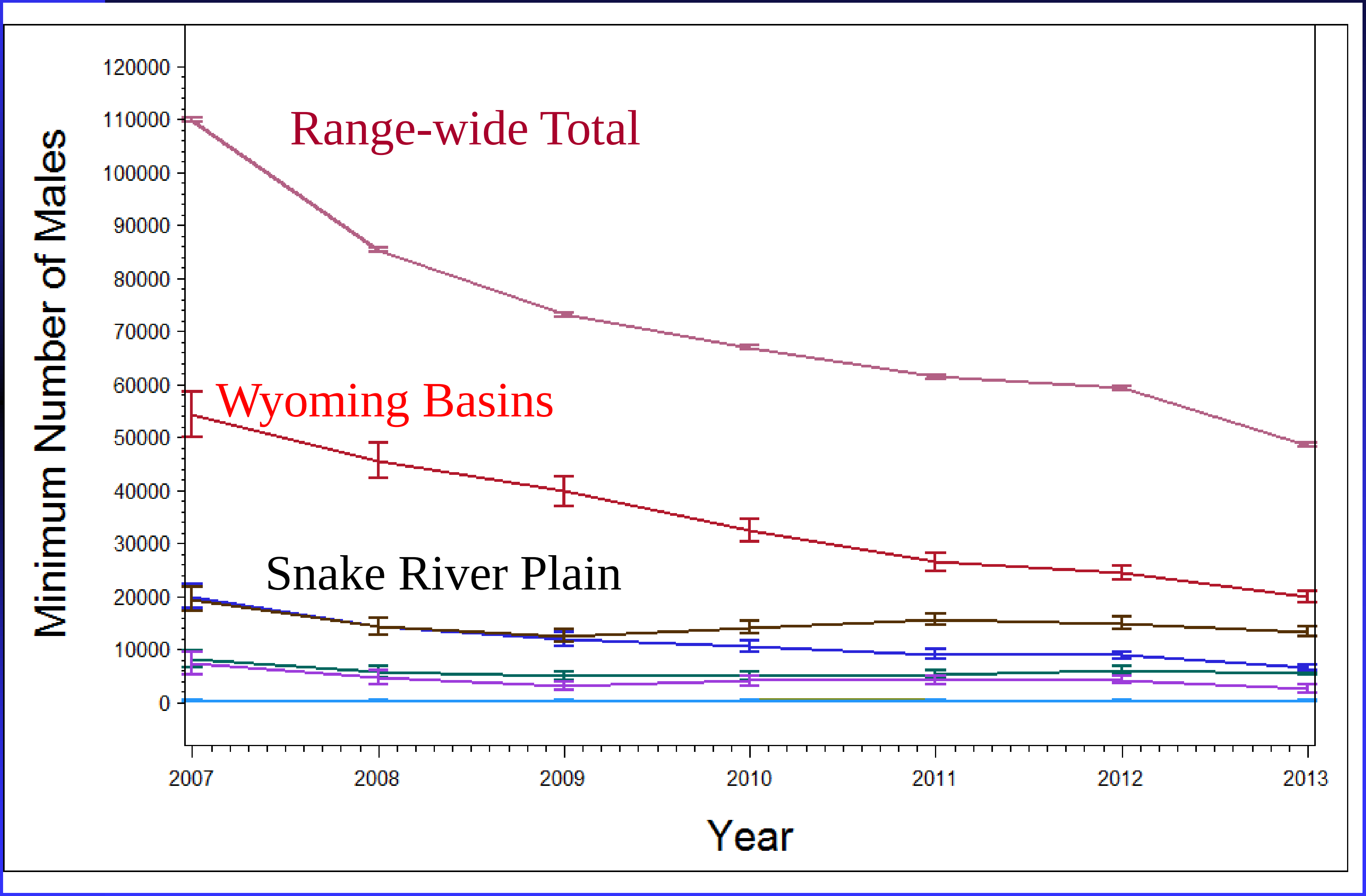
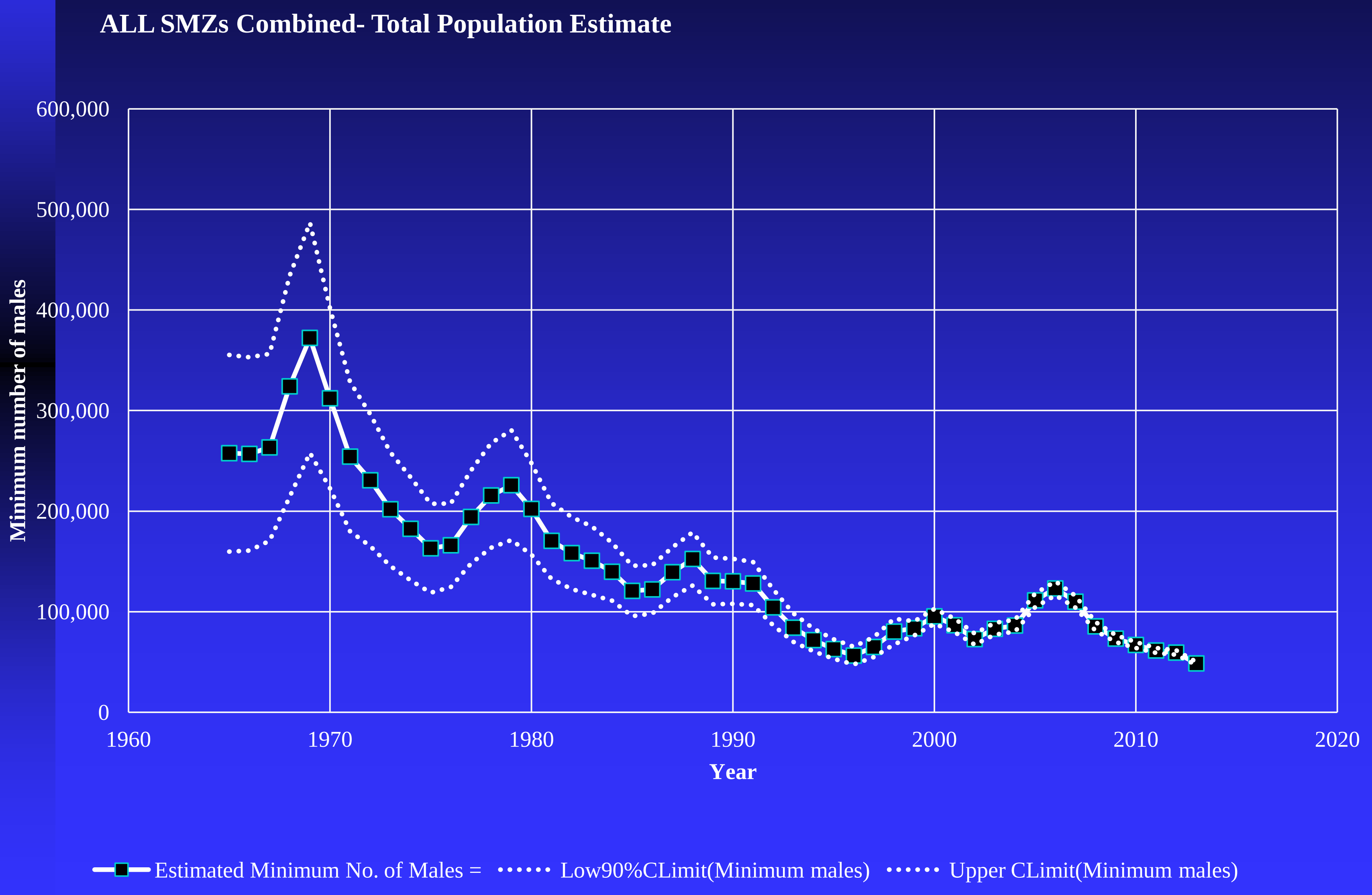


Table 2. Summary of estimated minimum male population attending leks in each Sage-Grouse Management Zone

	Estimated	Minimum	Number of	Males	
Sage-Grouse Management Zone	**2007**	**SE**	**2013**	**SE**	**Change**
I Great Plains	20,016	1,462	6,674	312	-67%
II Wyoming Basin[1]	54,282	2,636	20,006	646	-63%
III Southern Great Basin	8,202	1,085	5,485	38	-34%
IV Snake River Plain	19,510	1,404	13,371	550	-32%
V Northern Great Basin	7,429	1,312	2,573	468	-65%
VI Columbia Basin	310	98	291	56	-6%
VII Colorado Plateau[1]	241	52	241	NA	NA
Total Across All Zones except CO	98,616	3,736	44,297	1,019	-55%
Total Across All Zones	109,990		48,641		-56%

Range-wide Population Reconstruction 1965-2013



Models to Describe and Forecast

- Classic trend models: Constant decline or 2 periods
- Stochastic growth models classic in fisheries: Ricker or Gompertz model with carrying capacity
- Changing carrying capacity through time: continuous change or different periods or both
- Ricker or Gompertz models with time lags: 0, 1 or 2 yrs
- Gompertz State Space model with density dependence, stochastic (process) variation with observation error

TABLE 53. Candidate model set (top 4 models) and model statistics for estimating population trends and persistence probabilities for greater sage-grouse in Snake River Plain Management Zone IV, 1965-2013.

Model	Model statistic			
	r^2	k	ΔAIC_c	w_i
Gomperz t-1 + Year,Period	0.448	6	0	0.552
Gompertz t-1 + year	0.393	5	1.8	0.23
Gomperz t-1 + Period	0.353	5	4.7	0.053
Gomperz t-2 + Year,Period	0.376	6	5.6	0.034

Best model Snake River Plain Management Zone IV, 1965-2013.

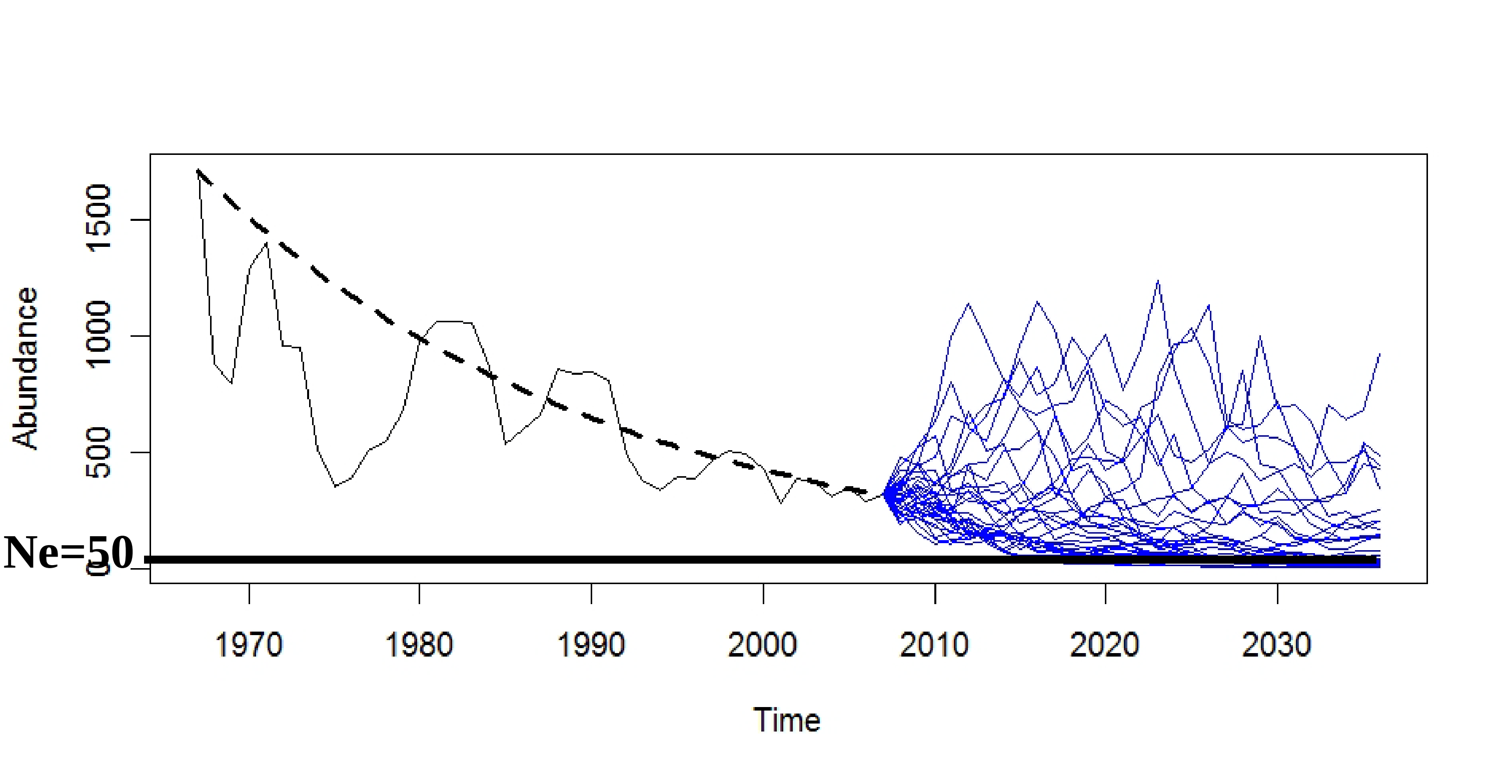
- Rate of change of male population =
- 25.475 – 0.4124 ln (N_{t-1}) + 0.156 Period – 0.011 Year
- In plain English: Population shows strong density dependence on log abundance in the previous year with a carrying capacity of 13,919 in 2013 which was 15.6% higher in early period and is declining at an average rate of 1.1% per year.

Best Models Across 6 Management Zones

Model	K	AICc	ΔAIC_c	w_i (Probability)
Gompertz t-1 + year	5	-958.8	0	98.00%
Gomperz t-1 + Year,Period	6	-951	7.8	1.98%
Ricker t-1 + Year	5	-941	17.8	0.01%
EGPE	3	-911.2	47.6	0.00%
Period	4	-885.5	73.3	0.00%

Probability of Extinction Under Model i

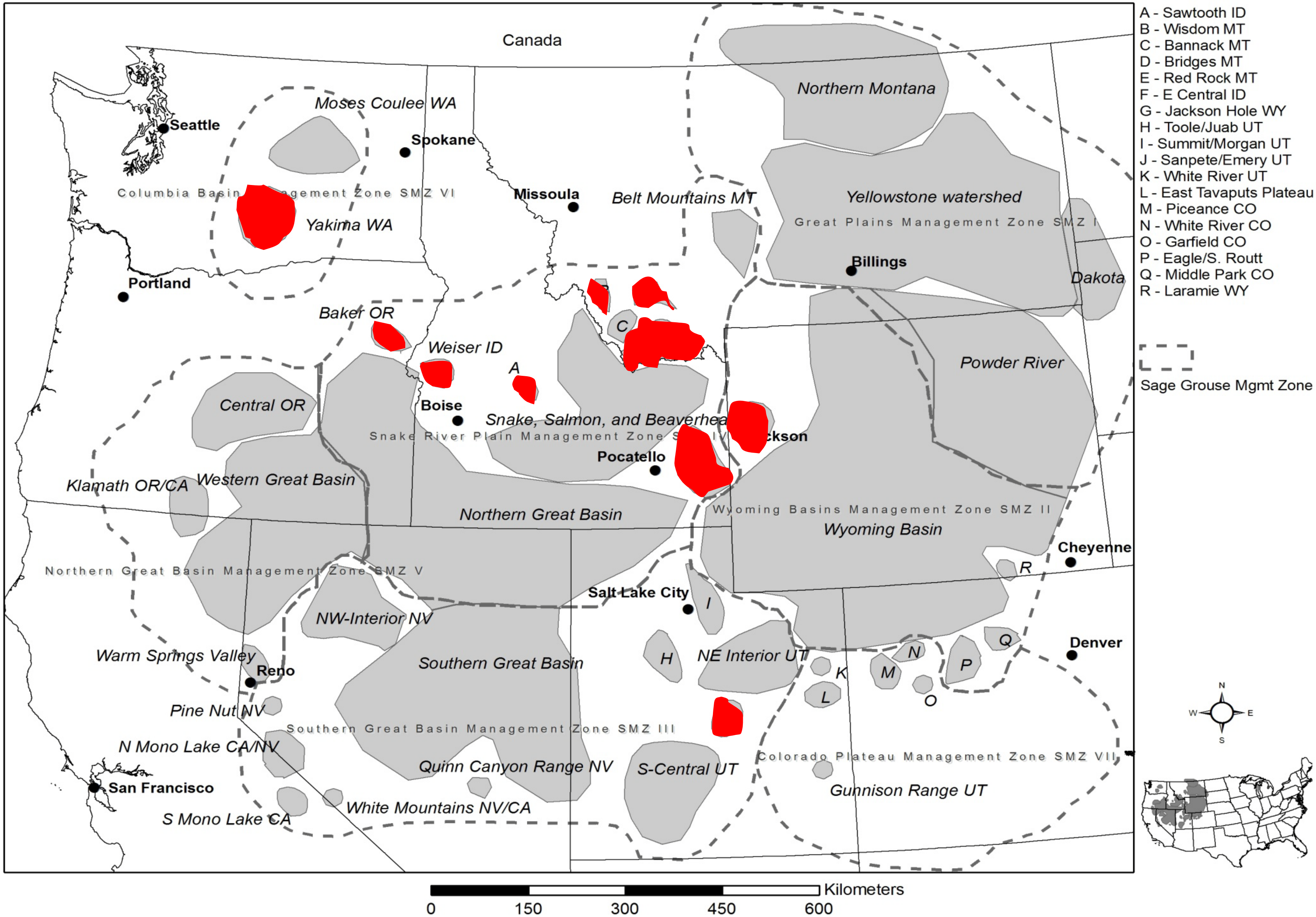
- Short term: Chance of falling below an effective minimum population size of 50 in 30 years.



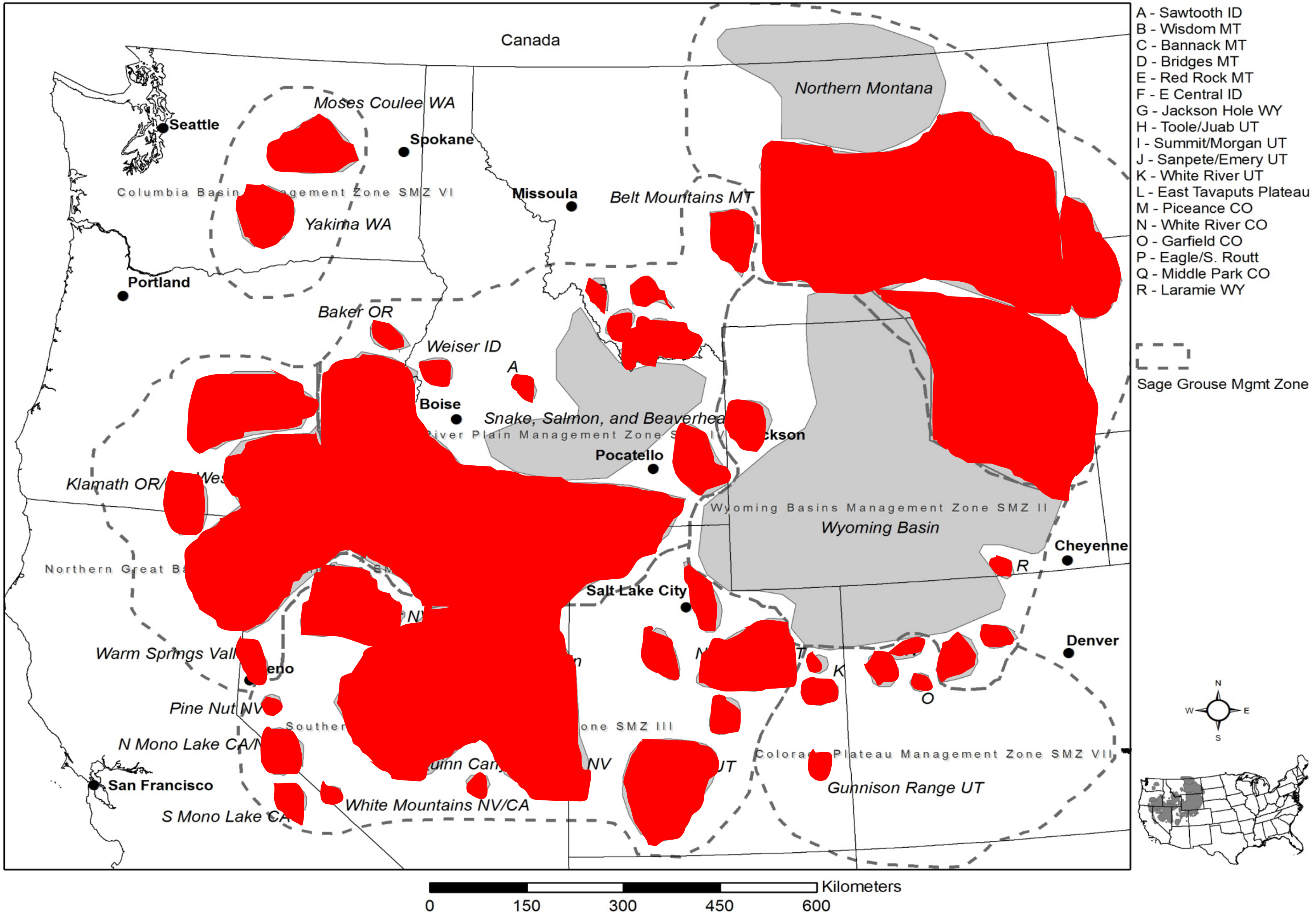
Multi-model Forecasts of Probability of Extinction

	Pr(Ne<50) in 30 years	Pr(Ne<500) in 100 years
	Ne=50	Ne=500
SMZ-IV		
Baker, OR	61.9	100.0
Bannock, MT	37.2	100.0
Northern Great Basin	12.6	92.3
Red Rocks, MT	0.1	91.9
Snake, Salmon, and Beaverhead, ID	3.3	20.7
Overall (S.E.)	2.1 (2.6)	46.7 (7.3)

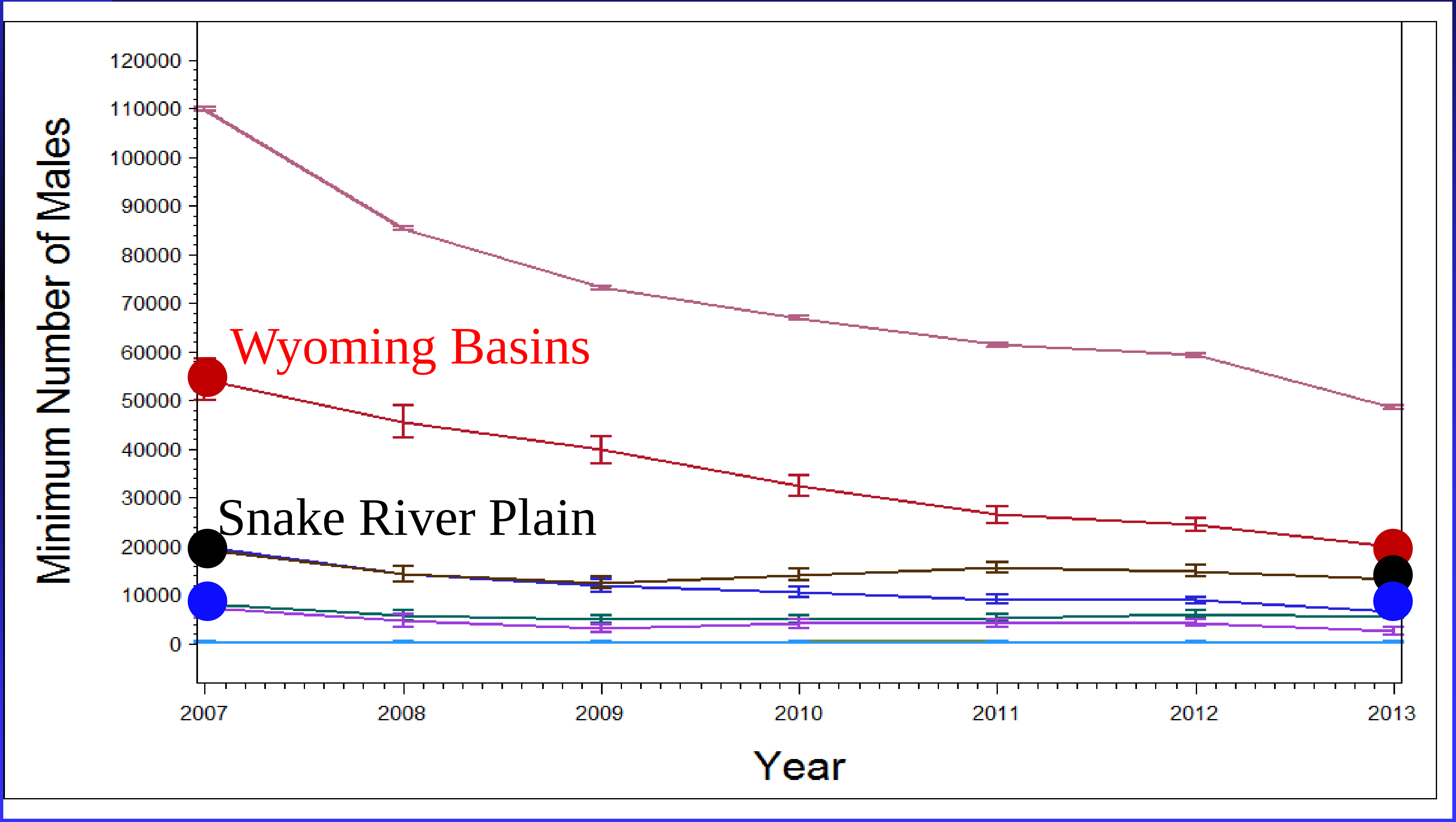
Short-term Probability of Extinction of Sage-grouse Populations



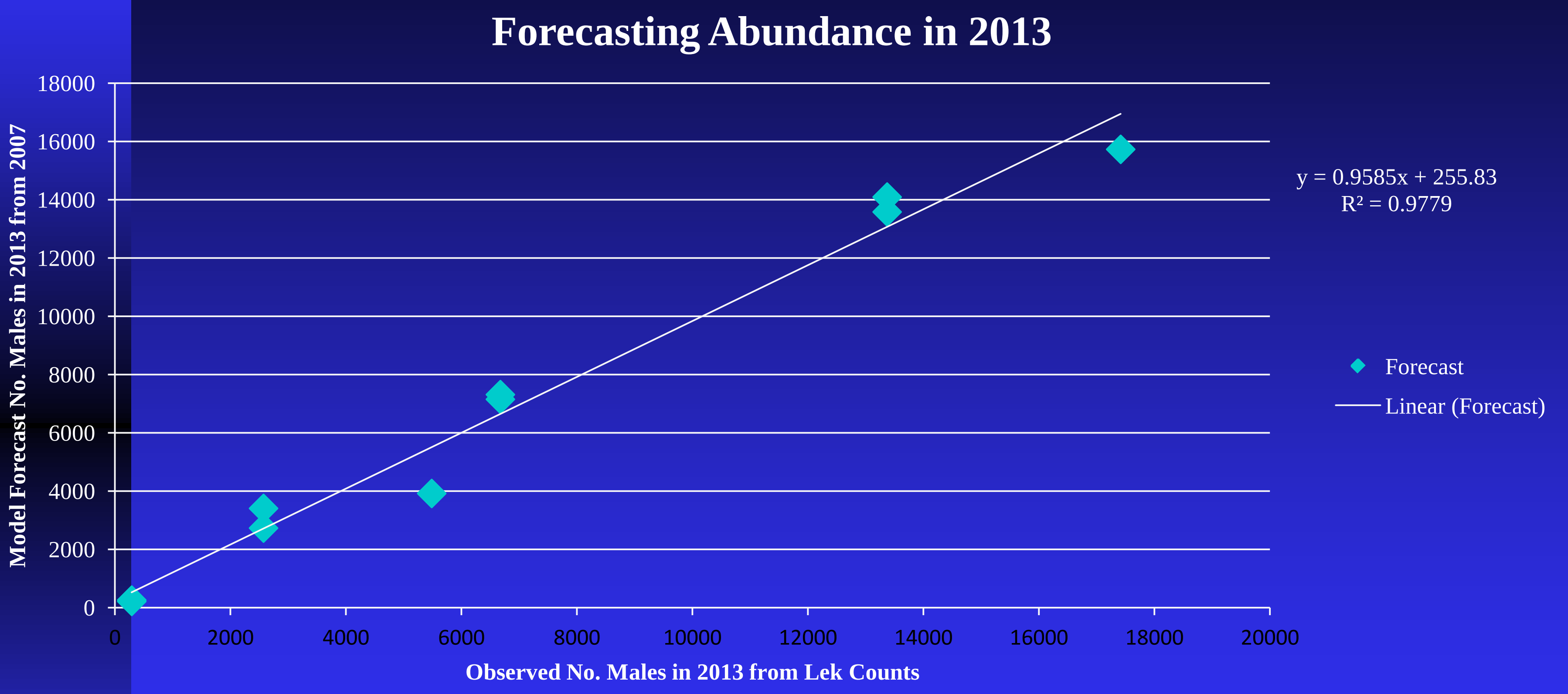
Long-term Probability of Extinction of Sage-grouse Populations



Are Sage-Grouse Population Forecasts Valid? Test this with forecasts from 2007 to 2013



Validity of Forecasts?



Forecasting abundance in 2013 starting with 2007 counts explained 97.8% of variation in 2013 counts.

Questions

- ogarton@uidaho.edu
- Garton et al. 2011 Chapter 19. Greater Sage-Grouse Population Dynamics and Probability of Persistence. *Studies in Avian Biology* (2011).
- Thanks for funding from
- USFWS, UI, IDFG, Pew Charitable Trusts

Population Reconstruction, $\theta(t)$ and Annual Rate of Change, $\lambda(t)$

Lek	2012	2013
COYOTE WATER H.	26	17
CRUTHERS BUTTE		13
FINGERS BUTTE	6	7
HEIFER RESERV.		
INEL RESERVOIR	0	
MUDDY RESERV.		
PARSON RESERV.	0	
PRATT LAKE	71	68
PRATT LAKE S.	19	15
QUAKING ASPEN A.	54	47
Total (both years)	176	154
$\lambda(t)$ $\theta(t)$	0.875	1.143

- Only use leks counted in both years

Population Reconstruction, $\theta(t)$ and Annual Rate of Change, $\lambda(t)$

Lek	2012	2013
COYOTE WATER H.	26	17
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- Only use leks counted in both years
- Estimate rate of change in next year as ratio of counts:
- $\lambda(2012)$ = 154/176 =0.875 = 87.5% or 12.5% decline
- $\theta(2012)$ =176/154 =1.143 or 114.3% or 14.3% increase