BREEDING BIRD SURVEY REGRESSION MODELS FOR THE BEAR RIVER WATERSHED CONSERVATION AREA

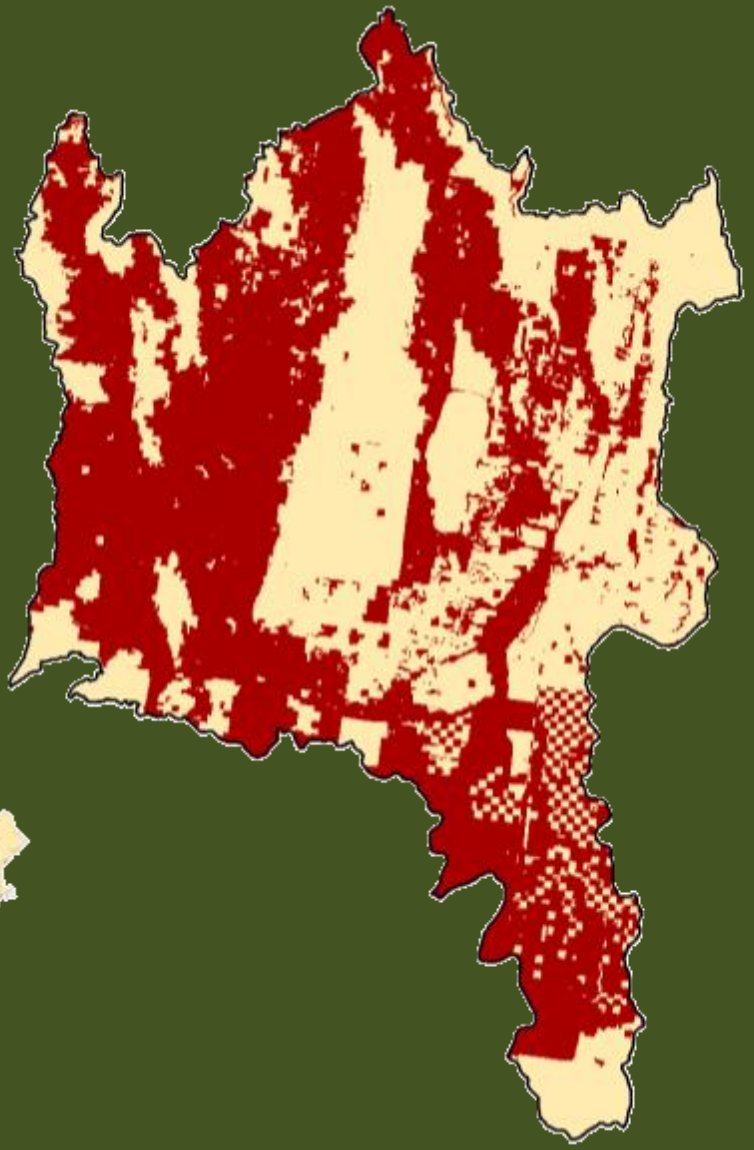
BEAR RIVER WATERSHED CONSERVATION AREA

Purposes of this discussion:

Address the requirement for "…. demonstrate application of the spatially-explicit biological planning and conservation design that result in measurable biological outcomes"

USFWS Director
BRWCA PPP Approval Letter
12/16/2010

BEAR RIVER WATERSHED CONSERVATION AREA



4.7 MILLON ACRE WATERSHED

2.5 MILLON ACRE PROJECT AREA

920,000 ACRE ACQUISTION APPROVAL

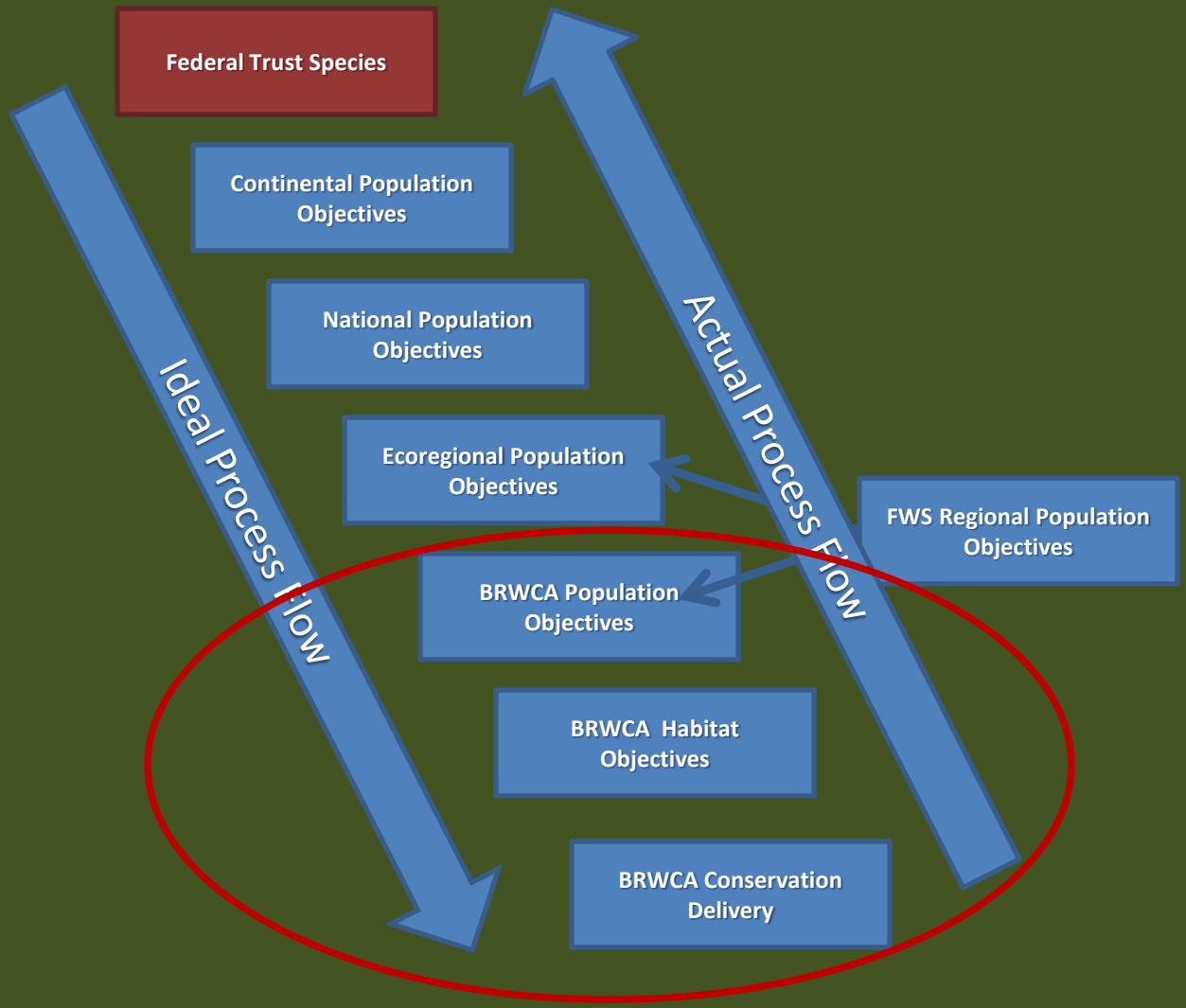
Project Location

PURPOSE OF THE BEAR RIVER WATERSHED CONSERVATION AREA:

- PROTECT AND RESTORE WATER QUALITY AND QUANTITY
- CONSERVE UPLAND, WETLAND, RIPARIAN, AND AQUATIC HABITATS
- WILDLIFE HABITAT CONNECTIVITY
- PROMOTE PARTNERSHIPS

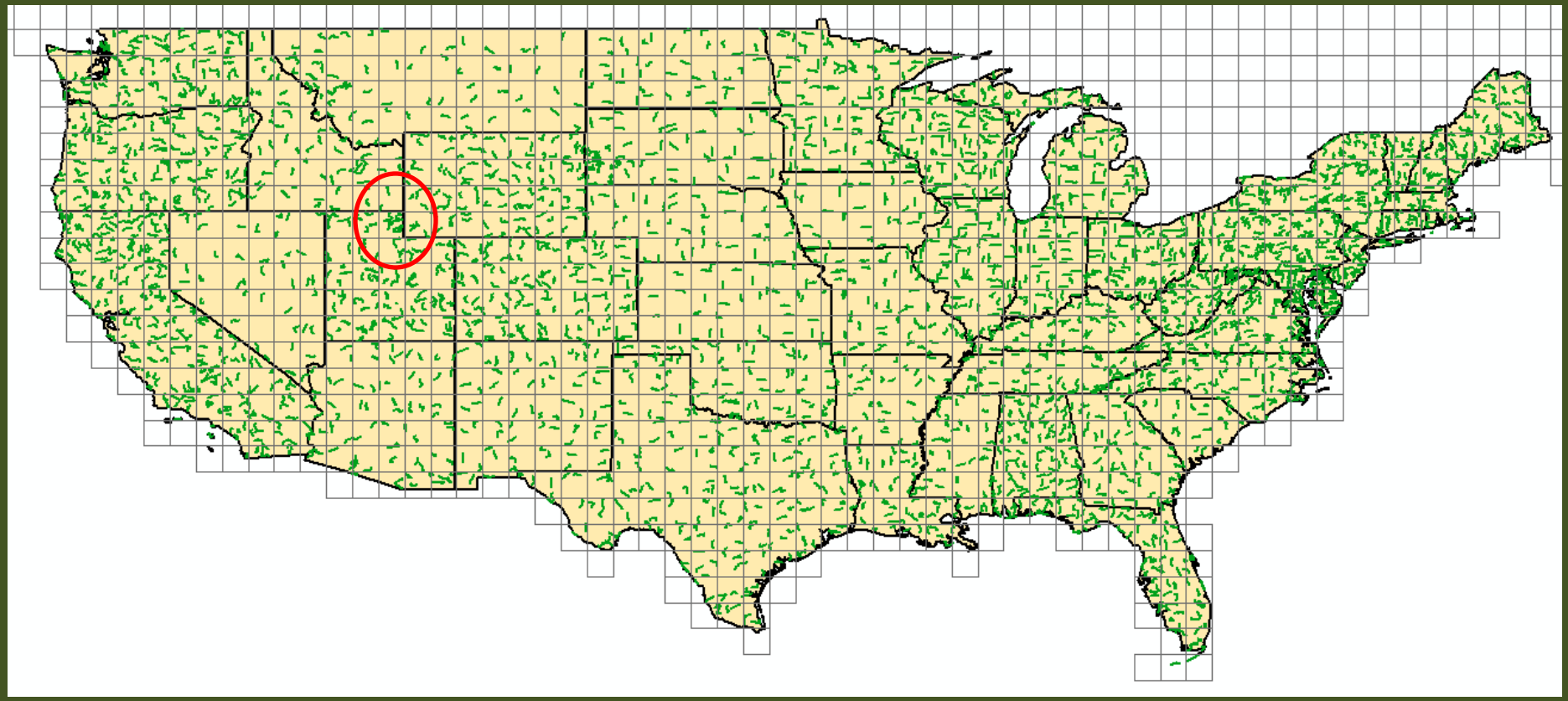
Provide Landscapes Capable of Sustaining Range-wide Populations of Federal Trust Species at Socially Viable Levels

How will BRWCA Contribute to this?

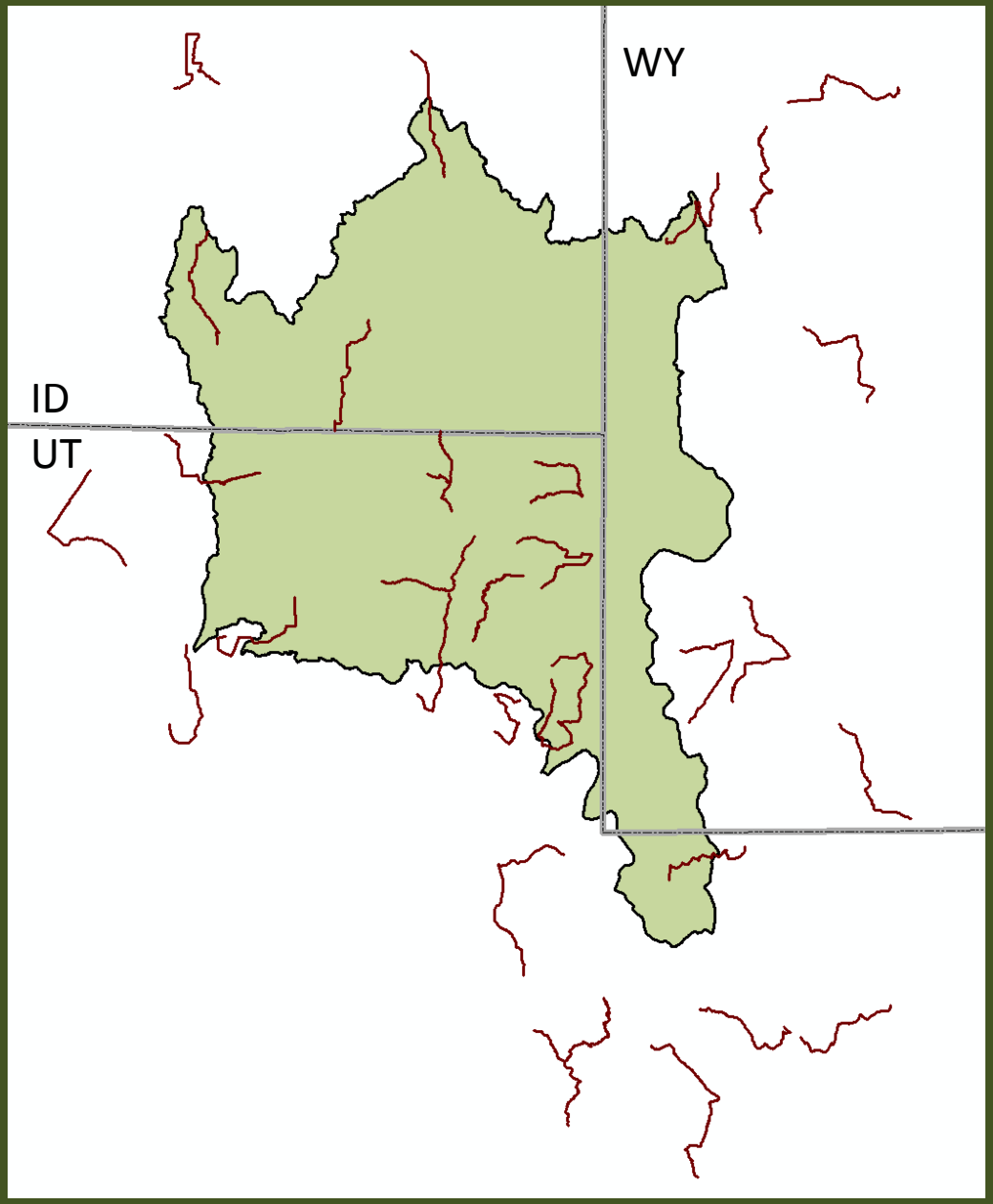


Breeding Bird Survey Routes By Degree Block

- Densities vary by state



BRWCA Breeding Bird Survey Routes



Project Area
- 4.8 million acres

33 total routes.
- Used 32 routes

BBS stops were created by
- Route observers (3)
- BBS web site (1)
- Derived from routes (29)

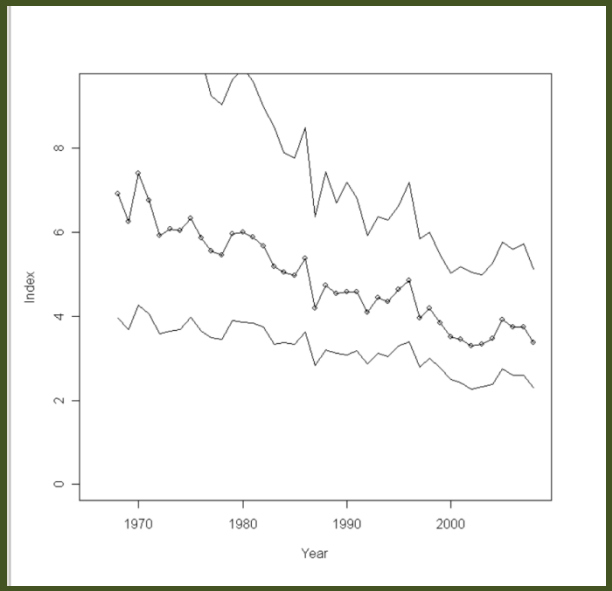
Draft BRWCA Focal Species List*

Species	BBS Total Observations	BBS Total Routes	BBS Total Stops
American avocet	3018	12	81
Black-necked stilt	1604	5	49
Lewis's woodpecker	12	2	6
Long-billed curlew	521	11	126
Northern pintail	529	8	99
Sage sparrow	398	12	128
Sage thrasher	3961	21	599
White-faced ibis	7159	8	113
Willow flycatcher	206	15	71

*in addition to Greater sage-grouse and Bonneville cutthroat trout

Sage Thrasher (*Oreoscoptes montanus)*

Southern Rockies
BBS TREND – 1966-2009

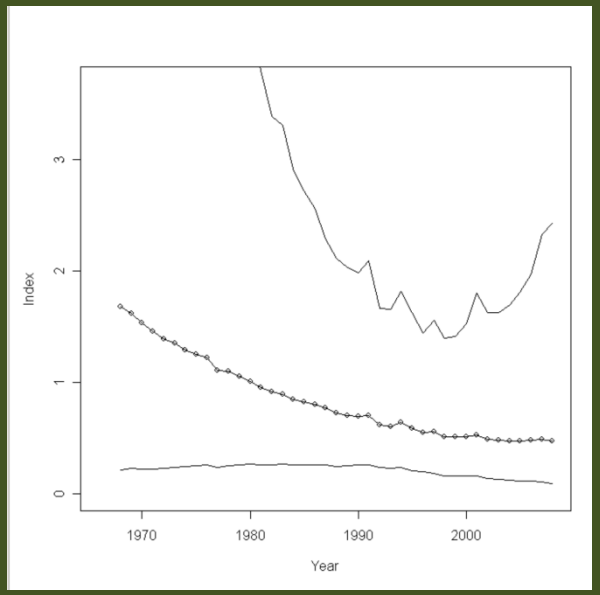


Survey-wide Abundance

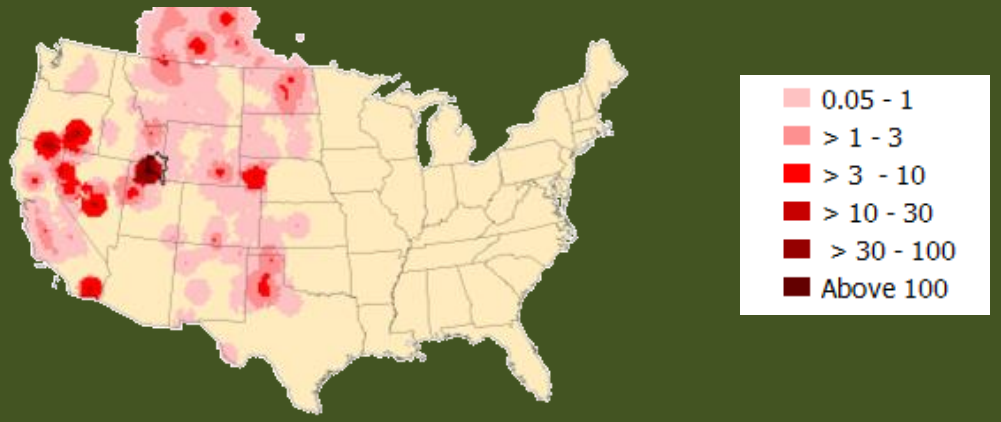
Survey-wide Trend

American avocet (*Recurvirosta americana*)

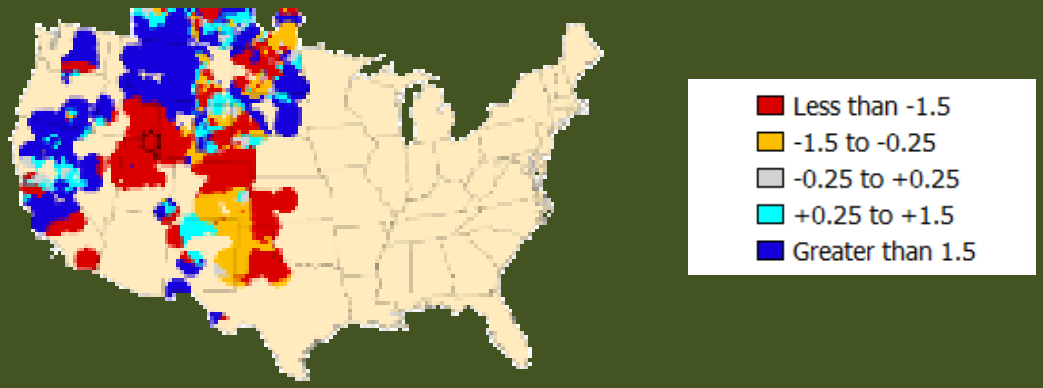
Southern Rockies
BBS TREND – 1966-2009



Survey-wide Abundance



Survey-wide Trend



Analysis Approach

- Competing Model Analysis
    - Compare candidate set of models using AICc
    - Two analyses to 1) determine landscape scale and 2) the final model selection within that scale.

- Validate Best Model
    - Goodness of Fit
    - Predictive ability
    - Spatial Autocorrelation

- Apply best model to landcover data in BRWCA

- Provide BRWCA planning team with priority maps and data layers

Potential Model Covariates

COVARIATE	DESCRIPTION
STOP	proxy for time of day
NORTH	UTM northing meters
EAST	UTM easting meters
ELEVATION	DEM meters
SLOPE	percent
GRASS	proportion in landscape
HAY	proportion in landscape
CROP	proportion in landscape
FOREST	proportion in landscape
SHRUB	proportion in landscape
WATER	proportion in landscape
URBAN	proportion in landscape
PATCHES	number in landscape
PONDS	number in landscape (NHD)
PRECIP	PRISM 30 year monthly May mean (mm)
ROUGHNESS	surface area ratio (1-4)

SATH Model Selection

- Used all BBS routes ran in year 2000
  - Corresponds with landcover imagery dates

- Run competing full models for landscape measurement (400m, 800m, 1200m, 1600m, 2400m, 3200m)
  - 1200m best model (Δ > 3 AICc)

- Poisson vs Negative Binomial Distributions
  - Mean: 0.24 Variance: 0.41
  - Negative Binomial (Δ > 21 AICc)
  - Likelihood Ratio Test: $P < 0.001$

- Tested need for zero-inflated models

Observed	Poisson	Negative Binomial
867	843	865

SATH Exploratory Competing Models Analysis

BBS Data Year: 2000
Model Type: Negative Binomial Regression
Landscape around each BBS stop : 1200 meter radius

MODEL	*LL*	*K*	*AICc*	*deltaAICc*	*weight*
NORTH + EAST + ELEV + URBAN1200 + GRASS1200 + WATER1200 + CROP1200 + FOREST1200 + SHRUB1200 + PATCH1200 + ROUGH1200	-492.52	13	1011.40	0.00	0.905
NORTH + EAST + ELEV + SLOPE + URBAN1200 + GRASS1200 + SHRUB1200 + FOREST1200 + HAY1200 + PATCH1200 + PRECIP1200 + ROUGH1200	-494.05	14	1016.51	5.11	0.070
FULL	-490.98	18	1018.65	7.25	0.024
NORTH + EAST + ELEV + SLOPE + URBAN1200 + GRASS1200 + WATER1200 + SHRUB1200 + FOREST1200 + HAY1200	-502.16	12	1028.62	17.22	0.000
NORTH + EAST + PATCH1200 + PONDS1200 + PRECIP1200 + ROUGH1200	-540.49	8	1097.11	85.71	0.000
NULL	-609.62	2	1223.25	211.85	0.000

BRWCA Sage Thrasher Model

$$SATH = EXP(\beta_0 + \beta_1(NORTH) + \beta_2(EAST) - \beta_3(ELEV) - \beta_4(URBAN) + \beta_5(GRASS) + \beta_6(WATER) + \beta_7(CROP) + \beta_8(FOREST) + \beta_9(SHUB) + \beta_{10}(PATCH) - \beta_{11}(ROUGH))$$

```
Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)  4.699e+00  8.312e+00   0.565  0.57182
NORTH        3.197e-06  1.101e-06   2.902  0.00370 **
EAST         1.295e-05  3.176e-06   4.076 4.57e-05 ***
ELEV        -3.411e-03  7.619e-04  -4.477 7.58e-06 ***
URBAN1200   -5.357e+00  3.192e+00  -1.678  0.09332 .
GRASS1200    2.558e+00  1.592e+00   1.607  0.10797
WATER1200    3.133e+00  1.386e+00   2.260  0.02380 *
CROP1200     4.200e+00  1.375e+00   3.054  0.00226 **
FOREST1200   3.897e+00  1.396e+00   2.792  0.00524 **
SHRUB1200    6.306e+00  1.250e+00   5.044 4.56e-07 ***
PATCH1200    3.350e-03  1.388e-03   2.413  0.01584 *
ROUGH1200   -2.521e+01  6.844e+00  -3.684  0.00023 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1
```

Sage Thrasher Model Validation

- Model Goodness of Fit:
  - Chi-squared test

- How well does the model predict? 2 tests

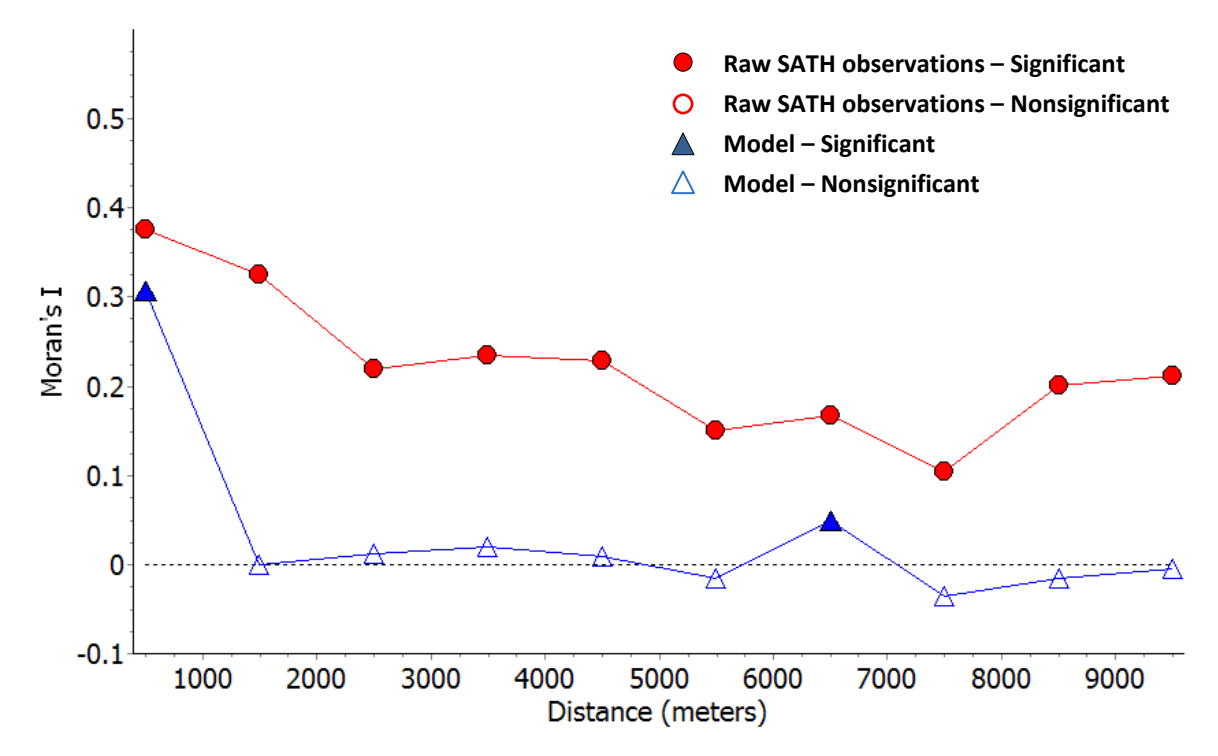
Year	Method	RMSE	MAE
2001	Observed vs Predicted	0.51	0.19
2000	10-fold cross validation	0.34	

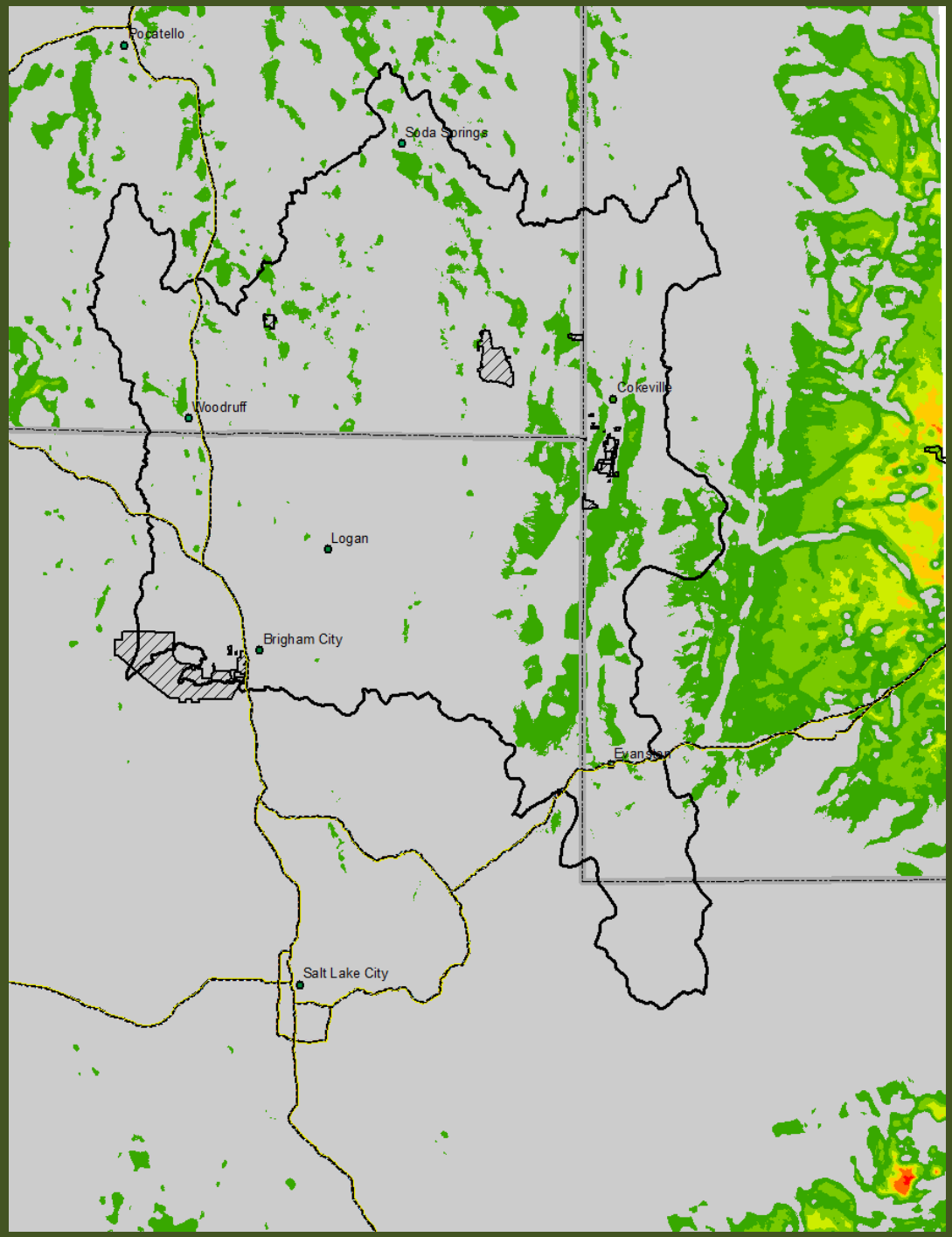
- What does this mean?
  - Large errors in predictions did not occur.
  - Average difference between predicted and observed SATH was 0.19 in 2001

Sage Thrasher Model Validation

Spatial Autocorrelation:

- Moran's I Corellograms
- Spatial autocorrelation *does* exist in the data
- The model accounts for most, *not all*, of the SA





Sage Thrasher

NB Regression Model using BBS data from 2000

Sage Thrashers

AMAV Model Selection

- Use all years combined
  - Only routes with observed AMAV
  - Used route variable as a random effect

- Logistic Regression
  - Habitat occupancy probability (0-1)

- Review correlation coefficients
  - Threshold = 0.7

- Run competing full models for landscape measurement (400m, 800m, 1200m, 1600m, 2400m, 3200m)
  - 800m, 1200m, 1600m (Δ 2 AICc)
  - 800m final landscape

AMAV Exploratory Competing Model Analysis

BBS Data Years: 1997 - 2010
Model Type: Logistic Regression (GLMM)
Landscape around each BBS stop : 800 meter radius

MODEL	*LL*	*K*	*AICc*	*deltaAICc*	*weight*
STOP + NORTH + EAST + ELEV + URBAN800 + GRASS800 + HAY800 + CROP800 + FOREST800 + SHRUB800 + ROUGH800	-537.168	12	1100.442	0.000	0.692
STOP + NORTH + EAST + ELEV + URBAN1200 + GRASS1200 + HAY1200 + CROP1200 + FOREST1200 + SHRUB1200 + ROUGH1200	-538.975	12	1104.055	3.613	0.113
FULL800	-534.329	17	1104.863	4.421	0.075
FULL1200	-534.469	17	1105.144	4.702	0.065
FULL1600	-534.845	17	1105.895	5.453	0.045
STOP + NORTH + EAST + ELEV + URBAN1600 + GRASS1600 + HAY1600 + CROP1600 + FOREST1600 + SHRUB1600 + ROUGH1600	-541.778	12	1109.662	9.219	0.006
NULL	-697.75	1	1399.500	299.05	0.000

BRWCA American Avocet Model

$$AMAV = \frac{e^x}{1+e^x}$$

$$x = (\beta_0 + \beta_1(NORTH) + \beta_2(EAST) - \beta_3(ELEV) - \beta_4(URBAN) - \beta_5(GRASS) + \beta_6(WATER) - \beta_7(CROP) - \beta_8(FOREST) - \beta_9(SHUB) - \beta_{10}(HAY) - \beta_{11}(ROUGH))$$

	coef	se(coef)	z	Pr(>|z|)
(Intercept)	1.044e+02	5.056e+01	2.0655	3.89e-02
STOP	1.804e-02	8.386e-03	2.1514	3.14e-02
NORTH	-2.258e-05	1.061e-05	-2.1284	3.33e-02
EAST	4.547e-05	1.488e-05	3.0552	2.25e-03
ELEV	-3.485e-03	2.390e-03	-1.4578	1.45e-01
URBAN800	-5.962e+00	3.094e+00	-1.9271	5.40e-02
GRASS800	-8.443e+00	1.710e+00	-4.9368	7.94e-07
HAY800	-5.688e+00	1.273e+00	-4.4687	7.87e-06
CROP800	-2.706e+00	8.495e-01	-3.1857	1.44e-03
FOREST800	-5.912e+00	5.871e+00	-1.0070	3.14e-01
SHRUB800	-8.015e+00	1.136e+00	-7.0577	1.69e-12
ROUGH800	-1.344e+01	1.646e+01	-0.8169	4.14e-01

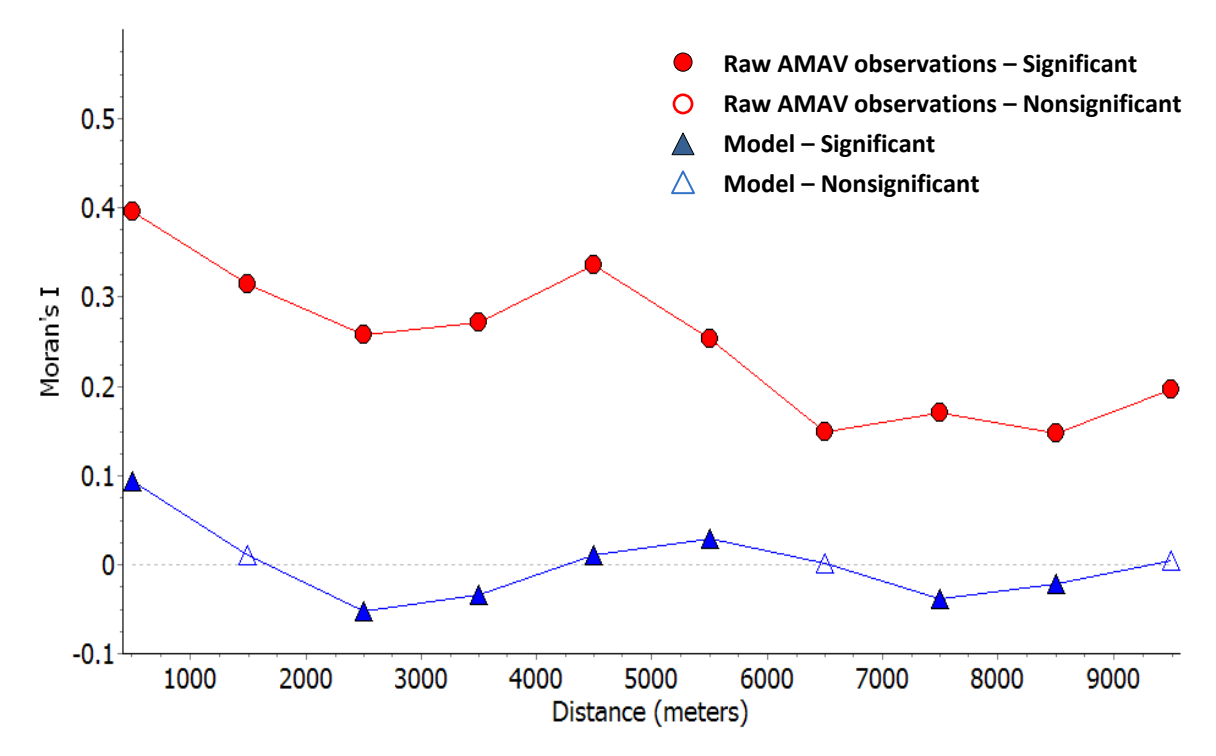
American Avocet Model Validation

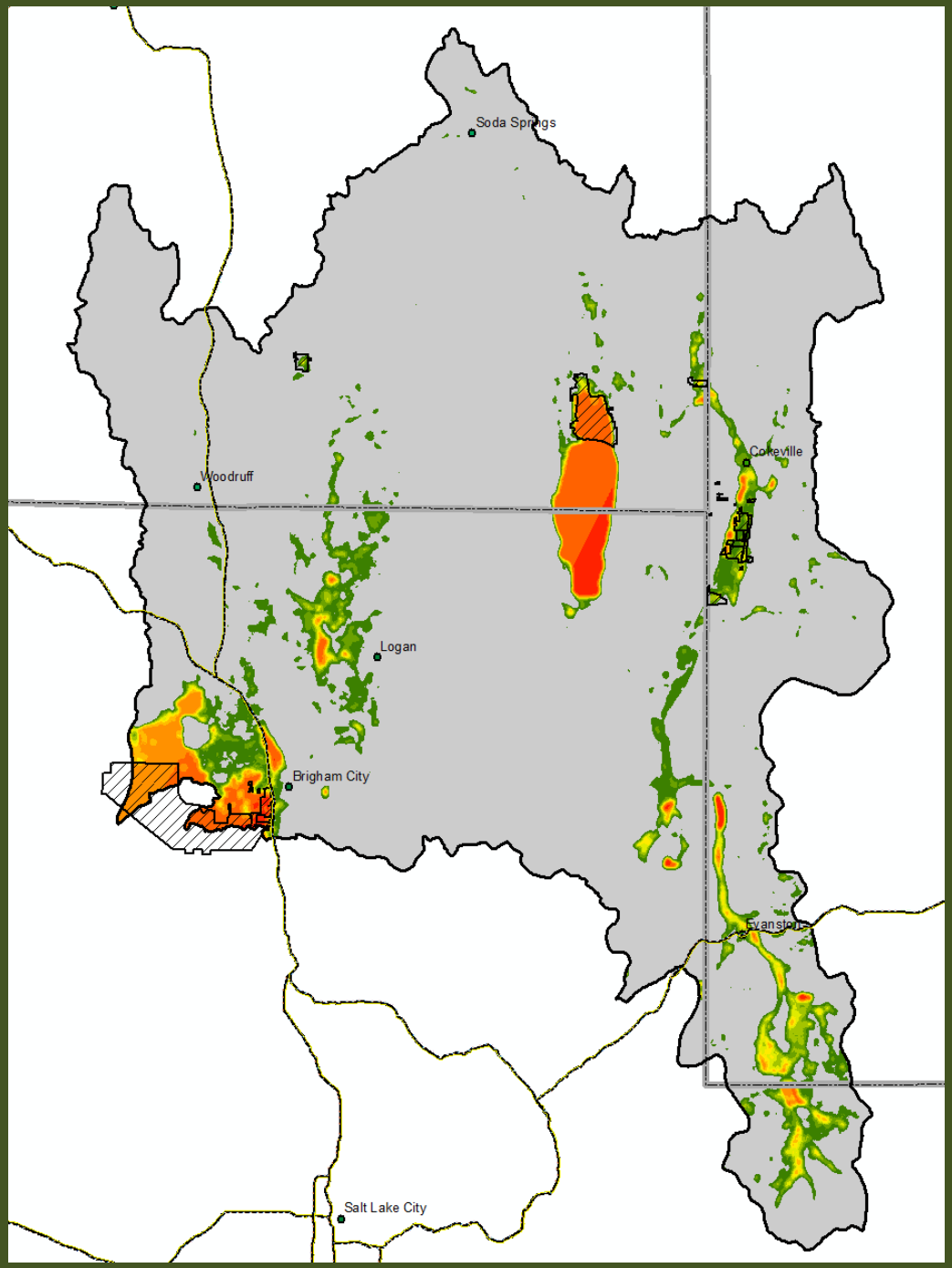
- Much more difficult with mixed-effects models
- Model Goodness of Fit:
  - Likelihood Ratio Test
  - AICc as a general GOF
- 10-fold cross validation
  - RMSE = 0.22
  - MAE = 0.11
  - Large prediction errors did not occur
- Spatial Autocorrelation

American Avocet Model Validation

Spatial Autocorrelation:

- Moran's I Corellograms
- Spatial autocorrelation *does* exist in the data
- The model accounts for some of the positive SA





American Avocet

BRWCA Draft Logistic Regression Model 1997 – 2000 BBS Data

Probability of Occupancy

High

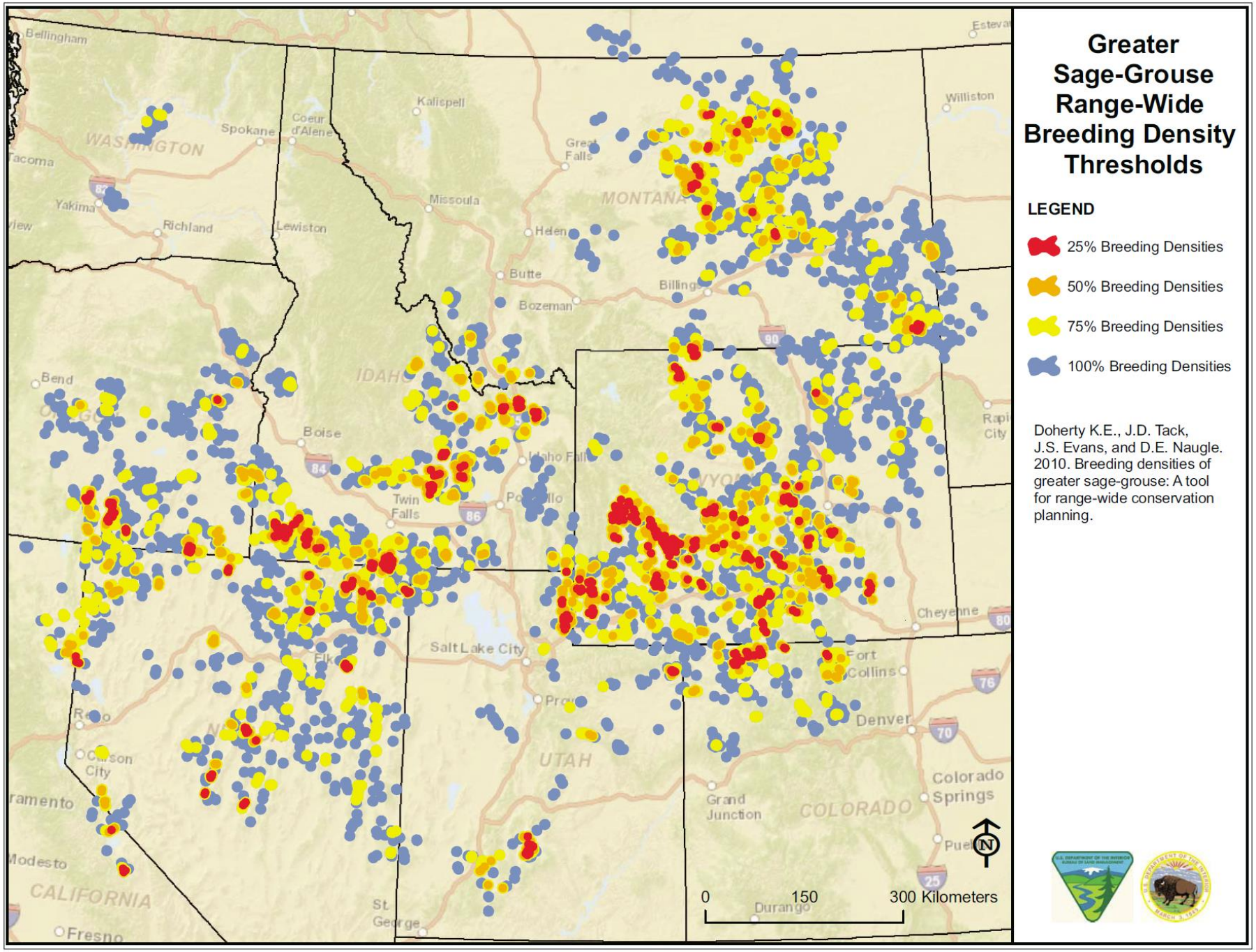
Low

Bringing It All Together

- Target conservation easements in the top areas for each focal species

- Use integrated approach when there is a priority area for one focal species that overlaps areas for other focal species
    - One of the overlaps MUST be in a priority area
    - Example

- Integrate other issues that may help prioritize within a species priority area
    - Connectivity
    - Must occur within a species focal area


Greater Sage-Grouse Range-Wide Breeding Density Thresholds
LEGEND
25% Breeding Densities
50% Breeding Densities
75% Breeding Densities
100% Breeding Densities
Doherty K.E., J.D. Tack, J.S. Evans, and D.E. Naugle. 2010. Breeding densities of greater sage-grouse: A tool for range-wide conservation planning.
0
150
300 Kilometers
N
WASHINGTON
IDAHO
MONTANA
WYOMING
UTAH
COLORADO
CALIFORNIA
Bellingham
Spokane
Coeur d'Alene
Kalispell
Great Falls
Williston
Tacoma
Yakima
Richland
Lewiston
Missoula
Helena
Butte
Billings
Bozeman
Bend
Boise
Idaho Falls
Twin Falls
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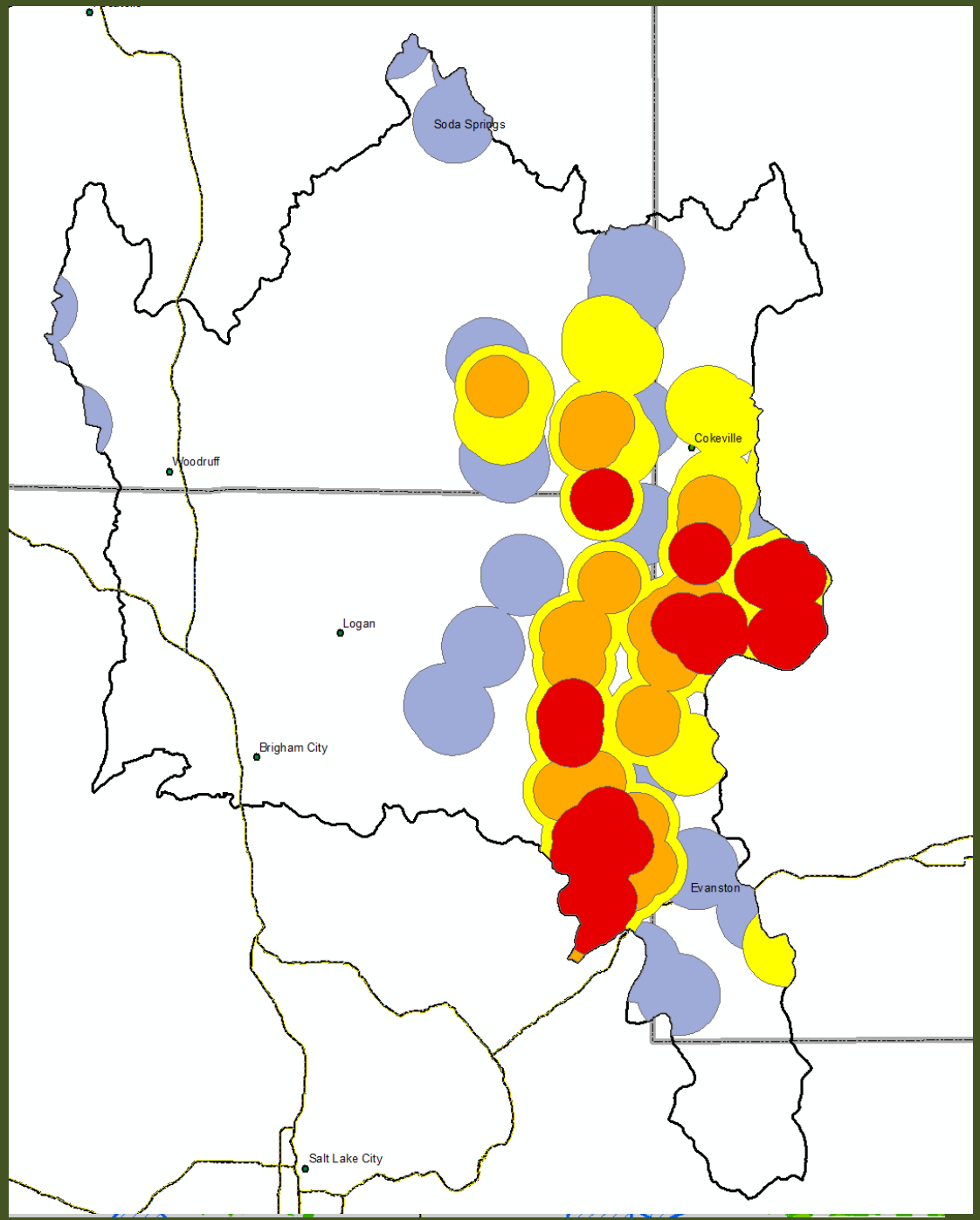
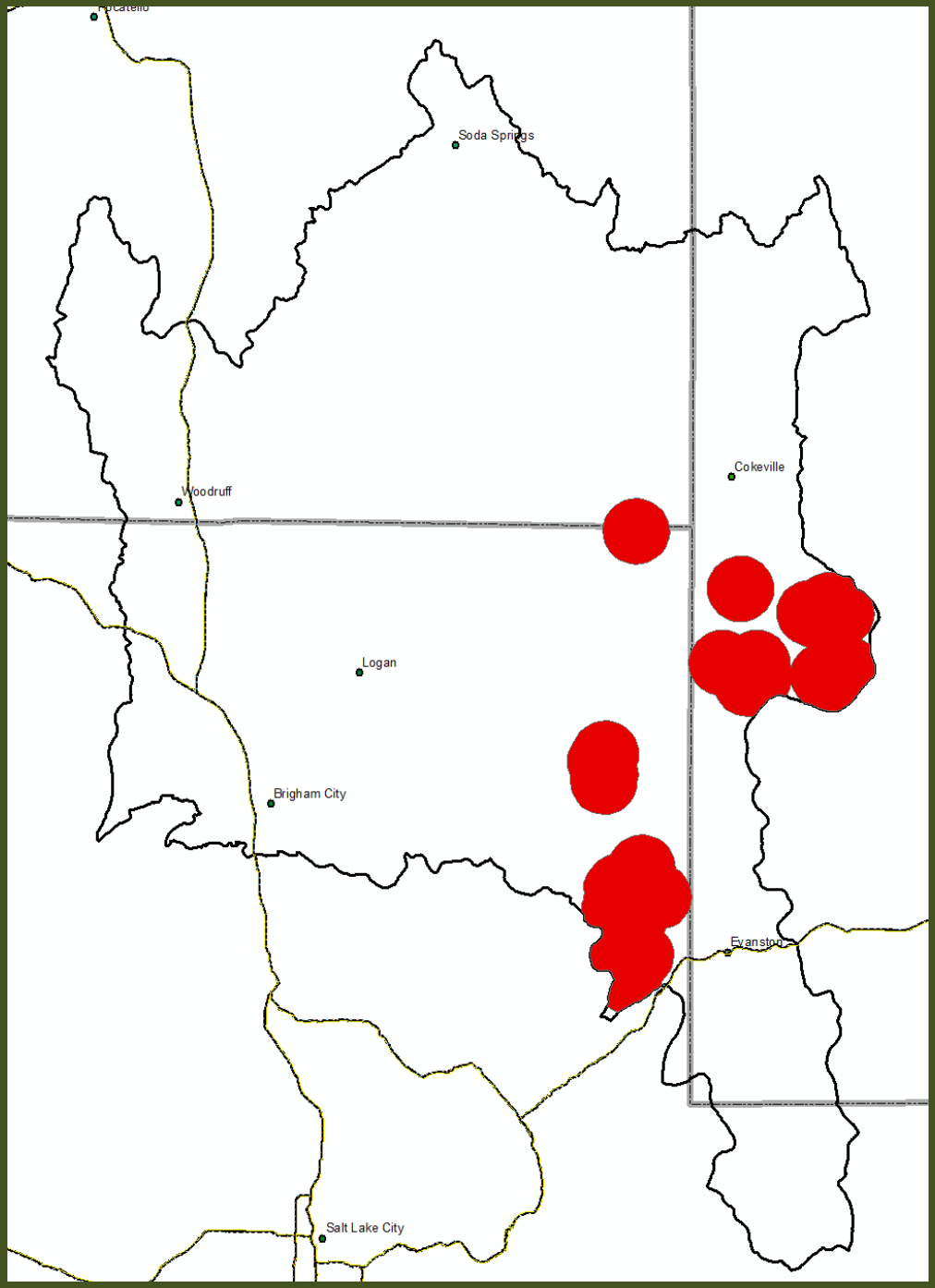
Grand Junction
Durango
Reno
Carson City
Modesto
Fresno
St. George



Greater Sage-Grouse Range-Wide Breeding Density Thresholds

LEGEND

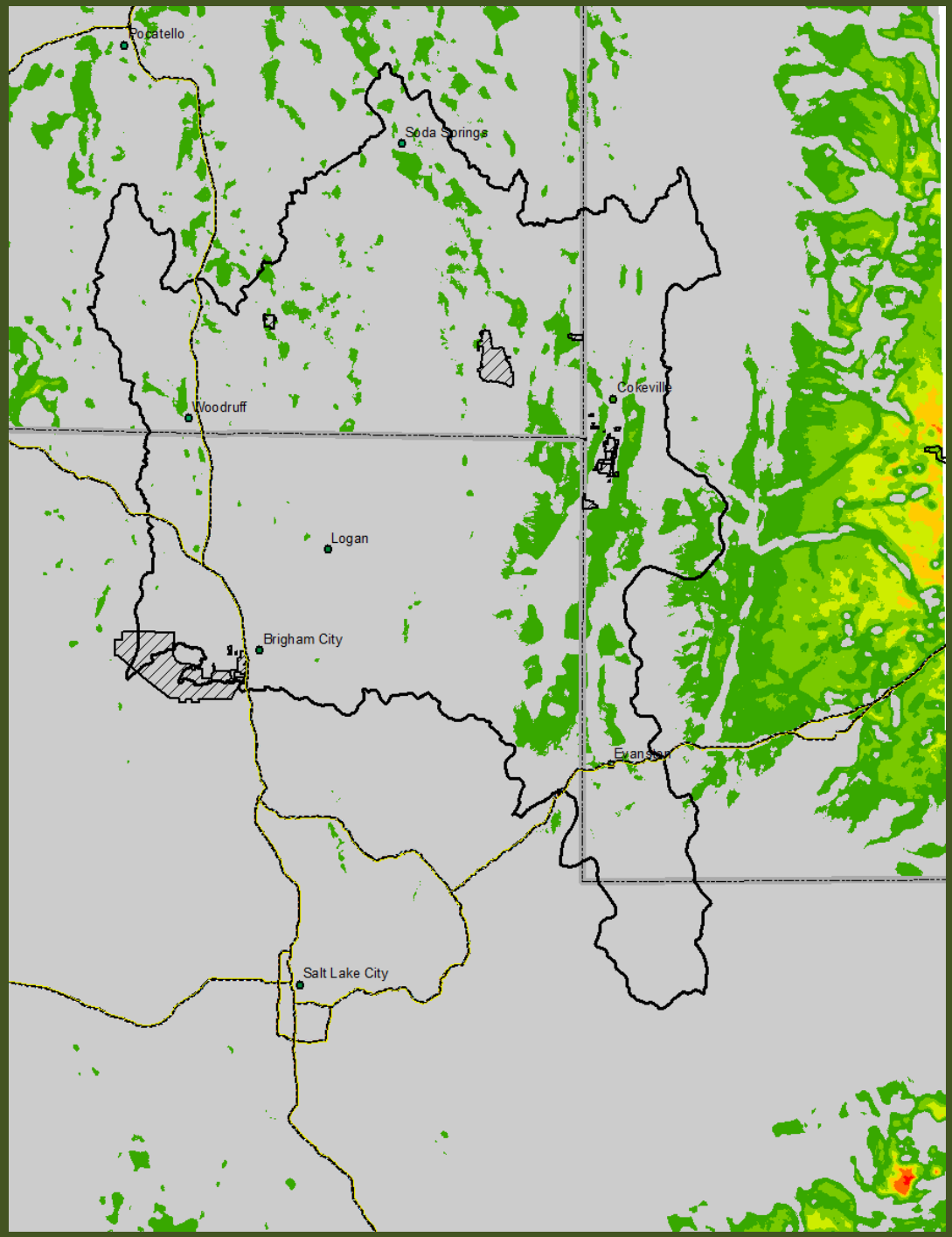
- 25% Breeding Densities
- 50% Breeding Densities
- 75% Breeding Densities
- 100% Breeding Densities



Greater Sage-Grouse Range-Wide Breeding Density Thresholds

LEGEND

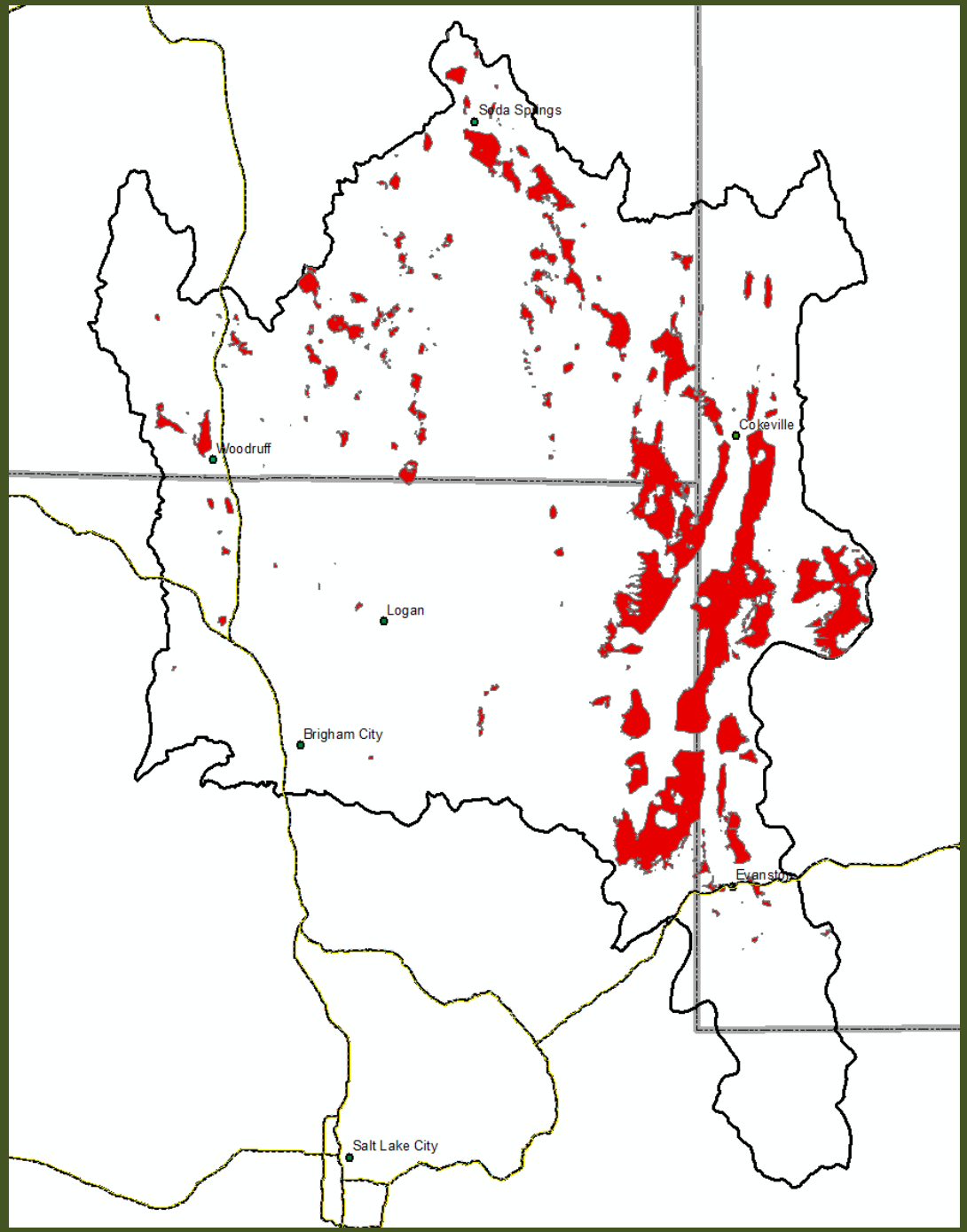
- 25% Breeding Densities
- 50% Breeding Densities
- 75% Breeding Densities
- 100% Breeding Densities



Sage Thrasher

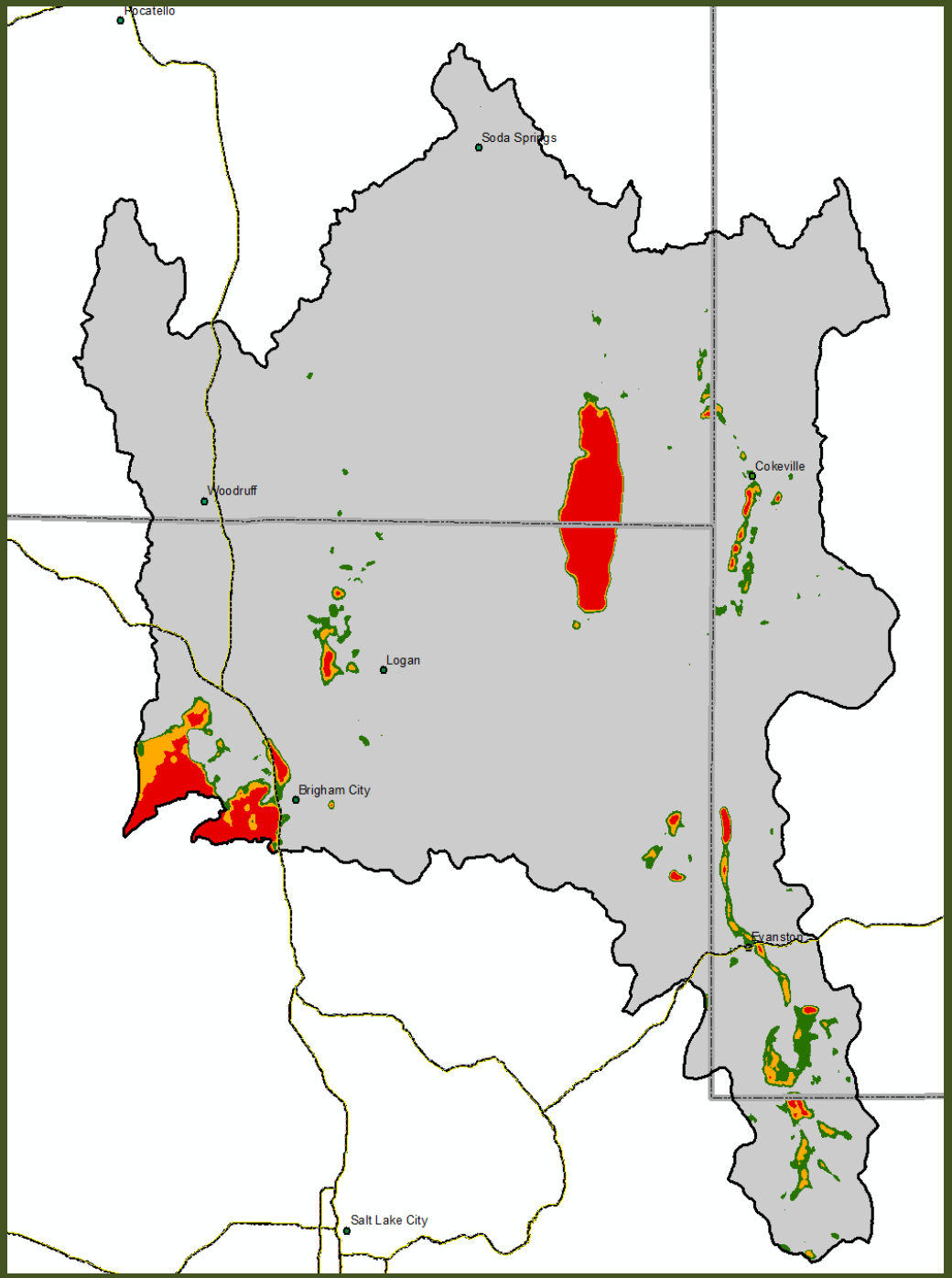
NB Regression Model using BBS data from 2000

Sage Thrashers



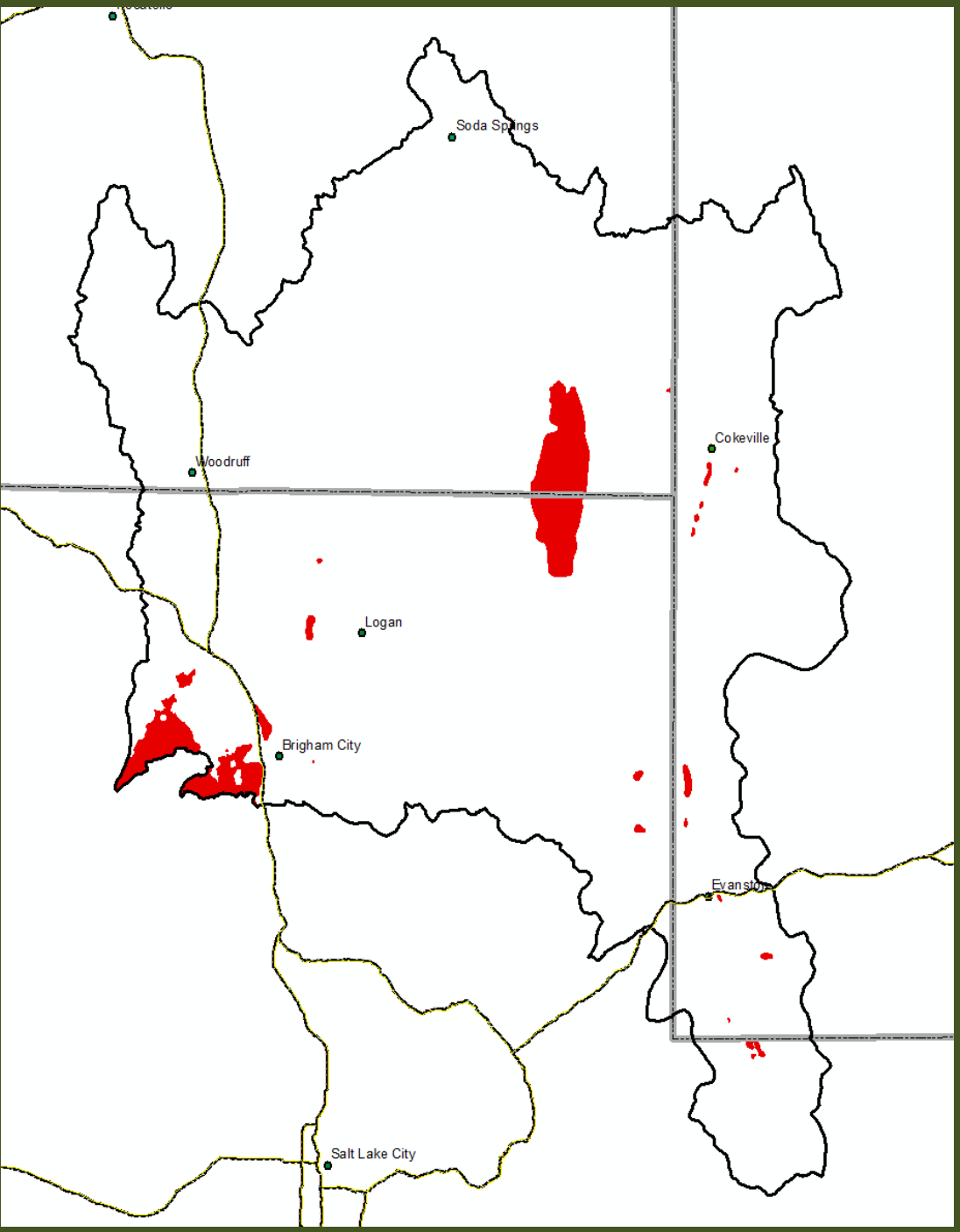
Sage Thrashers Priority Areas

American Avocet Priorities



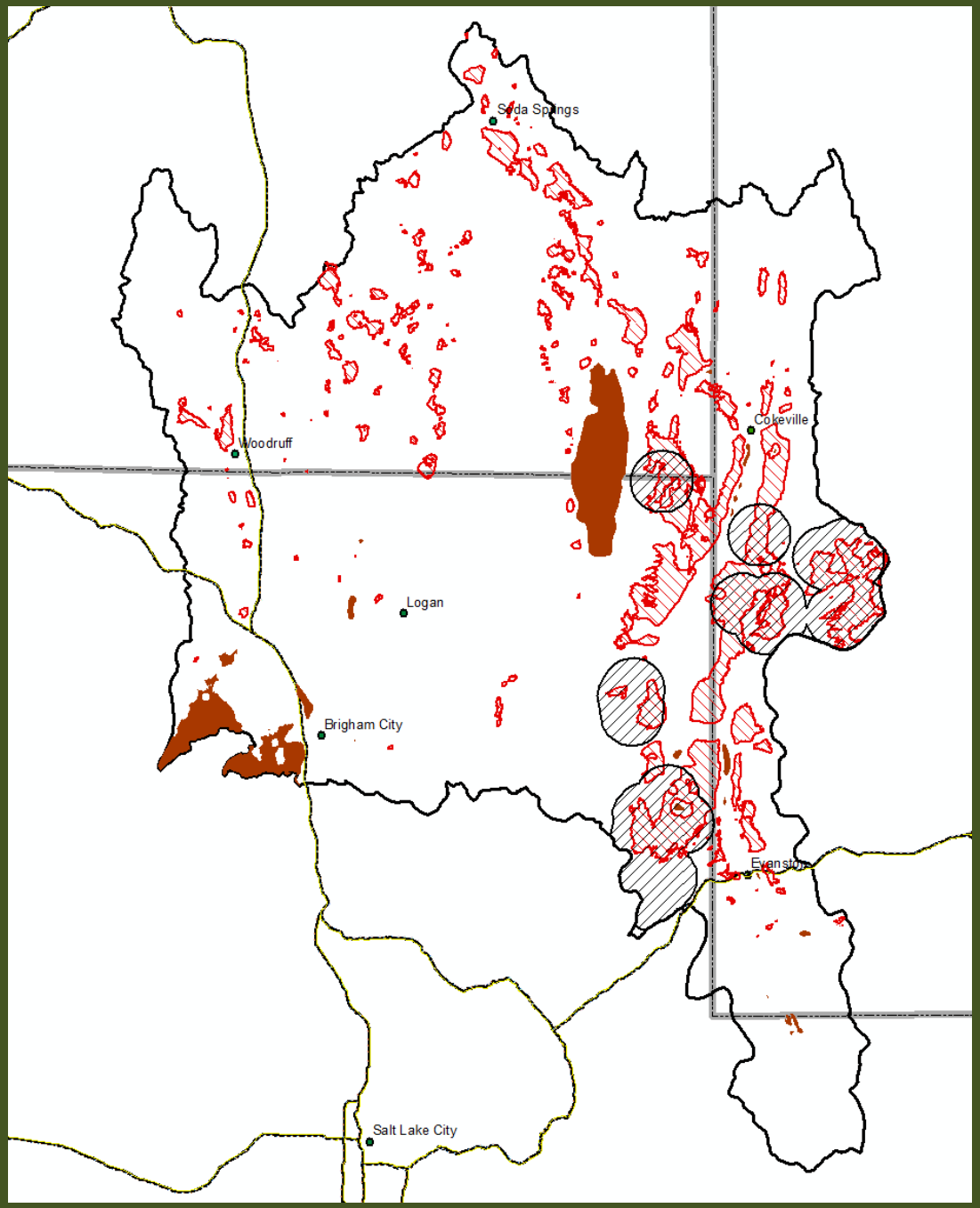
- Priority 1 (75%-100%)
- Priority 2 (50%-75%)
- Priority 3 (25%-50%)
- Priority 4 (0%-25%)

American Avocet Priorities



- Priority 1 (75%-100%)
- Priority 2 (50%-75%)
- Priority 3 (25%-50%)
- Priority 4 (0%-25%)

BRWCA Priorities



SAGR Priority 1

SATH Priority 1

AMAV Priority 1

Region 6 BBS Modeling Approach

- The approach CAN work outside of prairies. Several considerations.
  - Single year vs. multiple years of data
  - All routes vs. Only routes with observations

- Model specification
  - Poisson vs. Negative Binomial
  - Fixed effects vs. Mixed Effects

- Model Validation
  - Goodness of Fit
  - Predictiveness
  - Spatial Autocorrelation
  - Psuedo R-squared
  - AUC/ROC for Logistic models

- Deliverables
  - Maps, data, narratives – ALL?