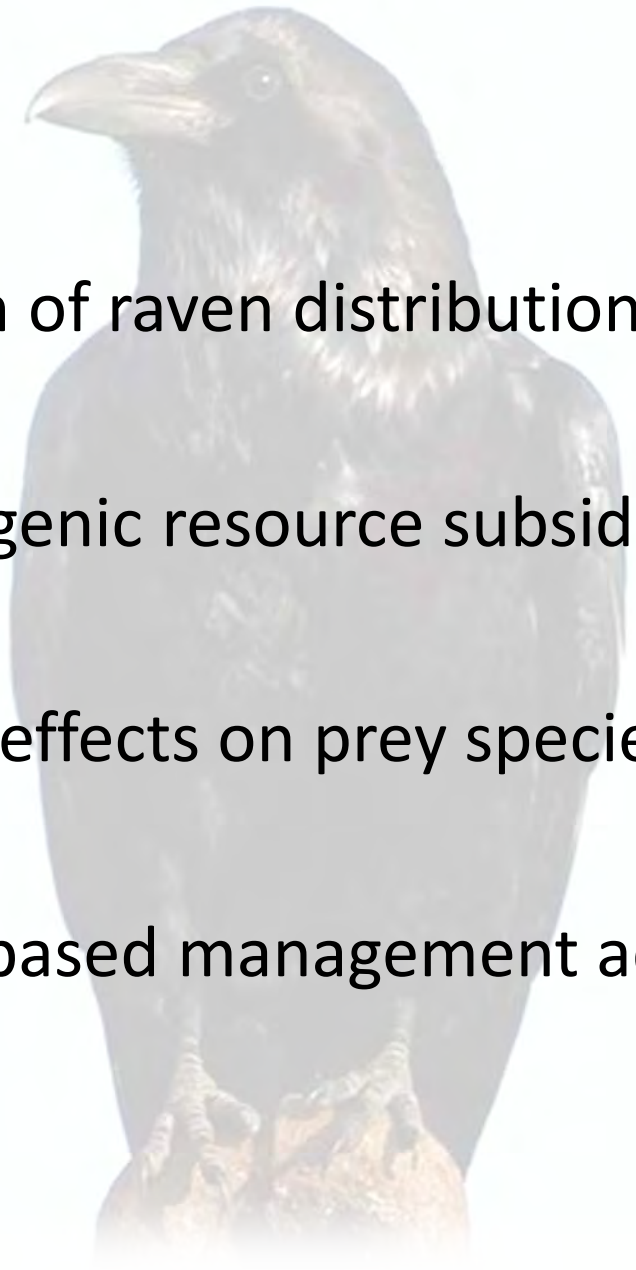
USGS
science for a changing world

Science to Inform Adaptive Management for Ravens

Peter S. Coates, Ph.D.
Research Wildlife Biologist
Western Ecological Research Center, U.S. Geological Survey

Overview Topics



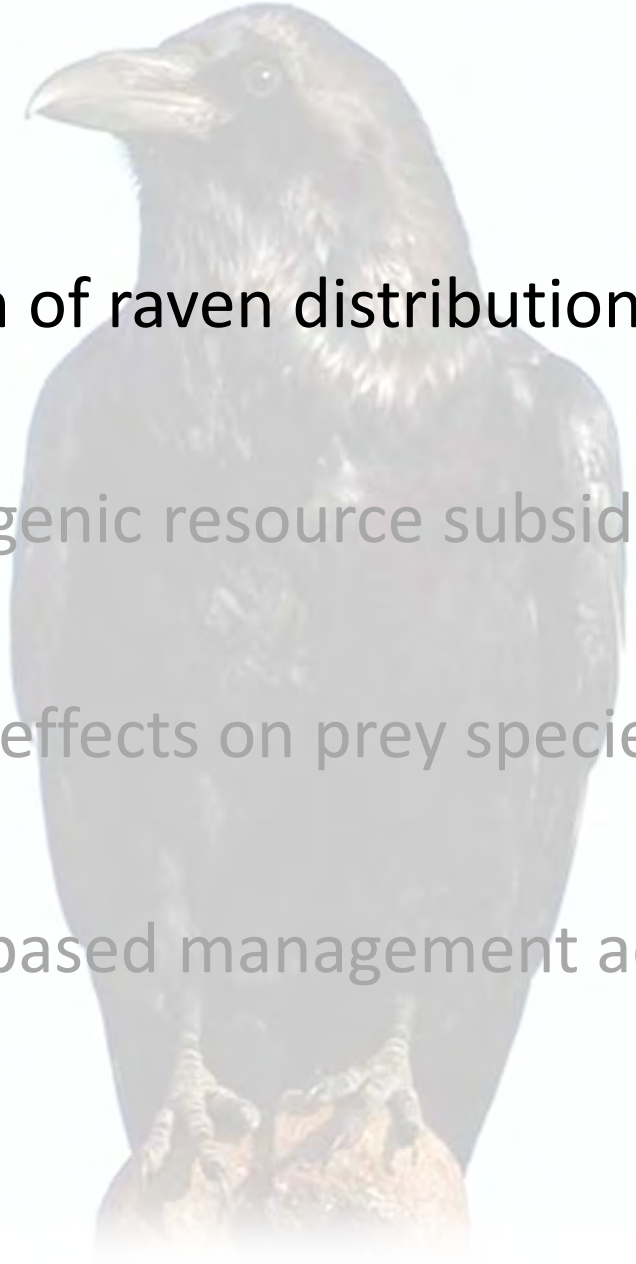
Problem: Expansion of raven distribution and abundance

Reasons: Anthropogenic resource subsidies

Impacts: Predation effects on prey species

Solutions: Science-based management action plan

Overview Topics



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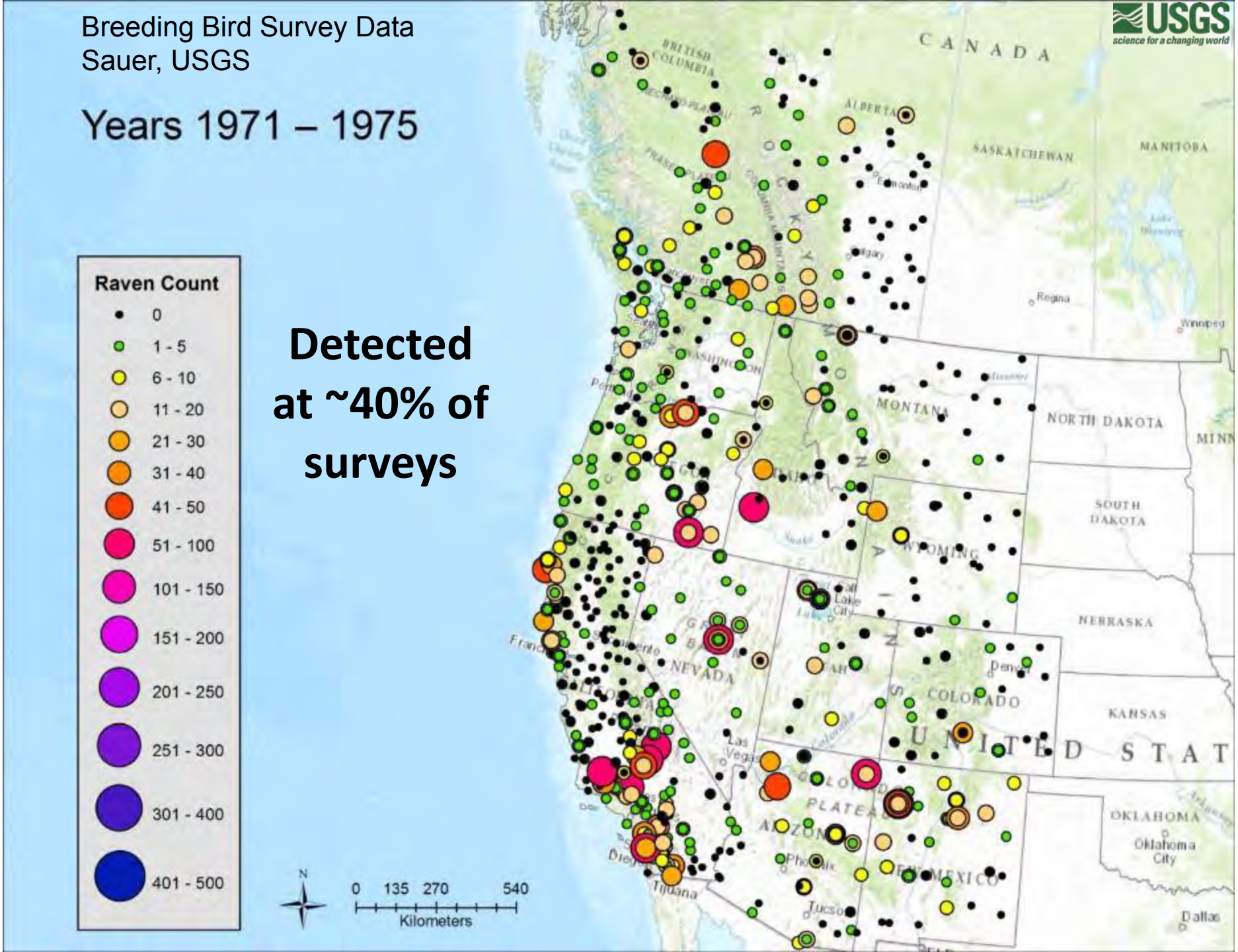
Breeding Bird Survey Data
Sauer, USGS

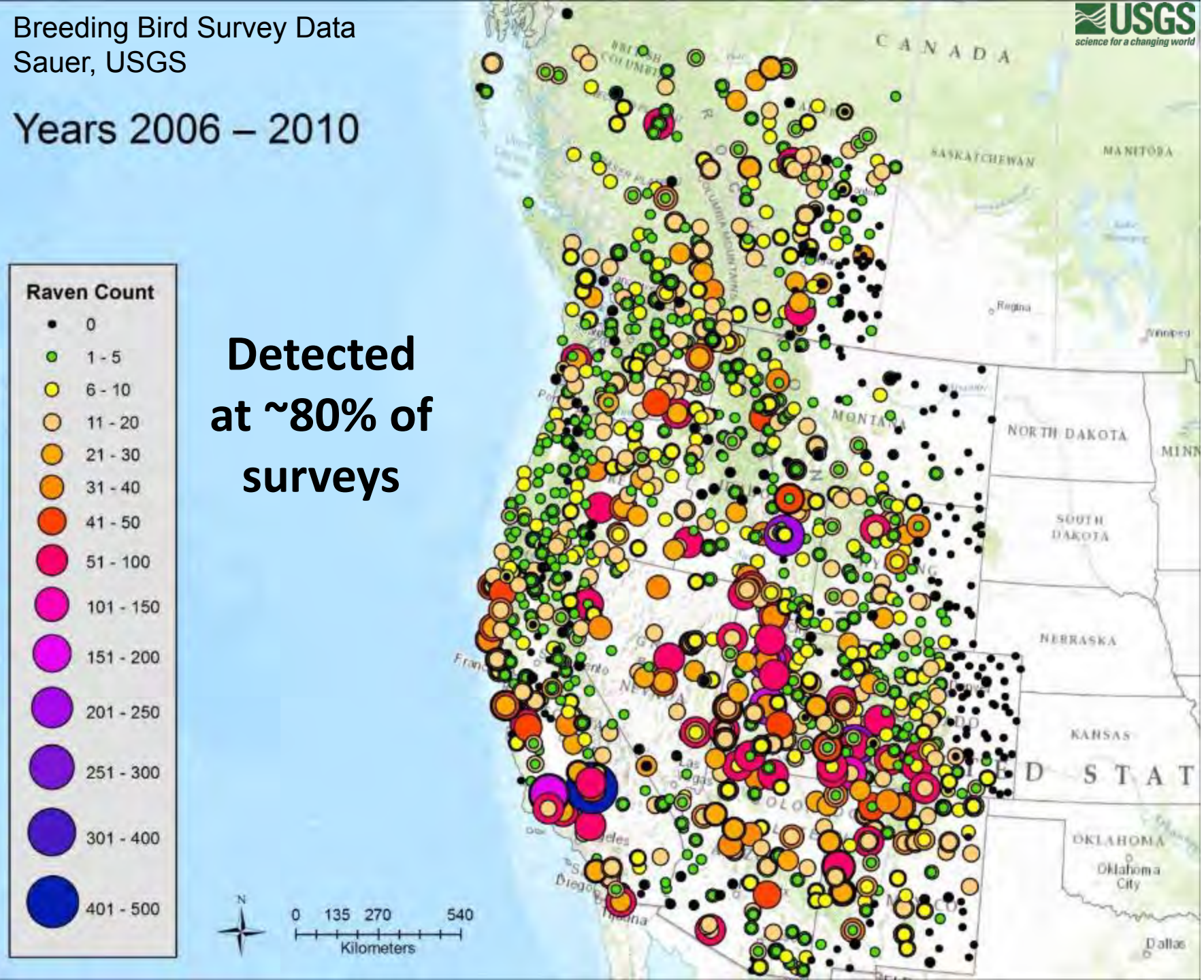
Years 1971 – 1975



Detected at ~40% of surveys

Breeding Bird Survey Data
Sauer, USGS

Years 2006 – 2010

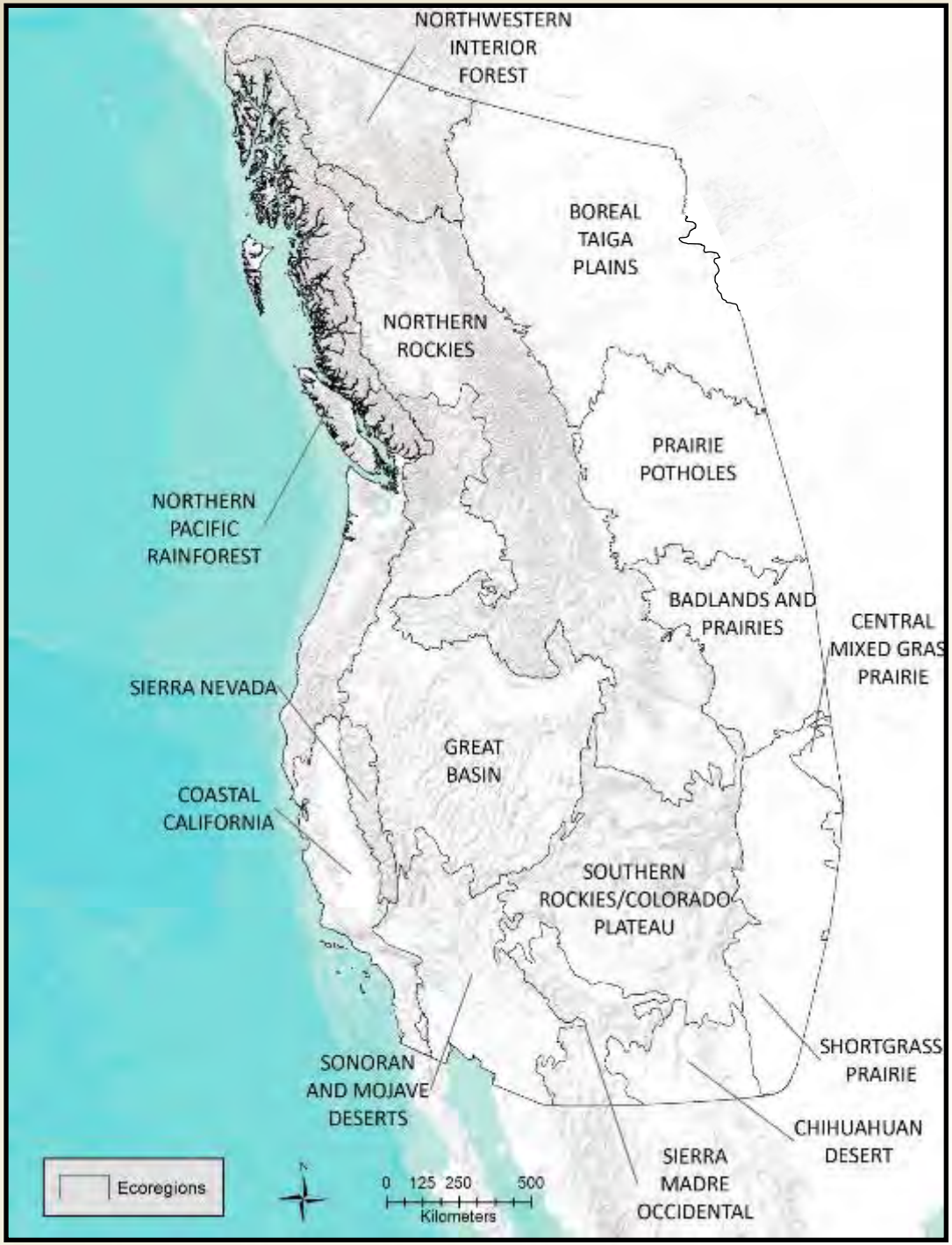


Detected at ~80% of surveys

Bird Conservation Regions

- 16 distinct regions
- International mapping team
- Ecologically distinct
  - Bird communities
  - Habitat

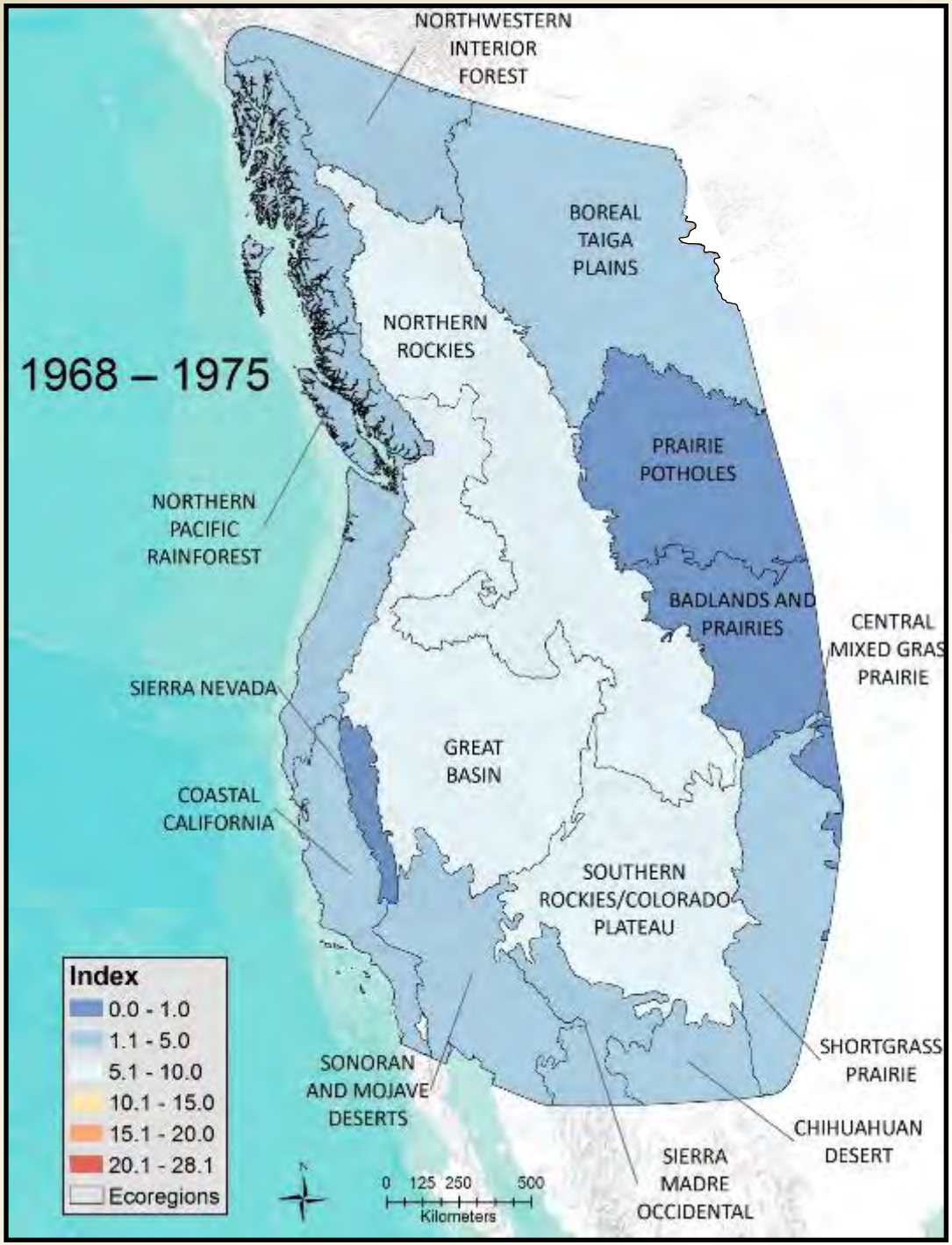
- Bayesian Hierarchical Model (Sauer and Link)
  - Route
  - Observer
  - Region



(BBS; Sarer and Link)

Surveys in the late 1960s and early 1970s

- **Nearly all areas** consisted of <10 ravens/survey
- **Highest raven count predictions**
  - Northern Rockies (>5)
  - Great Basin (>5)
  - Southern Rockies/ Colorado Plateu (<5)

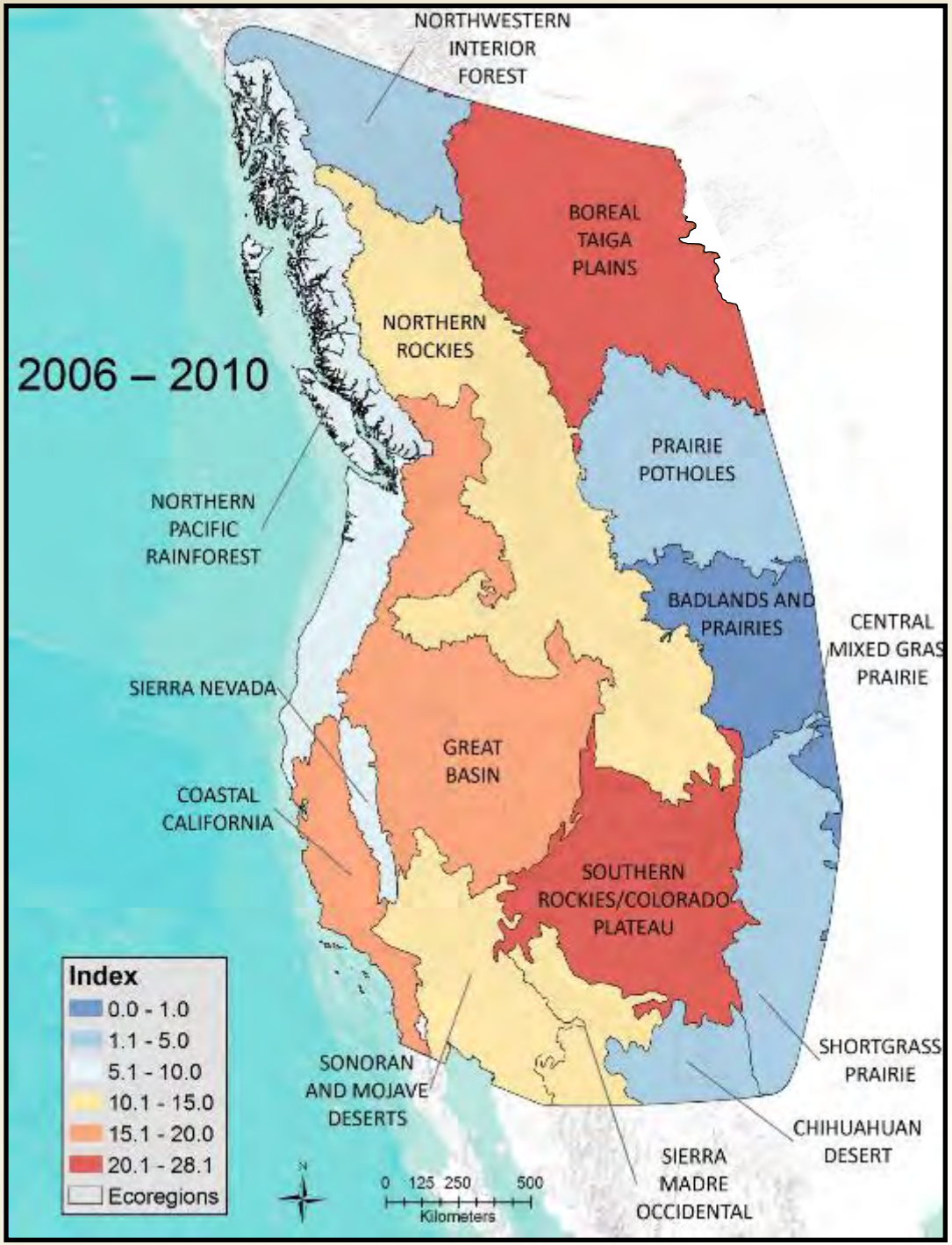


(BBS; Sarer and Link)

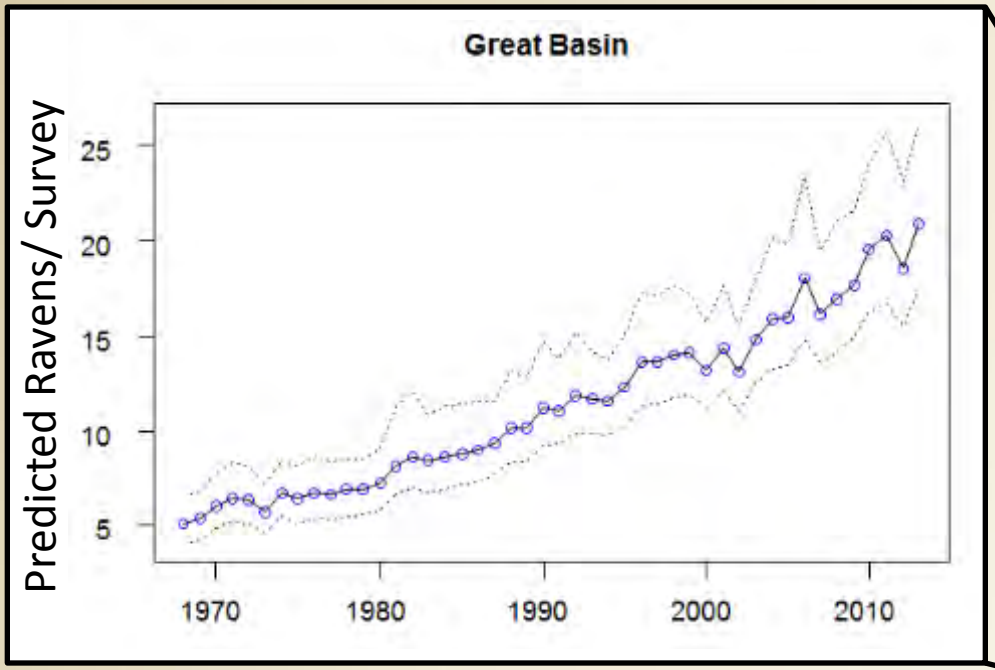
Increases in late 2000s

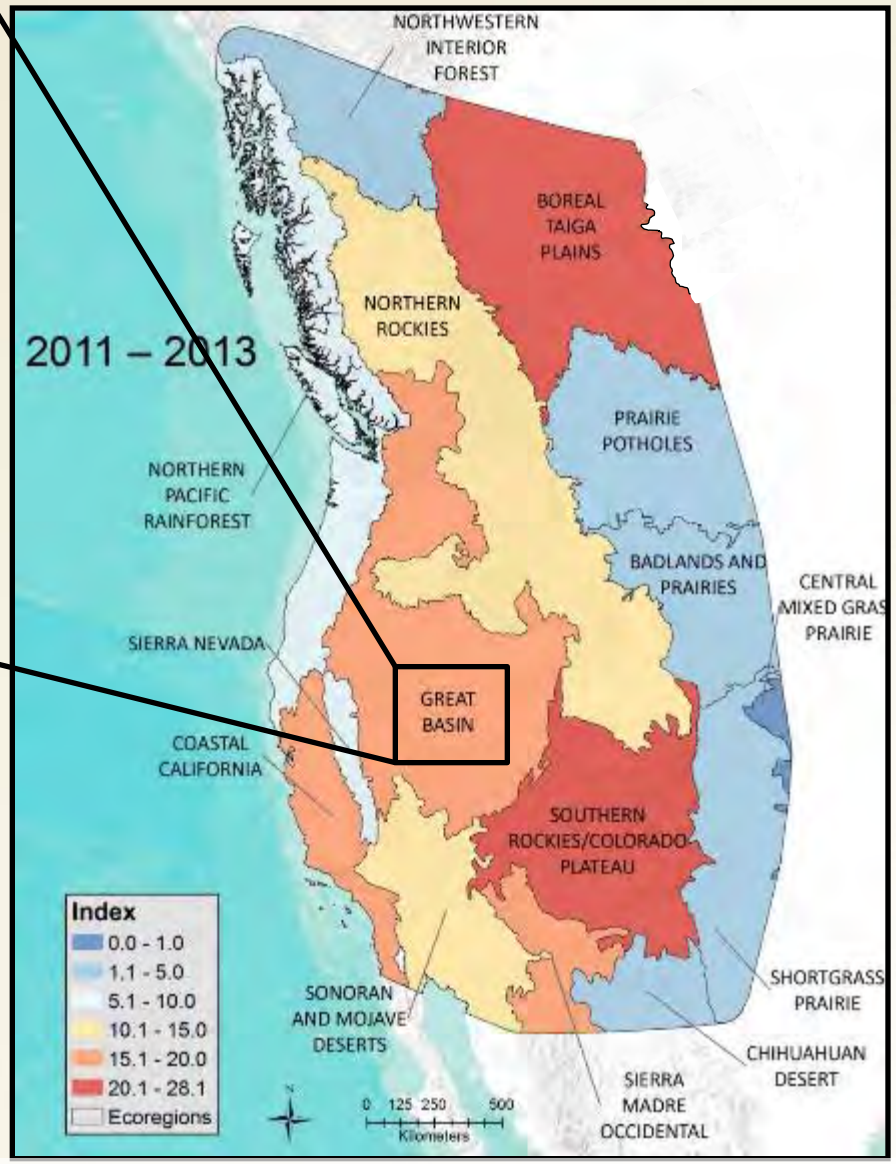
- Sonoran and Mojave to >10
- Great Basin to >15
- Coastal CA to >15
- Southern Rockies/Colorado Plateau to >20

No Decreases



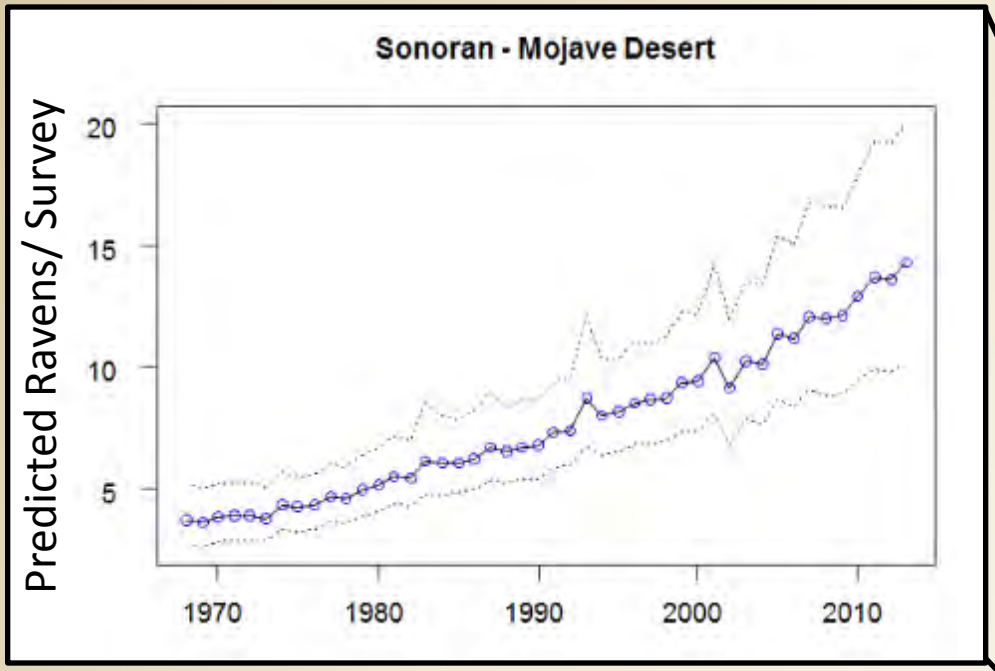
Raven Population Growth within Great Basin BCR

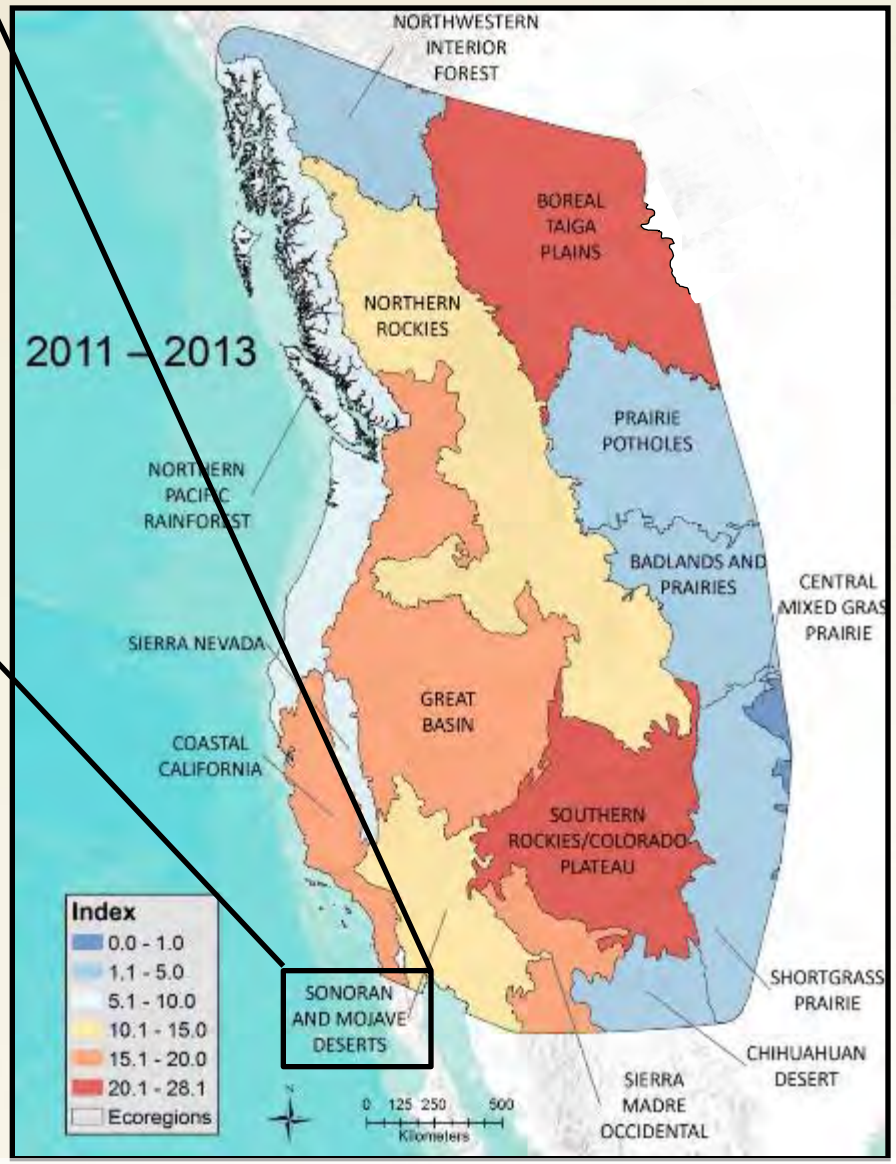




Preliminary Information—Subject to Revision. Not for Citation or Distribution

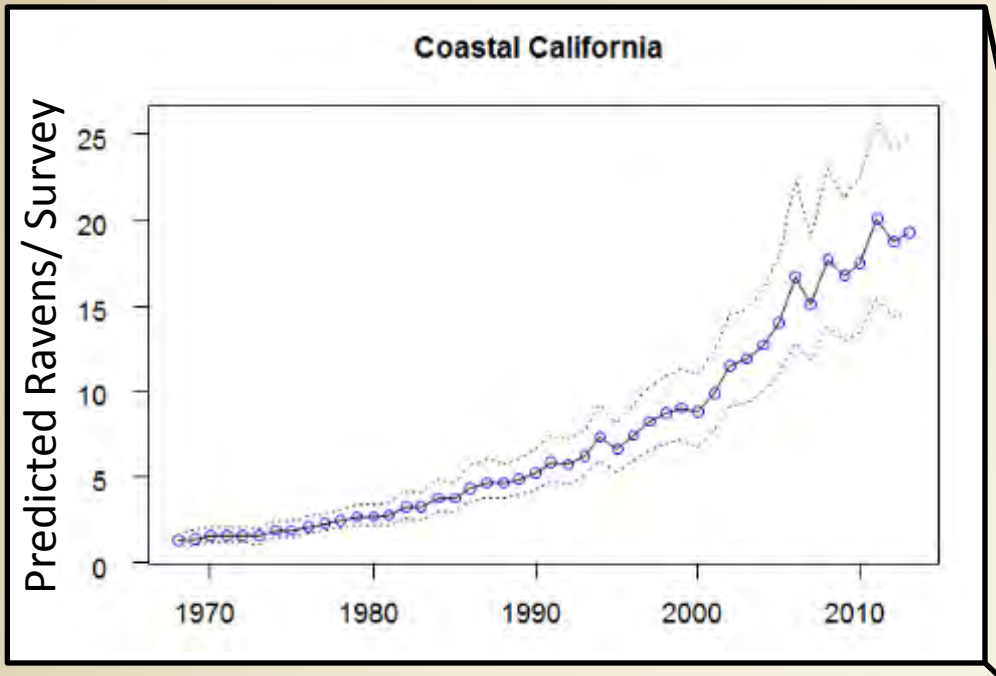
Raven Population Growth within Mojave/Sonoran BCR

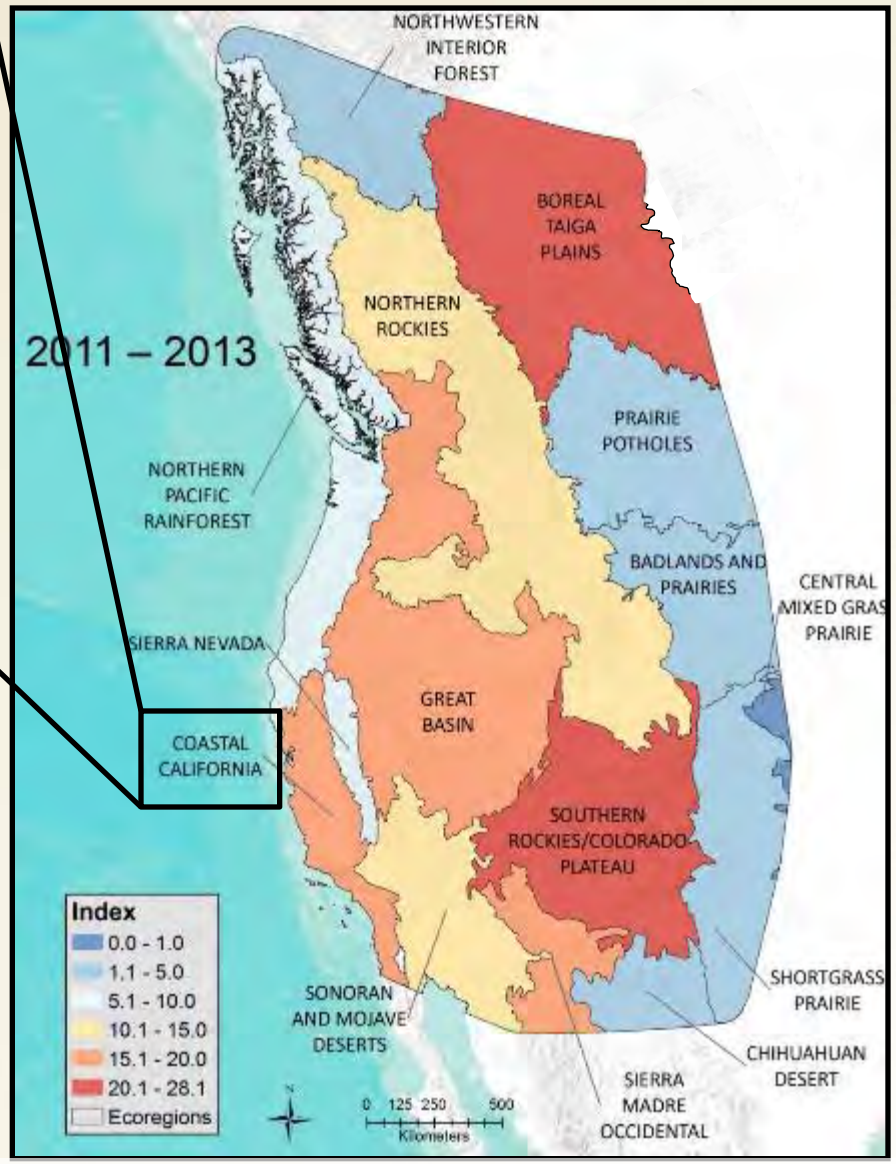




Preliminary Information—Subject to Revision. Not for Citation or Distribution

Raven Population Growth within Coastal California BCR





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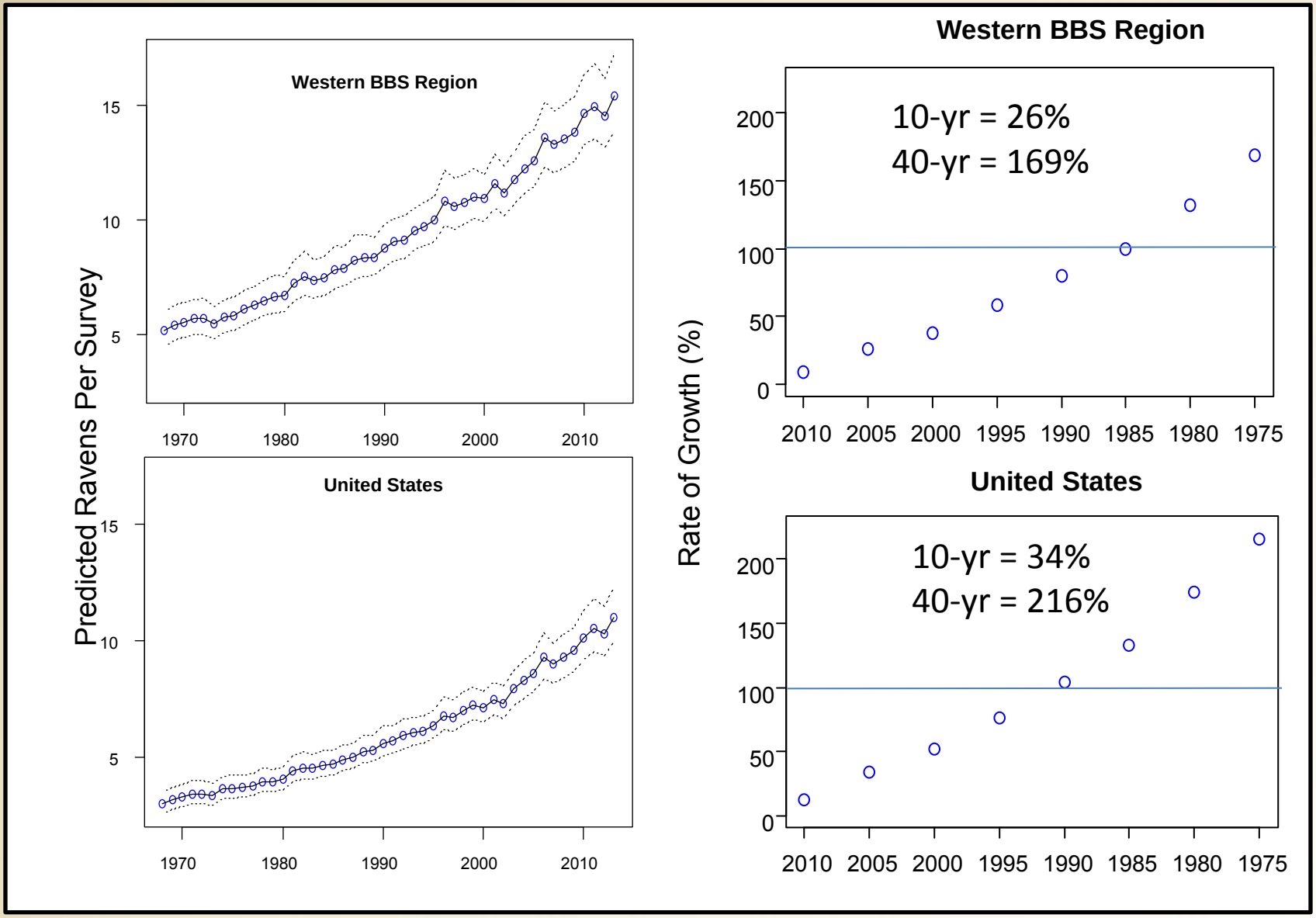
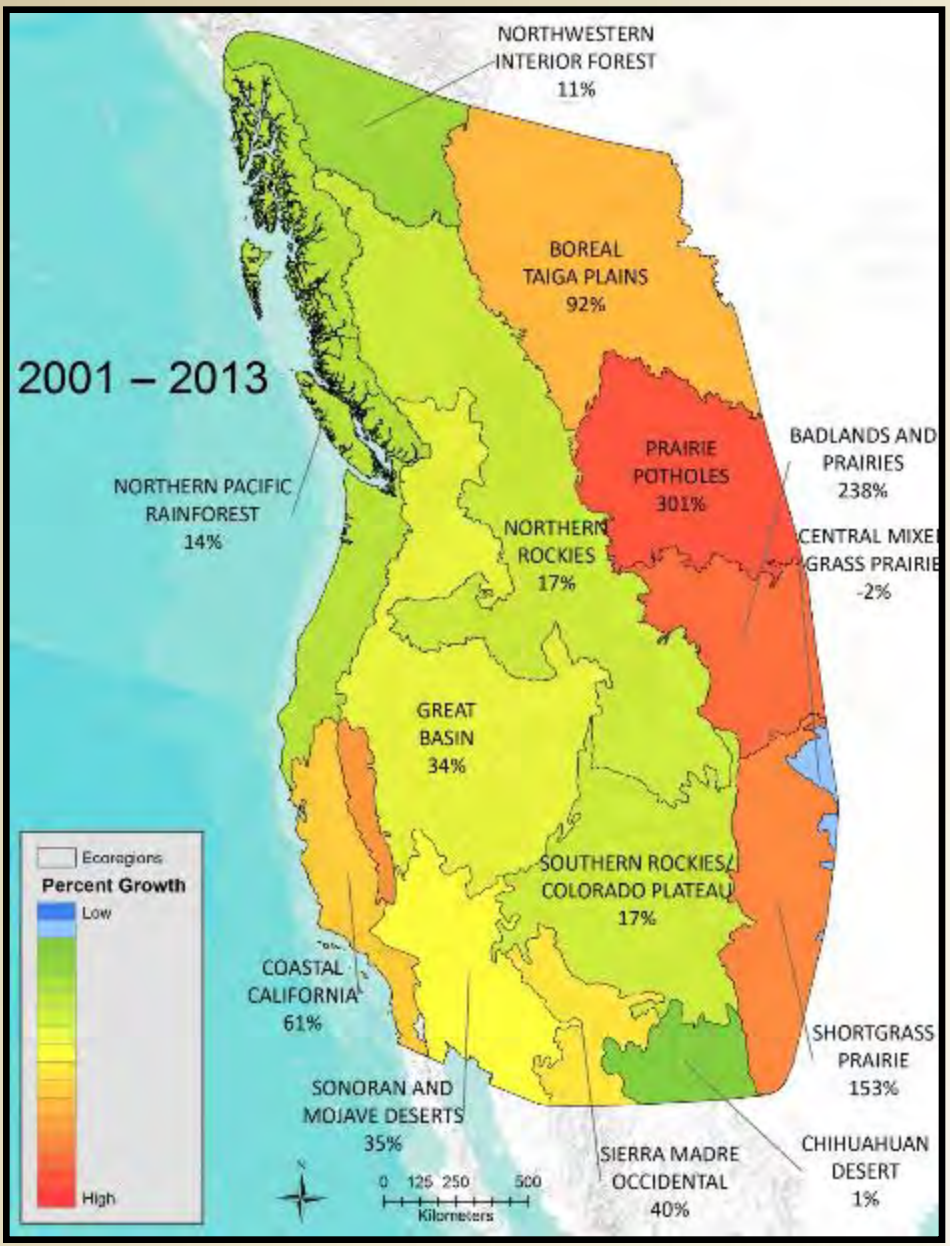
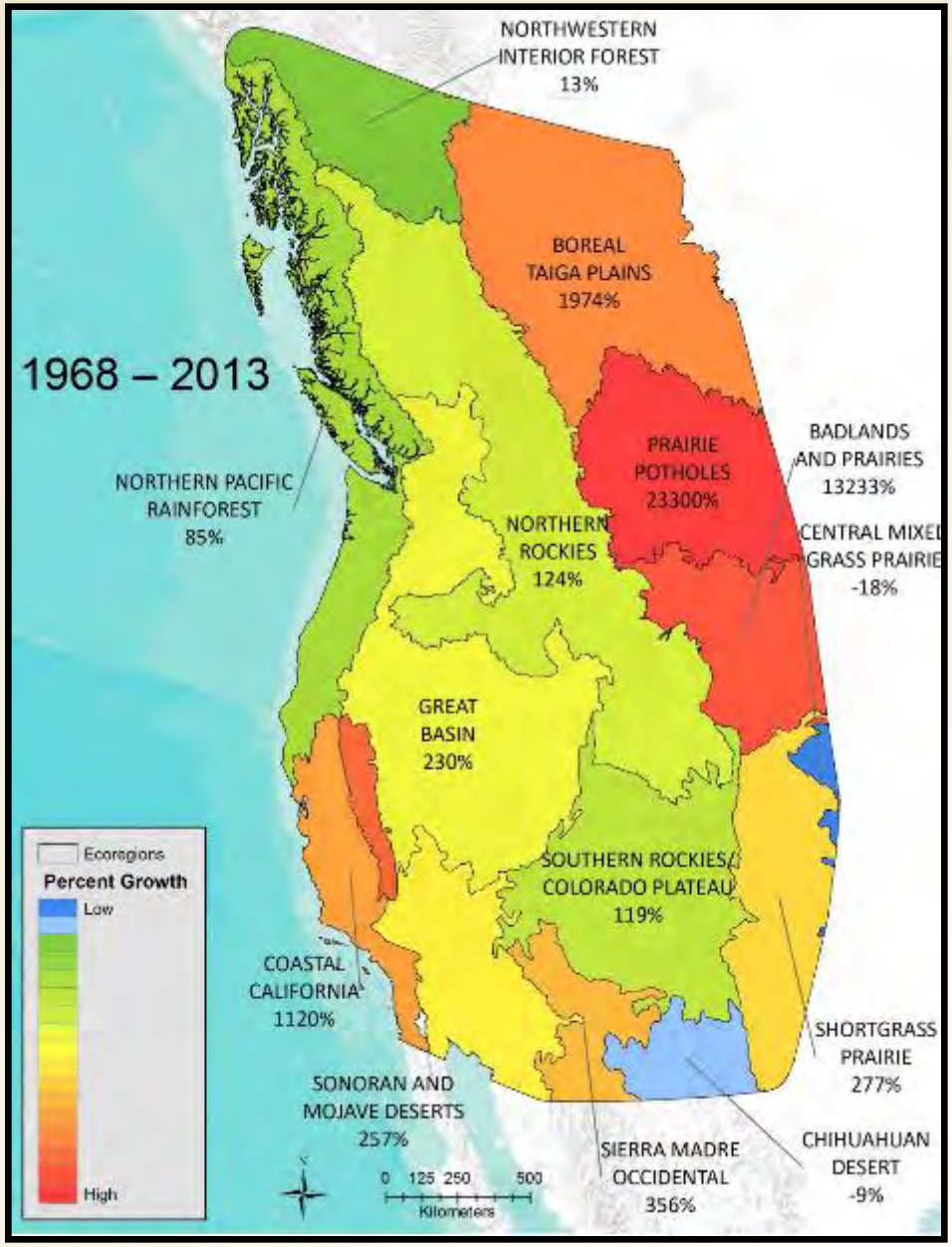
Percent of Surveys with Ravens Observed over Time



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

Modeled Growth Rates by Region





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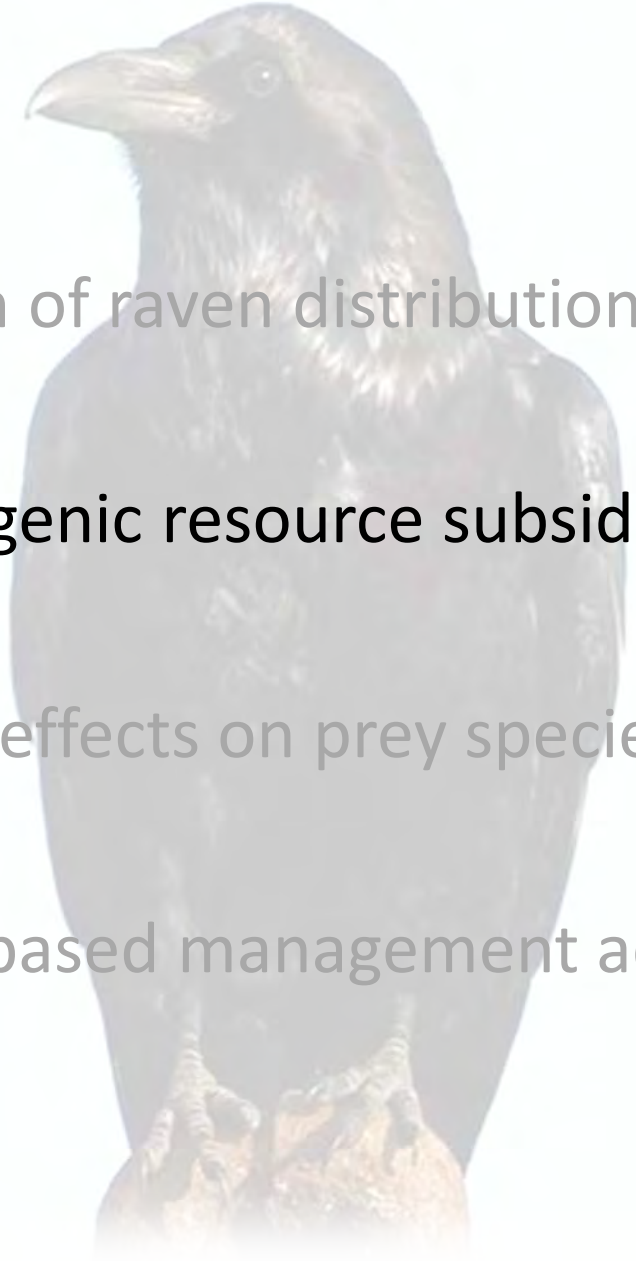
Overview Topics



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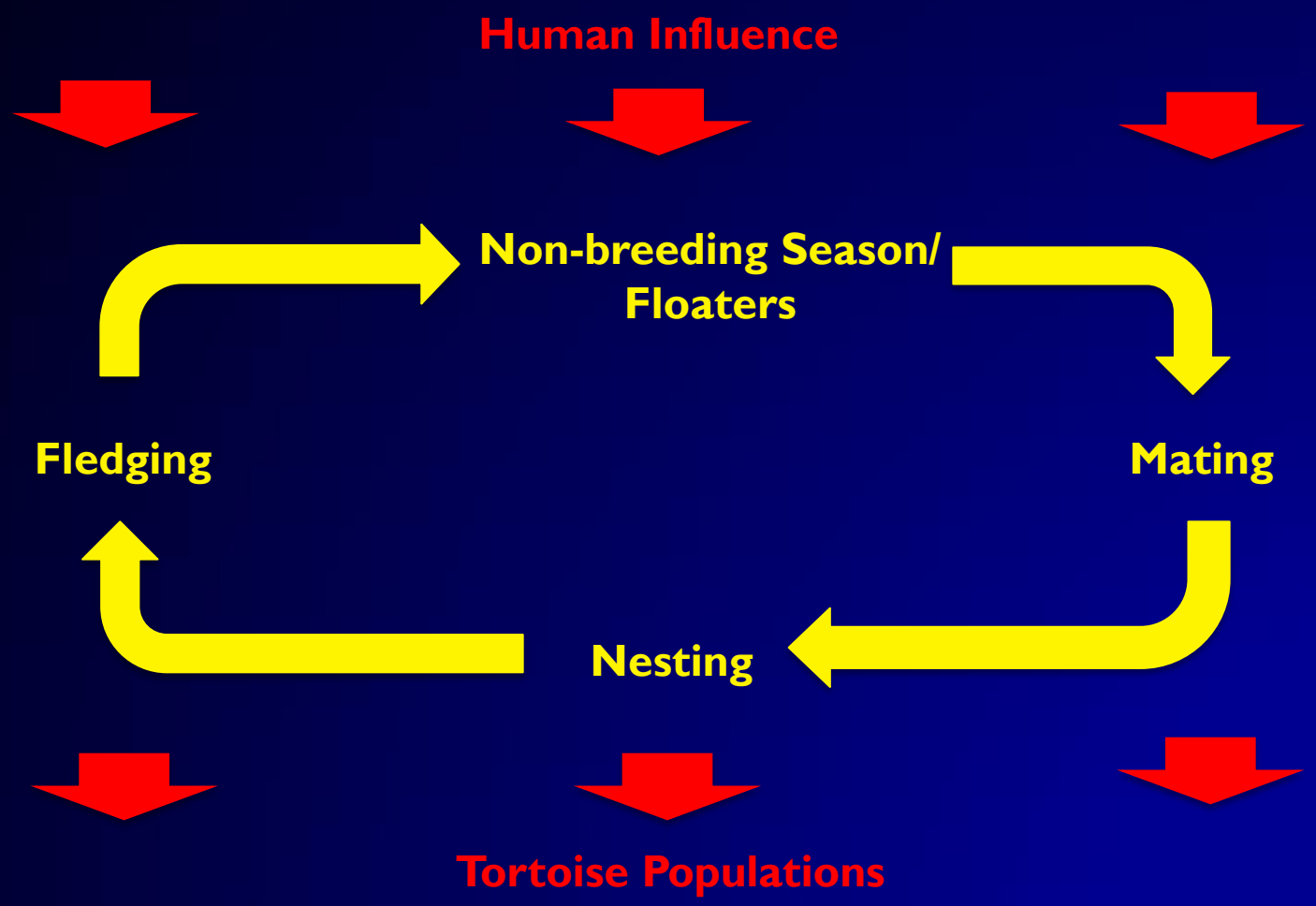
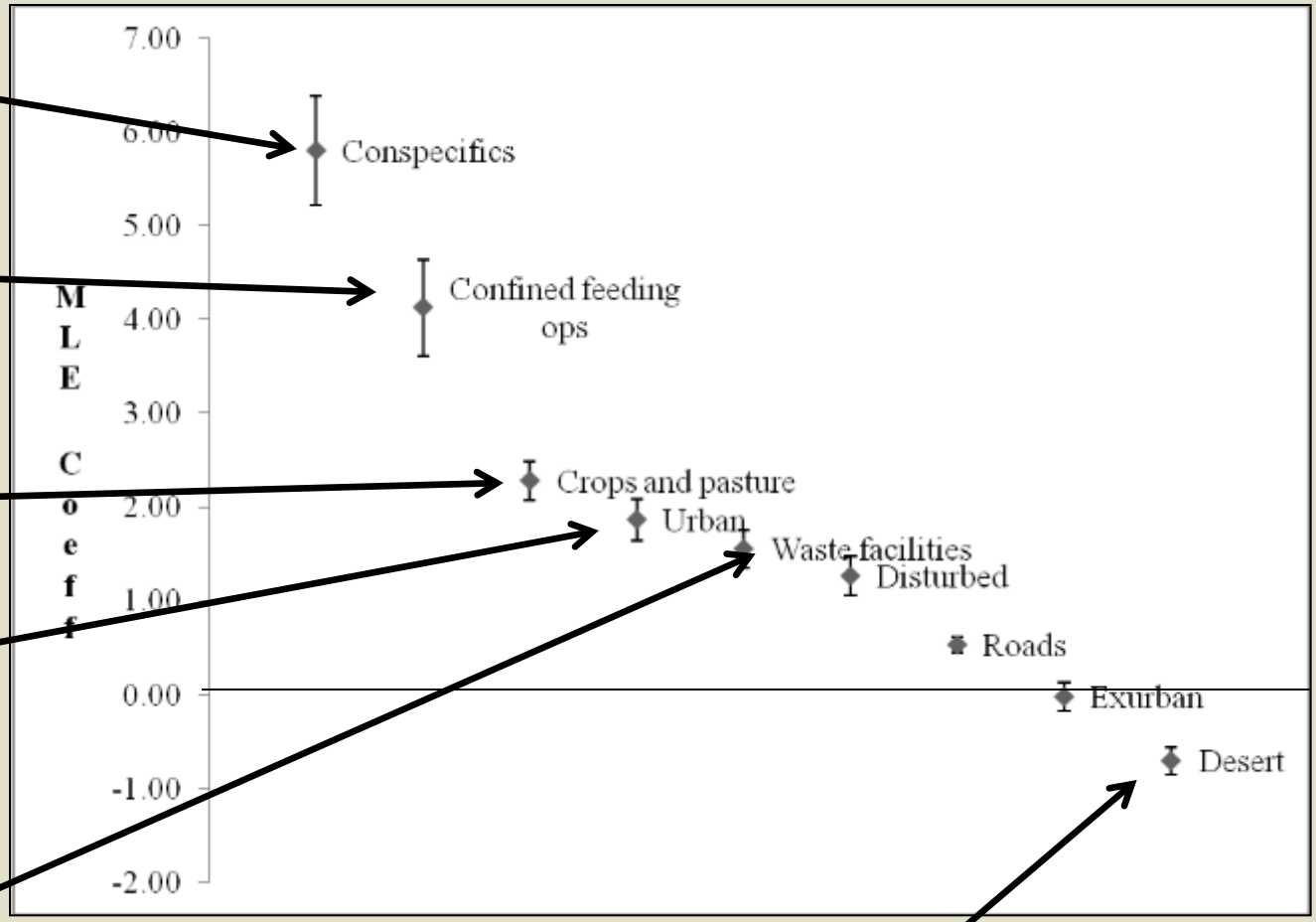
Conceptual Model



William Boarman, USGS, 2003

WHAT RESOURCES DO NONBREEDERS USE IN THE MOJAVE?

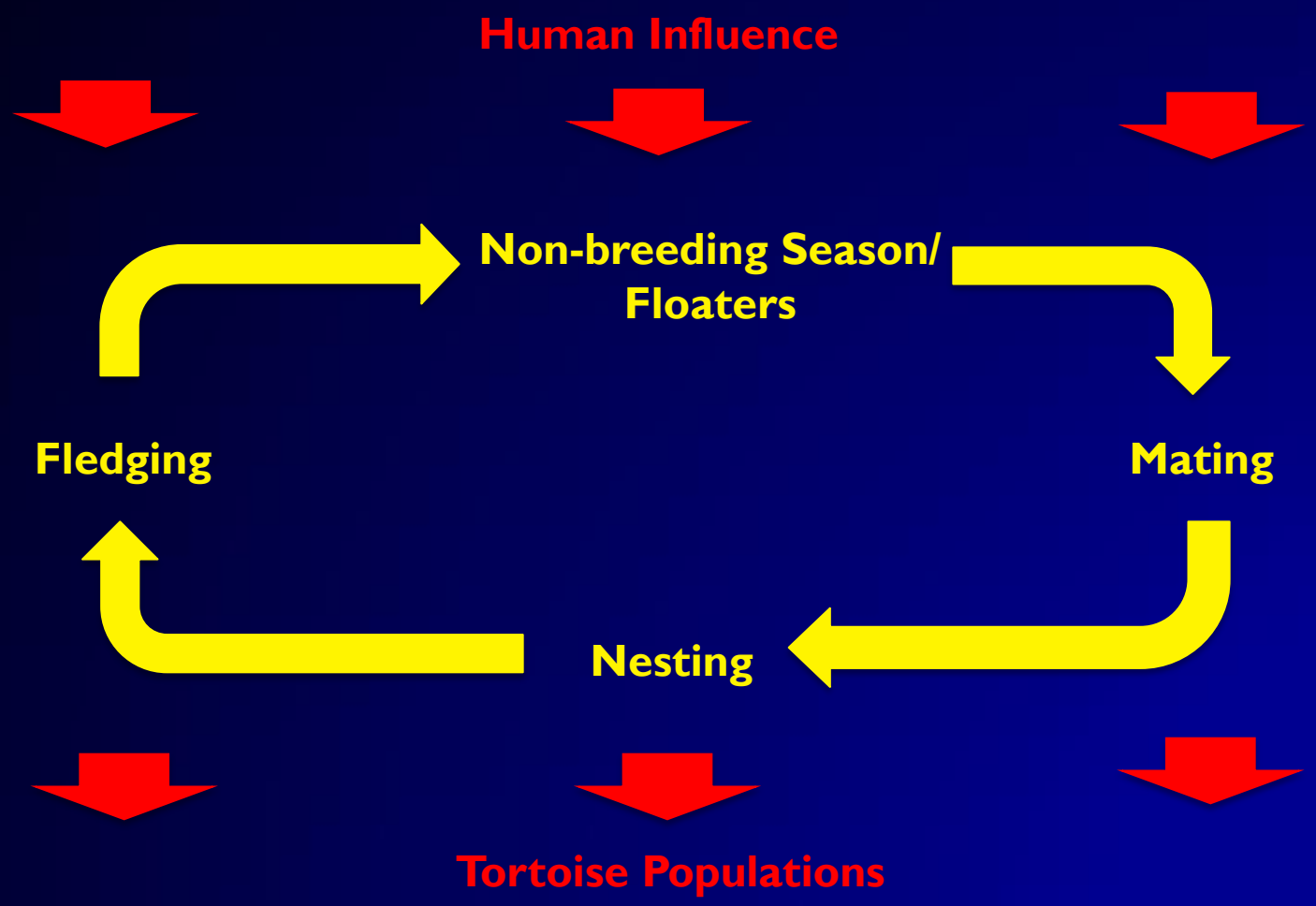
- Each other!
- Dairies & hobby farms
- Agriculture
- Towns
- Landfills & sewage ponds



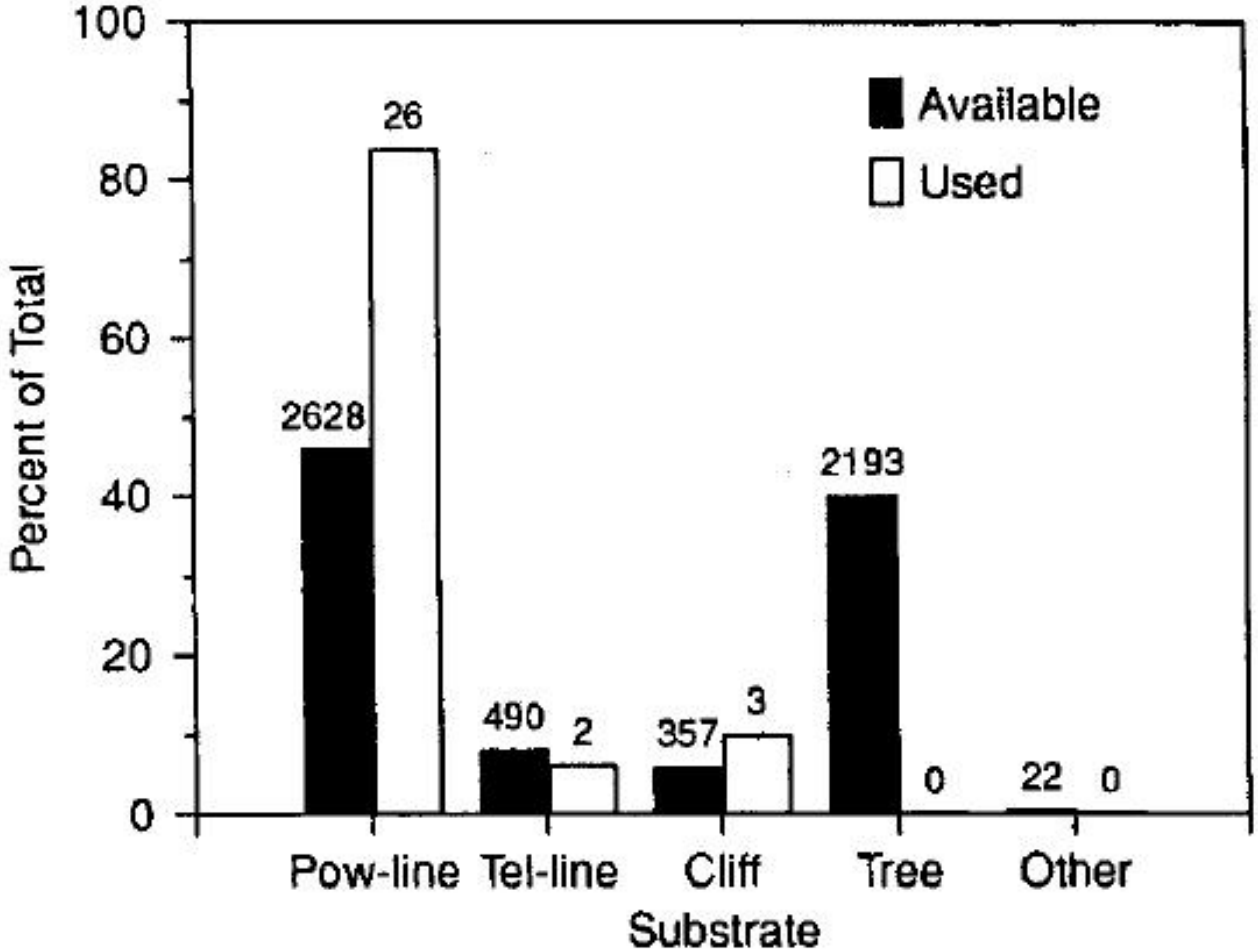
Nonbreeders rarely use desert

Webb et al. 2009 JWM 73:72-81

Conceptual Model



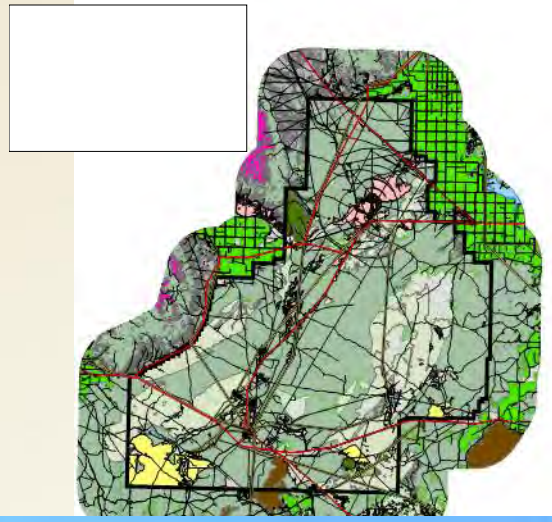
Used Power-lines for Nesting Substrate



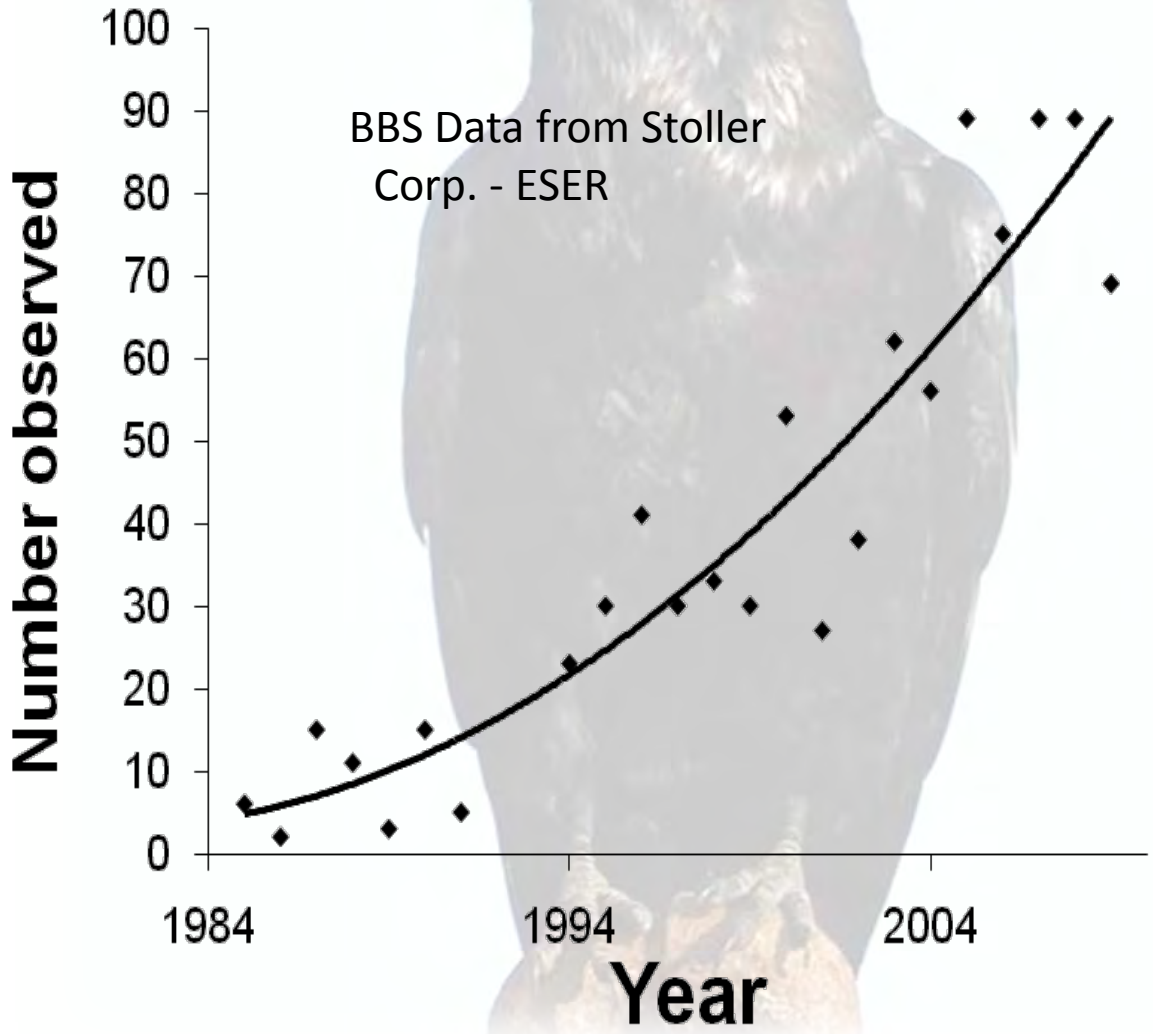
Knight and Kawashima 1993. JWM 57(2):266-271.

Washington
Montana
Idaho
Oregon
Wyoming
Idaho National Laboratory Study Area

ENTERING
INL
Idaho National Laboratory
INL Industrial and Research Complexes



Studies Focused on the Effects of Tall Structures on Ravens



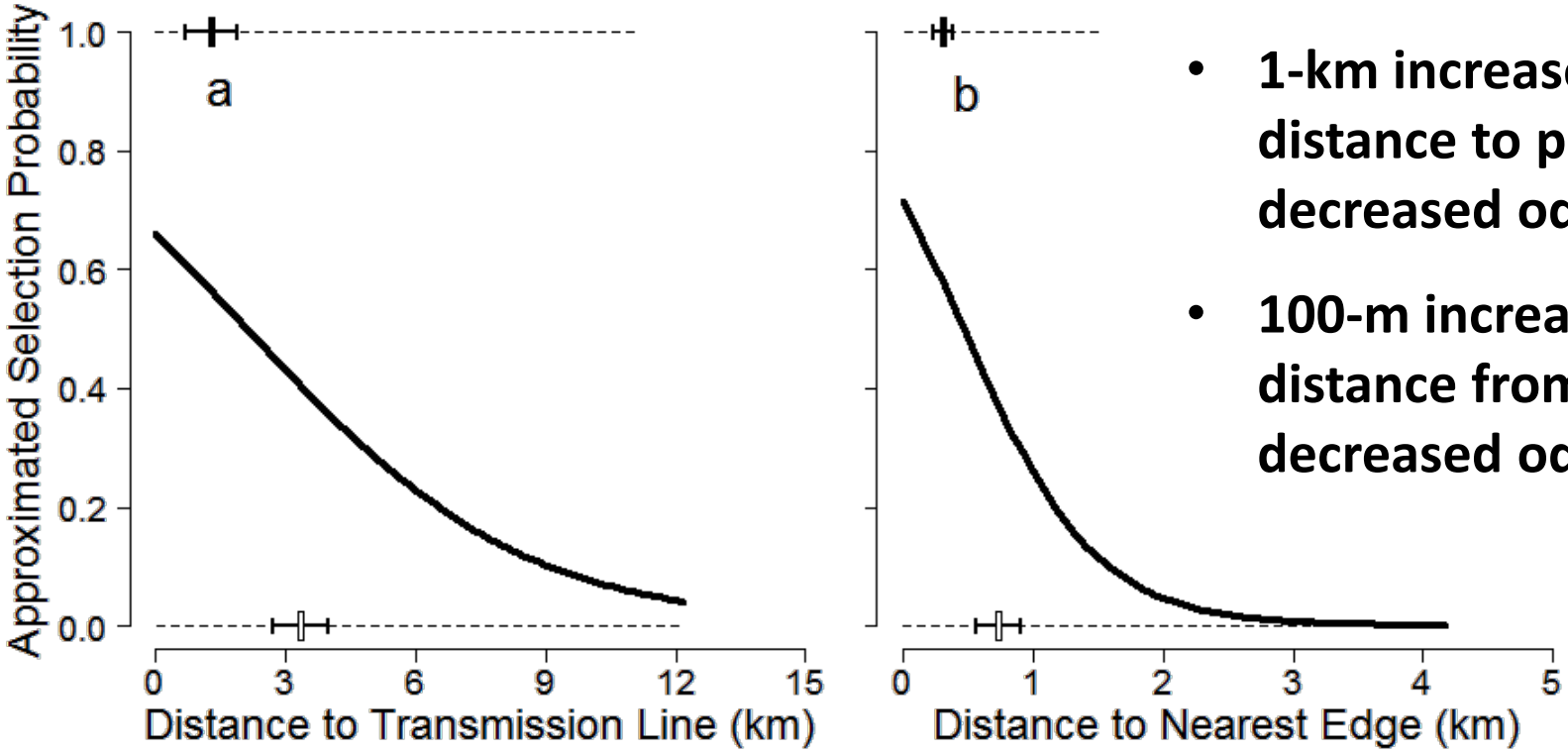
THE CONDOR
Ornithological Applications
www.cooper.org
Volume 116, 2014, pp. 000–000
DOI

RESEARCH ARTICLE

Selection of anthropogenic features and vegetation characteristics by nesting Common Ravens in the sagebrush ecosystem

Kristy B. Howe,[1,2] Peter S. Coates,[3*] and David J. Delehanty [1]

Findings



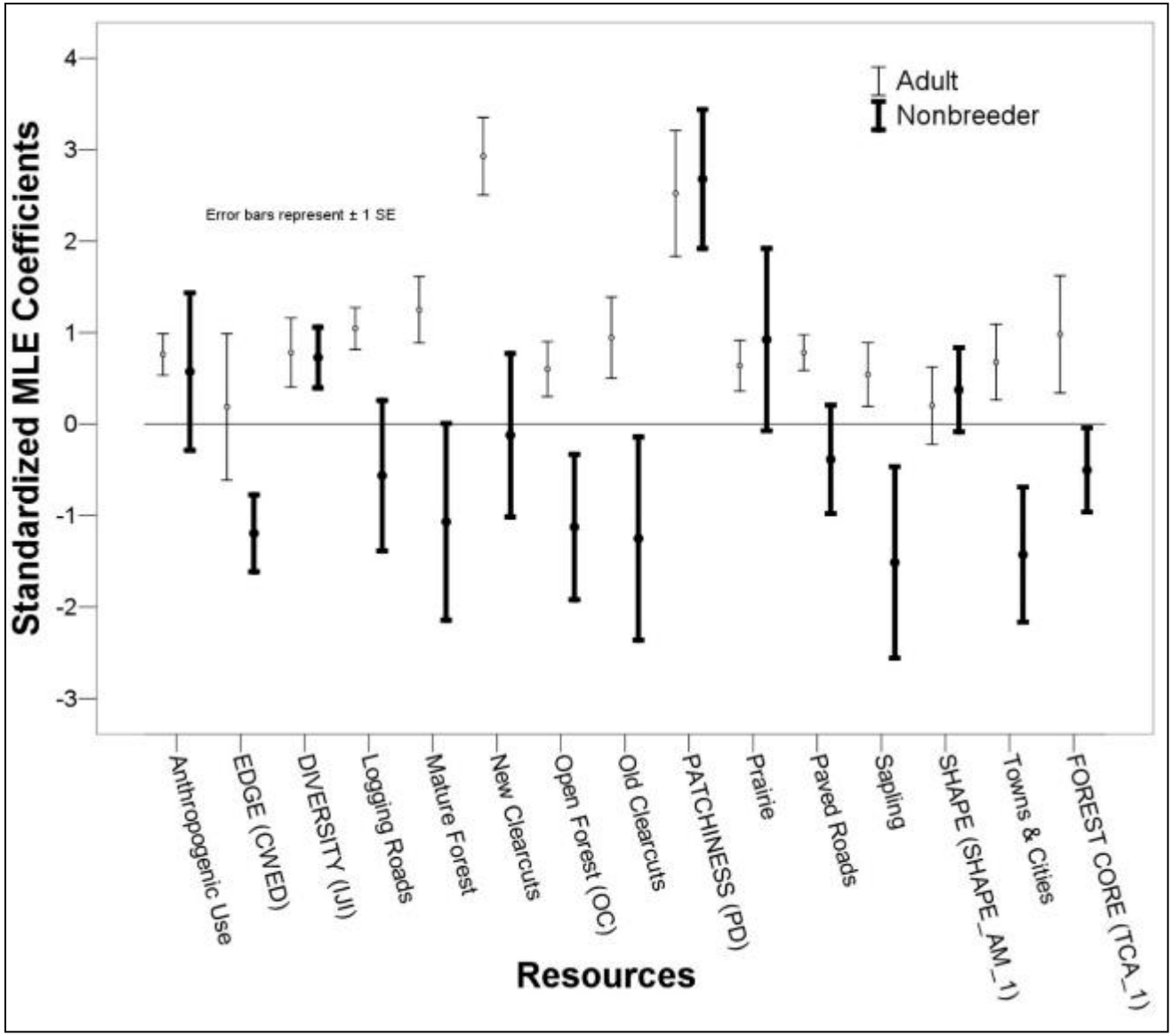
- **1-km increase in distance to power line decreased odds 31%**
- **100-m increase in distance from edge decreased odds 20%**

Post-Hoc Edge Analysis

Preferred big sagebrush/ native grass & non-native vegetation (102.1 ha)

Anthropogenic Nest and Perch Substrate

NONBREEDERS & BREEDERS USE DIFFERENT RESOURCES (WA)



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Ornithological Applications
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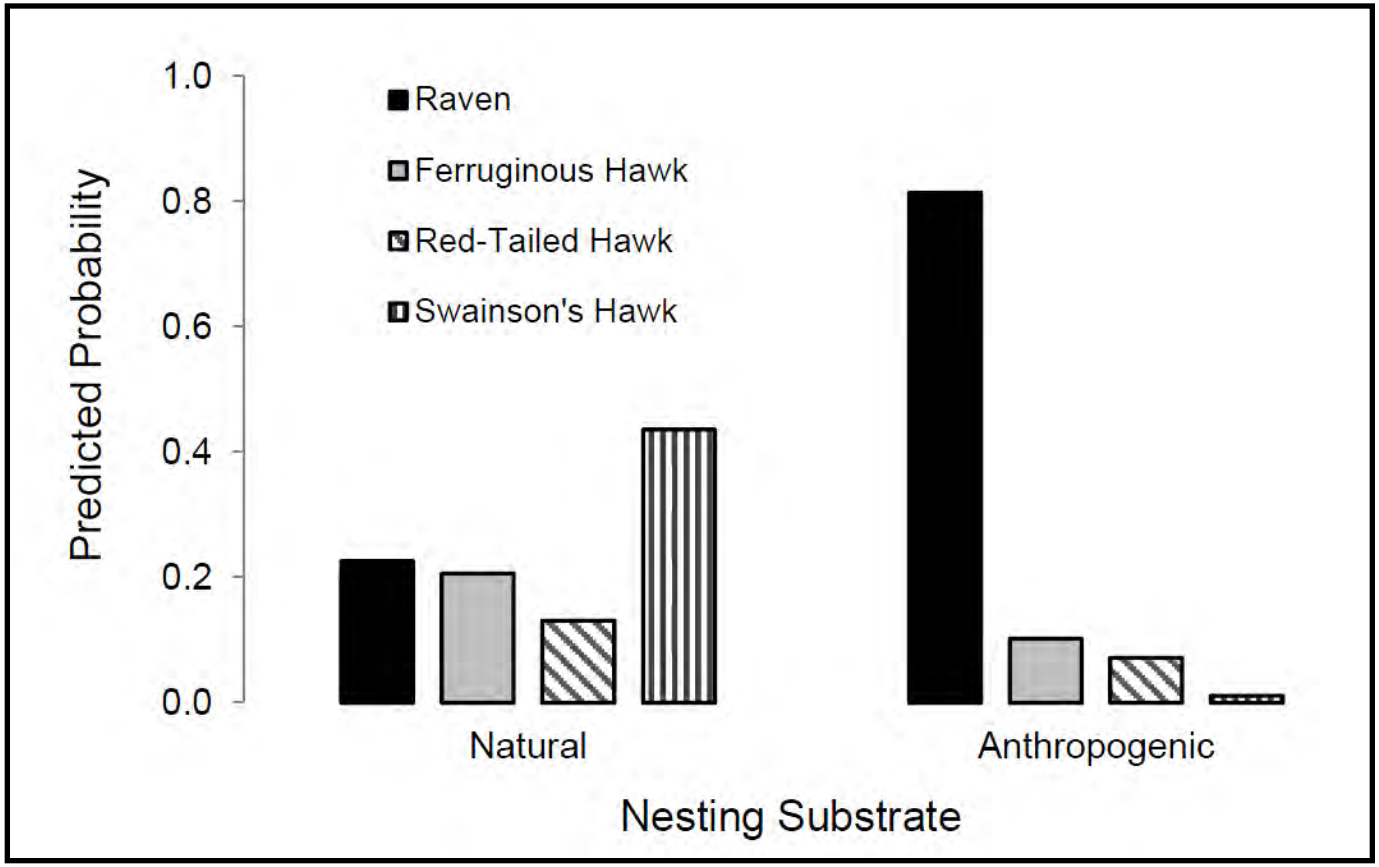
Volume 116, 2014, pp. 341–356
DOI: 10.1650/CONDOR-13-126.1

RESEARCH ARTICLE

Landscape alterations influence differential habitat use of nesting buteos and ravens within sagebrush ecosystem: Implications for transmission line development

Peter S. Coates,[1]* Kristy B. Howe,[1,2,3] Michael L. Casazza,[1] and David J. Delehanty[3]



Journal of Arid Environments 111 (2014) 68–78

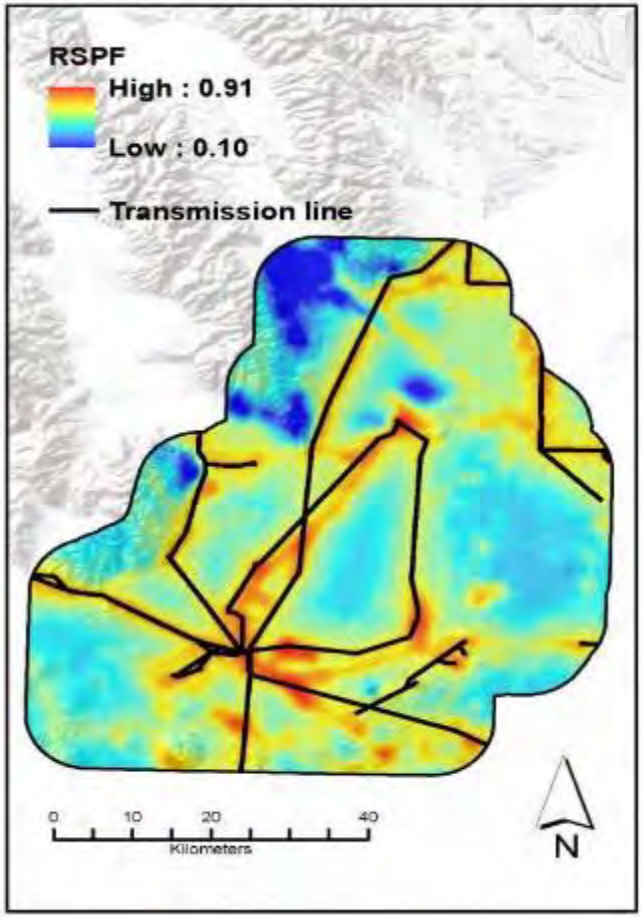
Contents lists available at ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

Common raven occurrence in relation to energy transmission line corridors transiting human-altered sagebrush steppe

Peter S. Coates [a,*], Kristy B. Howe [a,b,c], Michael L. Casazza [a], David J. Delehanty [b]



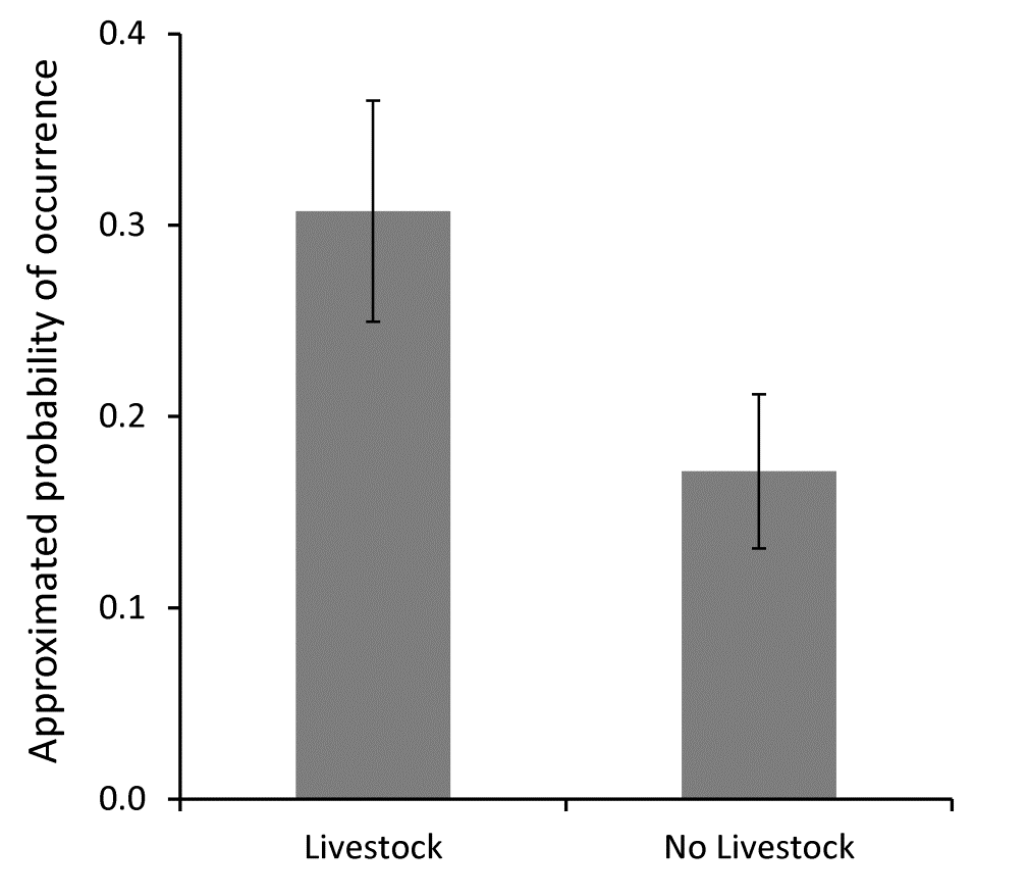
- Included non-resident (non-breeding) ravens – selected at larger spatial scales
- Effect of transmission line greatest within 2.2 km (4.5 km corridor)
- Additive effects of energy infrastructure and altered land cover types

Increased land cover edges, non-native vegetation, and patchiness

esa ECOSPHERE

Landscape characteristics and livestock presence influence common ravens: relevance to greater sage-grouse conservation

Peter S. Coates,[1,†] Brianne E. Brussee,[1] Kristy B. Howe,[1,2]
Kit Benjamin Gustafson,[1] Michael L. Casazza,[1] and David J. Delehanty[2]



Odds of raven occurrence increased 45.8% in areas where livestock were present

esa ECOSPHERE

Landscape characteristics and livestock presence influence common ravens: relevance to greater sage-grouse conservation

Peter S. Coates,[1,†] Brianne E. Brussee,[1] Kristy B. Howe,[1,2]
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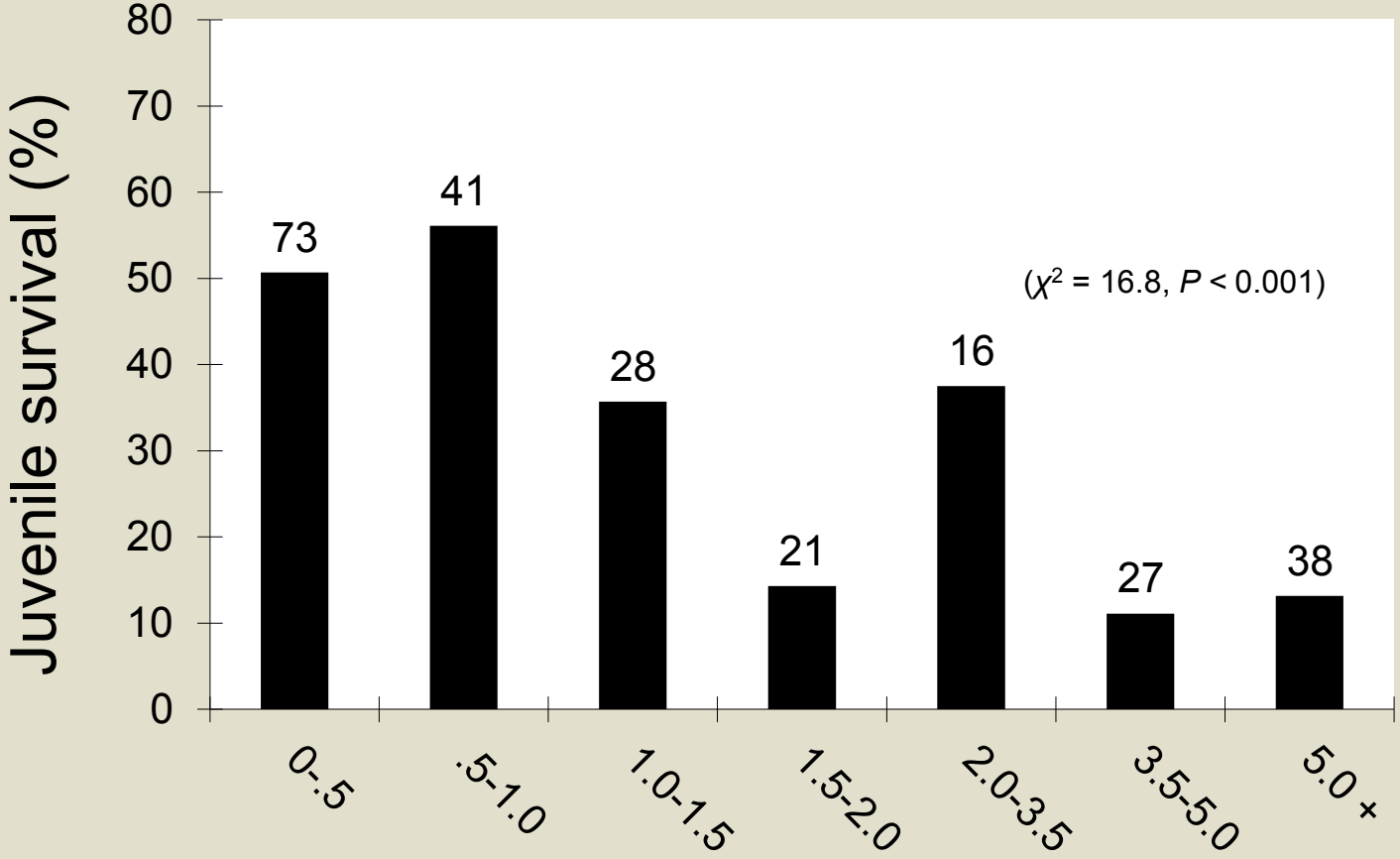
ANTHROPOGENIC RESOURCES INCREASE SURVIVAL TO DISPERSAL (CA)



Nest distance to nearest anthropogenic resource (km)

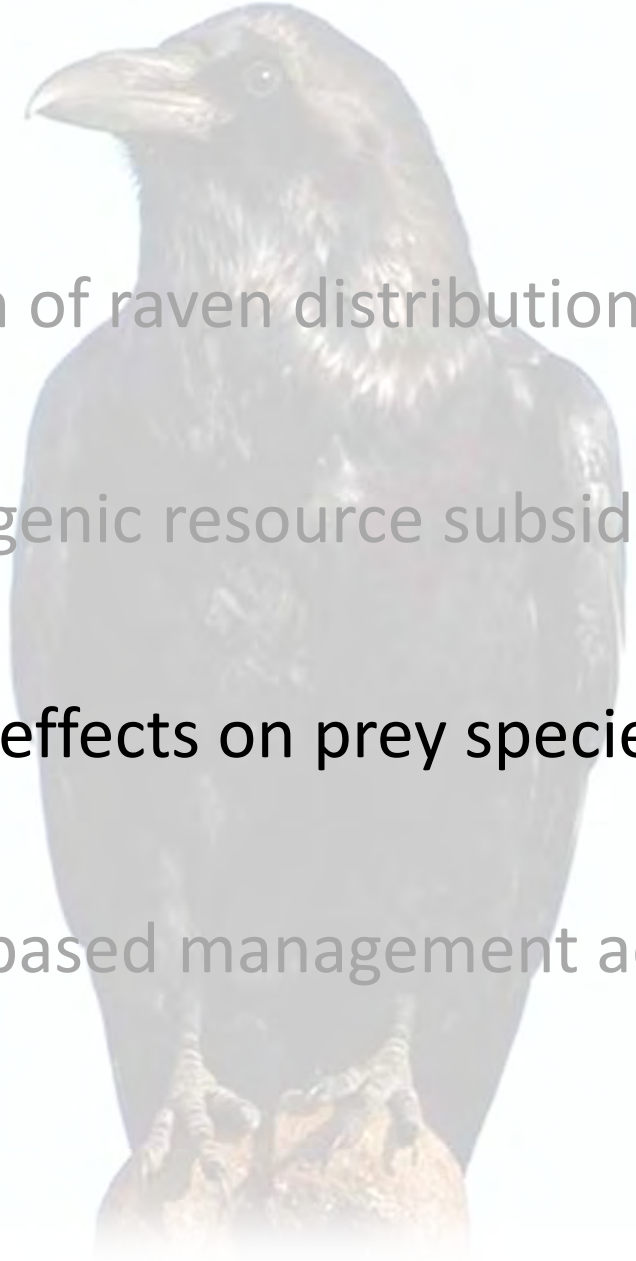
Webb et al. 2004 Condor 106:517-528

ANTHROPOGENIC RESOURCES INCREASE NONBREEDER SURVIVAL *AFTER* DISPERSAL (CA)

Post-dispersal Survival Models	ΔAIC
Cohort+ (9 months*__Distance food/water__)	0.00
Cohort+ (12 months*__Distance food/water__)	2.84
Cohort+ (15 months*__Distance food/water__)	6.24
Cohort+ (18 months*__Distance food/water__)	7.64

Webb et al. 2004 Condor 106:517-528

Overview Topics



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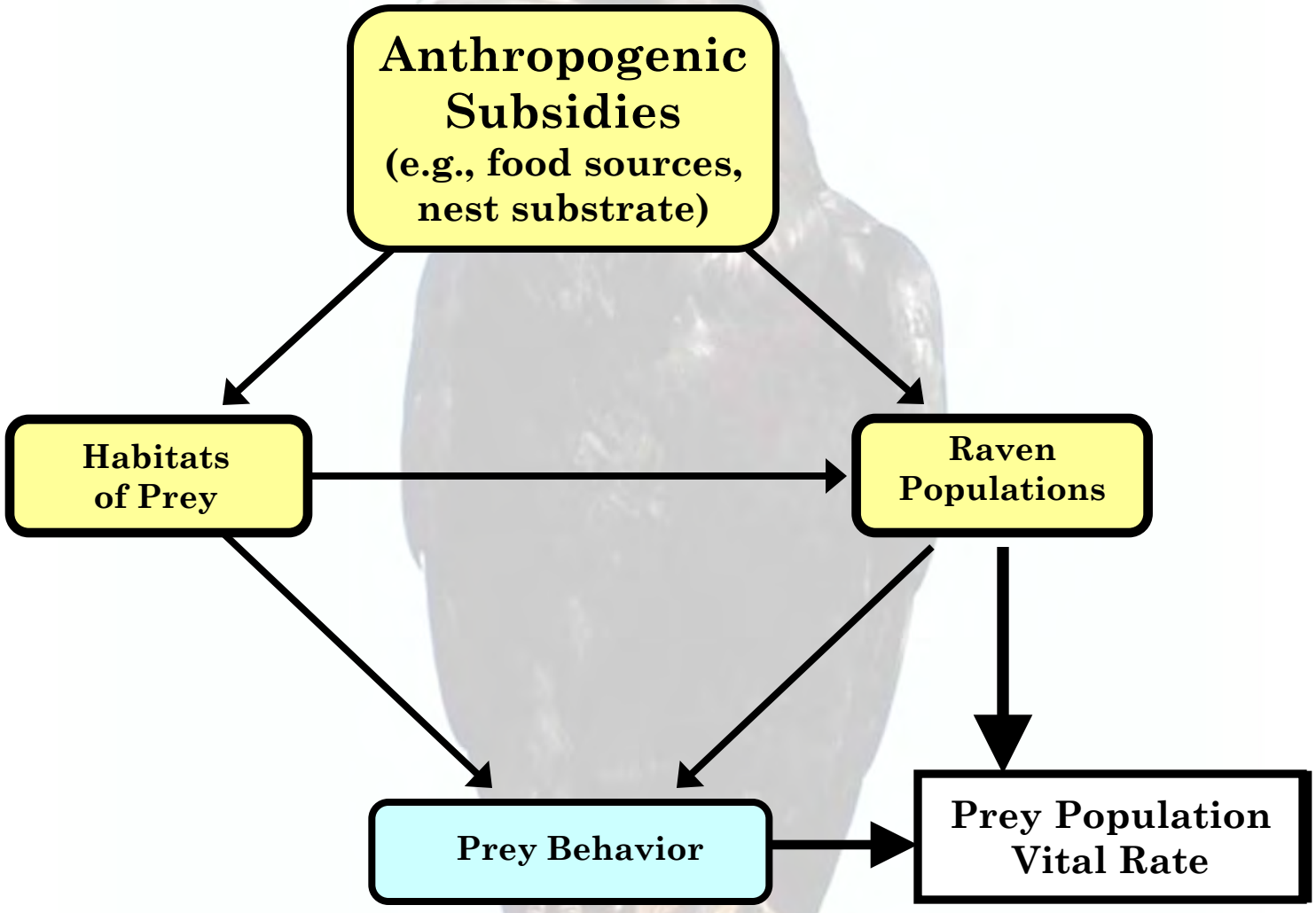
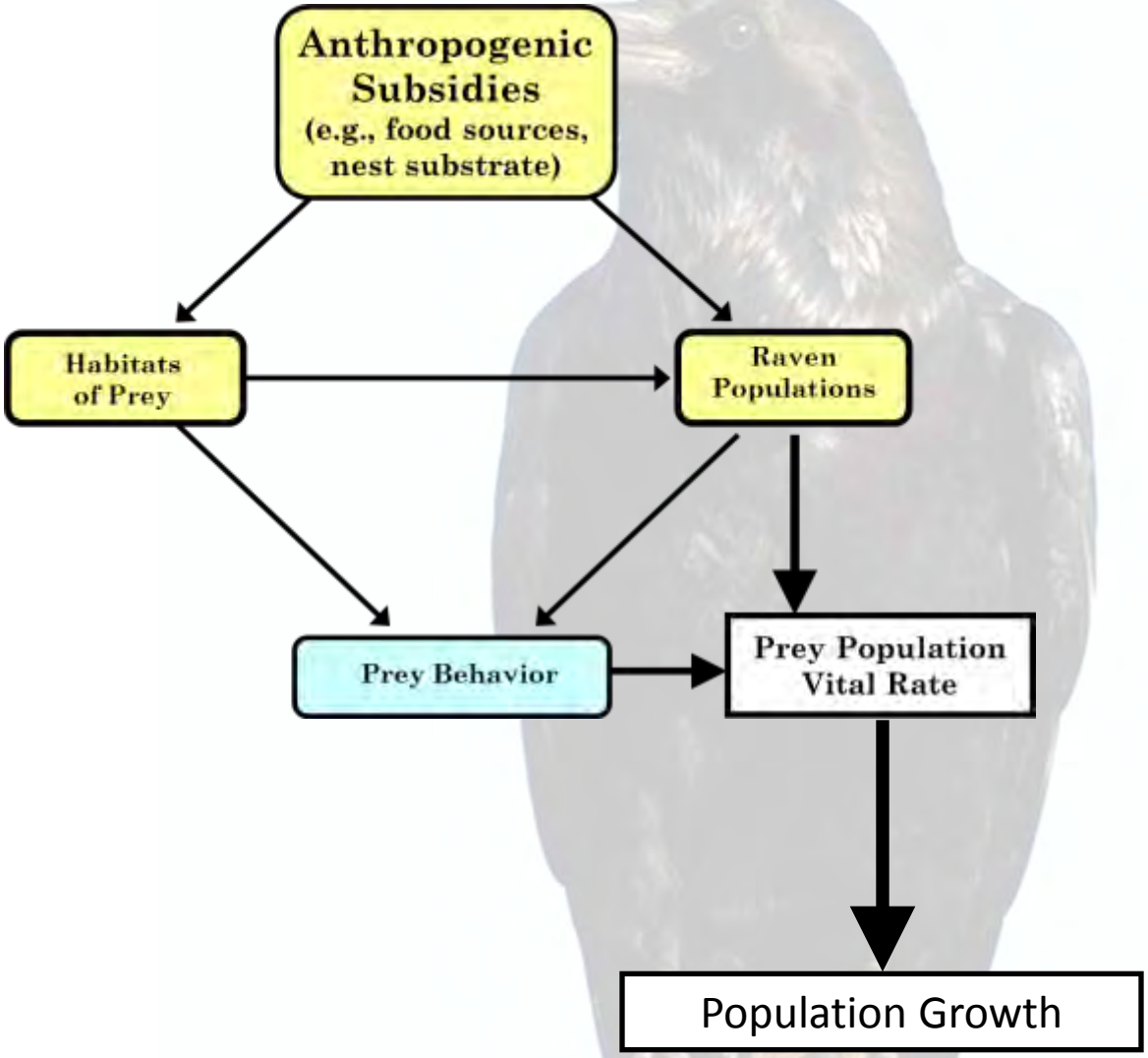
Anthropogenic Factors Indirectly Affect Prey



Indirect Effect – Nest Predation

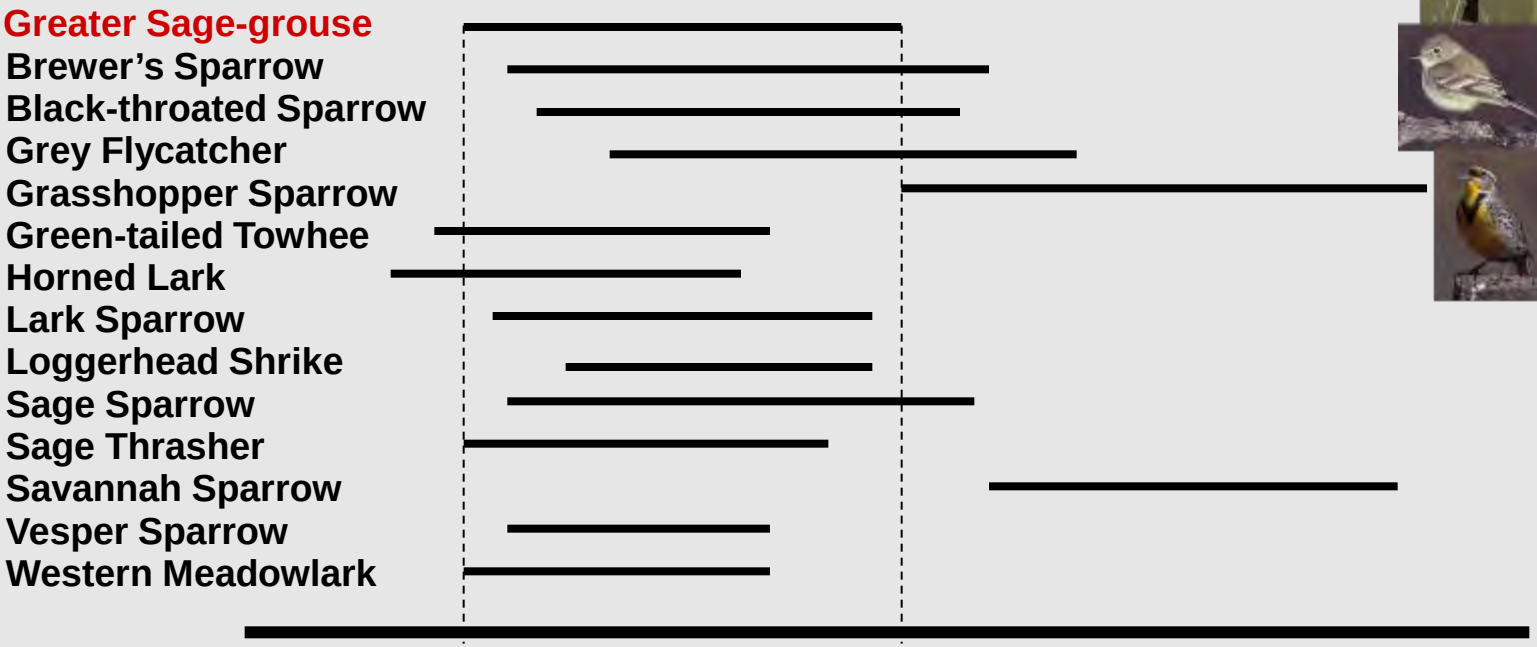


Indirect Effect – Nest Predation

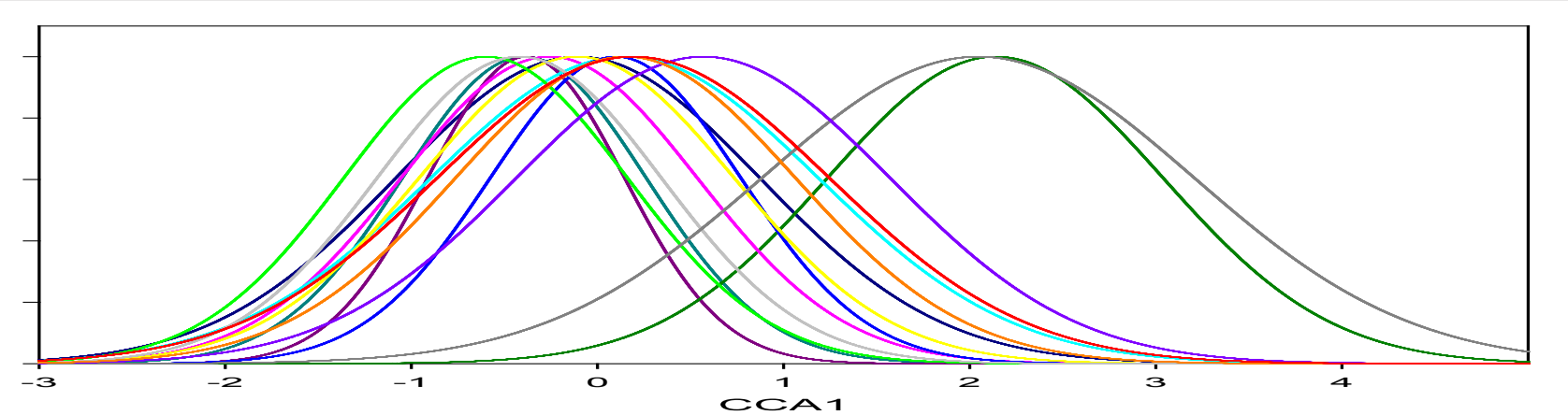
Common Name	Raven Impact # Sources	Likely or Potential Raven Impact	USESA (Year Listed)	U.S. States
Desert Tortoise	Numerous	High	T (1980)	T (CA, UT); S2 (AZ)
Piping Plover	Limited	Low	E / T* (1985)	E (DE, MD, ME, NC, ND, NH, NJ), S2B (MT); T (CO, FL, GA, KS, MA, NE, NM, VA; CT, SD, TX); SP (AL)
Greater Sage-Grouse	Numerous	High	NL	T (WA); S2 (ID); S3 (NV); SC (CO, UT)
Roseate Tern	Limited	Low	E/T^ (1987)	Ex (MD); E (MA, ME, NC, NH, NJ, NY, CT); T (FL)
Marbled Murrelet	Numerous	High	T^^ (1992)	E (CA); T (OR, WA)
San Clemente Loggerhead Shrike	Limited	Unknown	E (1977)	NL
California Condor	Limited	High	E/T*** (1967)	E (CA)
Gunnison Sage-Grouse	Limited	High	T (2014)	SC (CO); T (UT)
Greater Sandhill Crane	Numerous	High	NL	E (WA); T (CA); S3B (ID); SC (CO)
California Least Tern	Numerous	High	E (1970)	E (CA, OR)
Western Snowy Plover	Numerous	High	T^^^ (1993)	T (OR); SC (CO)

Greater Sage-Grouse as an Avian Indicator Species

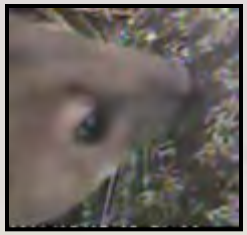
Hanser et al. (2011)

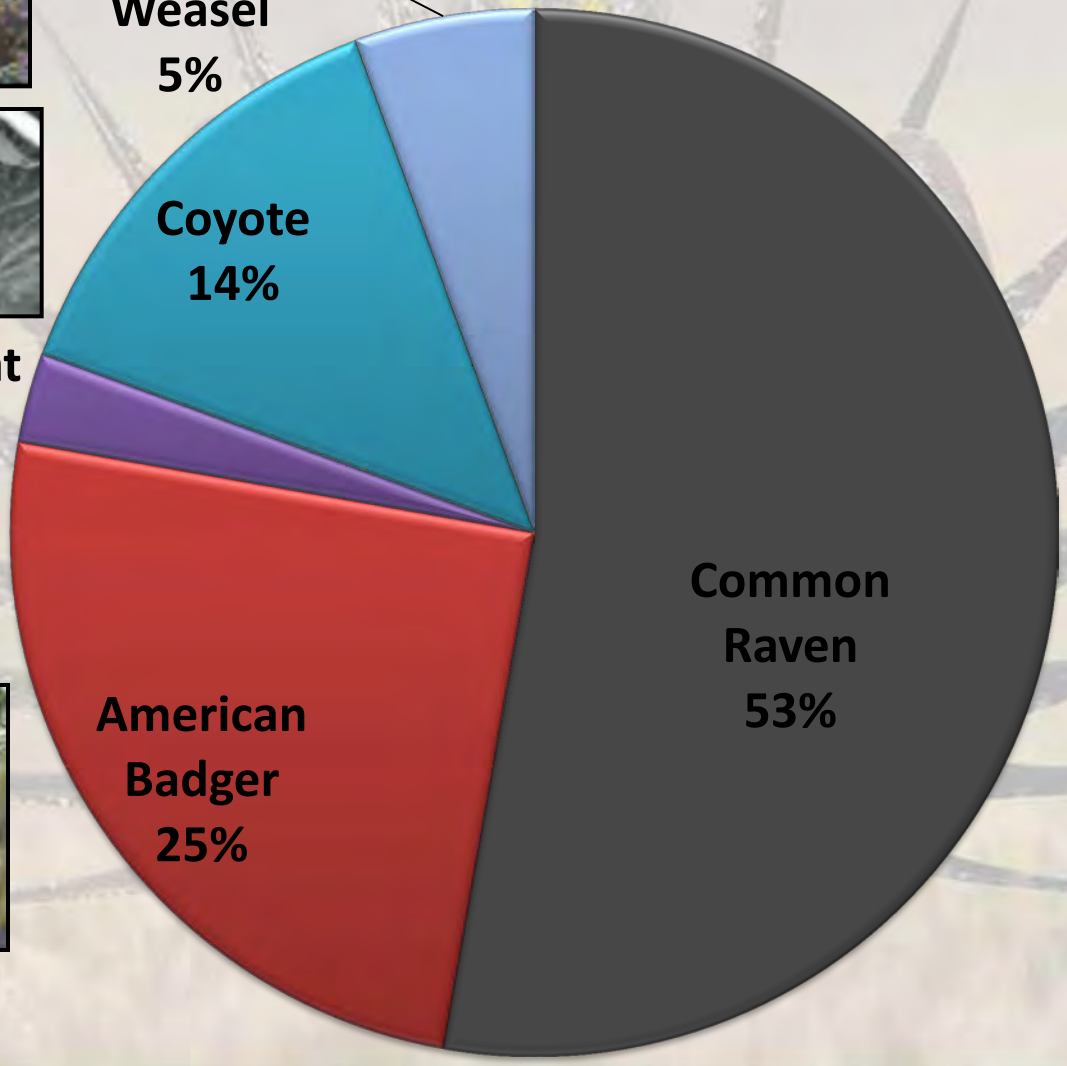


Sagebrush ← **Environmental Gradient** → Grassland



Ravens are most frequent predator (9 years of video data)





Coates et al. 2008. JFO 79:421–428.
Lockyer et al. 2013. JFWM 4: 242 – 254.
Casazza, USGS, unpublished

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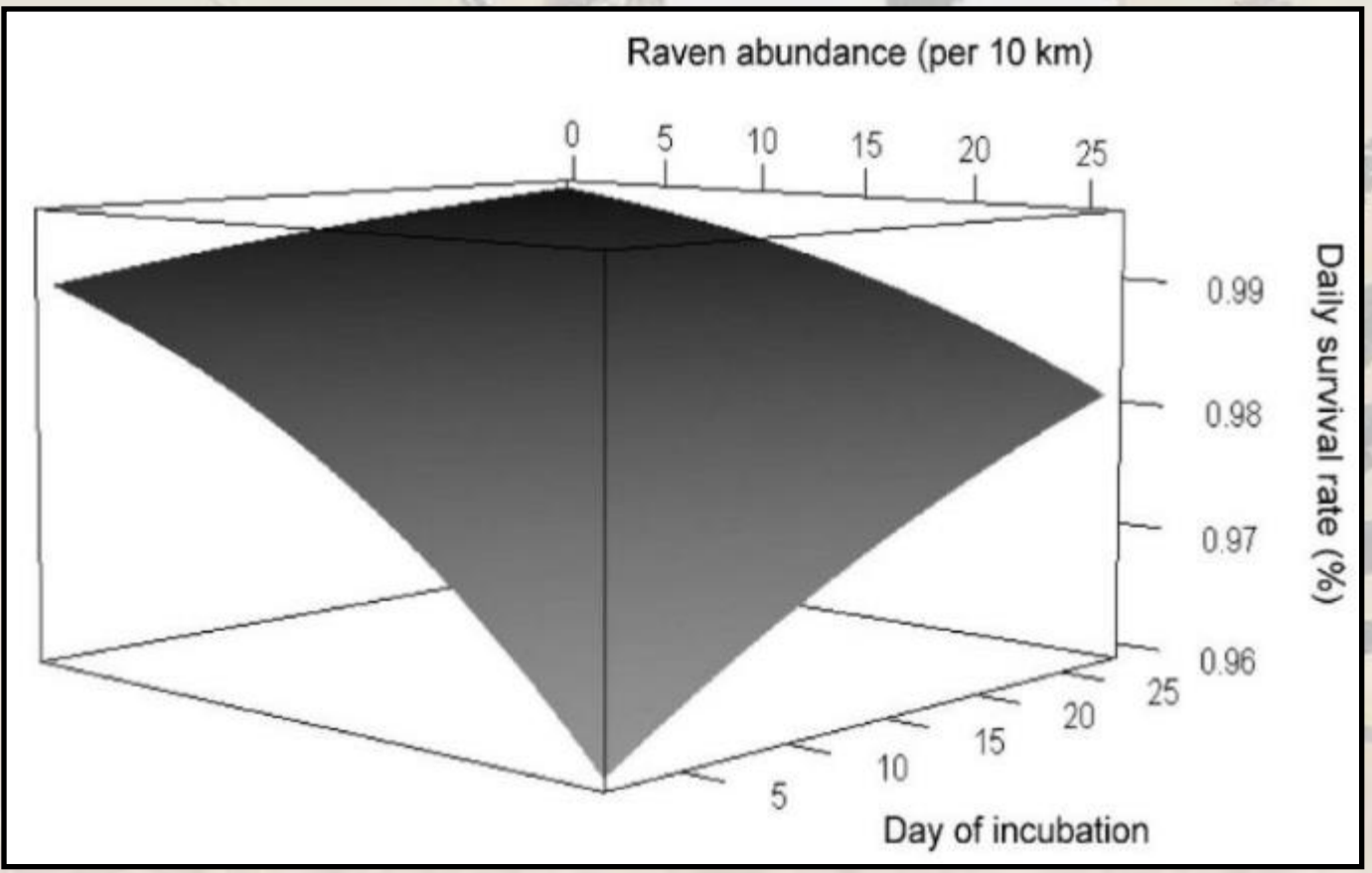
Lockyer et al. 2013. JFWM 4: 242 – 254.
Casazza, USGS, unpublished

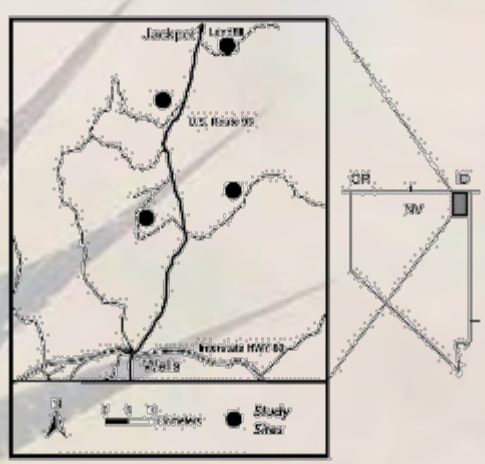
Journal of Wildlife Management 74(2):240–248; 2010; DOI: 10.2193/2009-047

Management and Conservation Article

Nest Predation of Greater Sage-Grouse in Relation to Microhabitat Factors and Predators

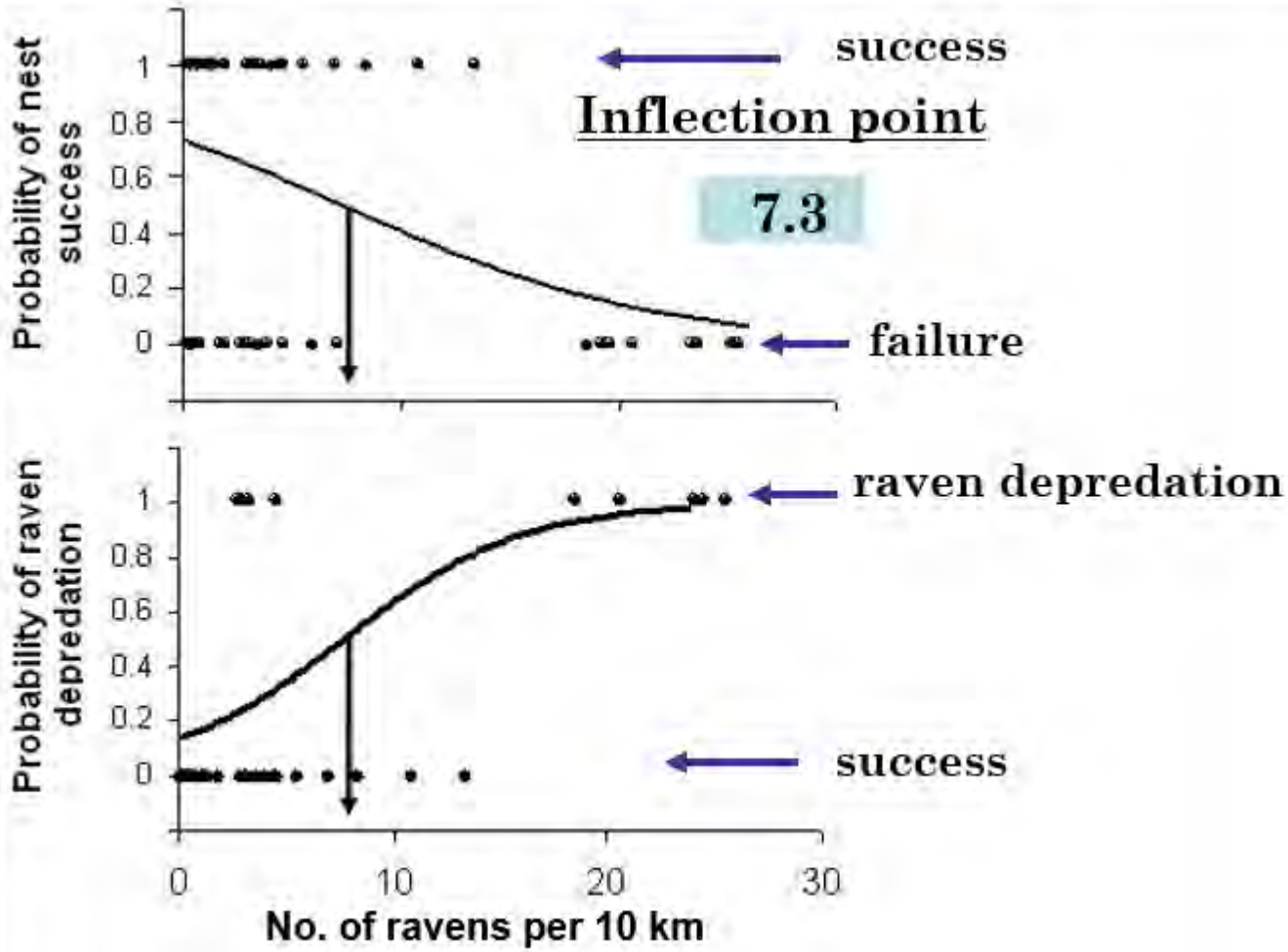
PETER S. COATES,[1] *Department of Biological Sciences, Idaho State University, Pocatello, ID 83209-8007, USA*
DAVID J. DELEHANTY, *Department of Biological Sciences, Idaho State University, Pocatello, ID 83209-8007, USA*





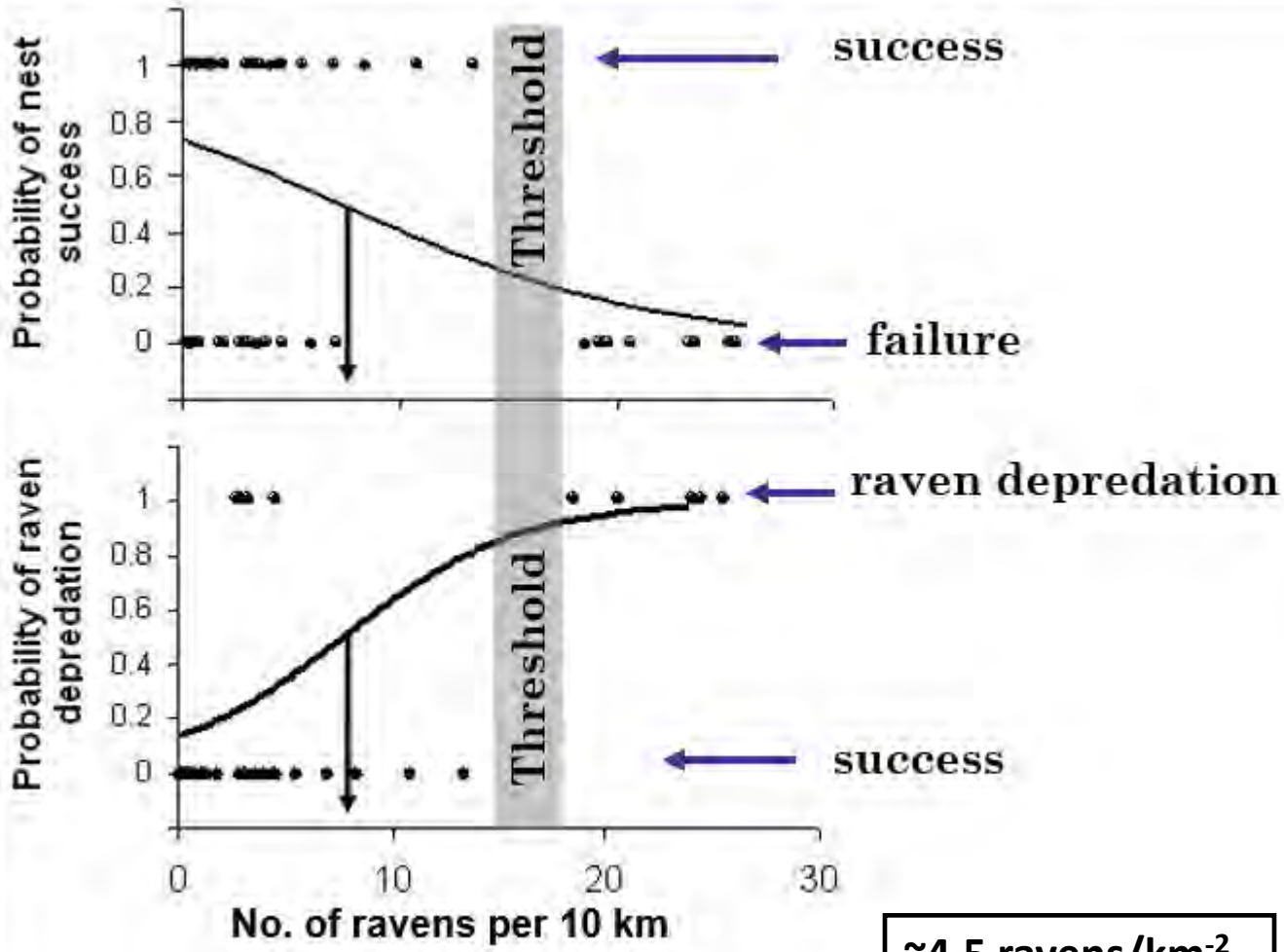
Sage-Grouse nest survival declines with increased raven numbers

Nests fail in areas of high raven abundance



Coates 2007. Dissertation. Idaho State University.

Threshold of raven abundance



~4.5 ravens/km^{-2}

Coates 2007. Dissertation. Idaho State University.

Ravens predation increases with less shrub cover

Resp.	Covariate	Estimate	95% CI lower	95% CI upper
Raven	raven	0.23	0.11	0.41*
	shrub cover	-0.08	-0.15	-0.02*
	grass	0.17	-0.63	0.41
	forb	0.16	-0.40	0.70
	understory	0.02	-0.04	0.08
	shrub height	0.00	-0.06	0.06
Badger	understory	0.10	0.03	0.12*
	forb	0.70	0.13	1.43*
	grass	0.23	-0.02	0.49
	shrub cover	0.02	-0.02	0.06
	shrub height	0.01	-0.01	0.42

1% decrease in shrub cover increased the odds of raven predation by 7.5%

20–30% sagebrush cover and >40% total shrub cover

Coates et al. 2010. JWM 74:240–248.

Important Interaction

Impacts on Prey Population Growth Rates?

Results from Taylor Study

Nest Survival Models

Model	AIC_c	ΔAIC_c	AIC_c Weights	Model Likelihood	# Parameters	Deviance
$S_{\text{Study Site}}$	941.70	0.00	0.96	1.00	5	931.68
$S_{\text{Study Site + Year}}$	949.46	7.76	0.02	0.02	15	919.31
$S_{\cdot\ \text{(Intercept Only)}}$	951.11	9.42	0.01	0.01	1	949.11
$S_{\text{Within Year Quadratic Trend (tt)}}$	953.01	11.31	0.00	< 0.01	2	949.00
$S_{\text{Within Year Linear Trend (t)}}$	953.06	11.37	0.00	< 0.01	2	949.06
S_{Year}	953.60	11.90	0.00	< 0.01	4	945.58

Study Site	Daily Survival Rate	SE	LCI	UCI
Bud Kimball	0.963	0.015	0.920	0.983
Fifteen Mile	0.979	0.005	0.967	0.987
Major Basin	0.961	0.009	0.939	0.975
Oregon Basin	0.972	0.005	0.961	0.980
Polecat Bench	0.943	0.008	0.926	0.957

Study Site	Nest Survival Rate	SE	LCI	UCI
Bud Kimball	0.348	0.054	0.241	0.454
Fifteen Mile	0.558	0.046	0.467	0.649
Major Basin	0.328	0.029	0.270	0.385
Oregon Basin	0.452	0.030	0.393	0.511
Polecat Bench	0.196	0.010	0.177	0.214

Results from Taylor Study

Causes of Nest Failure

Causes of Nest Failure as a Proportion of All Nests						
Study Site	Abandoned	Hen Mortality	Raven	Coyote	Unidentified	Other [1]
Bud Kimball	0.30	0.10	0.10	0.10	-	-
Fifteen Mile	0.05	0.05	0.03	0.20	0.08	-
Major Basin	0.09	0.03	0.03	0.09	0.06	0.25
Oregon Basin	0.03	0.08	0.10	0.13	0.13	0.03
Polecat Bench	0.10	0.06	0.19	0.21	0.18	0.03

[1] Major Basin: 6 Badger Depredations, 1 Snake Depredation, 1 Pronghorn Depredation (ate eggs in active nest)
Oregon Basin: 1 Fox Depredation, 1 Skunk Depredation
Polecat Bench: 2 Badger Depredations

Results

Mean Site-specific Lambda Values
(10,000 simulations per site)

Fifteen Mile = 1.52 (SE = 0.0006)

Oregon Basin = 1.32 (SE = 0.0004)

Major Basin = 1.10 (SE = 0.0002)

Polecat Bench = 0.84 (SE = 0.0001)

USGS Study

Effects of Anthropogenic Development

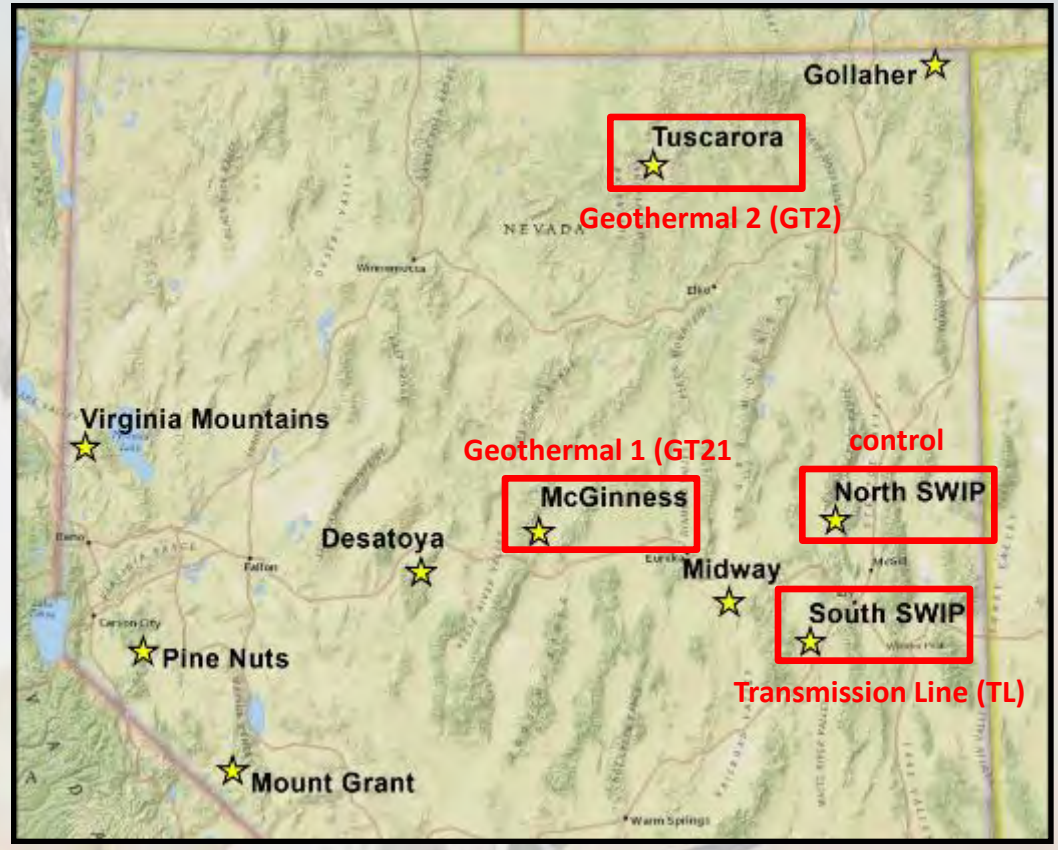
Longitudinal studies (4 sites)
GPS and VHF transmitters

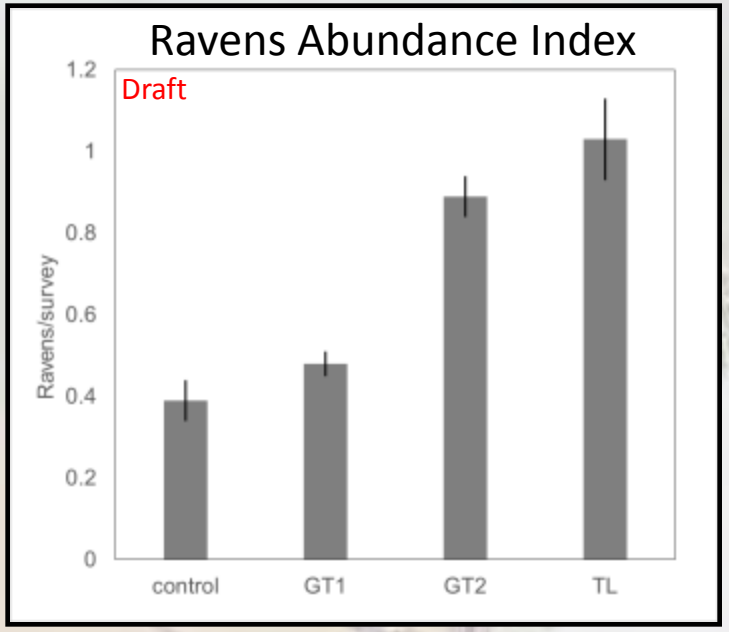
Objectives:

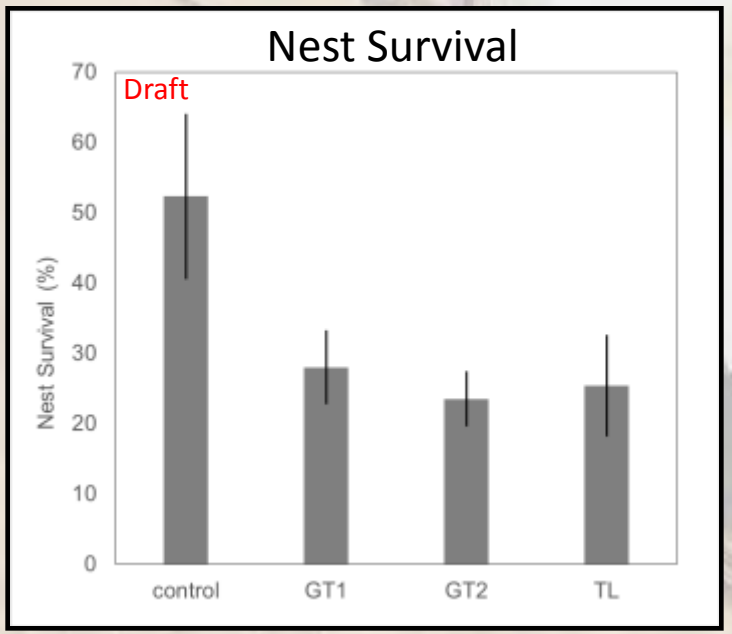
Estimate Development Influences on:

1) Raven abundance
2) Nest survival
3) Population growth

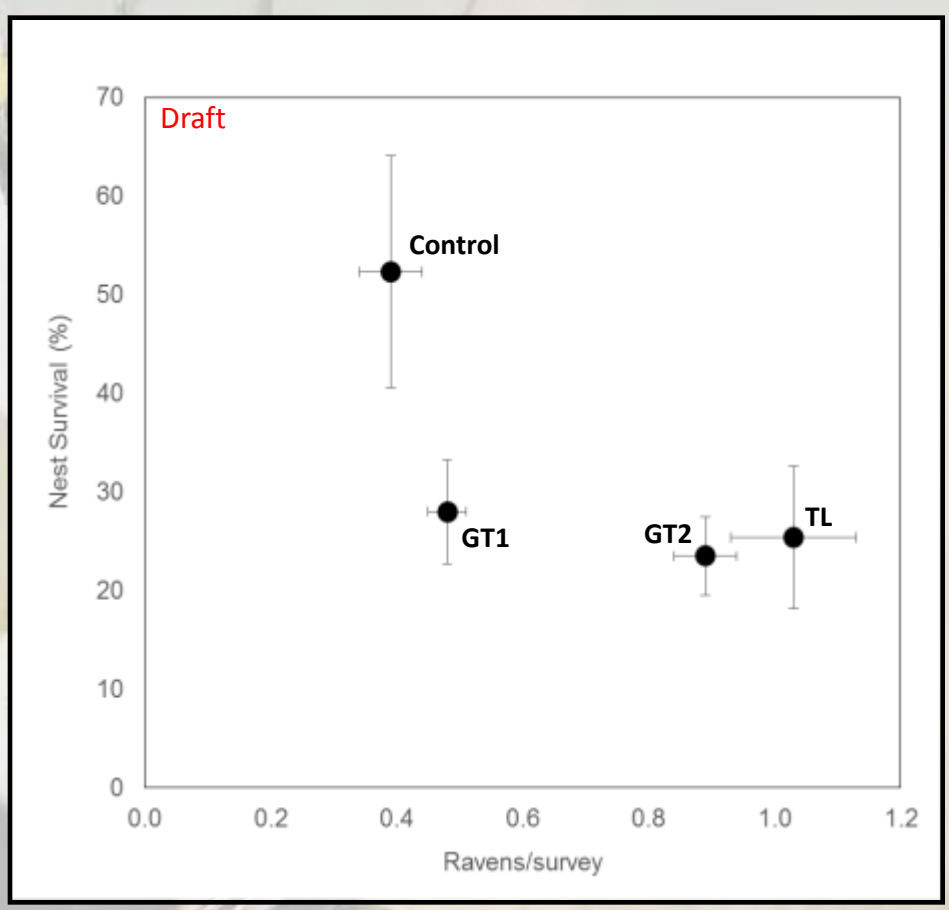
Other Objectives:
Movement, Space Use, Habitat Selection, Stress response







Variation in the number of ravens and nest survival among sites related to anthr



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Stage-Based Stochastic Population Model

Model

$$N_t = N_{t-1} \times g(s, f)$$

Recruitment component (*f*)

Nest Propensity	Clutch Size	Nest Survival	Hatchability	Chick Survival	Juvenile Survival
Prior (Taylor et al. 2012)	Poisson model	Proportional Hazards model	Binomial model	Binomial model	Prior (Taylor et al. 2012)

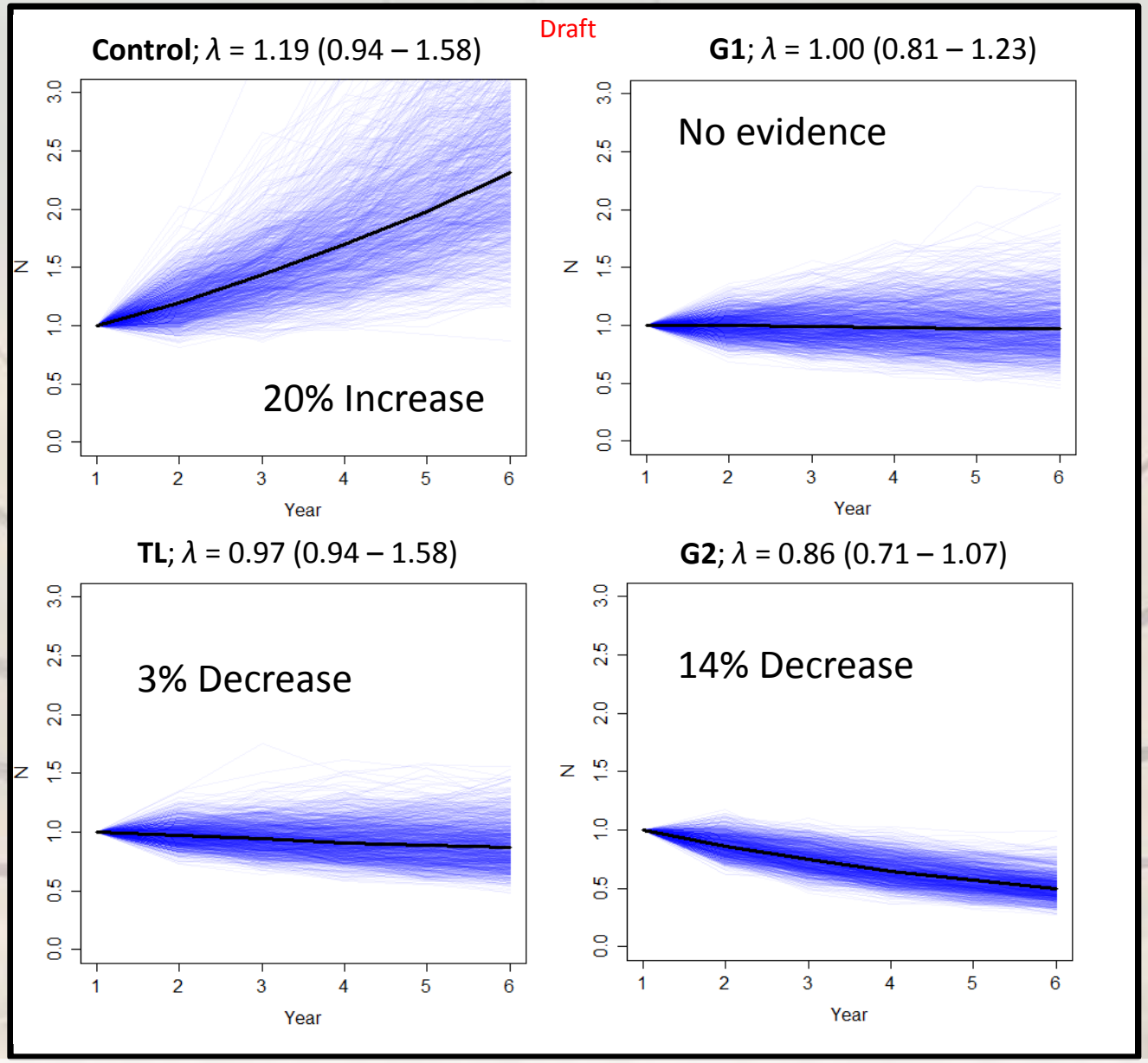
$$Fecundity = (np1 \times cl1 \times \boxed{ns1} \times h \times cs \times js) + [(1 - ns1) \times np2 \times cl2 \times \boxed{ns2} \times h2 \times cs2 \times js2]$$

Survival component (*s*) **Proportional Hazard Model**

Population growth (finite rate of change)

$$\lambda = \frac{N_t}{N_{t-1}}$$

Differences in Population Growth



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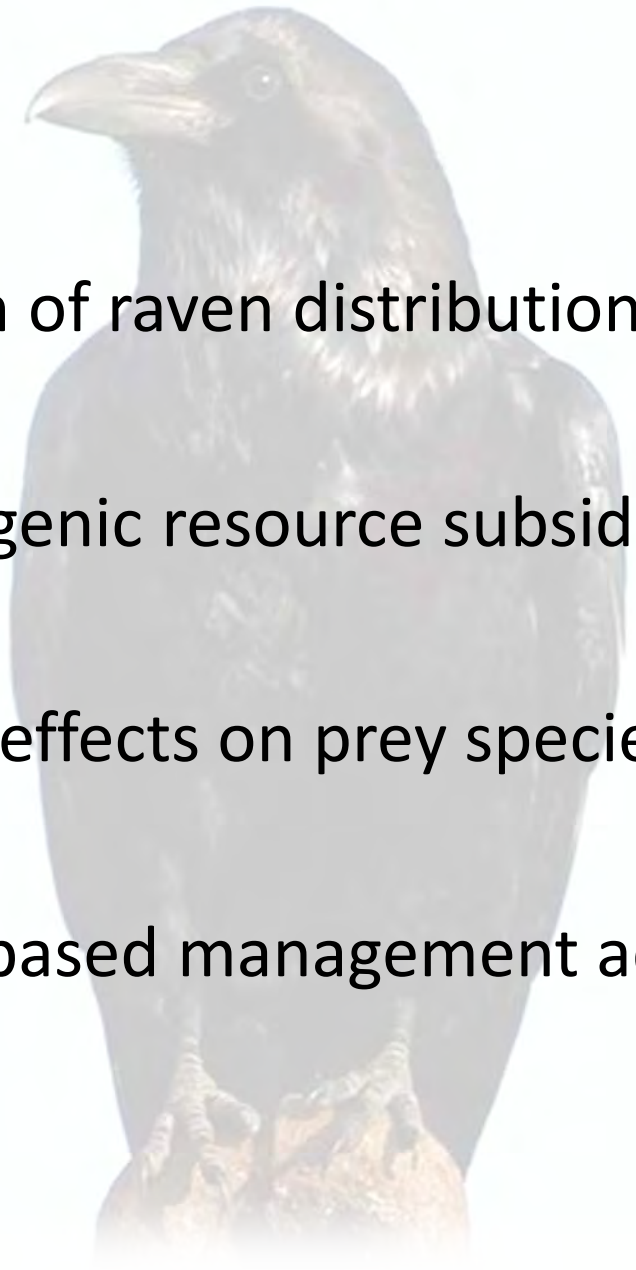
Overview Topics



Problem: Expansion of raven distribution and abundance

Reasons: Anthropogenic resource subsidies

Impacts: Predation effects on prey species

Solutions: Science-based management action plan

Don’t Panic – Find Solutions……Based on objective measures!

Example of Science-based Adaptive Management Plan

1. Mapping candidate areas for management (e.g., course-scale raven and prey species occurrence/abundance/density maps)

2. Conduct standardized raven survey protocol at sites
   - Estimate local-scale raven densities
   - Overlap with sensitive prey species

3. Prescribe management actions (three-tiered approach) based on science based on density estimates and published effects (thresholds)

4. Conduct post management monitoring

Example Management Actions

Objective 1 – Non-lethal; Maintain or improve habitat conditions for prey

Example for sage-grouse objectives:

- **Sagebrush cover 15 – 25%**
- **Total shrub cover >30%**
- **Shrub cover under 20%, then residual perennial grass cover >10%**

Potential Long-term Benefits

Example Management Actions

Objective 2 – Non-lethal; Reduce anthropogenic subsidies to ravens or reduce access to anthropogenic subsidies

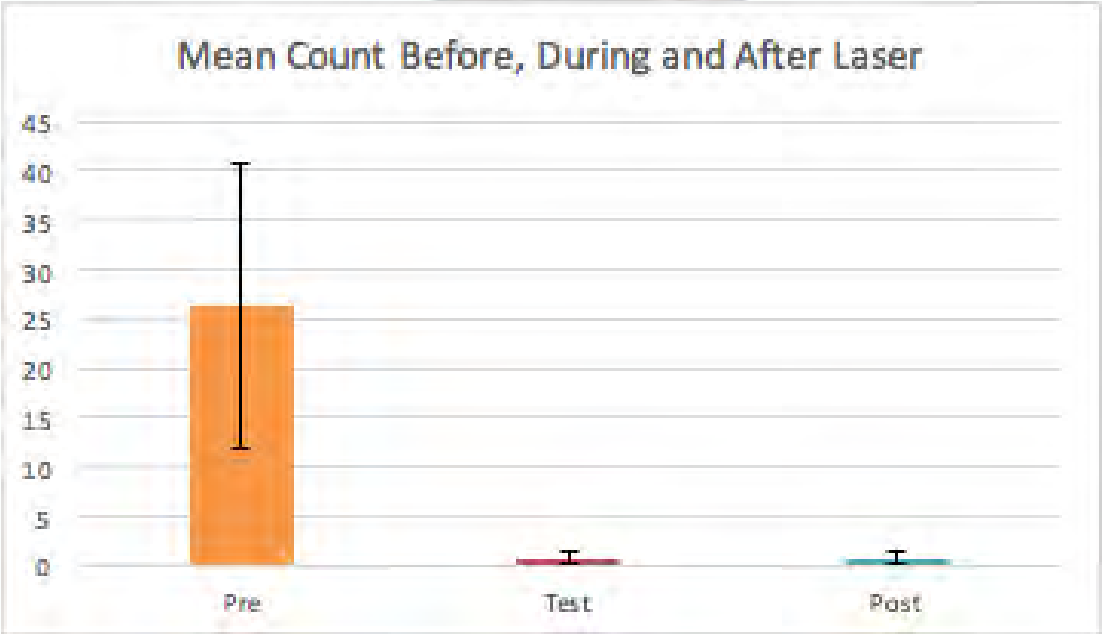
Collaborative approach:

- **Road kill removal (NDOT), disposal options**
- **Minimize available refuse from urban interface (ci county)**
- **Landfills and waste facilities (EPA)**
- **Carcass removal and regulation of private disposa (private landowners)**
- **Powerline and tower modifications (industry)**

Always applied in concert with objective 1

Potential Long-term Benefits

Example Management Actions



Hardshell Labs Raven Repulsion Test
31 August- 11 October, 2016.

Mean daily raven counts comparing test phases

Example Management Actions

Objective 3 – Lethal raven removal

- Application of DRC-1339 (corvicide)

  e.g., applied first 40 days of nesting season
- Raven nest removal
- Raven oil eggs
- Short and long-term actions

Always applied in concert with Objectives 1&2

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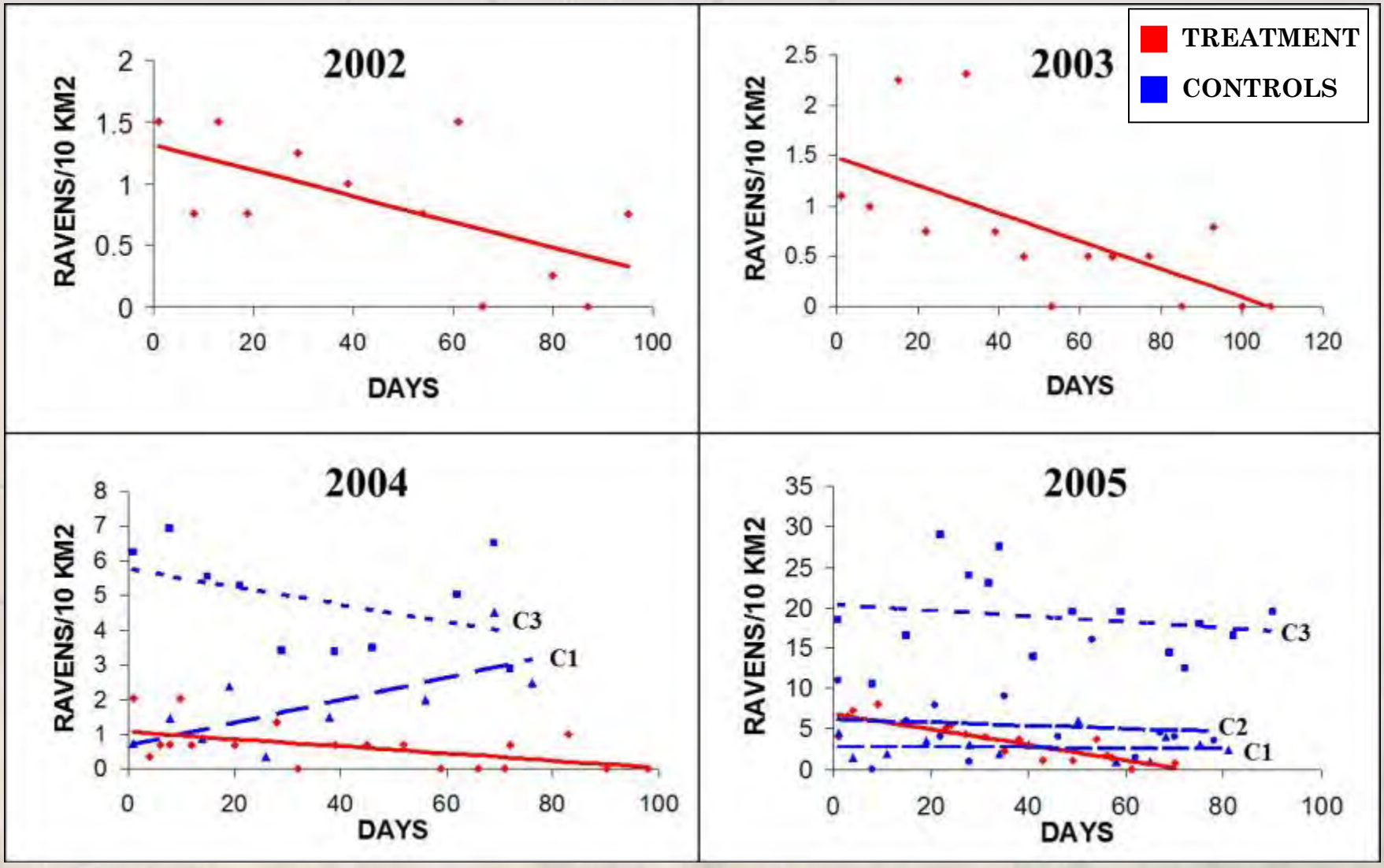
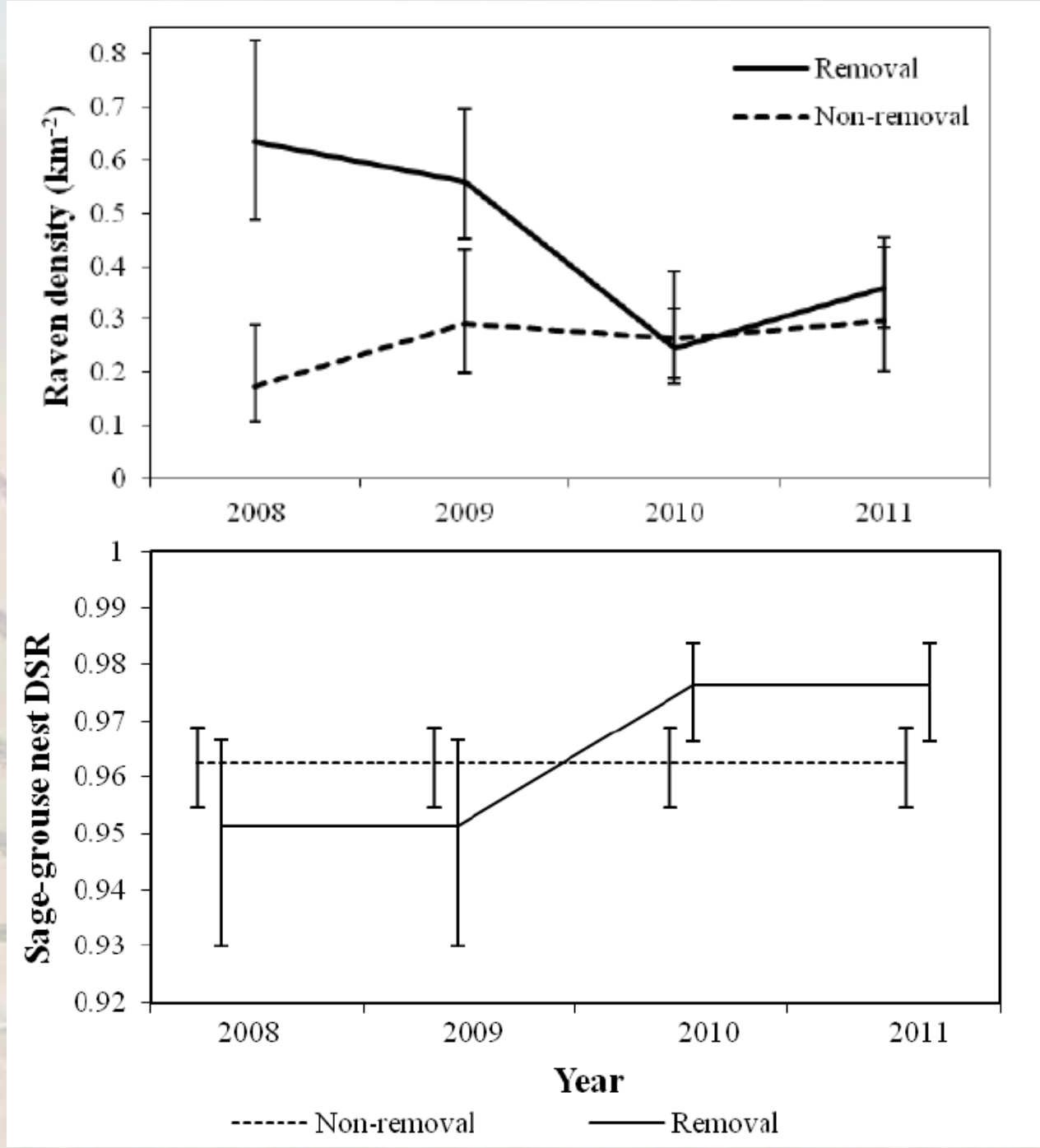
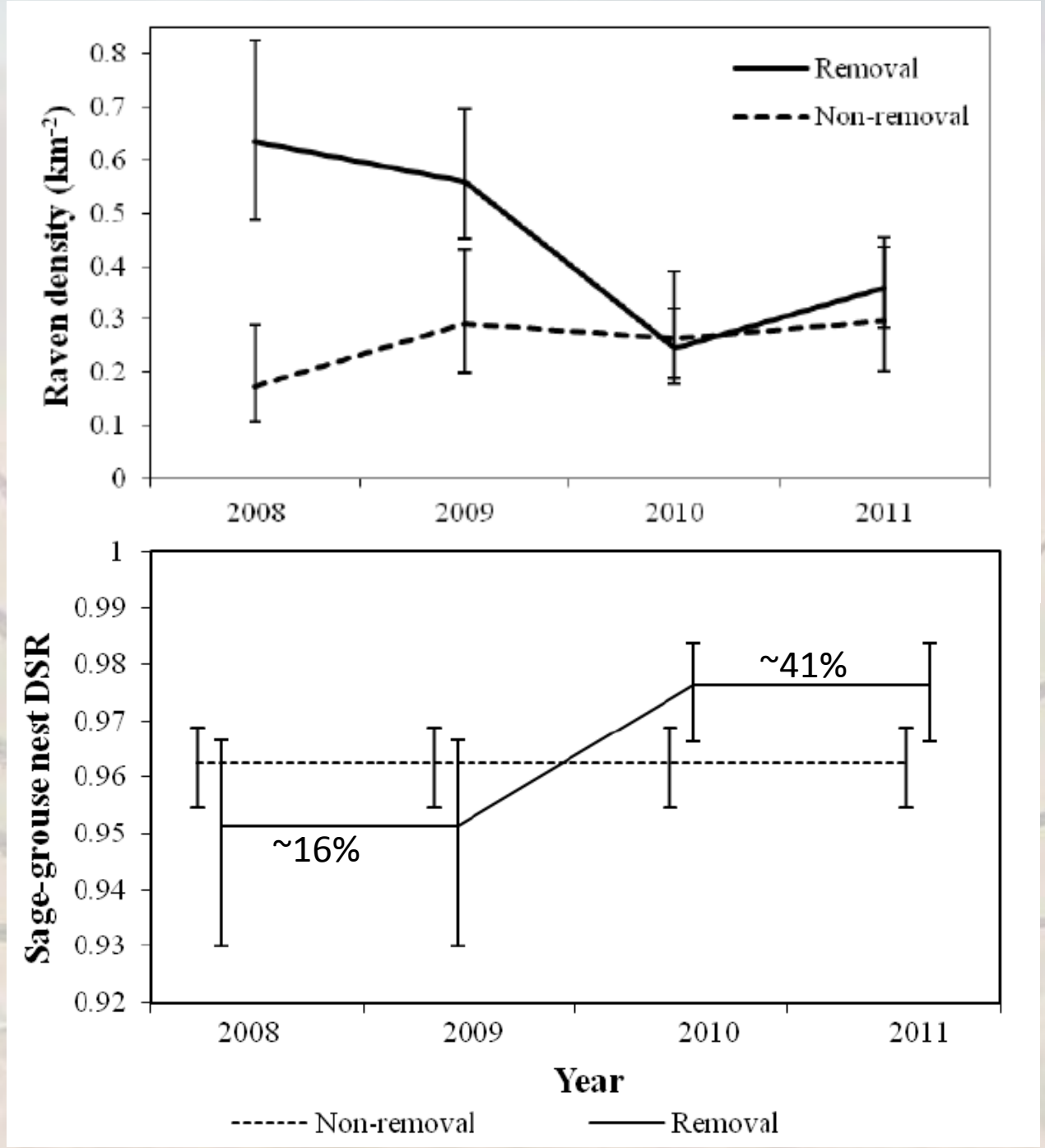
Reduction in Raven Numbers

2002 – 2005 Northeastern Nevada Study



Coates et al. 2007. Human Wildlife Conflicts 1:224–234.


Raven density (km-2)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Removal
Non-removal
2008
2009
2010
2011
Sage-grouse nest DSR
1
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
2008
2009
2010
2011
Year
Non-removal
Removal

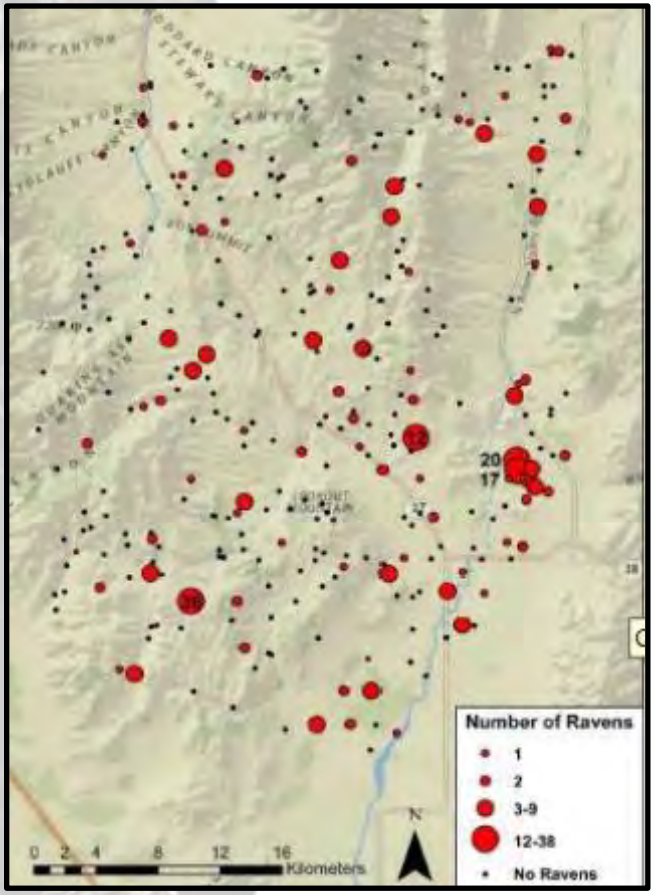


Effect consistent with:

~4.5 ravens/km^{-2}

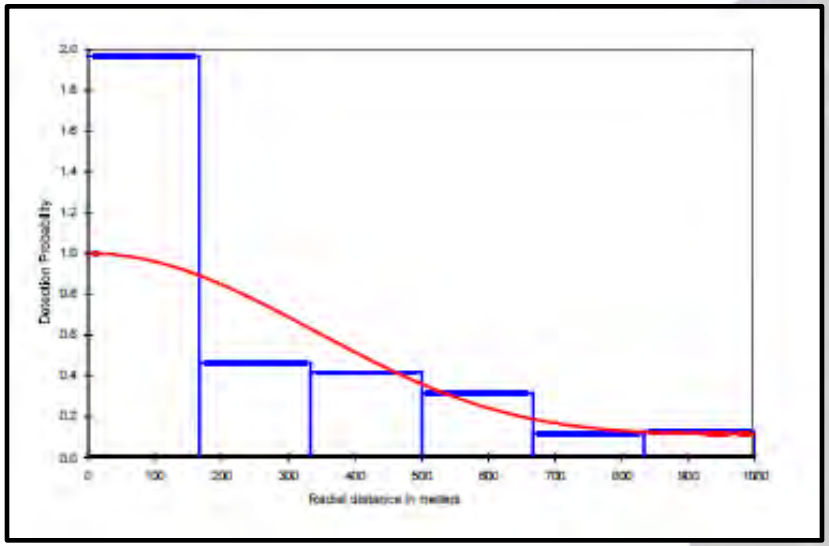
Calculated from past studies

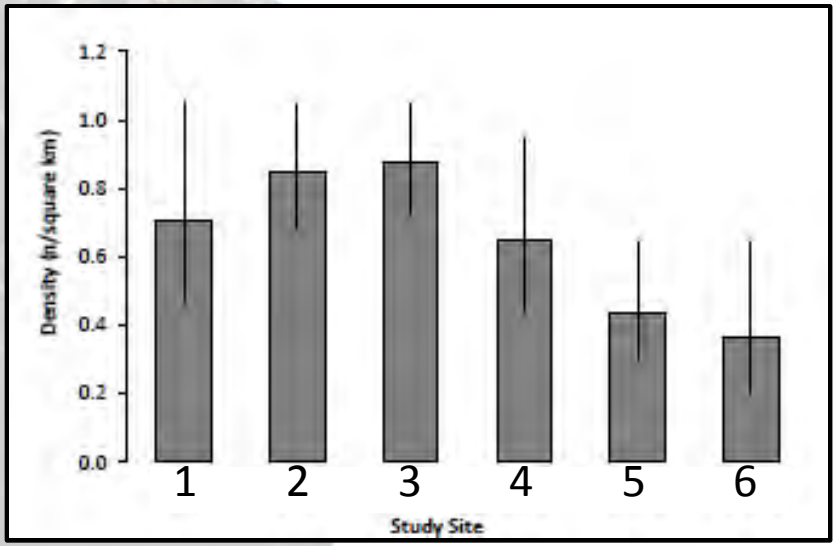
Survey and Estimating Density Example



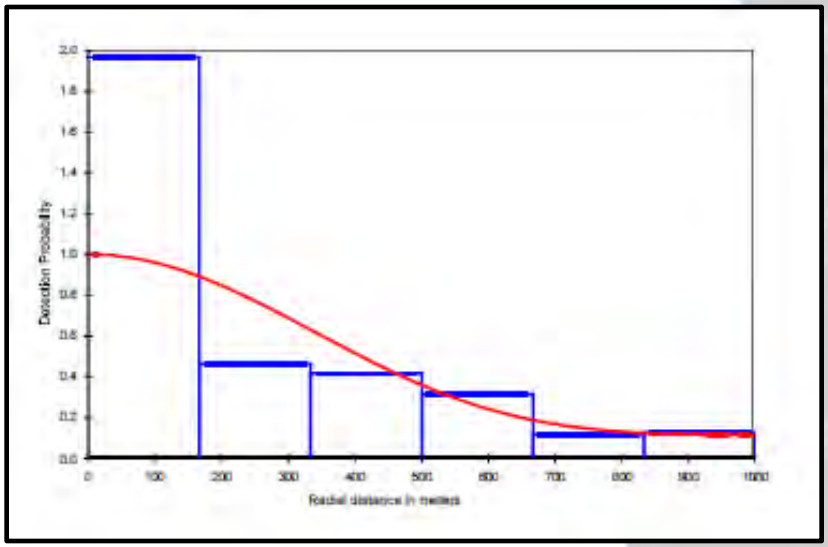
Field surveys coupled with course-scale mapping estimates

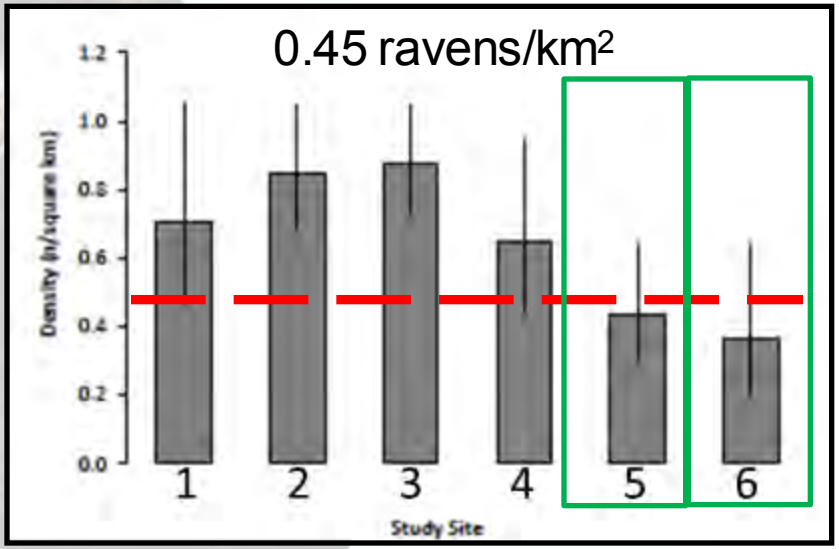
Survey and Estimating Density Example





Threshold Examples





Areas of Low Concern

Management Prescription

Objectives 1. Management actions that promote habitat aimed at reducing interactions between ravens and prey

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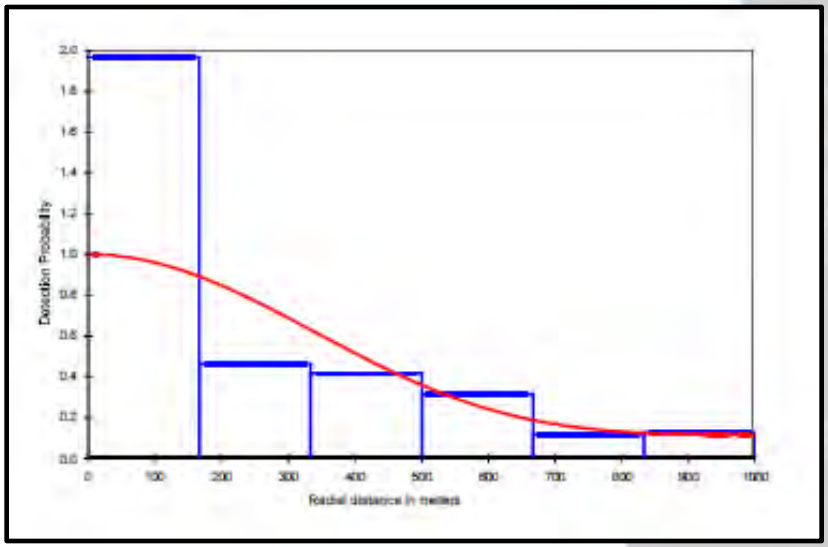
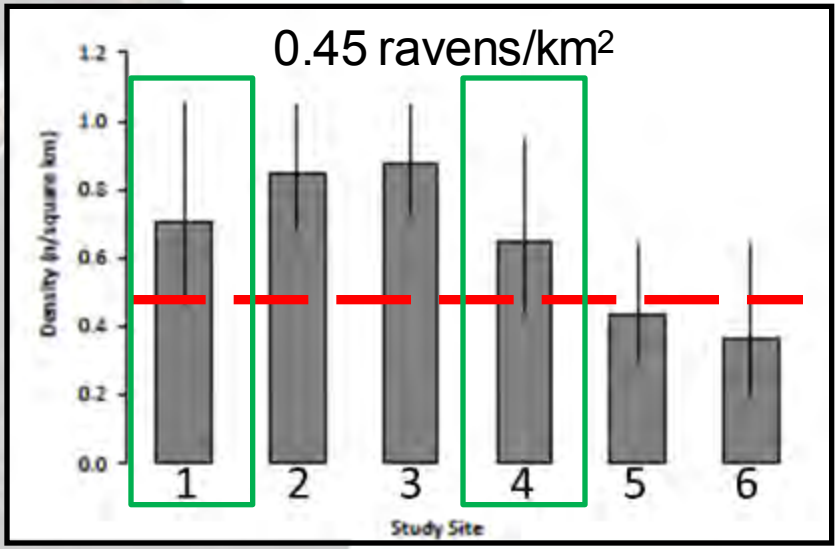
Threshold Examples





Areas of Moderate Concern

Management Prescription

Objectives 1&2 Management actions related to removal of or reduction of access to anthropogenic subsidies and habitat restoration actions.

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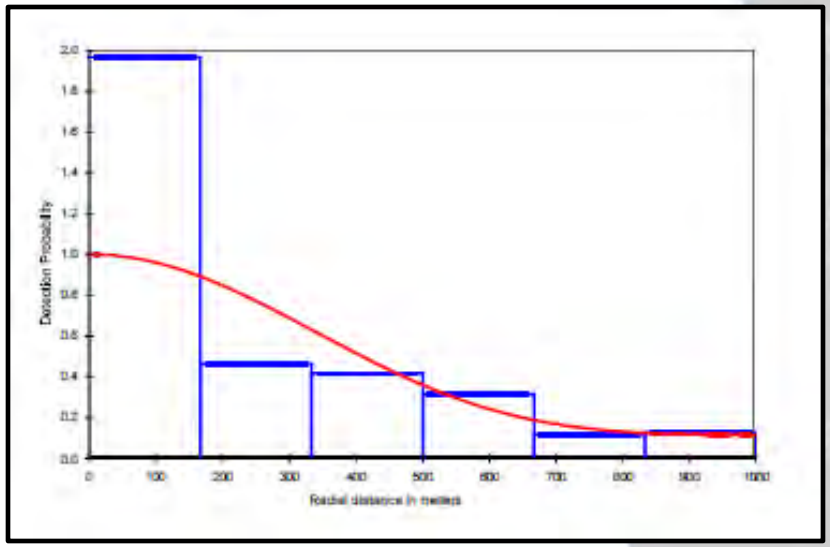
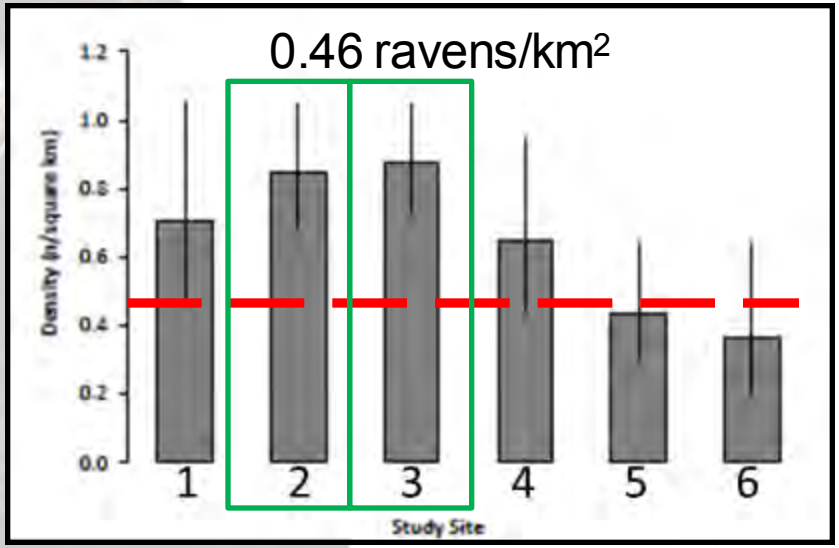
Threshold Examples



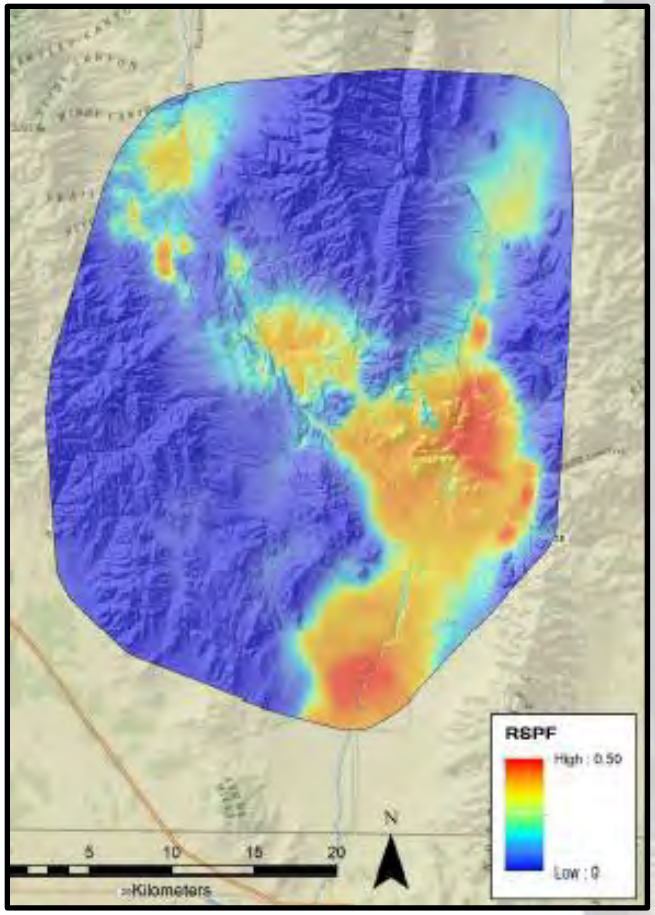


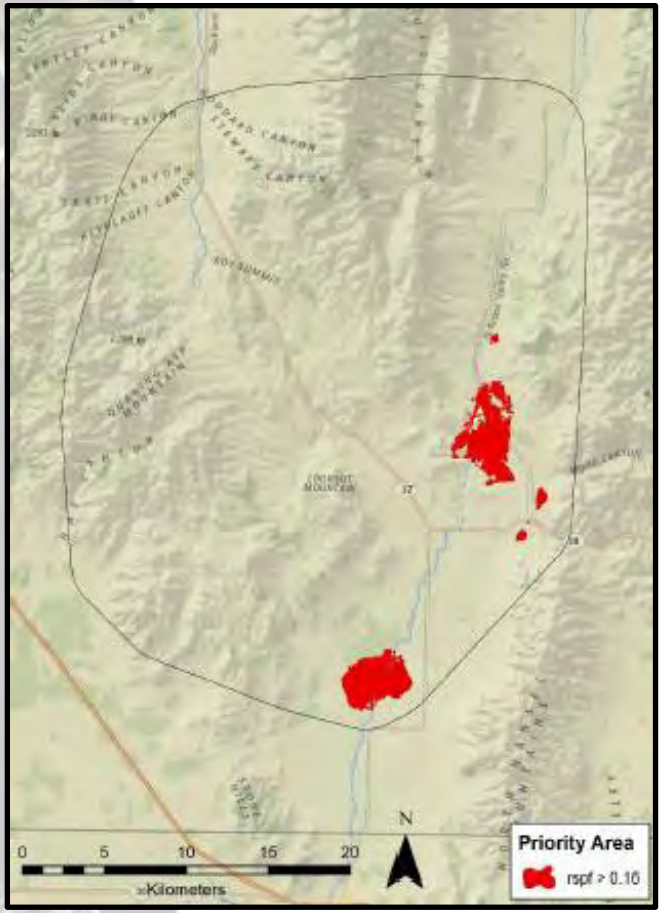
Area of High Concern

Management Prescription

Objectives 1, 2, & 3. Removal of anthropogenic subsidies, habitat restoration actions and direct raven treatment.

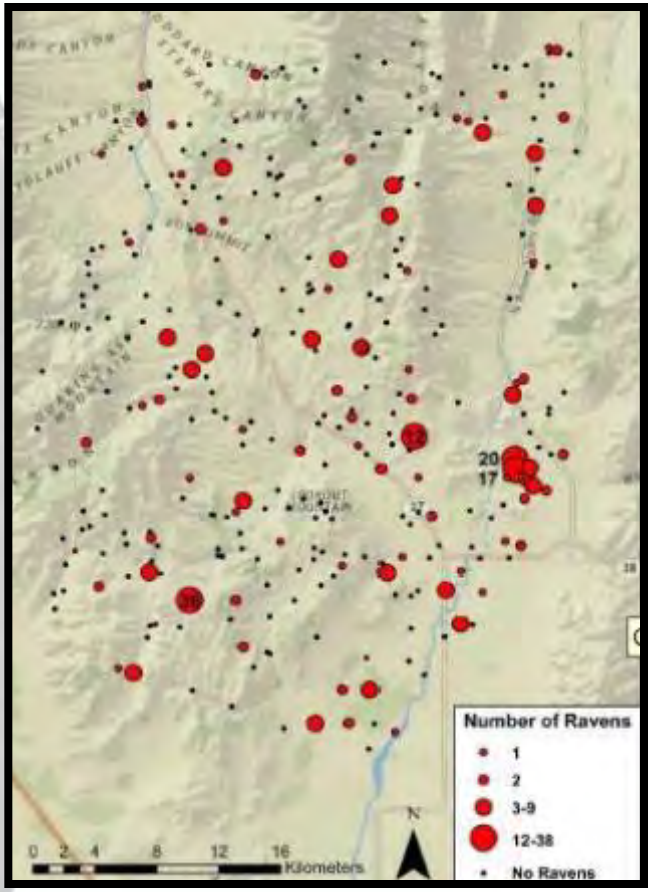
Identifying Problem Areas Example





Post-Monitoring Example

- **Continue standardized raven survey protocol**
- **Modify management actions based outcomes**
  - **Adjust plan to accommodate changes in raven numbers and use**
- **If possible, monitor species of concern for improvement in demographic rates/population monitoring**



Adaptive Management Example

- **Add new sites**
- **Remove sites that have improved**
- **Incorporate new data for additional species of concern**
- **Add new management actions based on new findings**

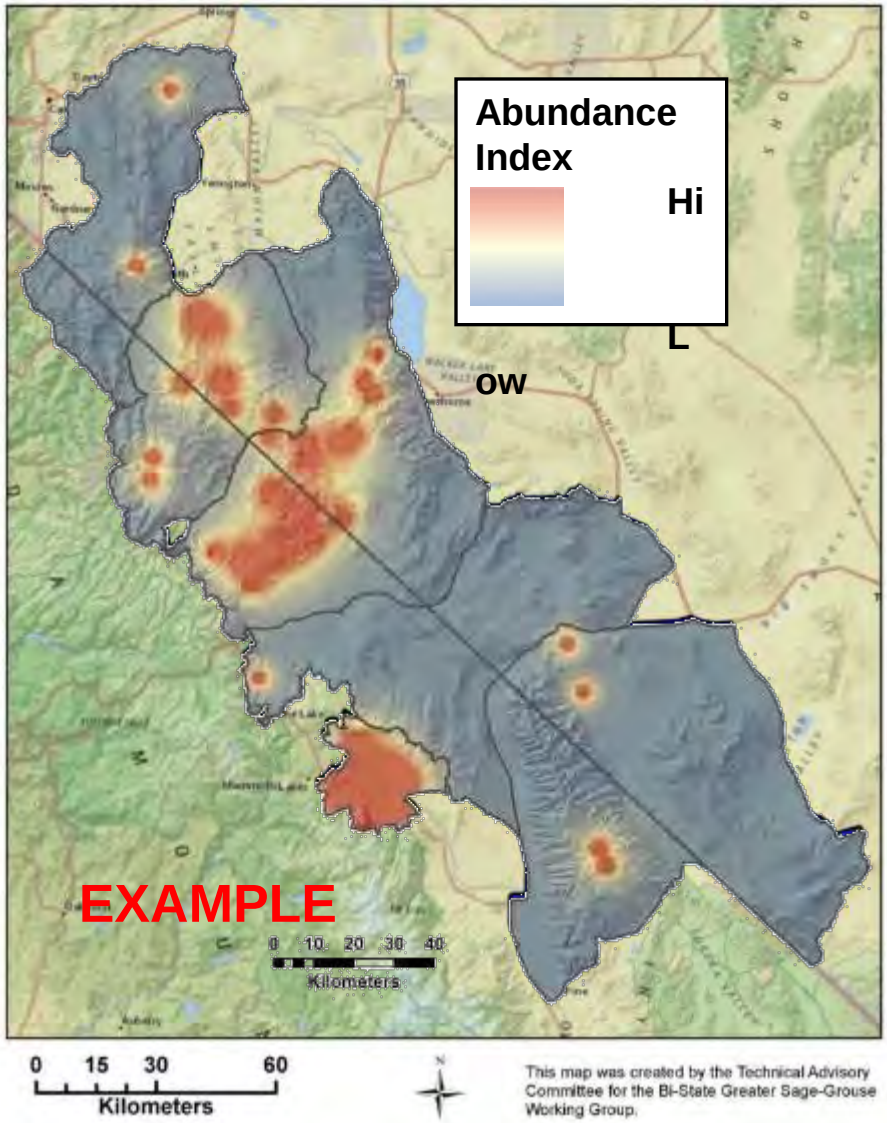
Conservation Planning Tools

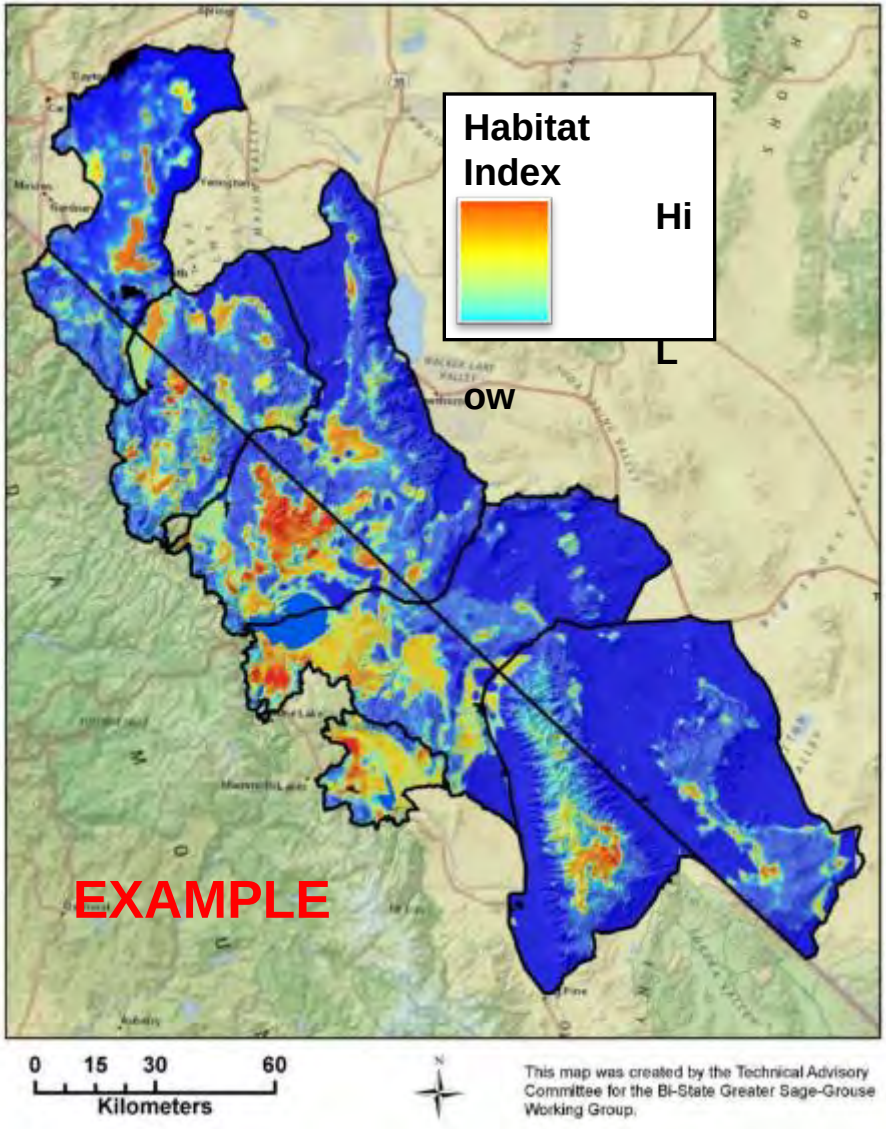
Using Analytical Tools to Minimize Anthropogenic Impacts:

Powerline Route and Sage-Grouse Example

Conservation Planning Tool – Bi-State Example

Sage-Grouse Abundance and Habitat Selection Indices





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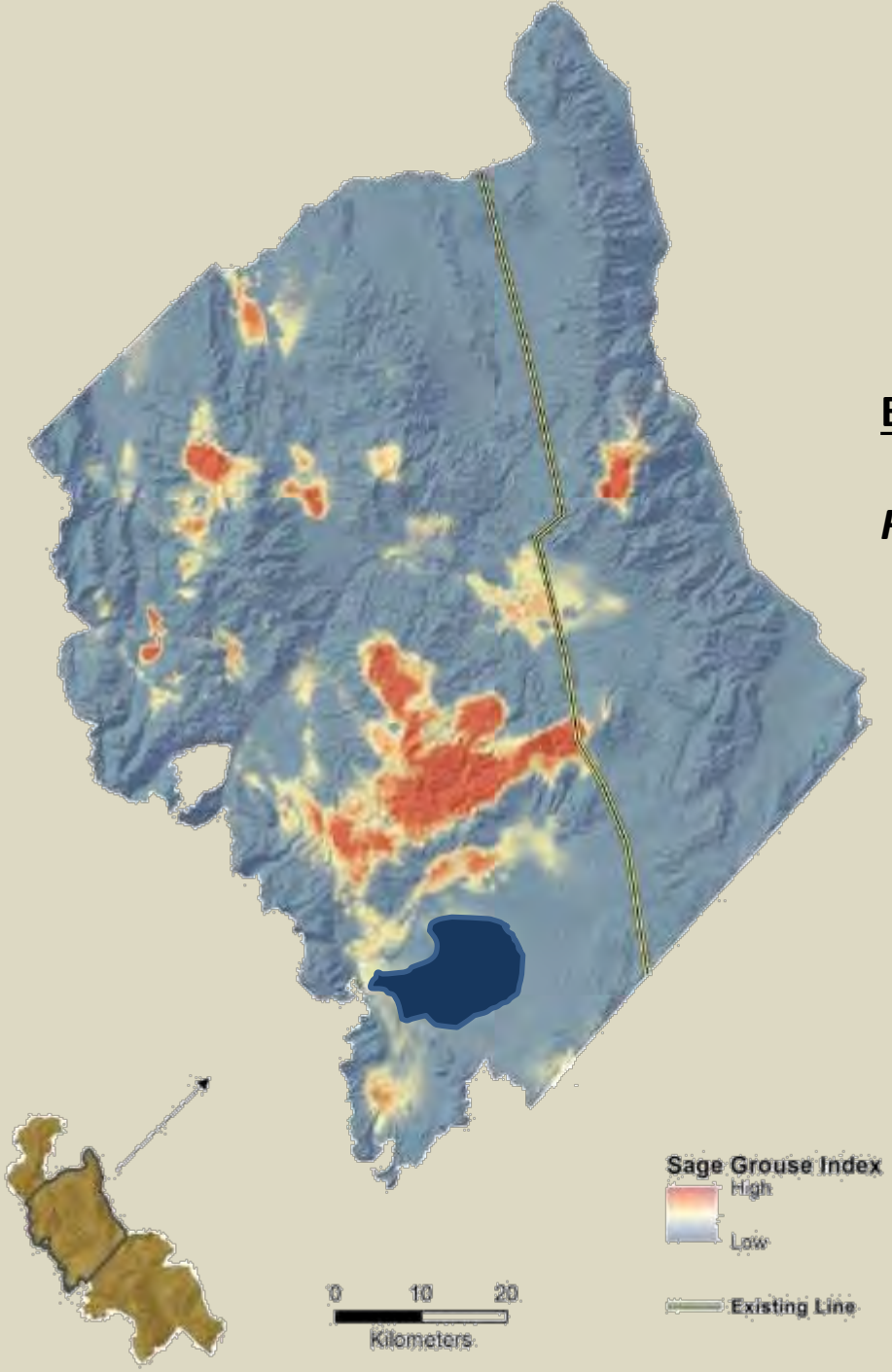

Example Scenario:

Response Index

Sage-Grouse Space Use

Sage-grouse Resource Selection Functions

USGS
science for a changing world

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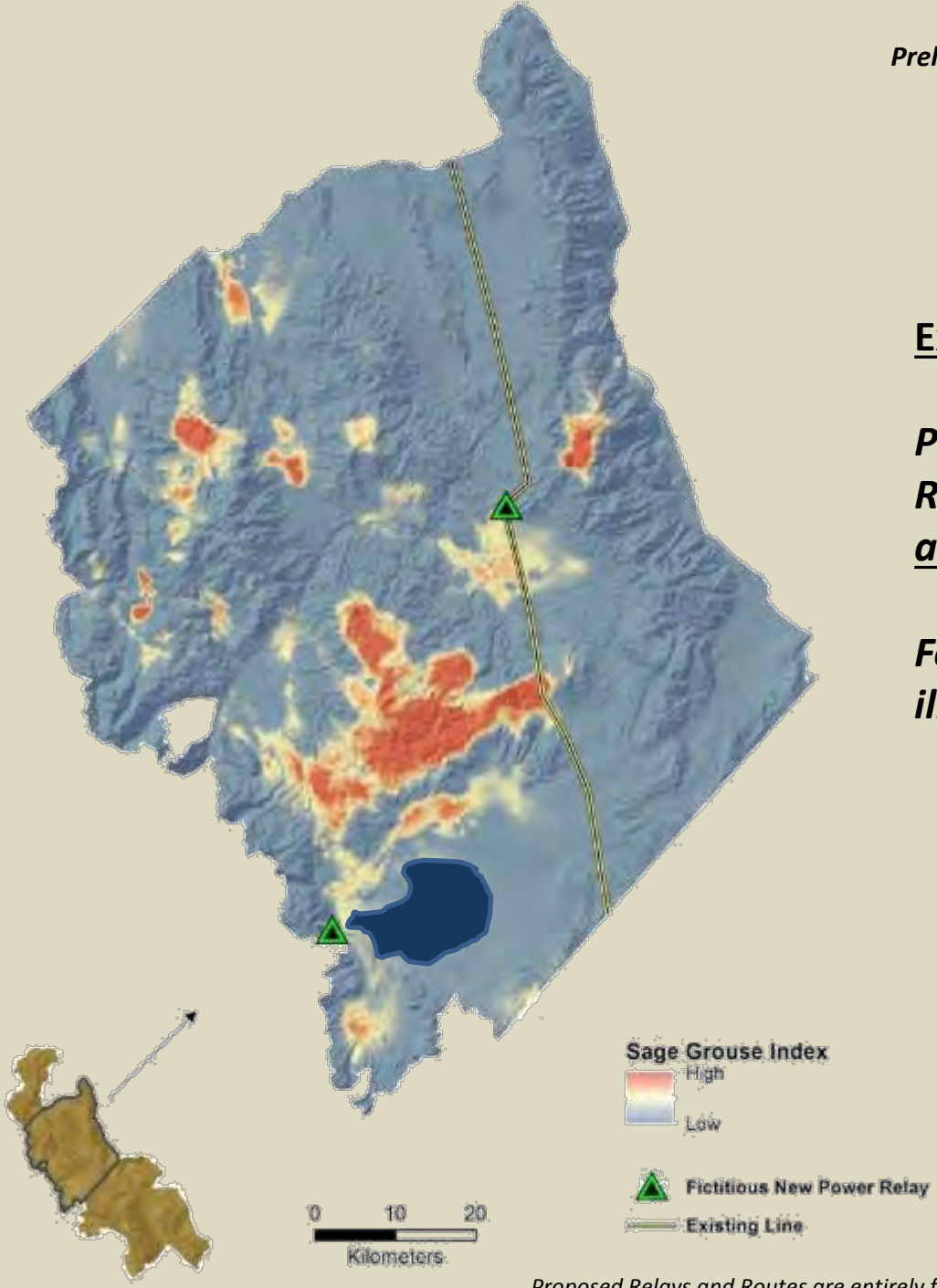

Example Scenario:

Proposed Relays and Routes that follow are entirely fictitious.

For example illustration only

Proposed Relays and Routes are entirely fictitious. For CPT example illustration only

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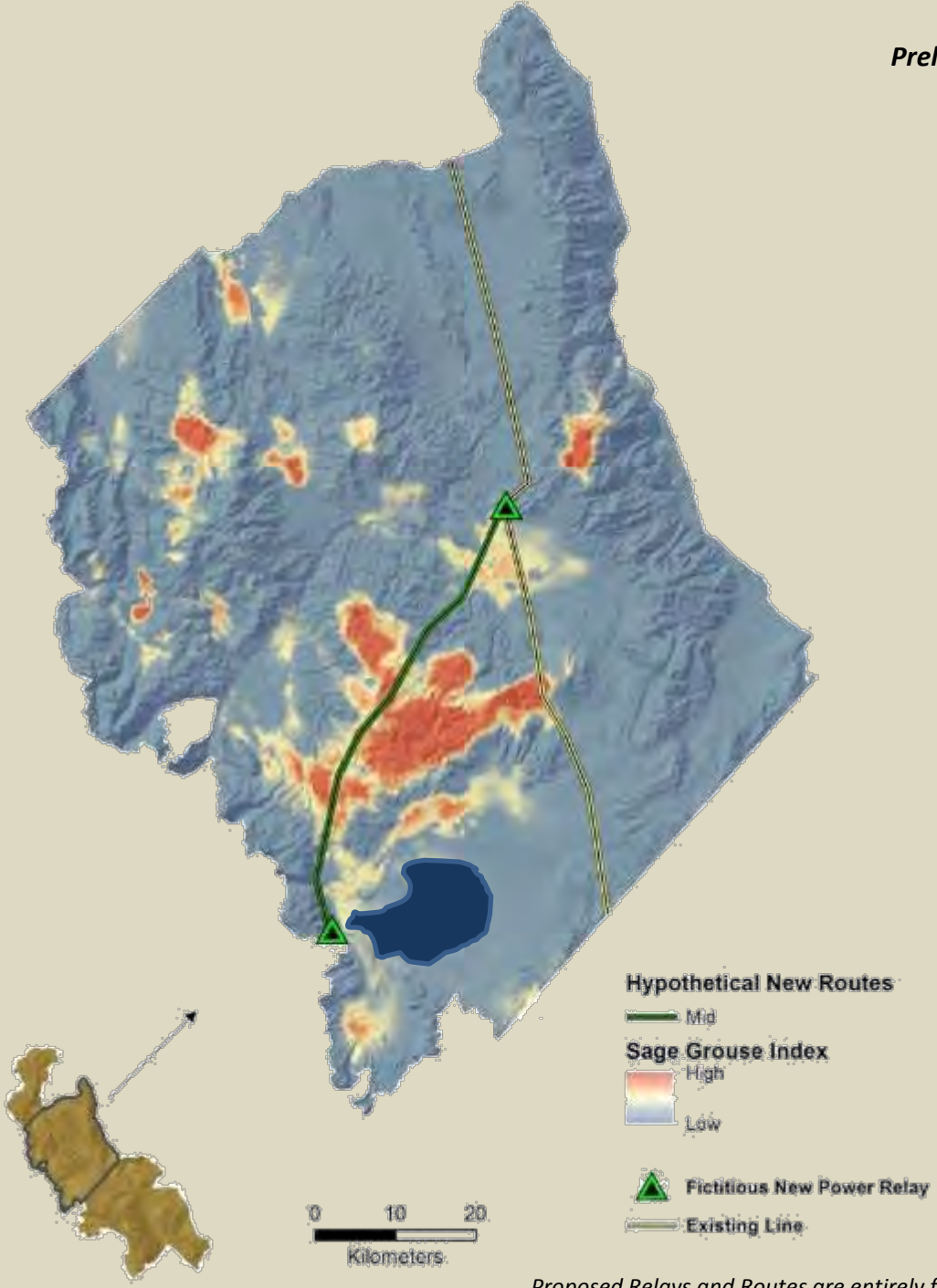

Proposed Relays and Routes are entirely fictitious. For CPT example illustration only

USGS
science for a changing world

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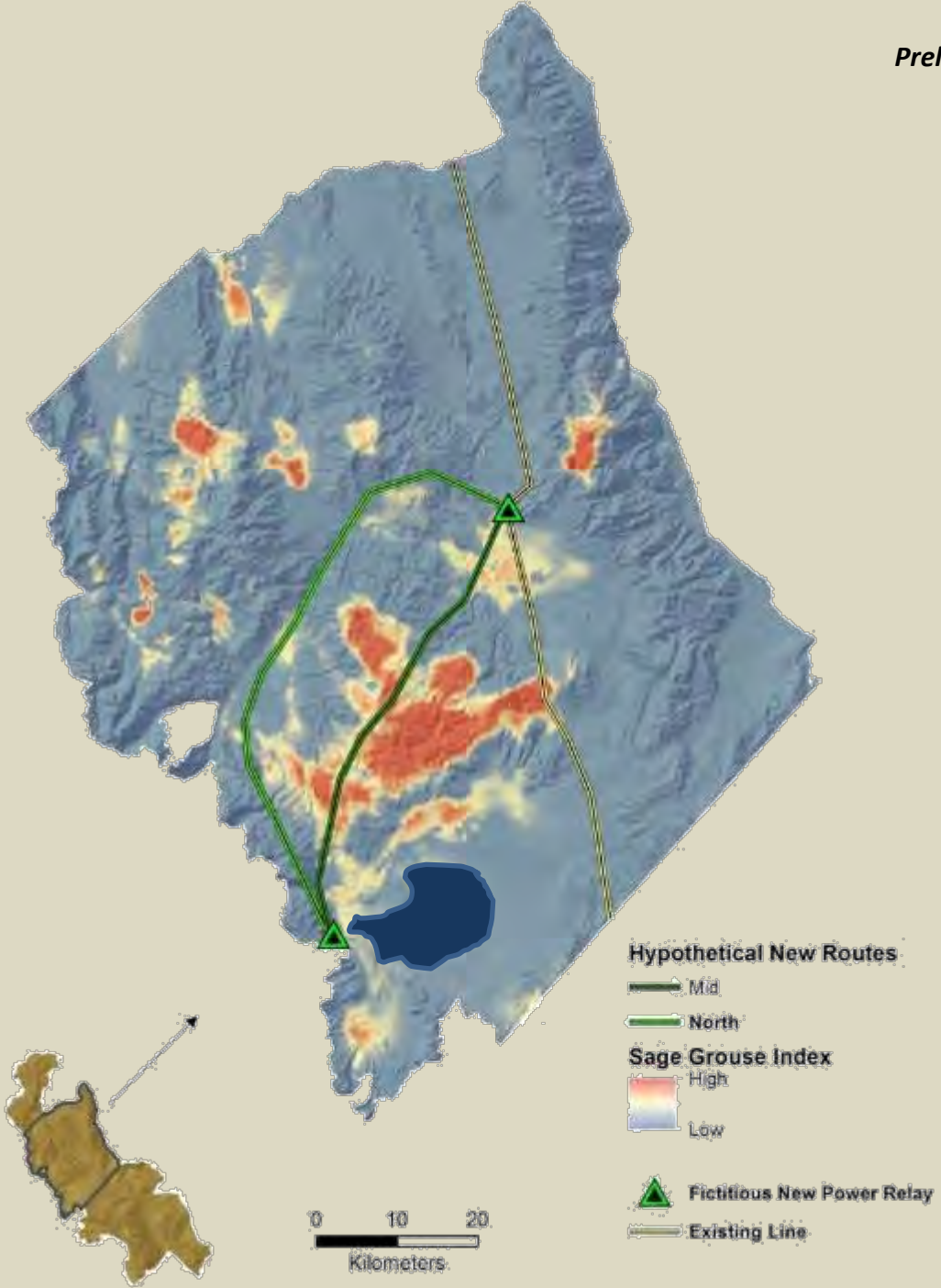

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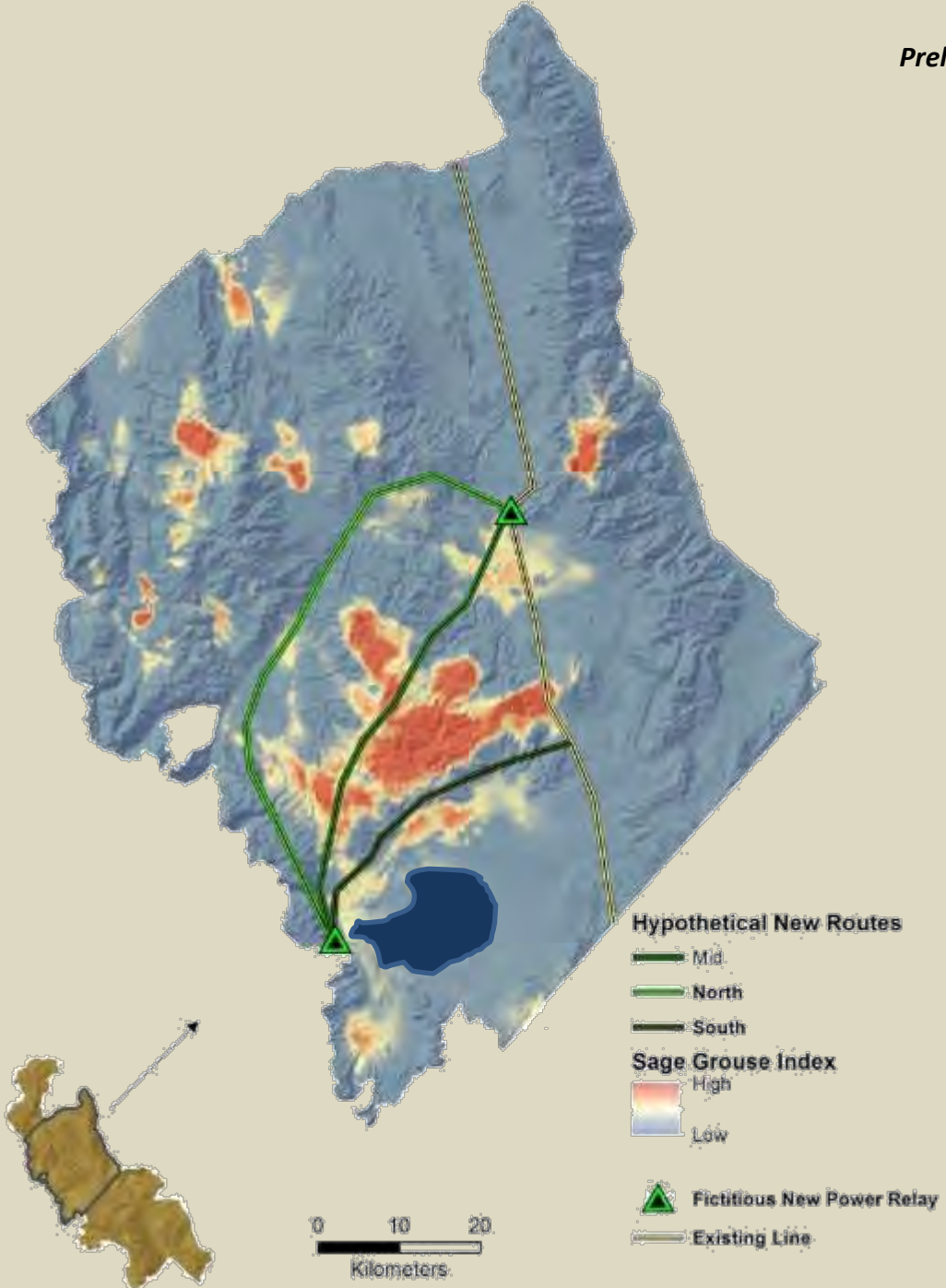
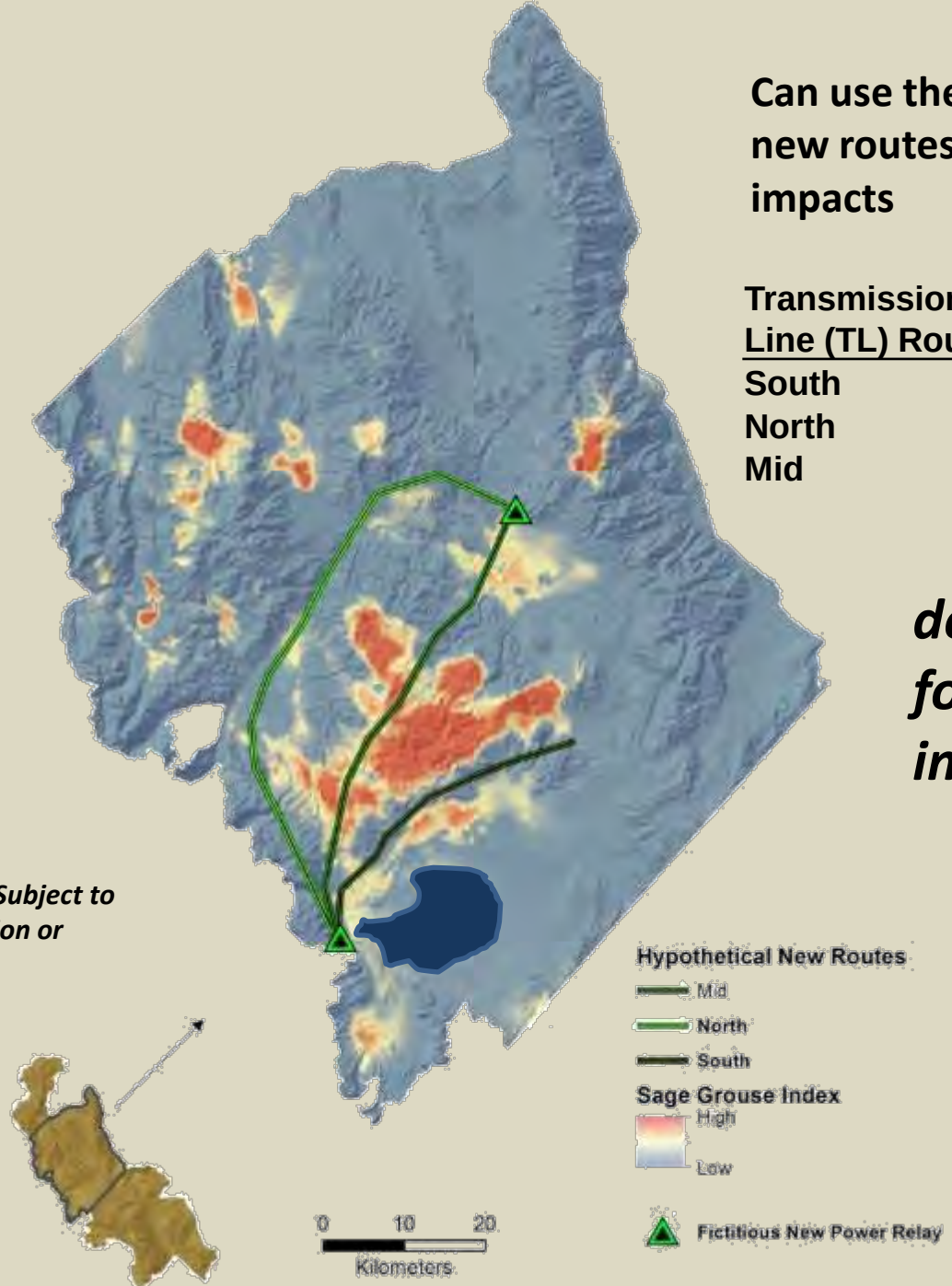


Proposed Relays and Routes are entirely fictitious. For CPT example illustration only

Can use the Σ SGI intersecting new routes to estimate potential impacts

Transmission Line (TL) Route	Σ SGI	Evidence Ratio
South	9.2	-
North	10.4	1.1
Mid	245.9	26.8

does not account for potential indirect effects



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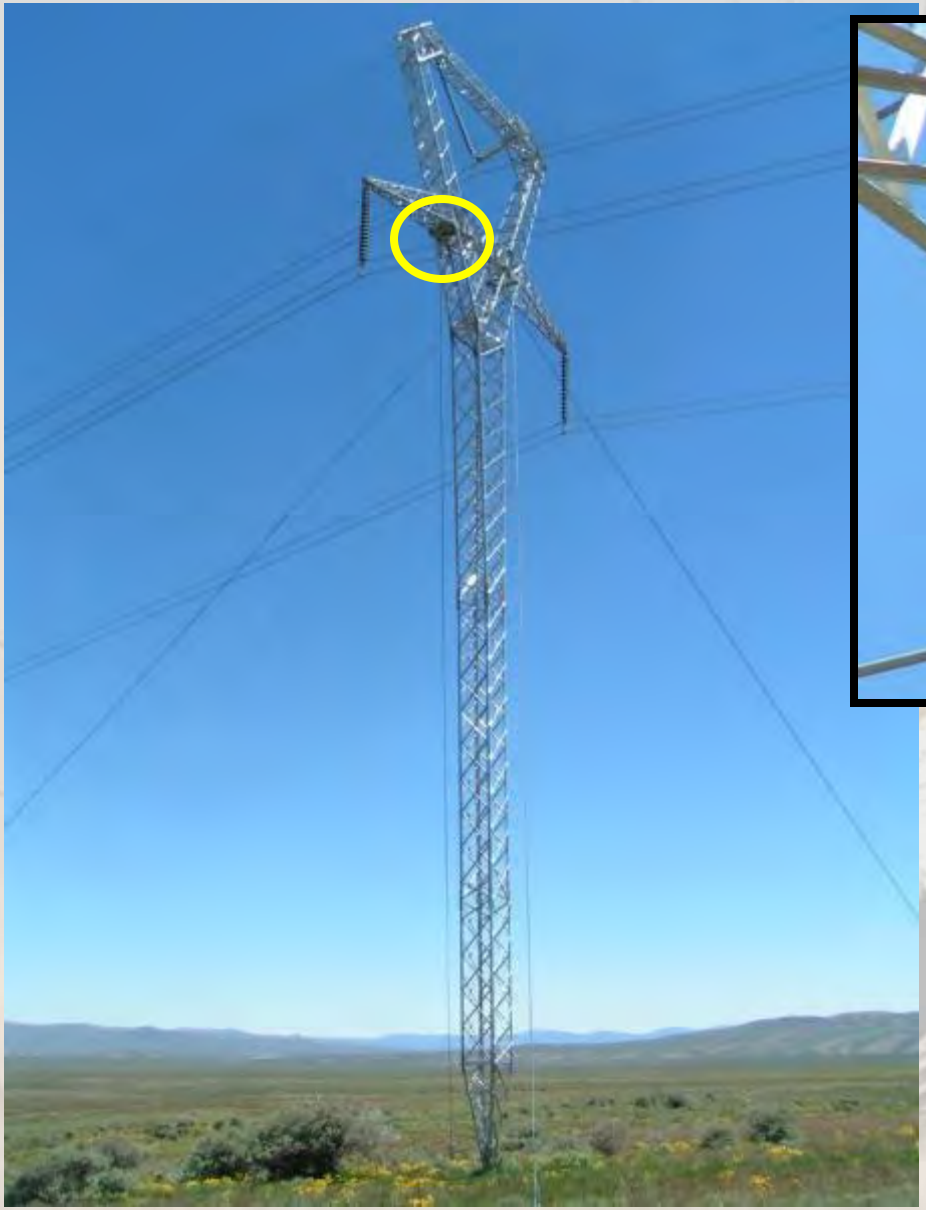
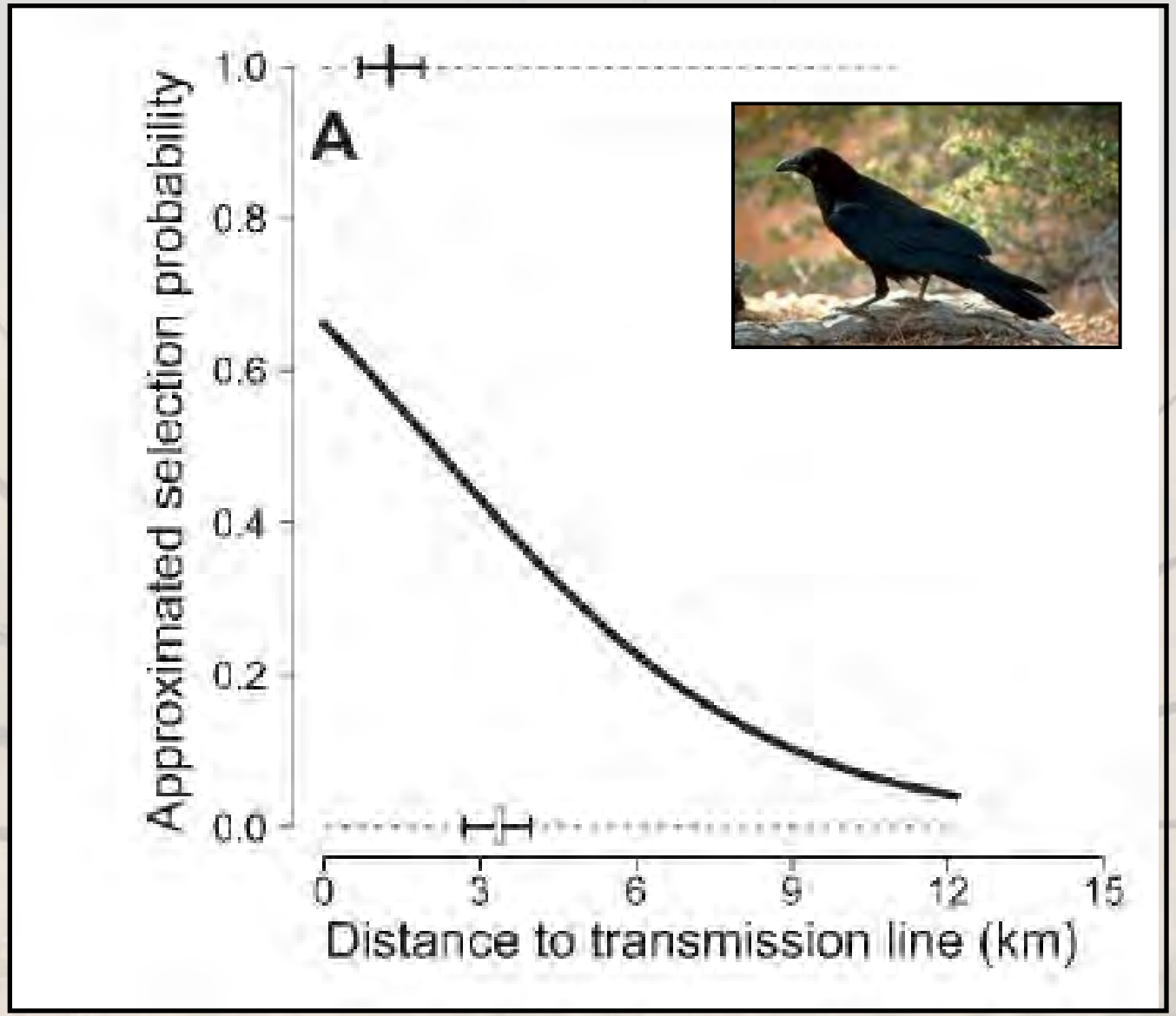
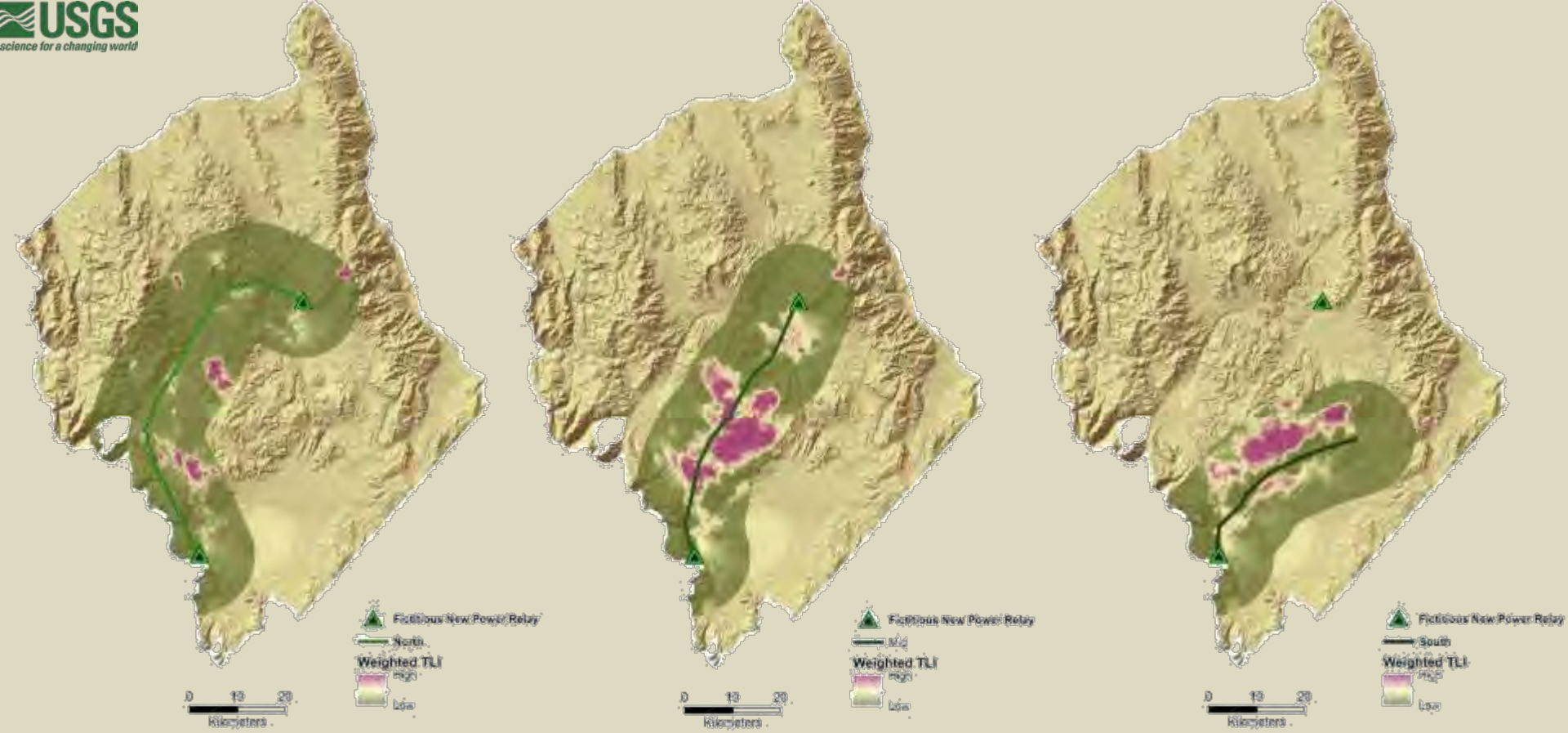
Proposed Relays and Routes are entirely fictitious. For CPT example illustration only



Accounting for distance based effects



Howe et al. Condor 116:35–49.



Transmission Line (TL) Route	TLI	Total Impact (TLI * # pixels)	Evidence Ratio
North	0.018	40335	-
South	0.169	239172	5.9
Mid	0.149	280896	7.0

Proposed Relays and Routes are entirely fictitious. For CPT example illustration only

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Take Home Points

- Breeding and non-breeding raven densities are growing drastically
- Anthropogenic resource subsidies are contributing to this growth
- Increasing evidence of raven numbers linked to low reproduction of prey species
  - current studies are evidencing impacts to population growth
- Science-based, multifaceted raven adaptive management action plans will likely be most successful
- Existing research findings can also guide strategic analytical planning of additional anthropogenic developments (e.g., type and placement)