

# RAVEN SCIENCE, ECOLOGY, AND MANAGEMENT: TARGETING SOLUTIONS WITH APPLIED SCIENCE



Pete S. Coates<sup>1</sup>, Joseph L. Atkinson<sup>1</sup>, William I. Boarman<sup>2</sup>, Brianne E. Brussee<sup>1</sup>, Michael P. Chenaille<sup>1</sup>, David J. Delehanty<sup>3</sup>, Seth J. Dettenmaier<sup>1</sup>, Jonathan B. Dinkins<sup>4</sup>, Ian A. Dwight<sup>5</sup>, Seth M. Harju<sup>6</sup>, Kerry L. Holcomb<sup>7</sup>, Pat J. Jackson<sup>8</sup>, Shawn T. O'Neil<sup>1</sup>, Brian G. Prochazka<sup>1</sup>, Mark A. Ricca<sup>1</sup>, Timothy Shields<sup>2</sup>, John C. Tull<sup>7</sup>, William C. Webb<sup>3</sup>, Sarah C. Webster<sup>1</sup>, Cali L. Wiese<sup>1</sup>

<sup>1</sup>U.S. Geological Survey | <sup>2</sup>Hardshell Labs, Inc. | <sup>3</sup>Idaho State University

<sup>4</sup>Oregon State University | <sup>5</sup>California Department of Fish and Game

<sup>6</sup>Heron Ecological, LLC | <sup>7</sup>U.S. Fish and Wildlife | <sup>8</sup>Nevada Department of Wildlife

## 22 peer-reviewed papers on raven ecology and management

Articles supported by NDOW \$3 predator fee:

- Raven population trends
- Occurrence, resource use and demography of ravens
- Density and occurrence modeling within Great Basin
- Nest predation impacts of ravens on sensitive species
- Ravens disrupt lekking sage-grouse
- Tortoise raven viable conflict threshold
- Rapid assessment to estimate raven densities
- Effects of lethal removal of ravens
- Manipulating raven reproduction to conserve prey species
- Science-based framework for management of ravens



# Estimating trends of common raven populations in North America, 1966–2018

**SETH M. HARJU**, Heron Ecological, LLC., P.O. Box 235, Kingston, ID 83839, USA  
*seth@heronecological.com*

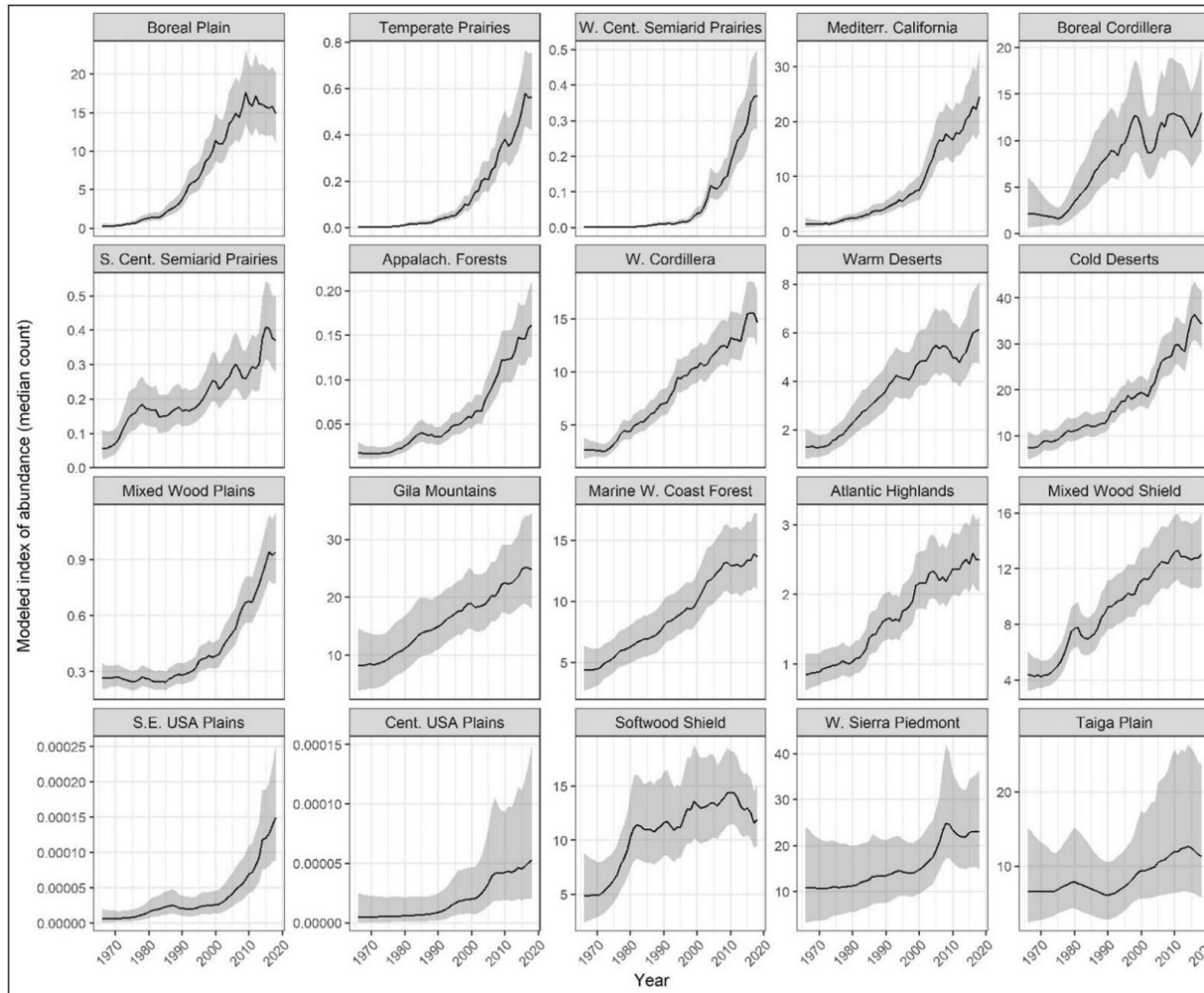
**PETER S. COATES**, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA

**SETH J. DETTENMAIER**, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA

**JONATHAN B. DINKINS**, Department of Animal and Rangeland Sciences, Oregon State University, 2921 SW Campus Way, Corvallis, OR 97331, USA

**PAT J. JACKSON**, Nevada Department of Wildlife, 6980 Sierra Parkway, Suite 120, Reno, NV 89511, USA

**MICHAEL P. CHENAILLE**, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA



# Estimating trends of common raven populations in North America, 1966–2018

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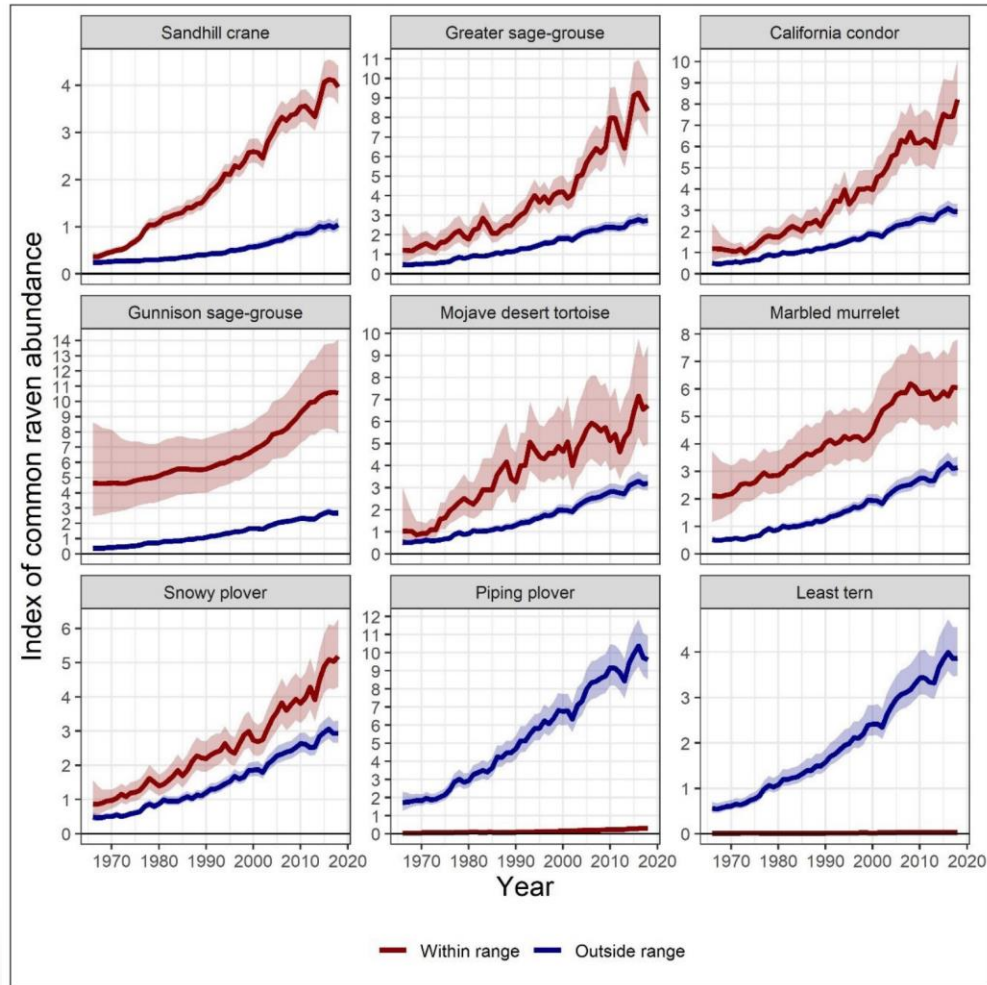
**PETER S. COATES**, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA

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**MICHAEL P. CHENAILLE**, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA





## Techniques

### A rapid assessment function to estimate common raven population densities: implications for targeted management

**BRIANNE E. BRUSSEE**, U.S. Geological Survey, Western Ecological Research Center, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA

**PETER S. COATES**, U.S. Geological Survey, Western Ecological Research Center, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA [pcoates@usgs.gov](mailto:pcoates@usgs.gov)

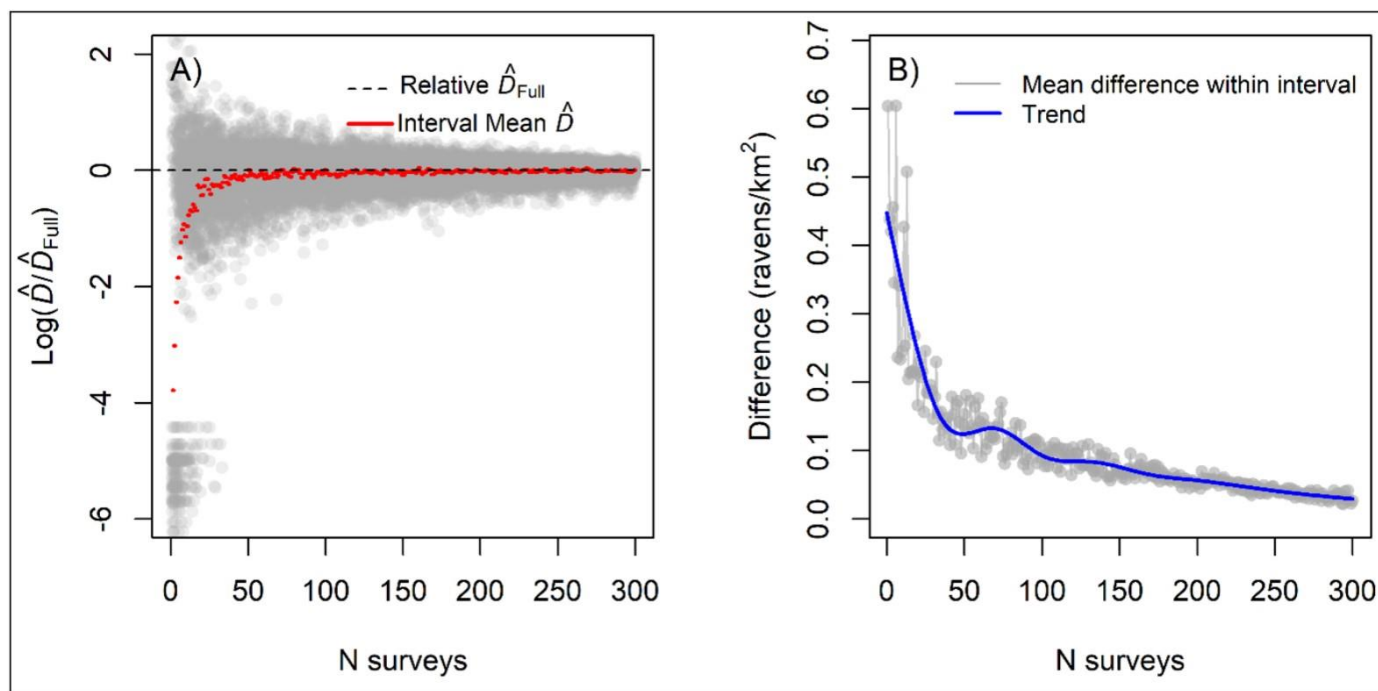
**SHAWN T. O'NEIL**, U.S. Geological Survey, Western Ecological Research Center, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA

**SETH J. DETTENMAIER**, U.S. Geological Survey, Western Ecological Research Center, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA

**PAT J. JACKSON**, Nevada Department of Wildlife, Reno, NV 89511, USA

**KRISTY B. HOWE**, Nevada Division of Natural Heritage, Carson City, NV 89701, USA

**DAVID J. DELEHANTY**, Idaho State University, Department of Biological Sciences, Pocatello, ID 83209, USA



## Case Study

# SMaRT: a science-based tiered framework for common ravens

**SETH J. DETTENMAIER**, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA

**PETER S. COATES**, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA [pcoates@usgs.gov](mailto:pcoates@usgs.gov)

**CALI L. ROTH**, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA

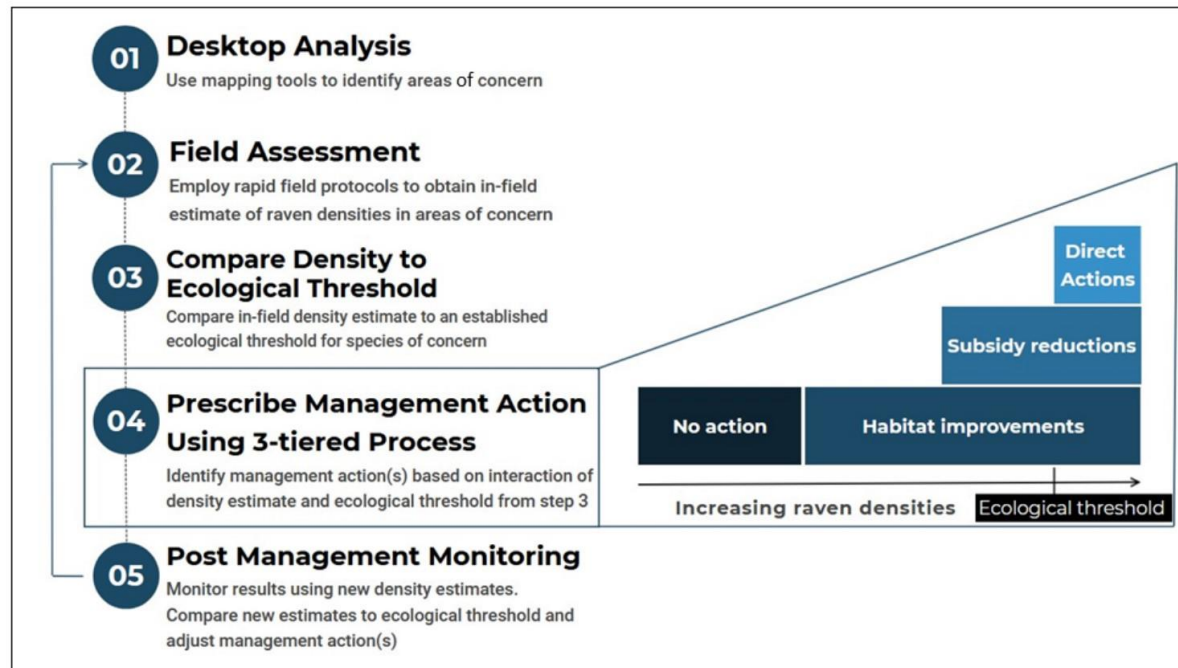
**SARAH C. WEBSTER**, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA

**SHAWN T. O'NEIL**, U.S. Geological Survey, Western Ecological Research Center, Dixon Field Station, 800 Business Park Drive, Suite D, Dixon, CA 95620, USA

**KERRY L. HOLCOMB**, U.S. Fish and Wildlife Service, Palm Springs Fish and Wildlife Office, 777 East Tahquitz Canyon Way, Suite 208, Palm Springs, CA 92262, USA

**JOHN C. TULL**, U.S. Fish and Wildlife Service, Science Applications, 1340 Financial Boulevard, Reno, NV 89502, USA

**PAT J. JACKSON**, Nevada Department of Wildlife, Reno, NV 89511, USA



## Problem

Expansion of raven distribution and abundance



Anthropogenic resource subsidies



Predation effects on sensitive species

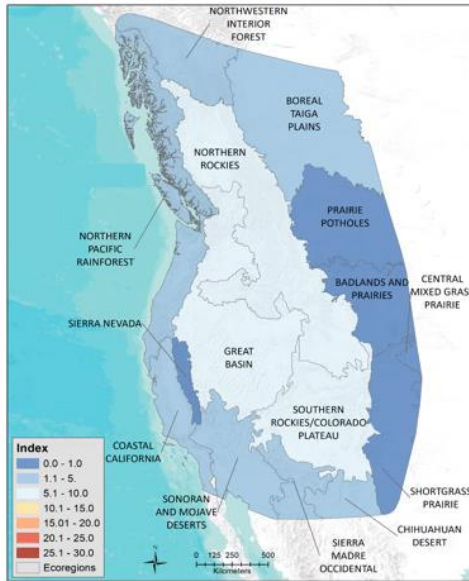
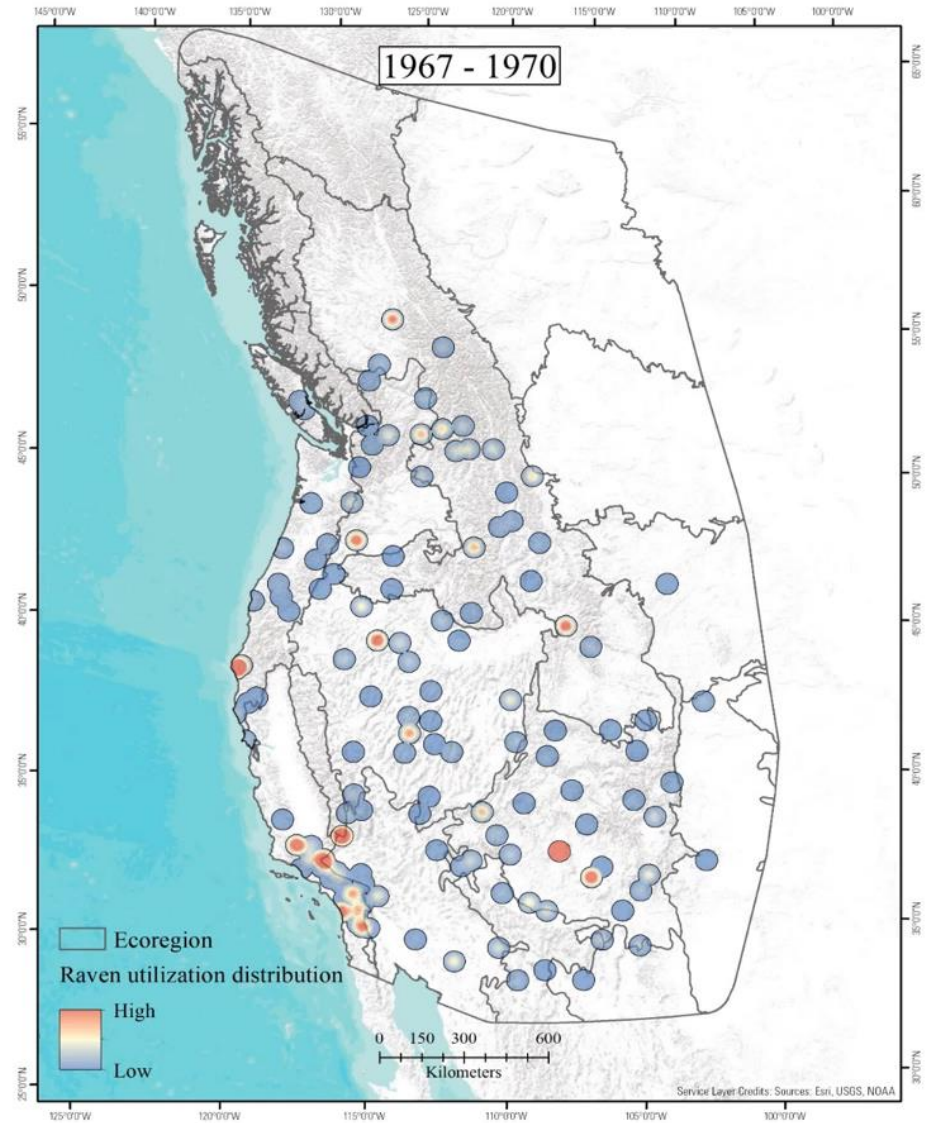
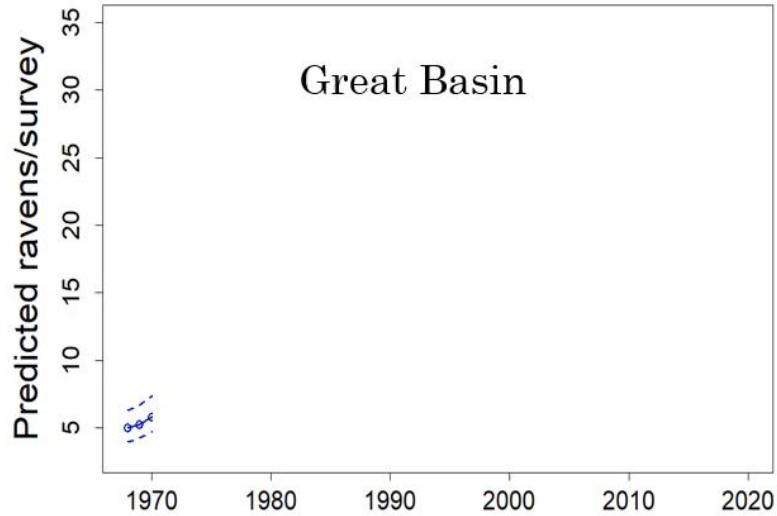
## Solution

Science-based tiered framework



Decision support tools - SMaRT

# Raven Populations are Increasing





# Reviewing the Raven Issue

## Problem

Expansion of raven distribution and abundance



**Anthropogenic resource subsidies**



Predation effects on sensitive species

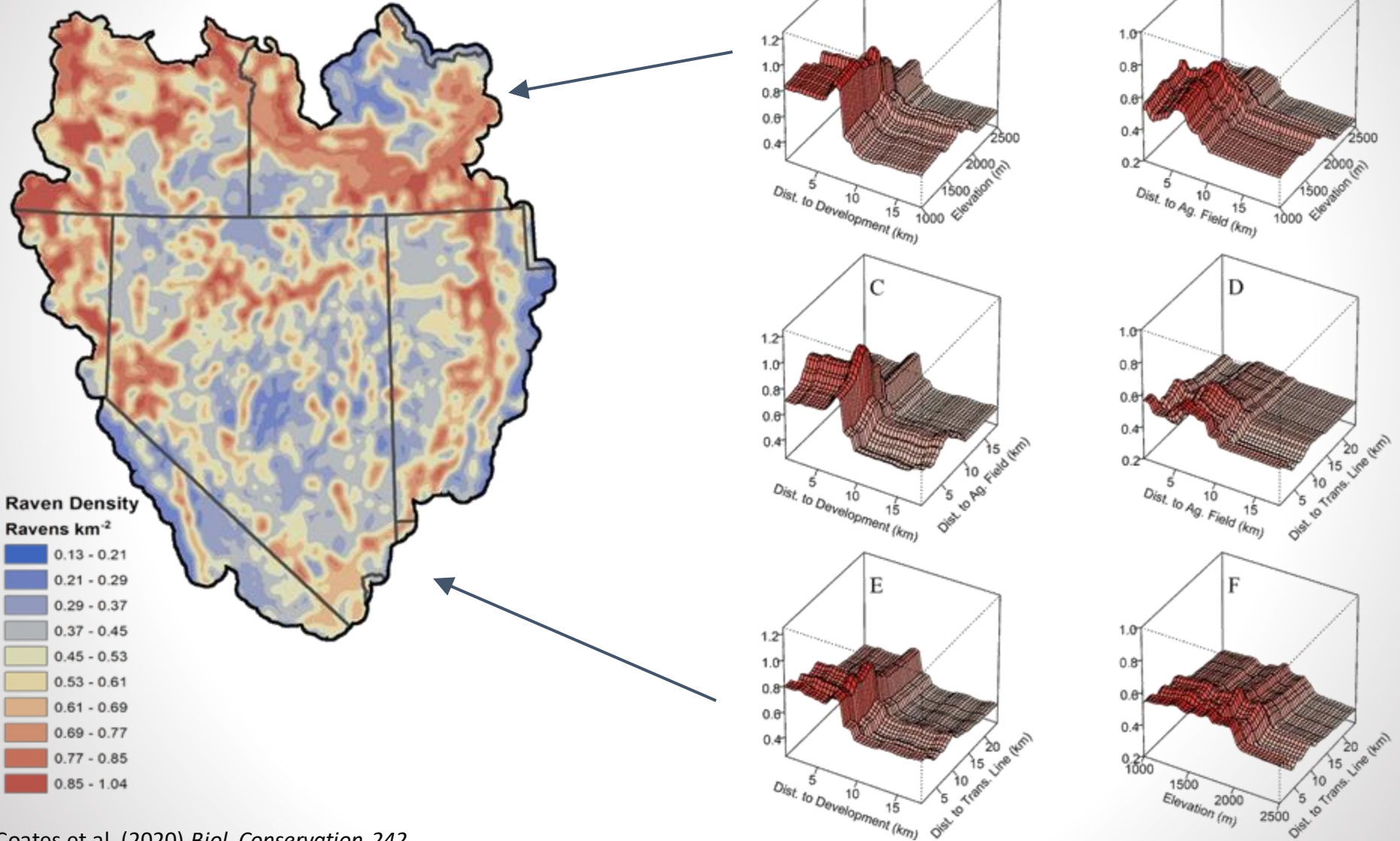
## Solution

Science-based tiered framework

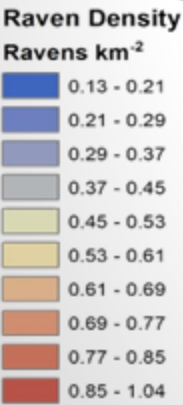
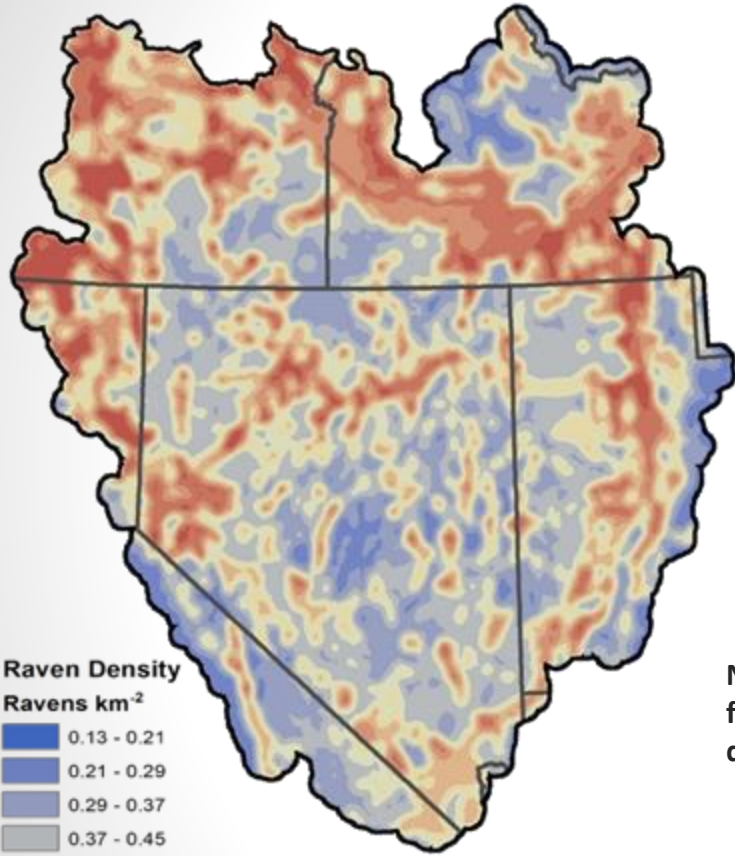


Decision support tools - SMaRT

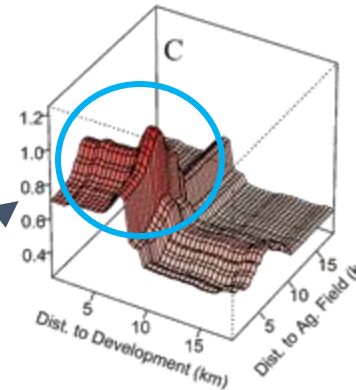
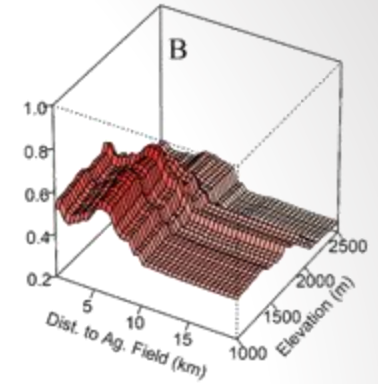
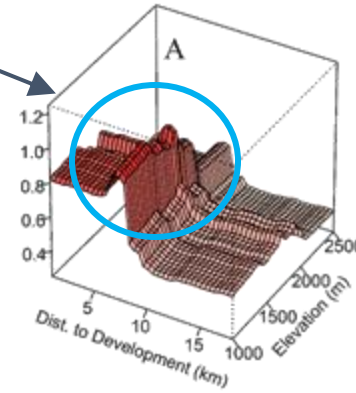
# Anthropogenic subsides influence density



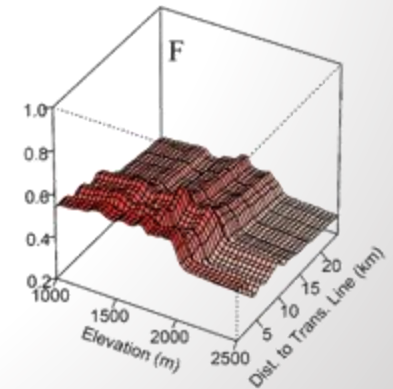
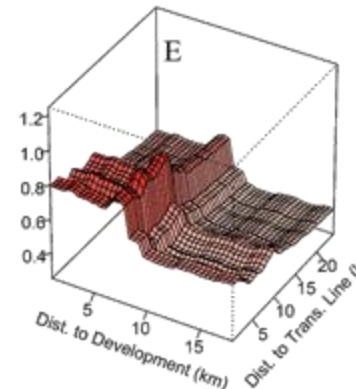
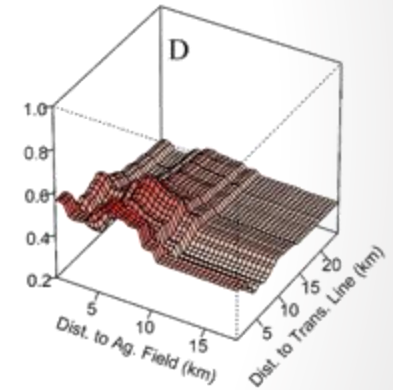
# Anthropogenic subsidies influence density



Near developed areas  
at lower elevation



Near agricultural  
fields and closer to  
development





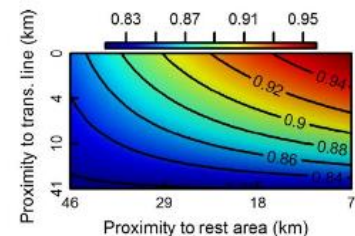
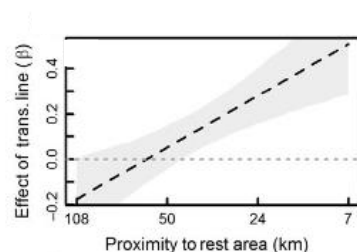
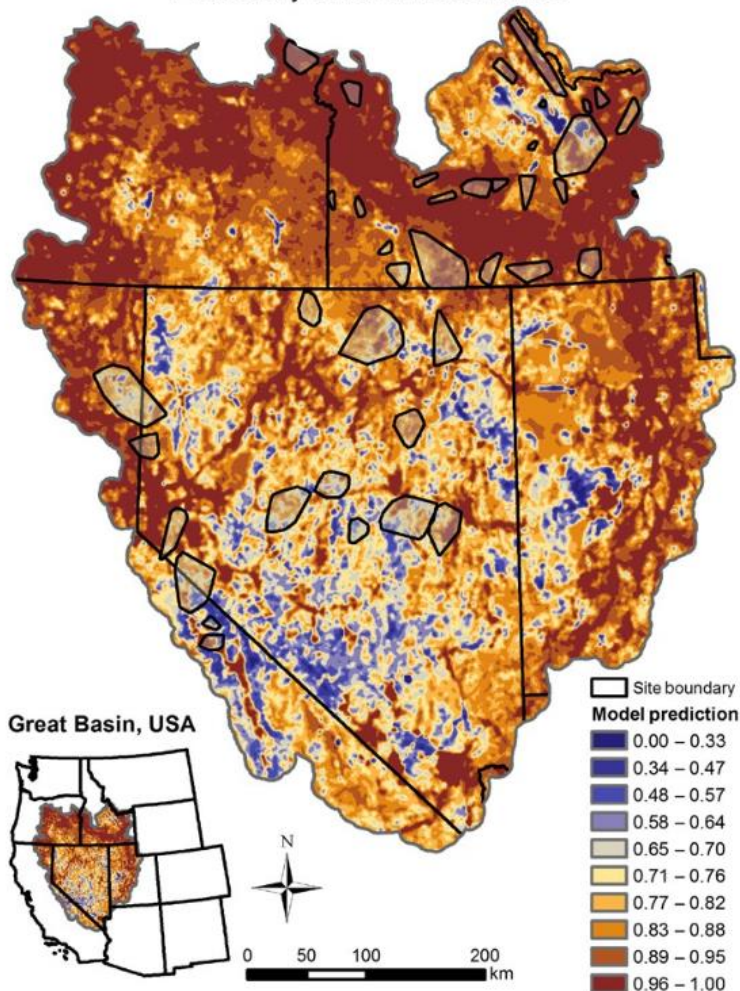
# Anthropogenic subsides influence occupancy

## Broad-scale occurrence of a subsidized avian predator: Reducing impacts of ravens on sage-grouse and other sensitive prey

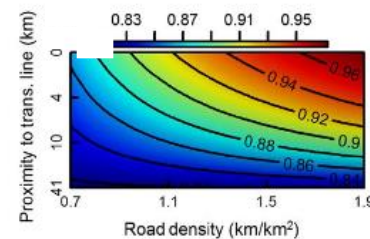
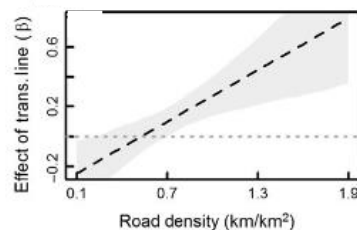
Shawn T. O'Neil<sup>1</sup> | Peter S. Coates<sup>1</sup> | Brianne E. Brussee<sup>1</sup> | Pat J. Jackson<sup>2</sup> | Kristy B. Howe<sup>3</sup> | Ann M. Moser<sup>4</sup> | Lee J. Foster<sup>5</sup> | David J. Delehanty<sup>6</sup>

<sup>1</sup>U.S. Geological Survey, Western Ecological Research Center, Dixon, California; <sup>2</sup>Nevada Department of Wildlife, Reno, Nevada; <sup>3</sup>Nevada Natural Heritage Program, Carson City, Nevada; <sup>4</sup>Idaho Department of Fish and Game, Boise, Idaho; <sup>5</sup>Oregon Department of Fish and Wildlife, Hines, Oregon and <sup>6</sup>Department of Biological Sciences, Idaho State University, Pocatello, Idaho

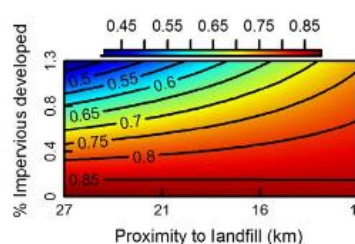
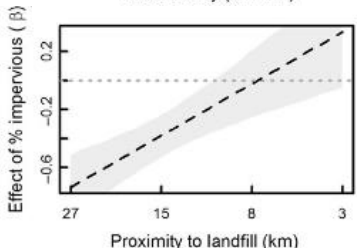
Probability of raven occurrence



Transmission line  
Rest area



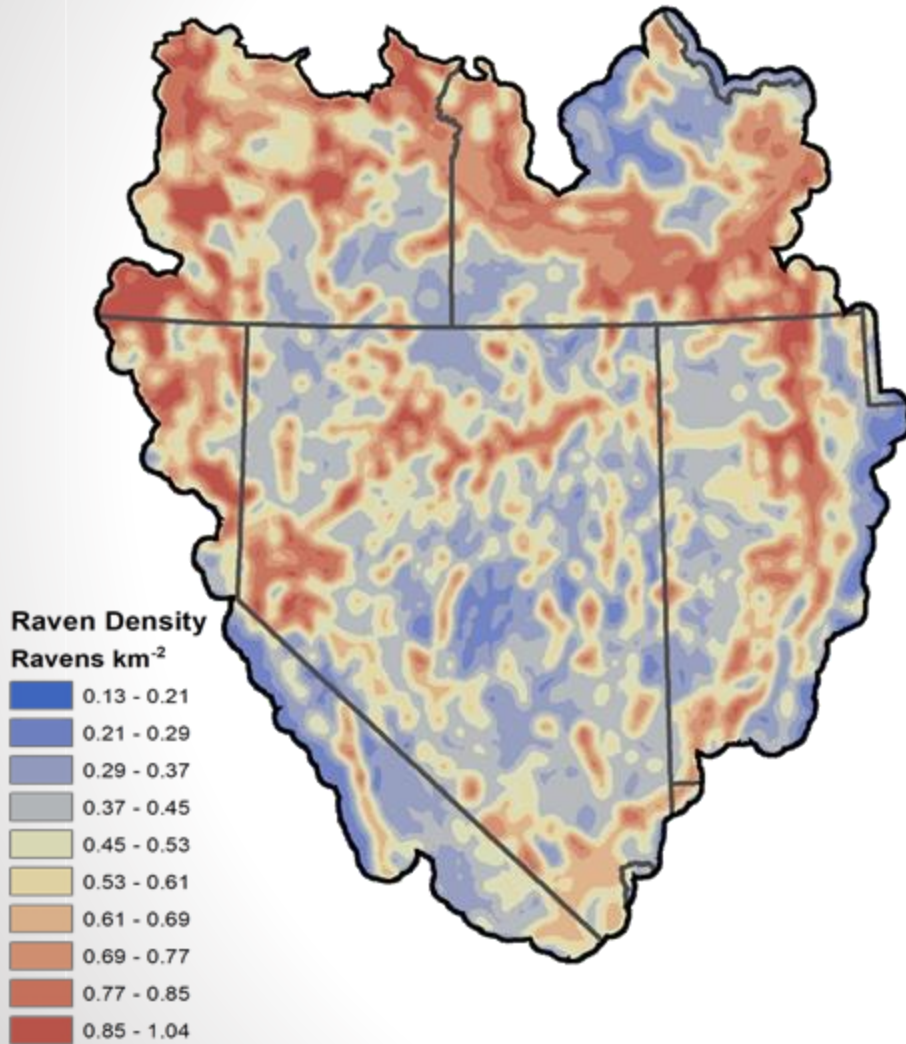
Transmission line  
Road density



Imperviousness  
Landfills



# Great Basin Raven Density and Numbers



Biological Conservation

Volume 243, March 2020, 108409



Broad-scale impacts of an invasive native predator on a sensitive native prey species within the shifting avian community of the North American Great Basin

Peter S. Coates <sup>a</sup>, Shawn T. O'Neil <sup>a</sup>, Brianne E. Brussee <sup>a</sup>, Mark A. Ricca <sup>a</sup>, Pat J. Jackson <sup>b</sup>, Jonathan B. Dinkins <sup>c</sup>, Kristy B. Howe <sup>d</sup>, Ann M. Moser <sup>e</sup>, Lee J. Foster <sup>f</sup>, David J. Delehanty <sup>g</sup>

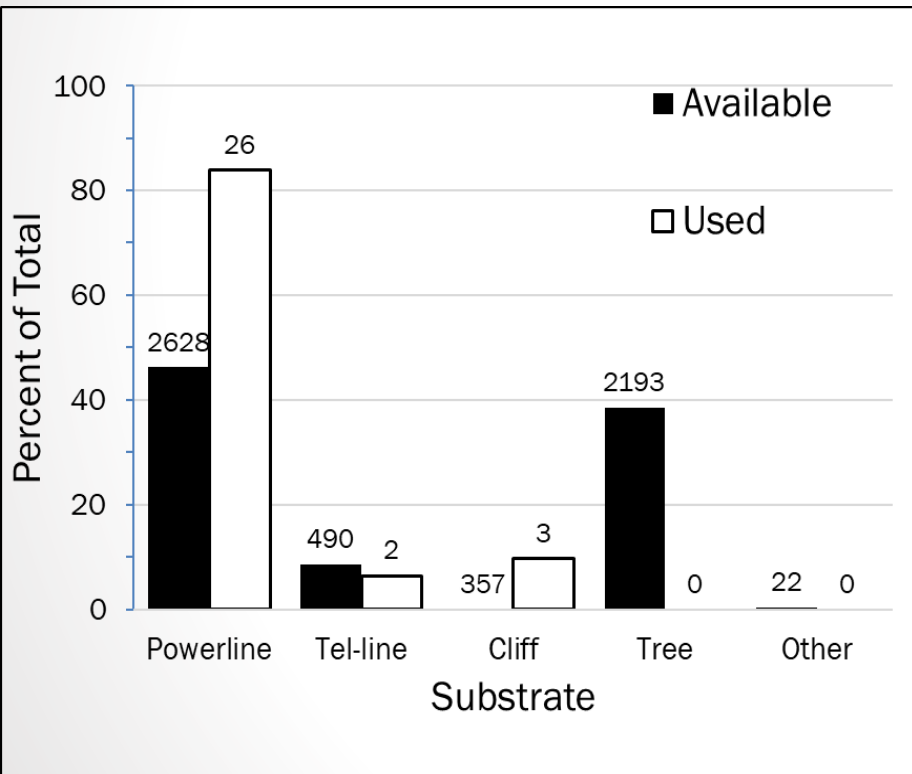
## Average raven density

0.54 ravens km<sup>-2</sup> (95% CI = 0.42–0.70)

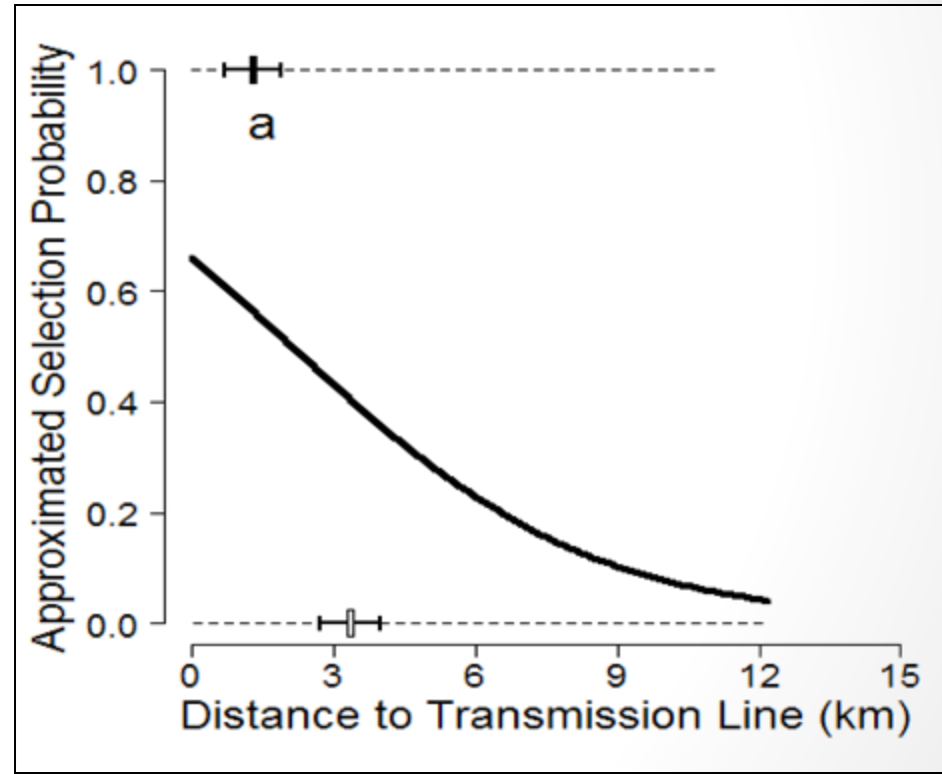
## Total abundance Great Basin

403,346 (95% CI = 310,783–522,803)

# Raven Nest Selection

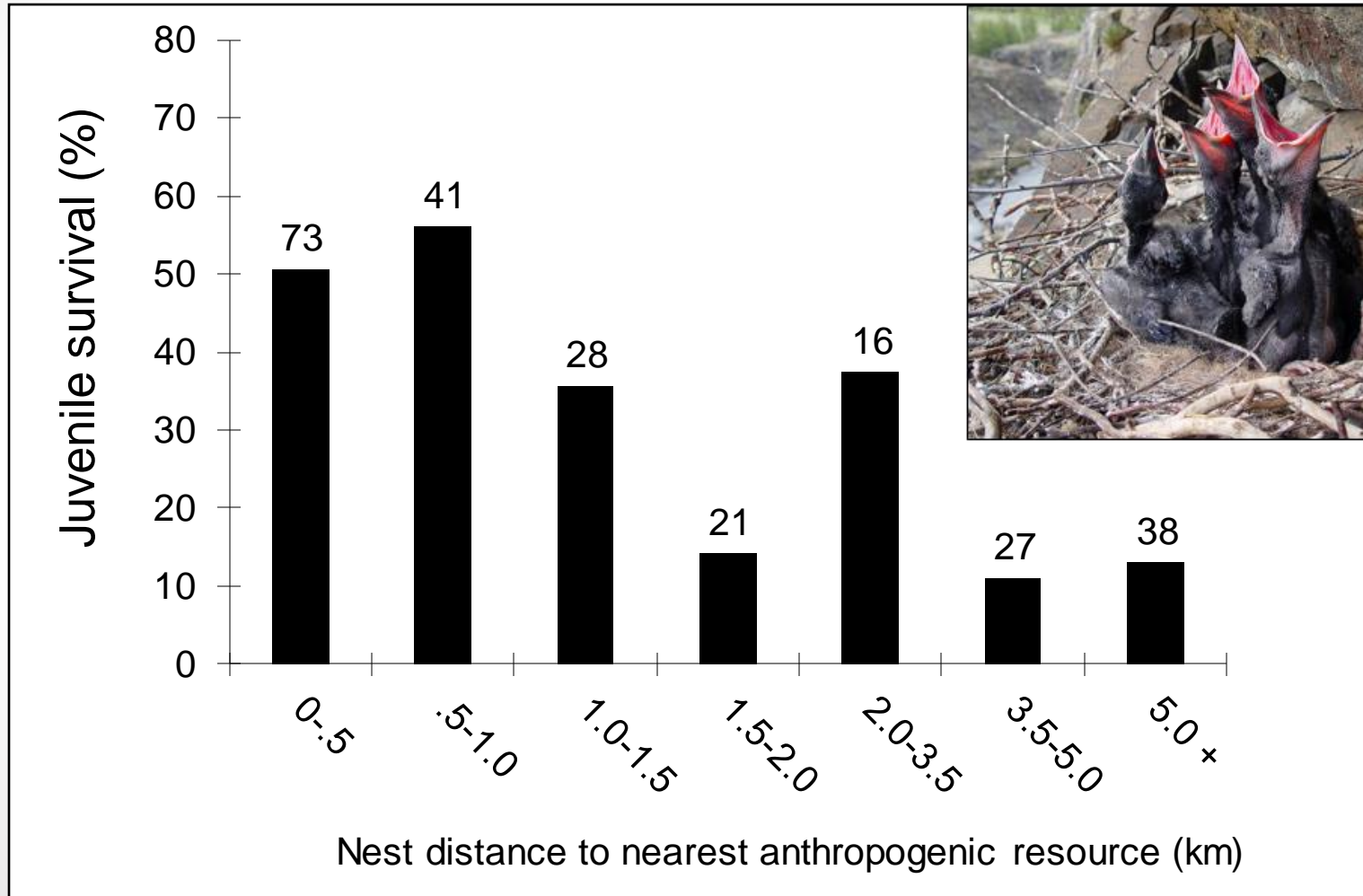


Knight and Kawashima. 1993. Responses of raven and red-tailed hawks to linear right-of-ways. *Journal of Wildlife Management* 57(2):266-271



Howe et al. 2014. Selection of anthropogenic features and vegetation characteristics by nesting common ravens in the sagebrush ecosystem. *The Condor: Ornithological Applications* 116:35-49

# Anthropogenic subsidies Benefit Ravens



## Problem

Expansion of raven distribution and abundance



Anthropogenic resource subsidies



**Predation effects on sensitive species**

## Solution

Science-based tiered framework



Decision support tools - SMaRT



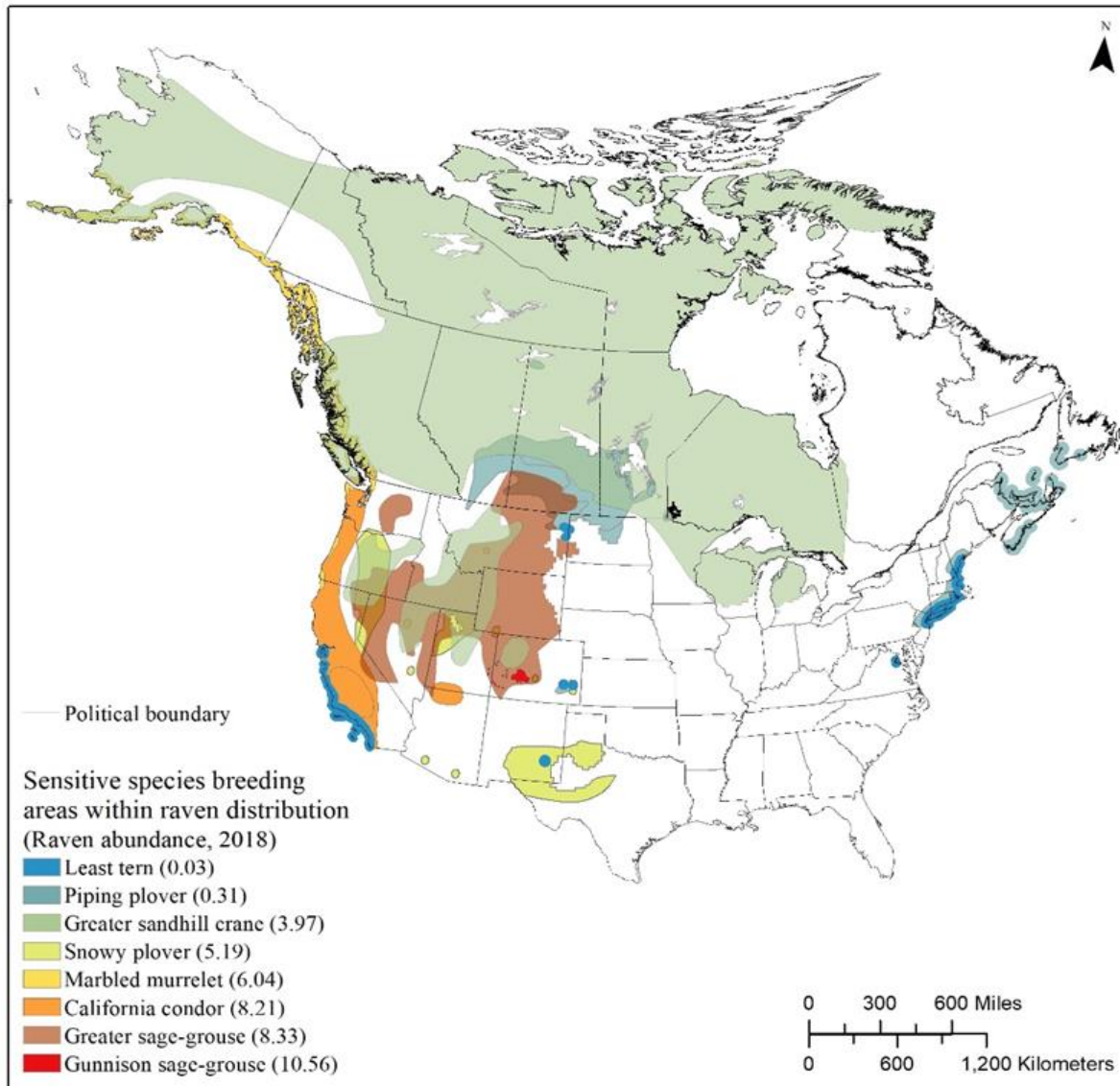
# Ecological Consequences

- Hyperpredation
- Spillover predation





# Ravens impact sensitive avian populations

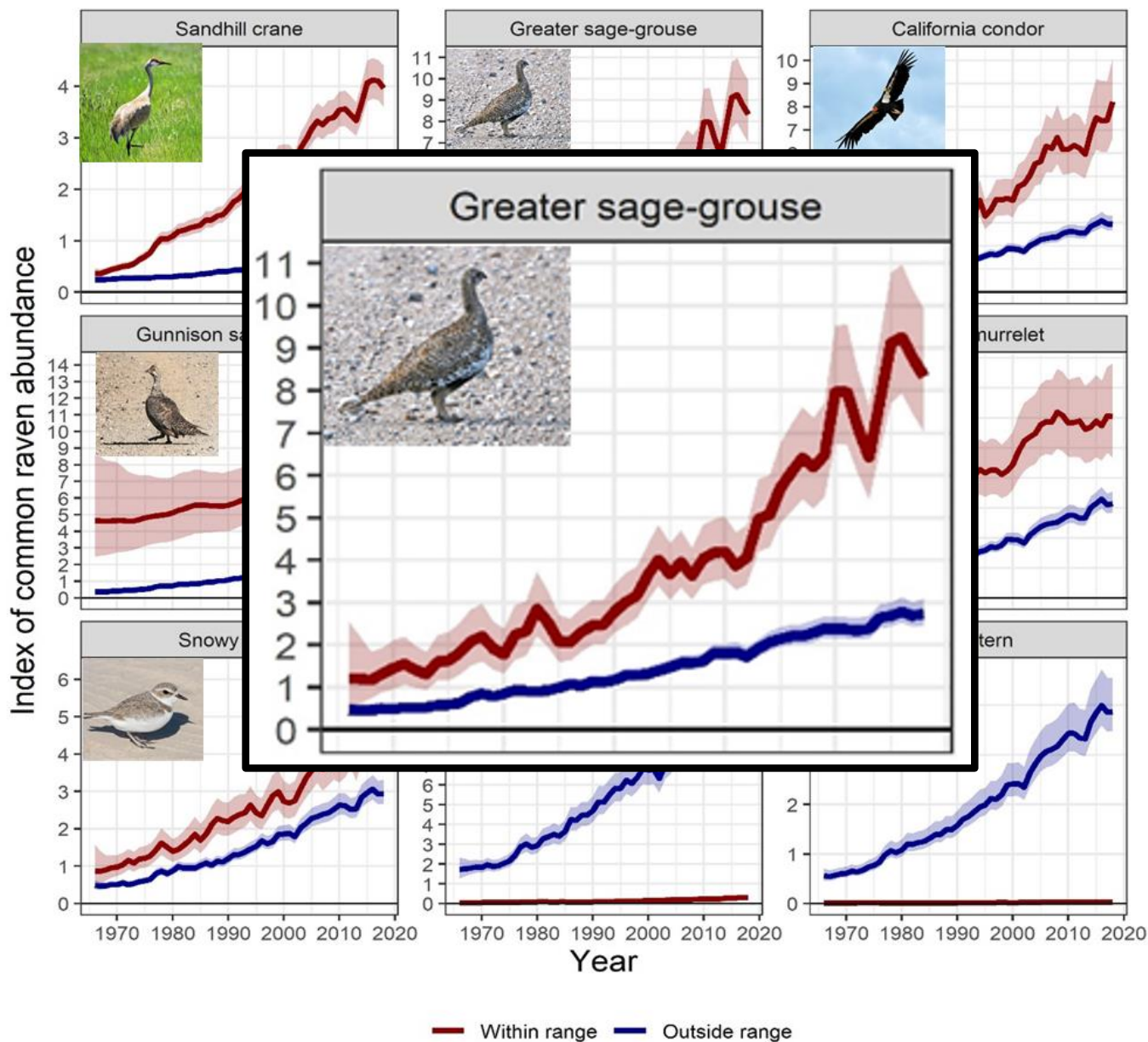


Jimmy Tang 2018

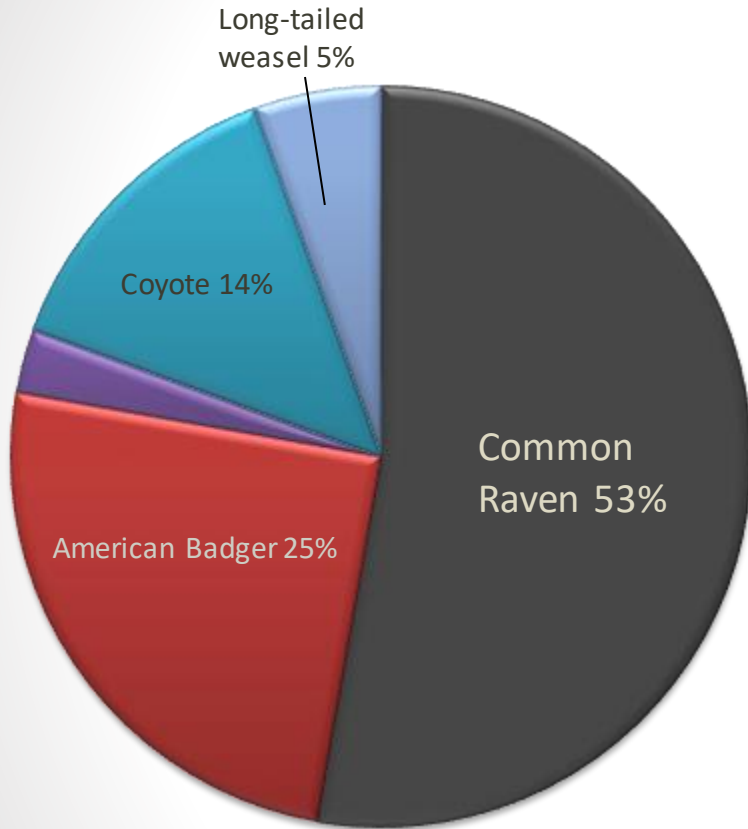
Coates et al. 2021. Synthesis of nest predation impacts of common ravens on sensitive avian species.

*Human-Wildlife Interactions*. 15(3). <https://doi.org/10.26077/962c-56f0>

# Ravens impact sensitive avian populations



# Ravens as effective sage-grouse egg predator



Predation on sage-grouse nests  
(9 years of video data; ISU)

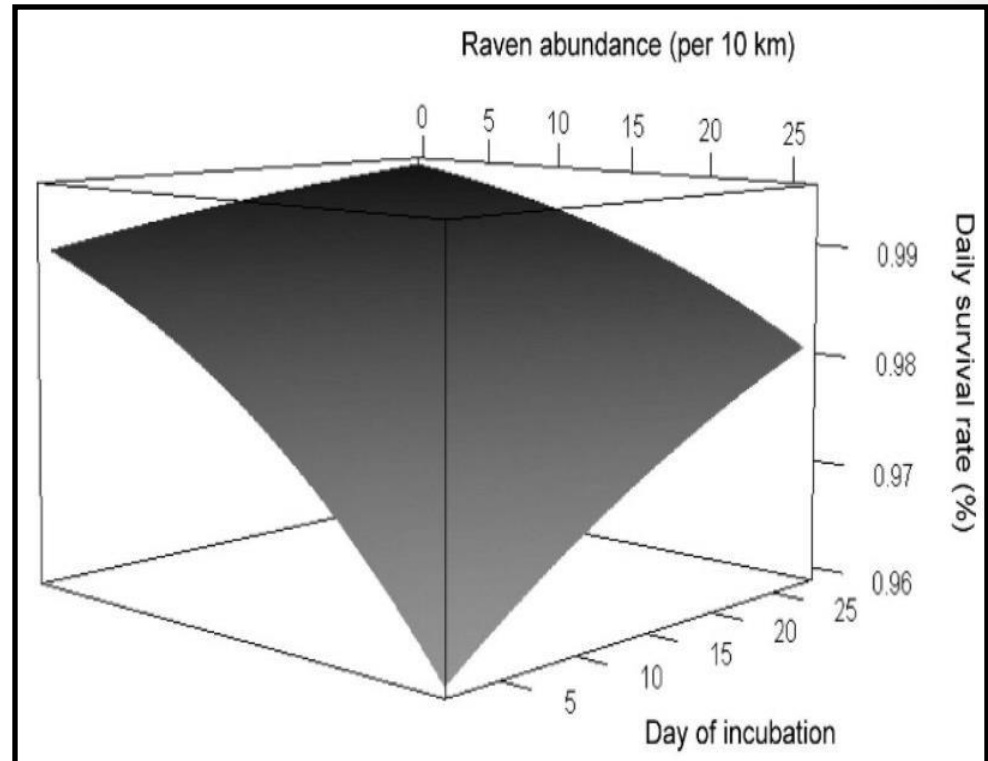
Journal of Wildlife Management 74(2):240–248; 2010; DOI: 10.2193/2009-047



*Management and Conservation Article*

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

PETER S. COATES,<sup>1</sup> *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*





# Shrub cover influences predation by ravens

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,<sup>1</sup> 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



95% CI

Resp.	Covariate	Estimate	lower	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%







Photo: Matt Lavin

## Problem

Expansion of raven distribution and abundance



Anthropogenic resource subsidies



Predation effects on sensitive species

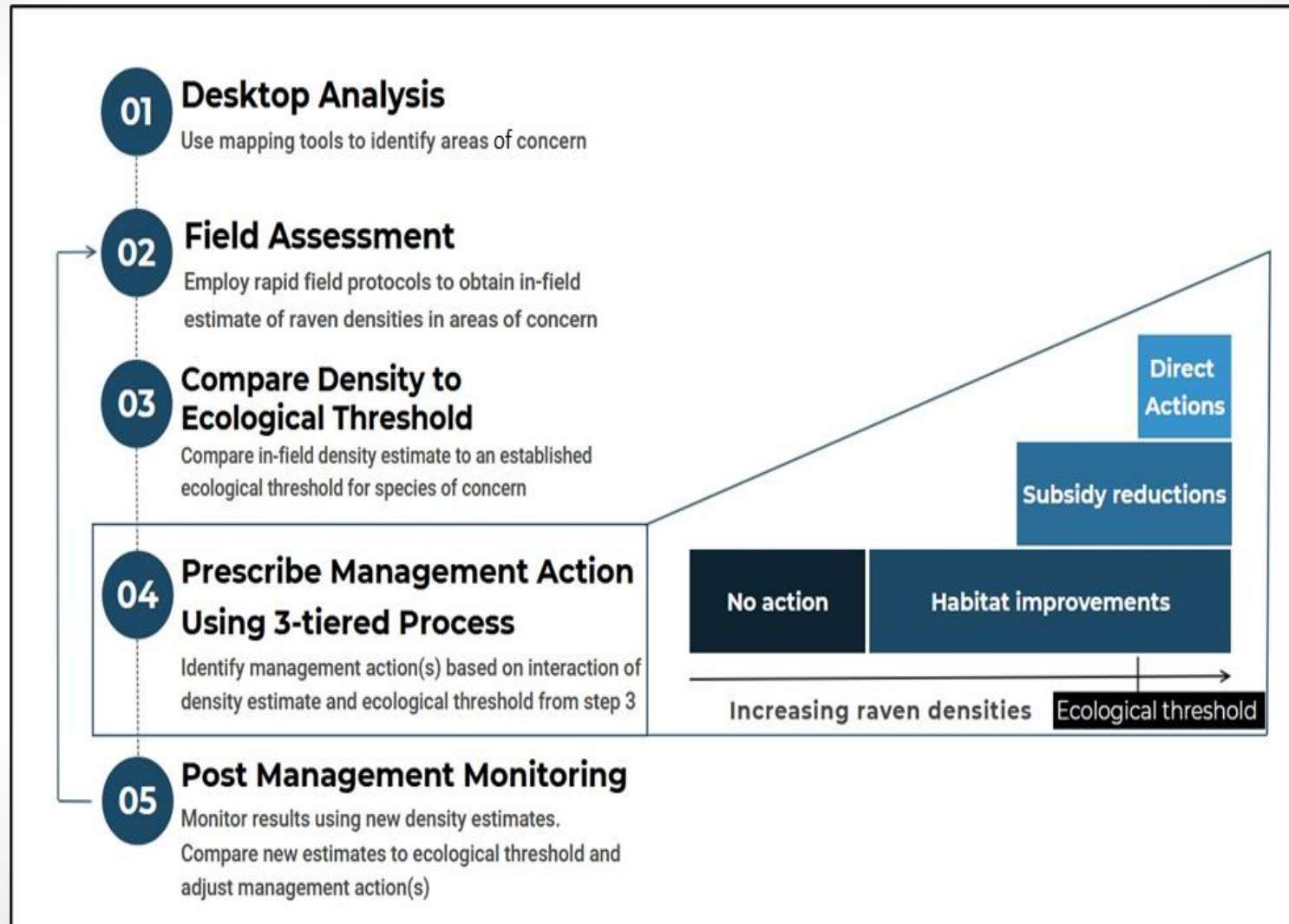
## Solution

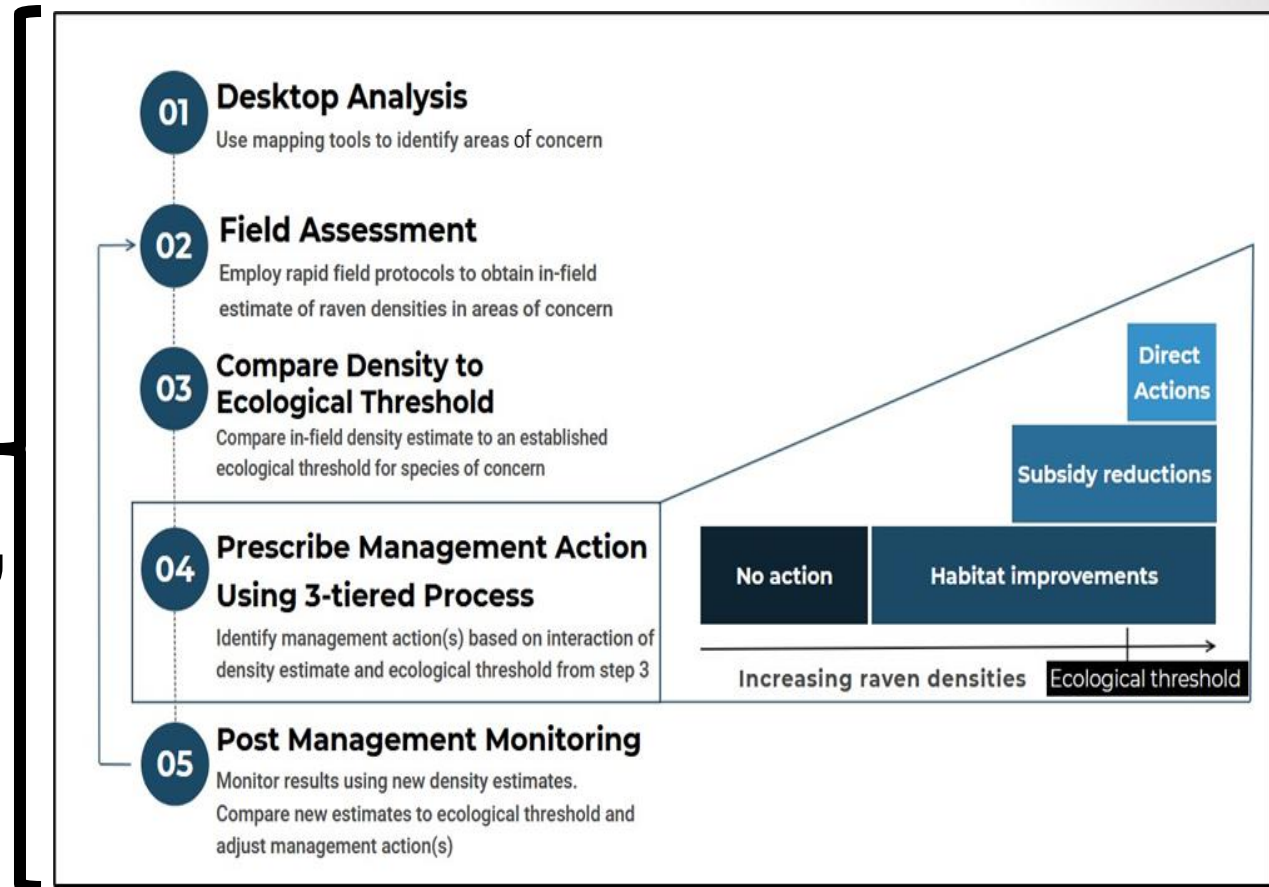
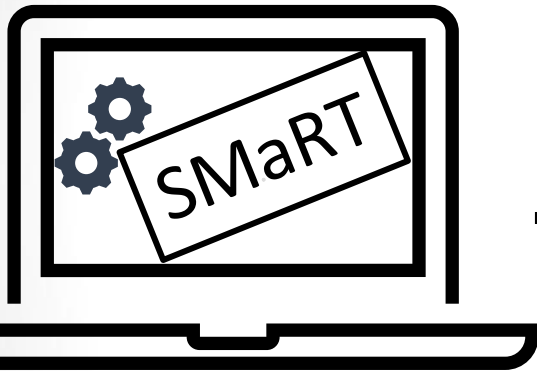
Science-based tiered framework



Decision support tools - SMaRT







The screenshot shows the SMaRT website interface. At the top left is the USGS logo. Below it is a navigation menu with the following items: Home, Management Tools, SMaRT (with sub-items: Design Management Site, Get Management Tier), and Documentation (with sub-items: Tool Guides, Citation, Resources, Partners). A callout box labeled "Link to USGS. gov" points to the USGS logo. Another callout box labeled "SMaRT tool menu" points to the SMaRT sub-item. A third callout box labeled "Additional resources and information" points to the Documentation sub-item. The main content area features the title "Raven Decision Support Software" and the subtitle "A suite of decision support tools for adaptive raven management". Below this is a photograph of a raven perched on a rock. At the bottom of the page is a footer with links: DOI Privacy Policy, Legal, Accessibility, Site Map, Contact USGS, US Department of the Interior, DOI Inspector General, White House, E-gov, No Fear Act, FOIA. A callout box labeled "DOI related links in footer" points to this footer area.

<https://rconnect.usgs.gov/smart/>



Documentation

Option 3: select  
Turn on a guide layer of interest, click the target polygon, and save that shape as your survey site

Select Area

Clear Map

To clear drawn shapes, use the draw toolbar. See the [user guide](#) for instructions

Please define survey site using one of the available options

minimum density to consider  
0

Set Density

Clip site by density

Upload your own guide layer

Navigate to guide shapefile

Browse .dbf + .prj + .shp + .shx

GIS data info

- Streets
- Topography
- Imagery
- Raven Density
- Raven Abundance
- Raven Density x Occupancy
- Counties
- BLM WA
- BLM WSA
- USFS WA
- PLSS Townships
- SG Management Zones
- PMUs

Disclaimer: This software is preliminary or provisional and is subject to revision

Leaflet | © OpenStreetMap contributors, CC-BY-SA

DOI Privacy Policy | Legal | Accessibility | Site Map | Contact USGS

US Department of the Interior | DOI Inspector General | White House | E-gov | No Fear Act | FOIA

<https://rconnect.usgs.gov/smart/>

- SMaRT (beta)
  - Design Management Site
  - Get Management Tier
- Documentation

Select method to calculate density:

Rapid Assessment Function



DENSITY ADDED

Use RAF when you have raw survey data. See the [user guide](#) for information on parameterizing this section

## Calculate density from surveys and raven observations using the Rapid Assessment Function

Enter surveys/observations per site sepatated by commas; e.g., site1, site2, site3

Number of Surveys:

100, 100, 100

Number of Ravens:

10, 40, 130

Calculate the RAF

Show 10 entries

ravens	surveys	prediction	lwr	upr	lwr2	upr2	error
10	100	0.0964181808676047	0.0488631682392785	0.190255072210917	0.0488631682392785	0.337114992159313	-0.146859919948396
40	100	0.343370442559183	0.17401991465817	0.677527402854371	0.17401991465817	0.720178827232999	-0.0426514243786285
130	100	1.01142194745062	0.512573831181495	1.99576001261482	0.273322017213593	1.99576001261482	0.239251813967902

Showing 1 to 3 of 3 entries

Previous 1 Next

Download RAF results

Disclaimer: This software is preliminary or provisional and is subject to revision



- Home
- Management Tools
  - SMaRT (beta)
    - Design Management Site
    - Get Management Tier
- Documentation

Steps 2-4   Density   **Threshold**   Plan

## Identify ecological threshold

Select known threshold:

sage-grouse

- sage-grouse
- desert tortoise
- custom

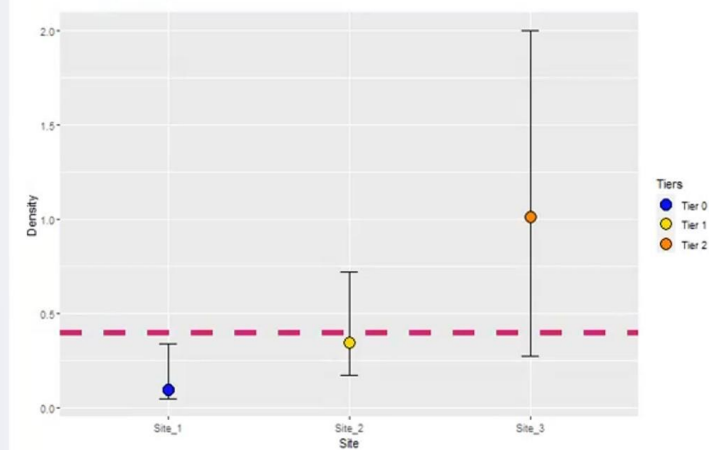
0.4

ravens/km<sup>2</sup>

Coates et al. 2020

Save threshold

## Raven Density



Disclaimer: This software is preliminary or provisional and is subject to revision



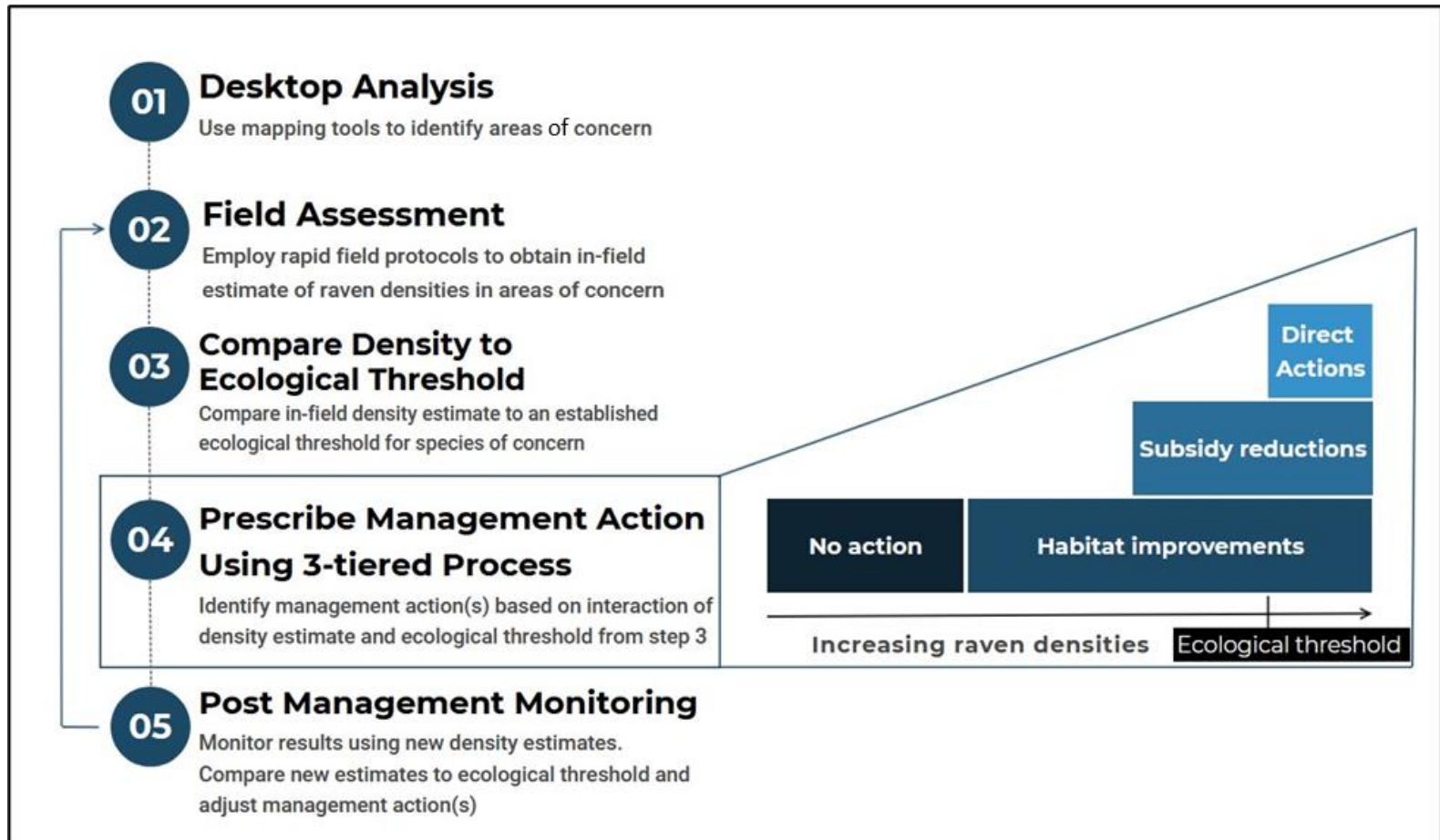
- Site\_1
- Site\_2
- Site\_3

Show  entries

	Tier	Target.Species	Management.Category	Management.Method	Management.Option	Resource.Type	Target	SOURCE
2	Tier 1 - Habitat Improvements	GRSG	Habitat Restoration	GRSG Recovery	Seed or plant sagebrush/native shrubs	Sage-grouse Habitat	Habitat	Created by user on 2022-01-27 using the USGS SMaRT tool <a href="https://doi.org/10.5066/P9B5ANSM">https://doi.org/10.5066/P9B5ANSM</a>
3	Tier 1 - Habitat Improvements	GRSG	Habitat Restoration	GRSG Recovery	Place grazing exclusion around sagebrush/native shrubs	Sage-grouse Habitat	Habitat	Created by user on 2022-01-27 using the USGS SMaRT tool <a href="https://doi.org/10.5066/P9B5ANSM">https://doi.org/10.5066/P9B5ANSM</a>
4	Tier 1 - Habitat Improvements	GRSG	Habitat Restoration	GRSG Recovery	Apply herbicide to remove cheatgrass or other invasive plants	Sage-grouse Habitat	Habitat	Created by user on 2022-01-27 using the USGS SMaRT tool <a href="https://doi.org/10.5066/P9B5ANSM">https://doi.org/10.5066/P9B5ANSM</a>
5	Tier 1 - Habitat Improvements	GRSG	Habitat Restoration	GRSG Recovery	Remove pinyon and juniper in areas of conifer expansion	Sage-grouse Habitat	Habitat	Created by user on 2022-01-27 using the USGS SMaRT tool <a href="https://doi.org/10.5066/P9B5ANSM">https://doi.org/10.5066/P9B5ANSM</a>
6	Tier 1 - Habitat Improvements	GRSG	Habitat Restoration	GRSG Recovery	Seed or plant native forbs and grasses	Sage-grouse Habitat	Habitat	Created by user on 2022-01-27 using the USGS SMaRT tool <a href="https://doi.org/10.5066/P9B5ANSM">https://doi.org/10.5066/P9B5ANSM</a>
7	Tier 1 - Habitat Improvements	GRSG	Habitat Restoration	GRSG Recovery	Place grazing exclusion around native forbs and grasses	Sage-grouse Habitat	Habitat	Created by user on 2022-01-27 using the USGS SMaRT tool <a href="https://doi.org/10.5066/P9B5ANSM">https://doi.org/10.5066/P9B5ANSM</a>
18	Tier 2 - Subsidy Reductions	CORA	Food Resources	Containment	Bury or cover livestock burial pits	Persistent Point Source	Livestock - Pits	Created by user on 2022-01-27 using the USGS SMaRT tool <a href="https://doi.org/10.5066/P9B5ANSM">https://doi.org/10.5066/P9B5ANSM</a>
19	Tier 2 - Subsidy Reductions	CORA	Food Resources	Harassment Devices	Install acoustic hazing devices or effigies around livestock burial pits	Persistent Point Source	Livestock - Pits	Created by user on 2022-01-27 using the USGS SMaRT tool <a href="https://doi.org/10.5066/P9B5ANSM">https://doi.org/10.5066/P9B5ANSM</a>
	Tier 2 - Subsidy Reductions				Apply nonlethal chemical	Persistent Point Source	Livestock - Pits	Created by user on 2022-01-27 using the USGS SMaRT tool <a href="https://doi.org/10.5066/P9B5ANSM">https://doi.org/10.5066/P9B5ANSM</a>

<https://rconnect.usgs.gov/smart/>

# Supporting adaptive management



A photograph of a raven being handled by a person wearing white gloves. The raven is lying on a light-colored surface. A yellow data tag is attached to its leg. The tag contains handwritten information: "Common Raven 01-01-01", "6 mi. N. of Reno", "N-17262-118 W-3104-010", and "J. Spencer Jr.". The text "How many ravens to remove?" is overlaid in white on the image, with a white underline underneath it.

How many ravens to  
remove?

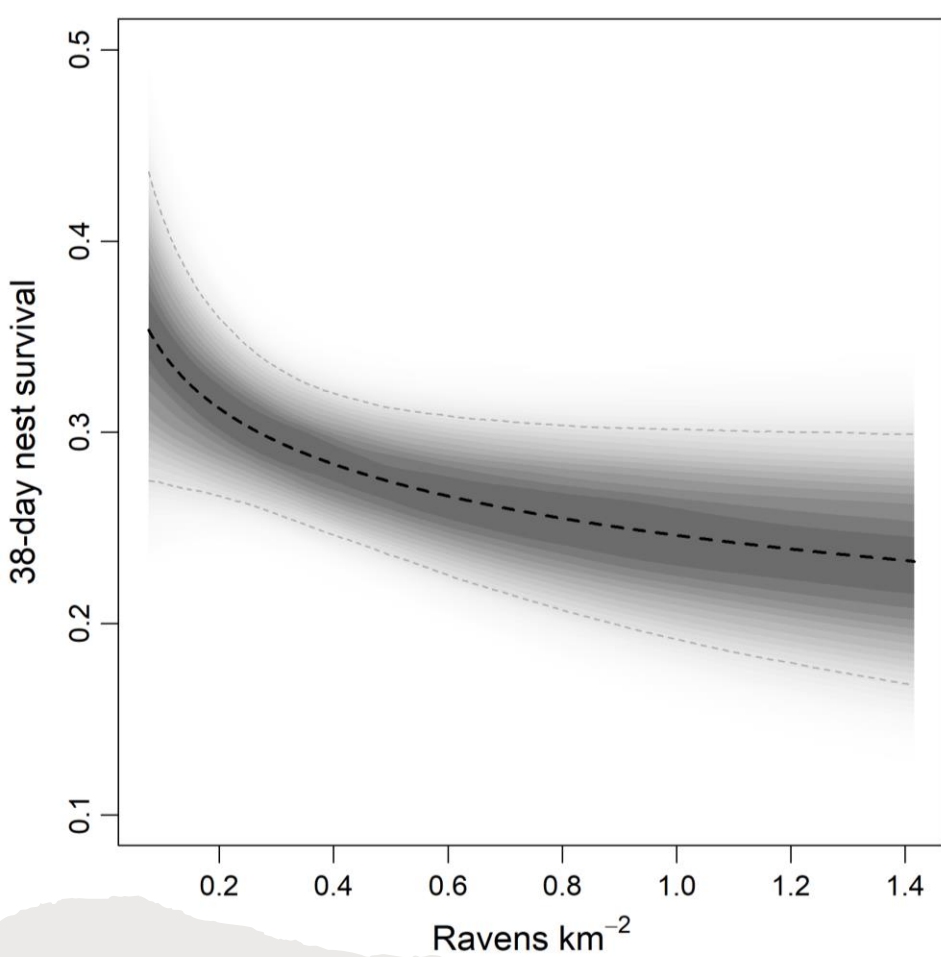




**APHIS**



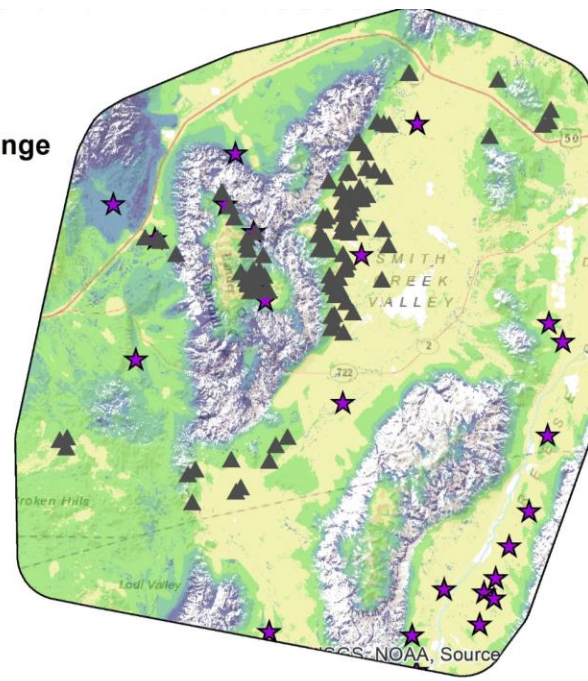
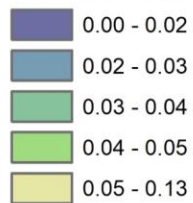
Are management  
actions effective?



# Refining thresholds

Where to  
remove?

**Nest survival change**









# Simulated egg-oiling treatment

# Simulated egg-baiting treatment







Cost/benefit?



**01 Desktop Analysis**  
Use mapping tools to identify areas of concern

**02 Field Assessment**  
Employ rapid field protocols to obtain in-field estimate of raven densities in areas of concern

**03 Compare Density to Ecological Threshold**  
Compare in-field density estimate to an established ecological threshold for species of concern

**04 Prescribe Management Action Using 3-tiered Process**  
Identify management action(s) based on interaction of density estimate and ecological threshold from step 3

**05 Post Management Monitoring**  
Monitor results using new density estimates. Compare new estimates to ecological threshold and adjust management action(s)

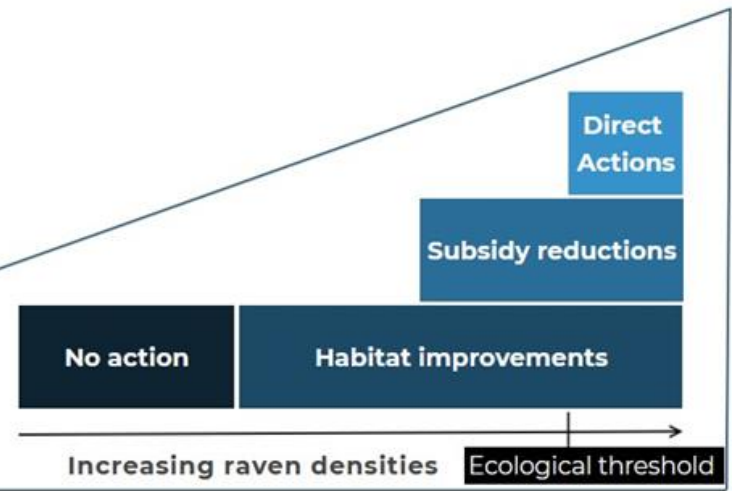








Photo: isoldyou (eBay username)





Photo: isoldyou (eBay username)

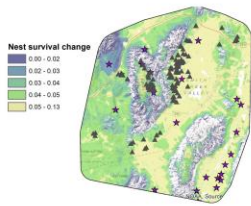
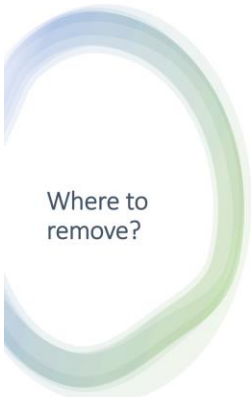
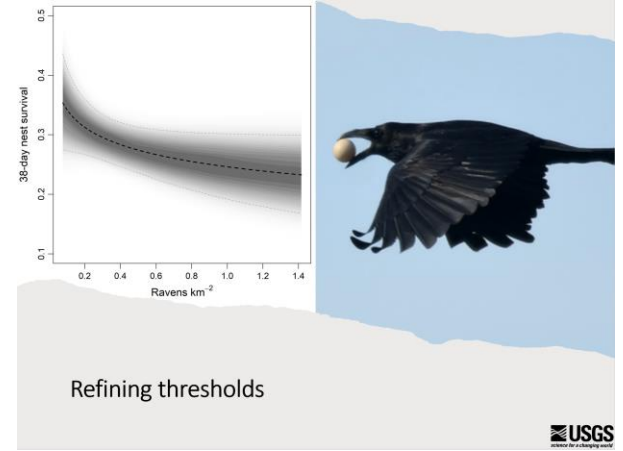


Jason Cipriani/CNN Underscored



Are management actions effective?

USGS



Questions?

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