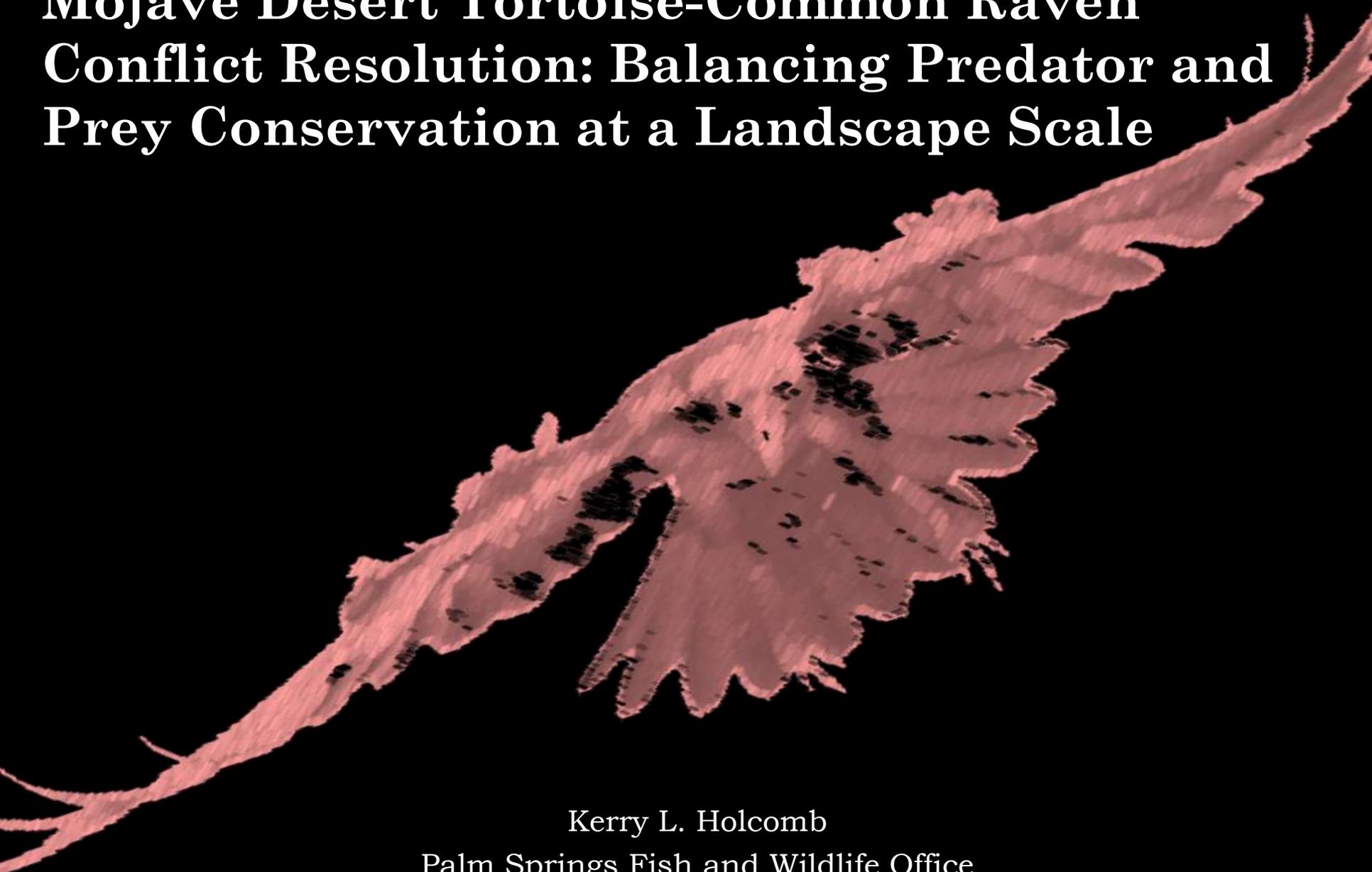


Mojave Desert Tortoise-Common Raven Conflict Resolution: Balancing Predator and Prey Conservation at a Landscape Scale



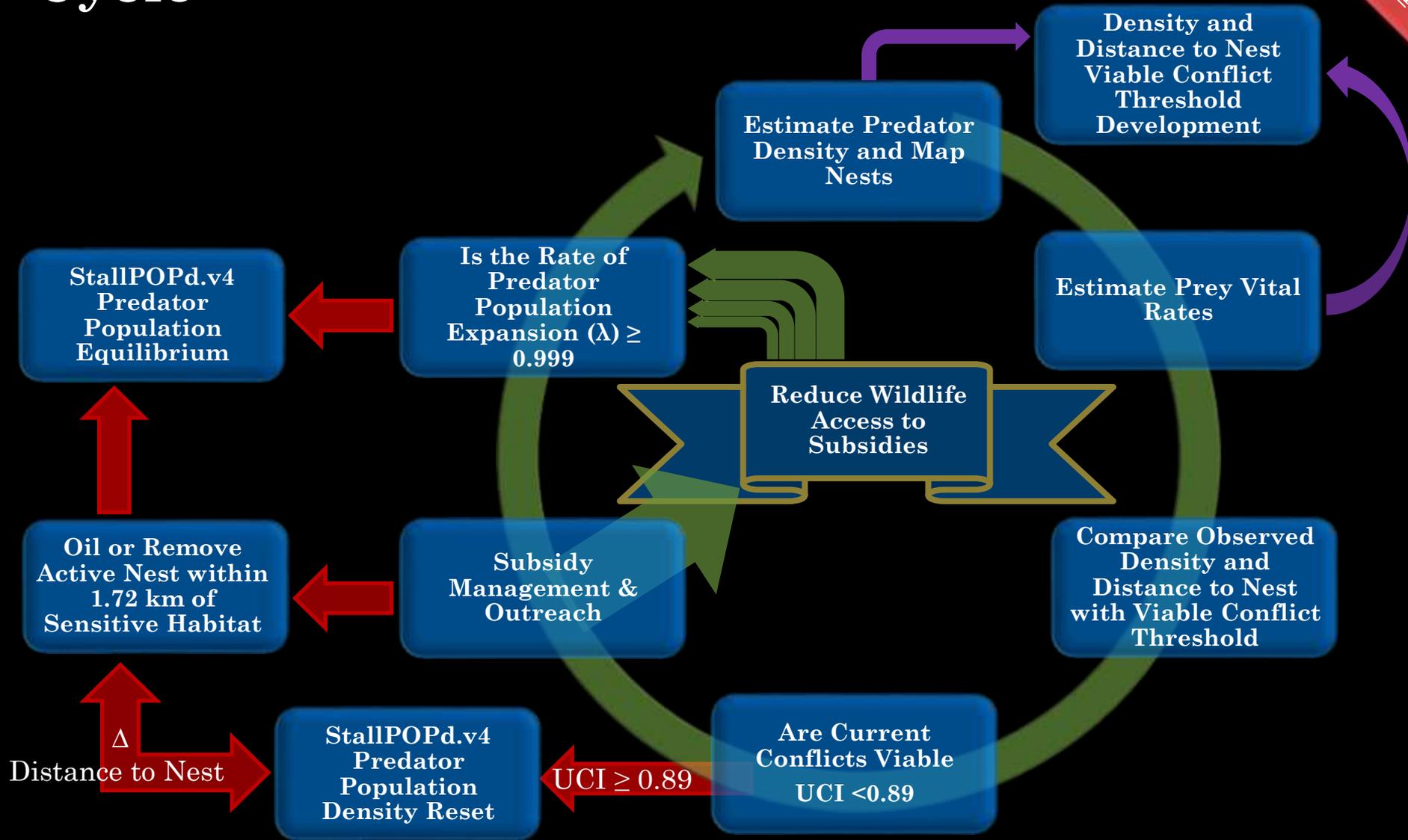
Kerry L. Holcomb

Palm Springs Fish and Wildlife Office

Kerry_Holcomb@fws.gov

Annual Adaptive Conflict Resolution Cycle

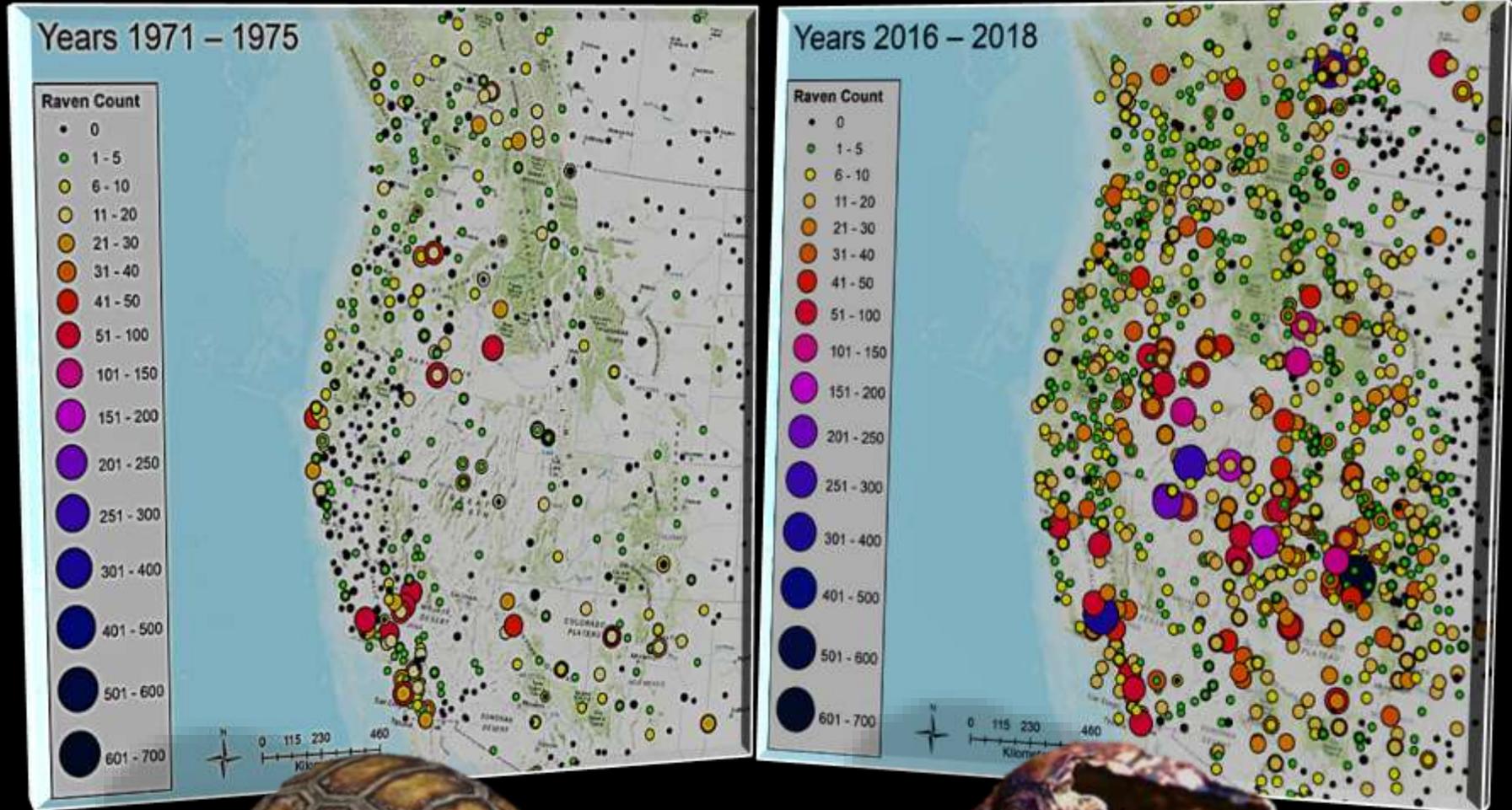
Introduction



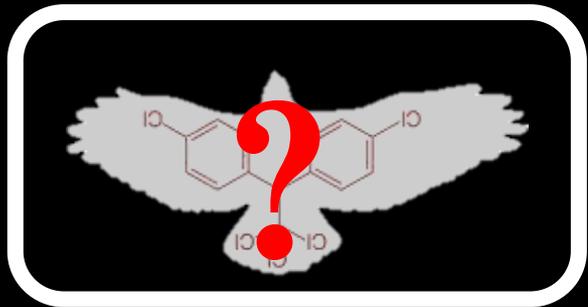
Breeding Bird Survey: Common Raven

Introduction

(Sauer and Link)



Drivers of this Population Explosion



Credit: Kevin Powell



Viable Conflict Threshold Development

- ❖ **Decoy survival** (a proxy of 0 to 10 year-old tortoise survival) was measured using 78 PIR-camera monitored Mojave desert tortoise decoys, 5 novel-objects, and 3 camera-only controls placed at random.
- ❖ **Common raven density** was estimated in each monitoring area using randomly placed point counts
- ❖ **Distance to nearest nest** as well as median distance to nest was estimated using a geodatabase of 732 previously active common raven nests, observed as active between March 2013 – July 2020
- ❖ The effects of common raven **density** and **distance** to nearest previously active common raven nest on decoy **survival** were then described by carrying out a Bayesian share frailty model.

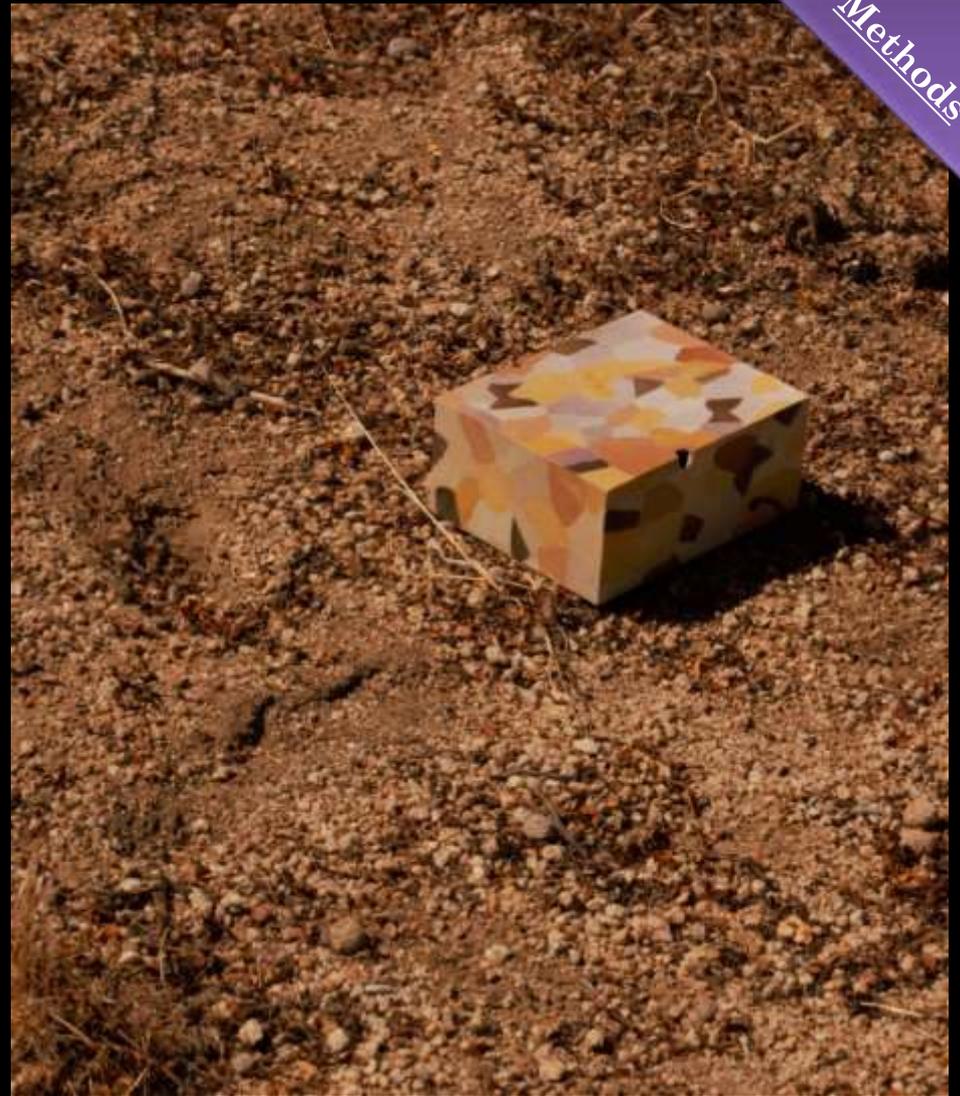
Desert Tortoise Decoy Survival Trials

- ❖ Decoy survival probability
- ❖ $CH_{annual} = UH_{1day} * T_{days} * P_{day}$
- ❖ 168 days active annually (Agha et al. 2015)
- ❖ 19% exposure during days active (Daly et al. 2019)
- ❖ Decoys were placed in open or at the edge of a dripline, if shrub cover was ≤ 2 -m from an assigned random point



Novel-object Control

- ❖ Estimates attraction to a novel object, which is larger and less cryptic than the decoy
- ❖ Always placed in the open, and on bare ground whenever possible.



PIR Camera-only Control

- ❖ Estimates attraction to camera set alone
- ❖ Values > 0 were not observed, thus decoy estimates of tortoise survival were not corrected for camera set attraction.
- ❖ Camera set is never concealed more than partially for controls



Concealment = Partial

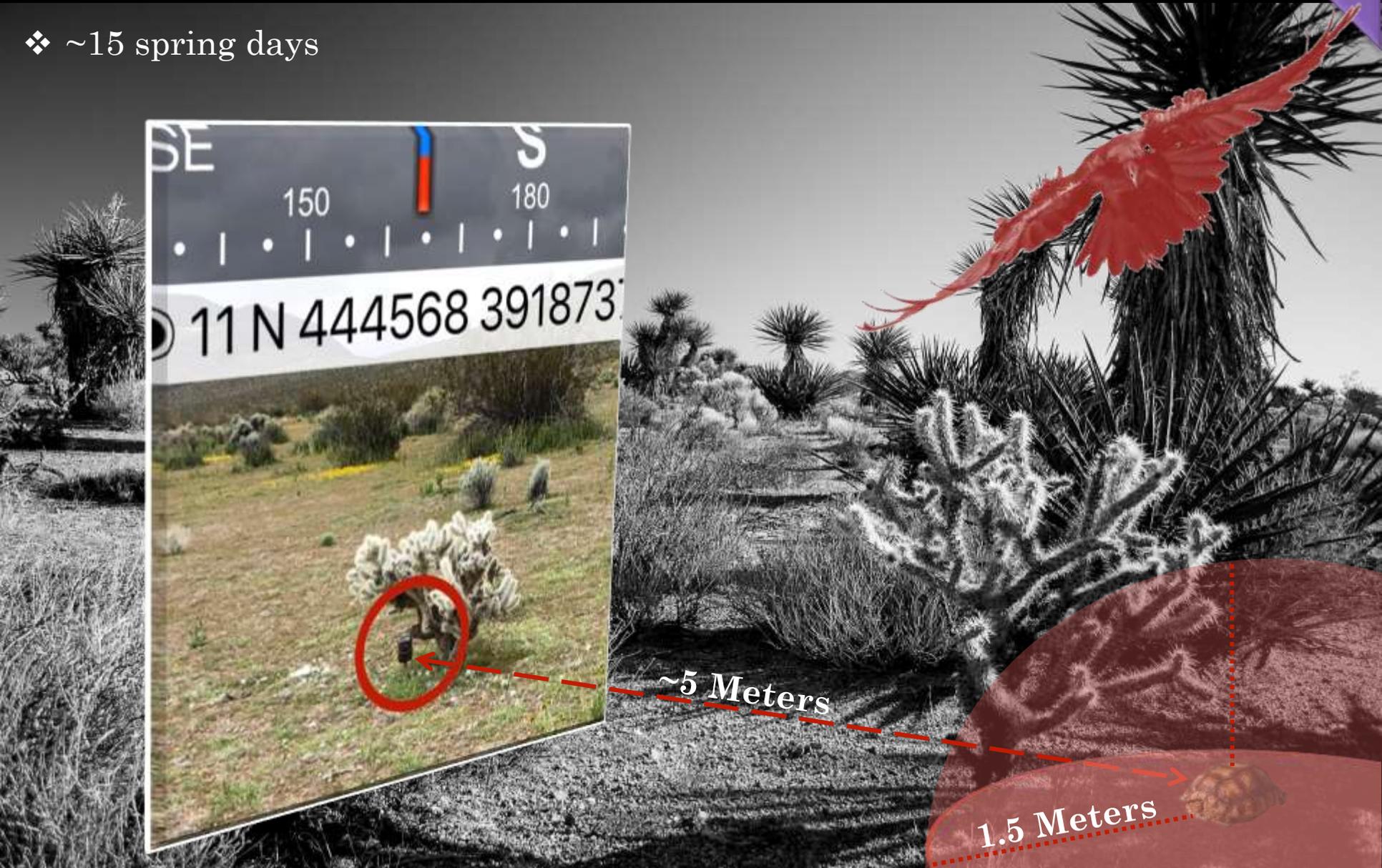
Sample Space & Schedule

❖ ~15 spring days



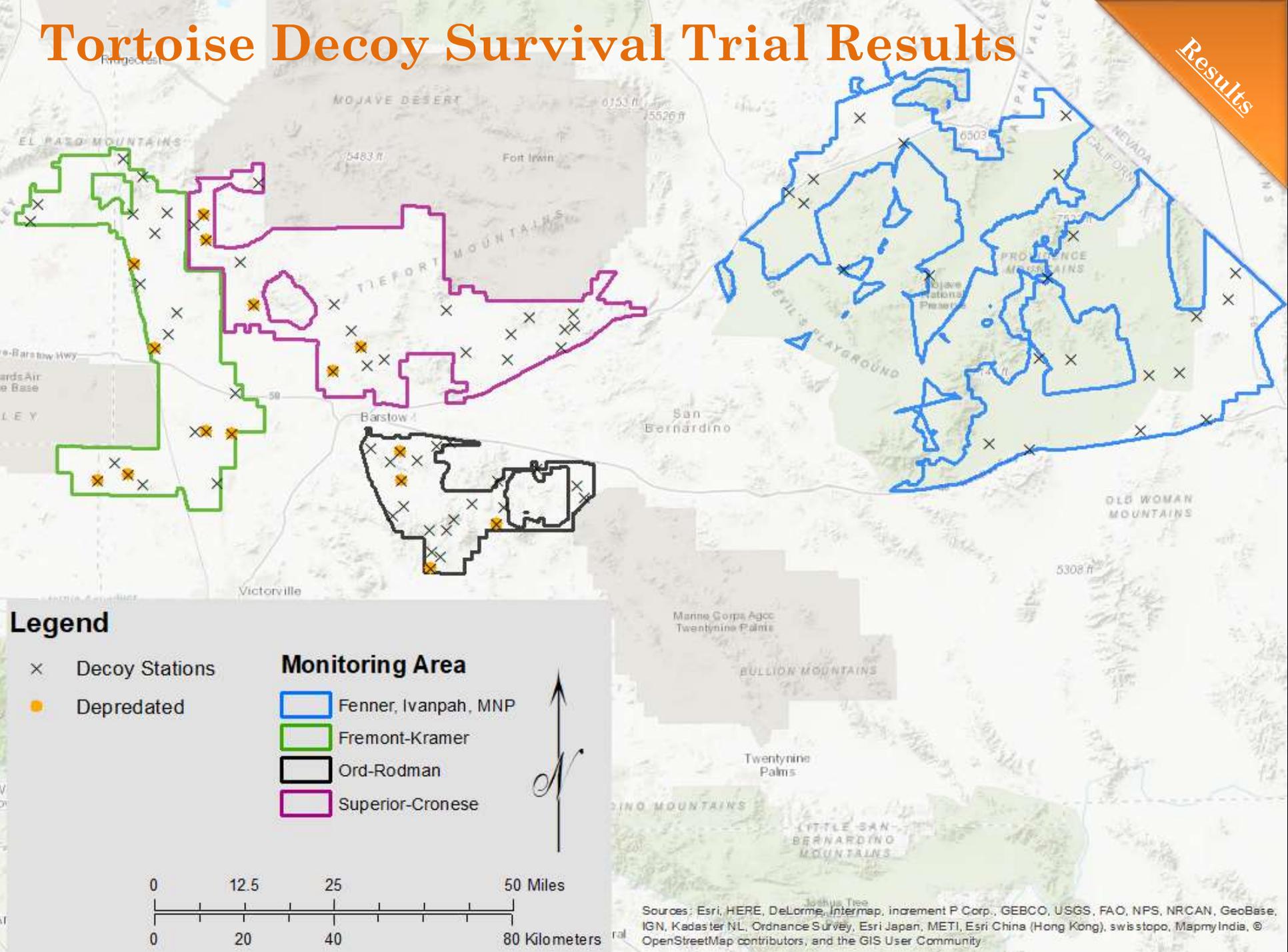
~5 Meters

1.5 Meters



Tortoise Decoy Survival Trial Results

Results



Legend

- × Decoy Stations
 - Depredated
- Monitoring Area**
- Fenner, Ivanpah, MNP
 - Fremont-Kramer
 - Ord-Rodman
 - Superior-Cronese

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

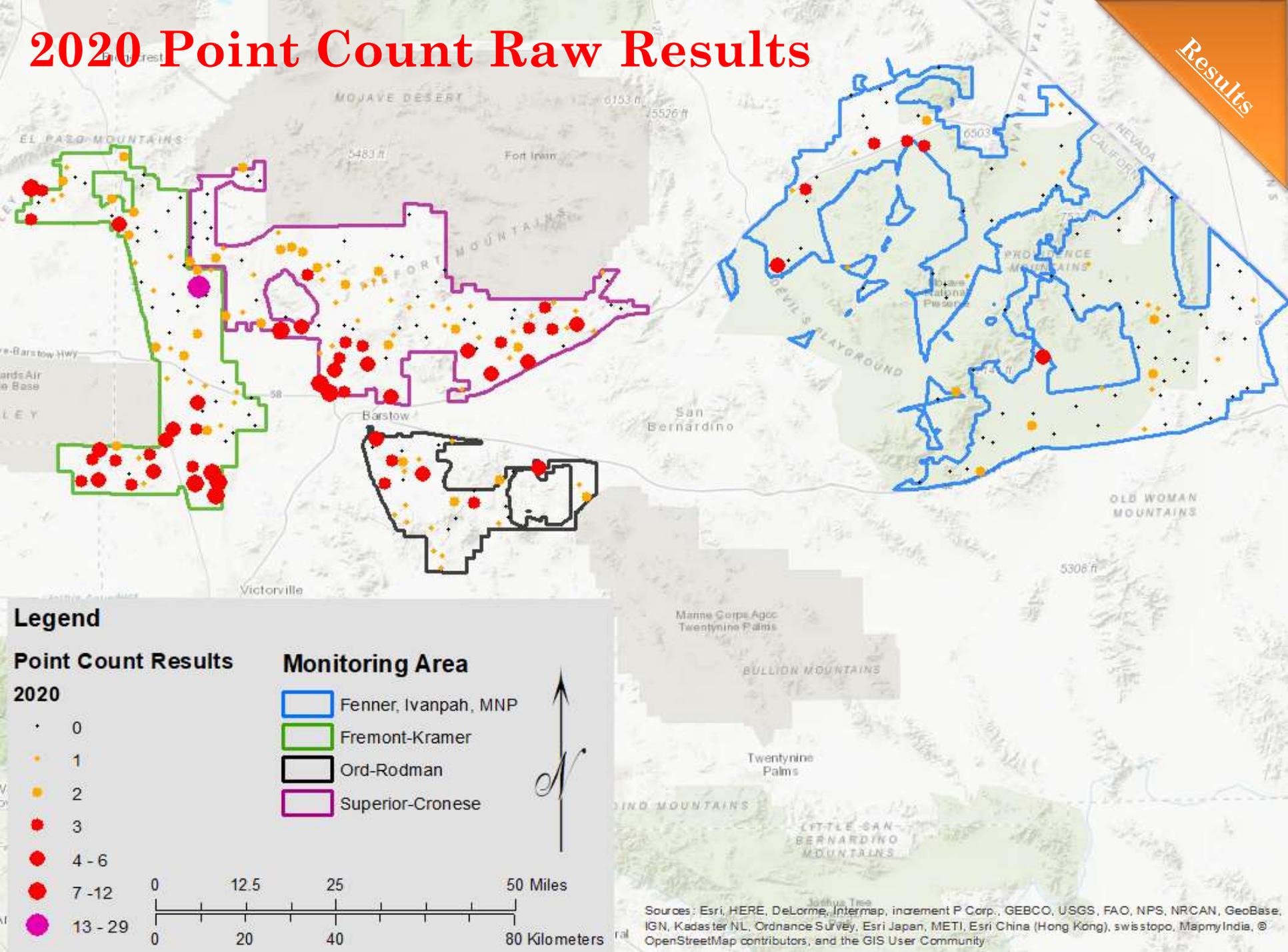


~2-km

~2-km

2020 Point Count Raw Results

Results



Legend

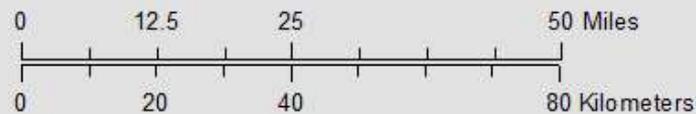
Point Count Results

2020

- 0
- 1
- 2
- 3
- 4-6
- 7-12
- 13-29

Monitoring Area

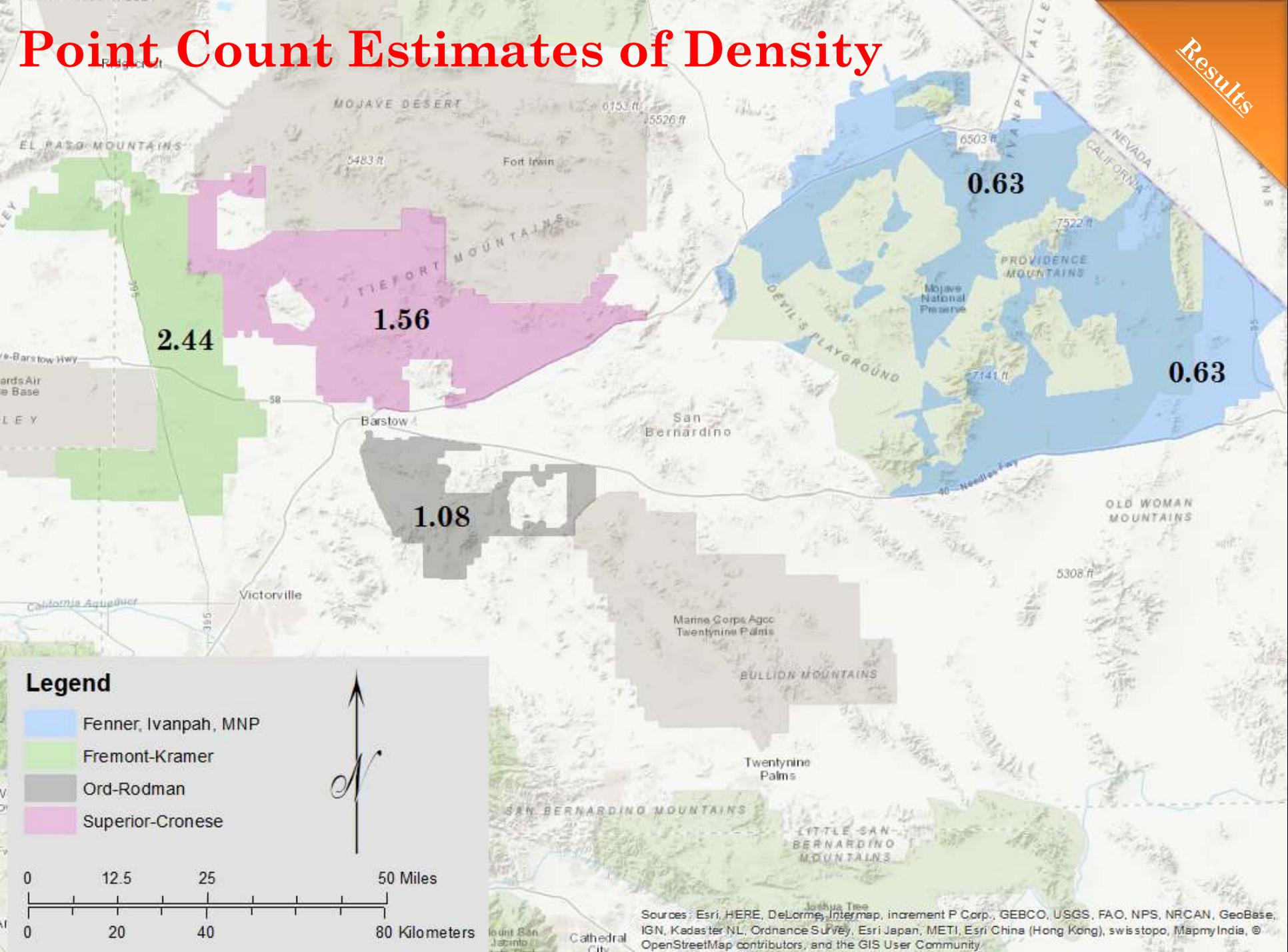
- Fenner, Ivanpah, MNP
- Fremont-Kramer
- Ord-Rodman
- Superior-Cronese



Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Point Count Estimates of Density

Results



Legend

- Fenner, Ivanpah, MNP
- Fremont-Kramer
- Ord-Rodman
- Superior-Cronese

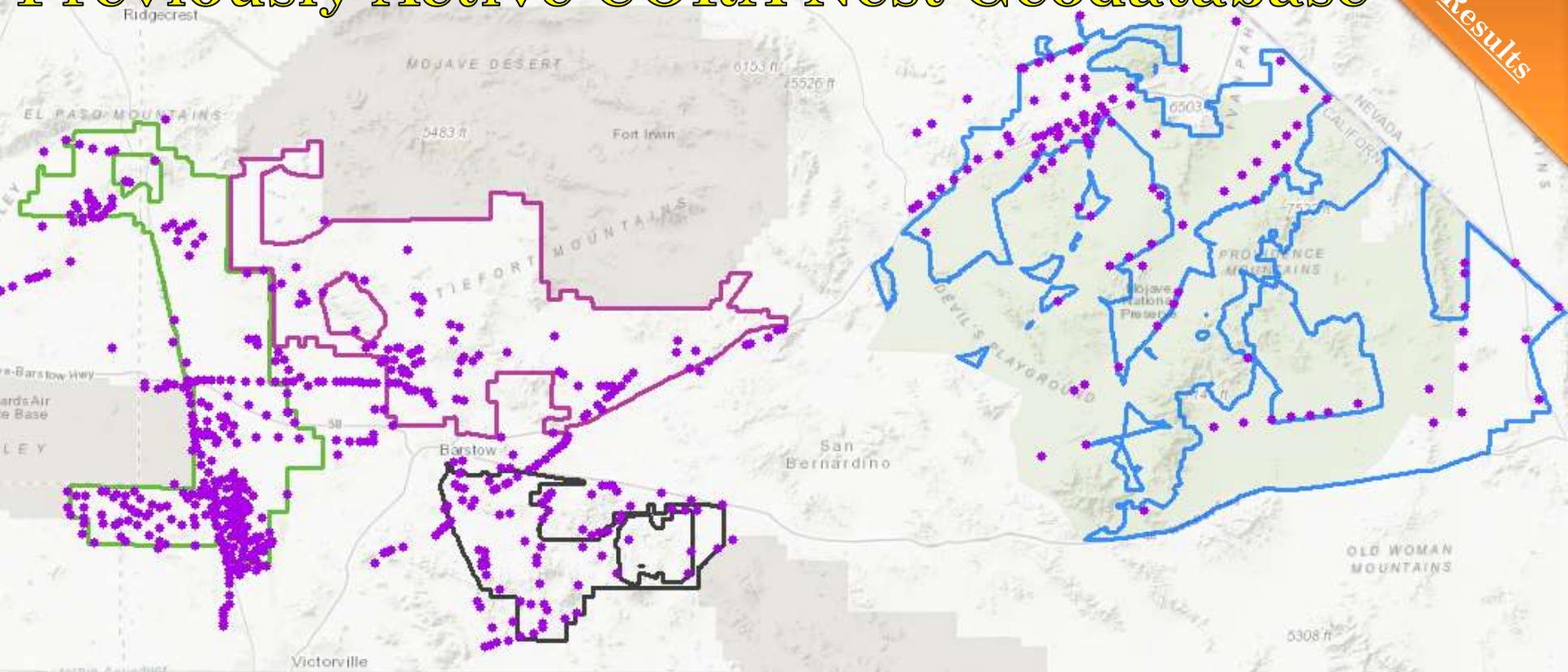
0 12.5 25 50 Miles

0 20 40 80 Kilometers

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Previously Active CORA Nest Geodatabase

Results

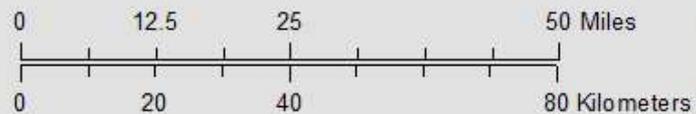


Legend

Common Raven Nest
2013 - 2020

Monitoring Area

-  Fenner, Ivanpah, MNP
-  Fremont-Kramer
-  Ord-Rodman
-  Superior-Cronese



Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Estimating the Effect of Distance, Density, and interactions using a Bayesian Shared Frailty Model

$$CH_{annual} = \exp(\alpha + \beta_{dist} * X_{dist[i]} + \beta_{dens} * X_{dens[i]} + \beta_{int} * X_{dist[i]} * X_{dens[i]} + \gamma_i)$$

$$S_{annual} = \exp(-CH_{annual}) - O_{mortality}$$

Juvenile Mojave Desert Tortoise Vitality Rates

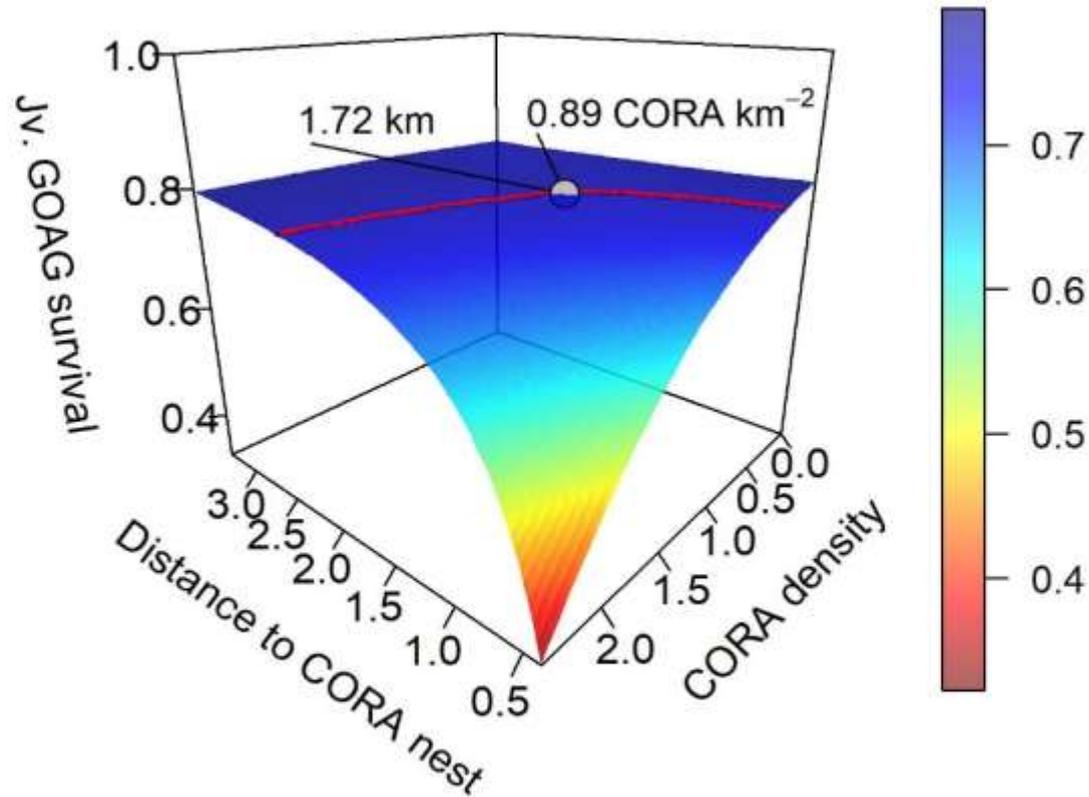


Methods

Study (yr.)	Annual Mortality	Annual Mortality due to Ravens	Annual Mortality due to Other
McGovern et al. 2020 (18-19)	0.250	0.063	0.188
Daly et al. 2019 (15-16)	0.620	0.296	0.324
Tuberville et al. 2019 (12-13)	0.674	0.283	0.391
Nagy et al. 2015 (04)	0.938	0.438	0.500
Nagy et al. 2015 (07)	0.906	0.656	0.250
Mean	0.677	0.347	0.331

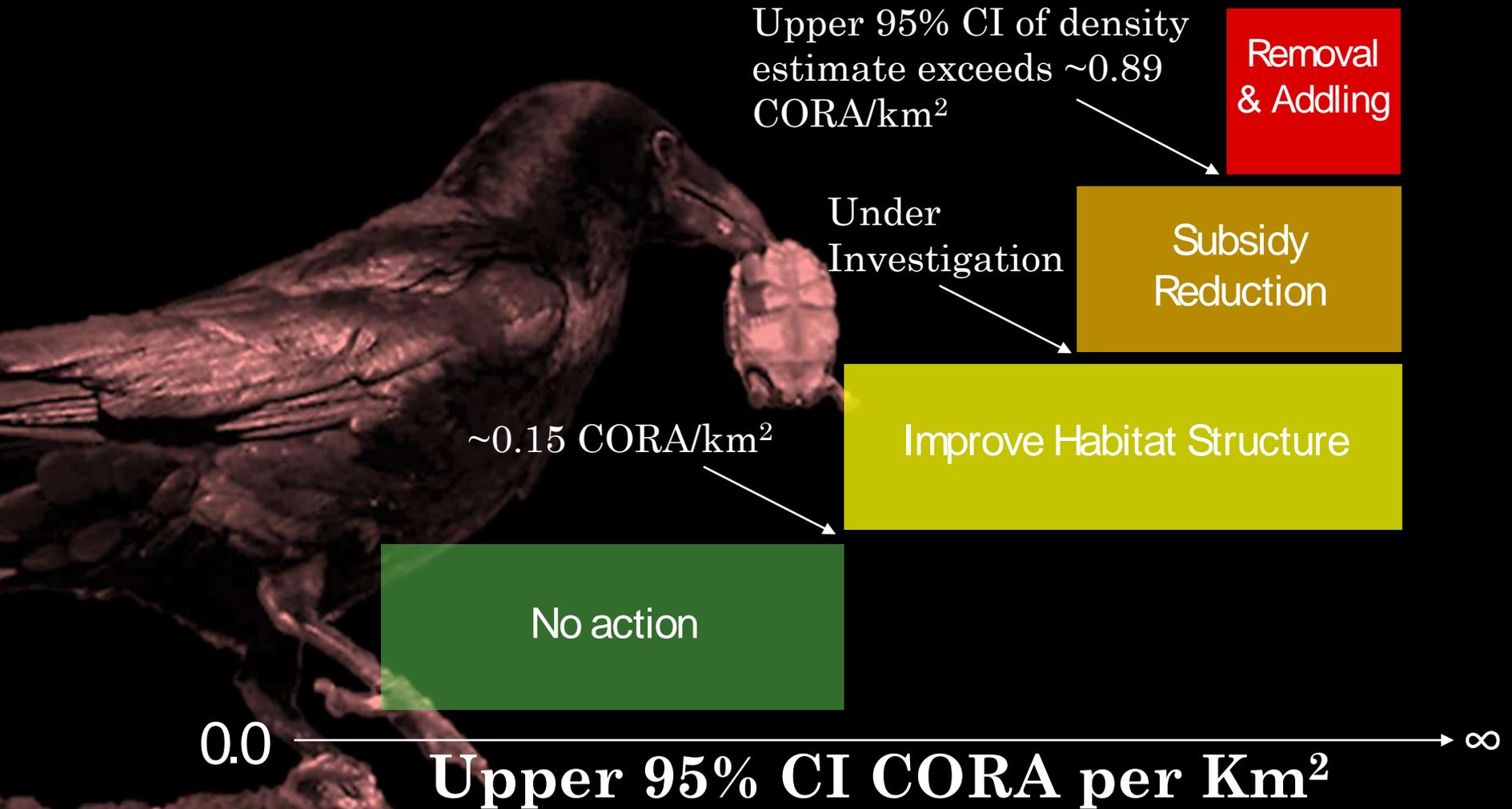
$$S_{annual} = \exp(-CH_{annual}) - O_{mortality}$$

Mojave desert tortoise – Common Raven Viable Conflict Threshold



Tiered Management Intensity Framework

Discussion



StallPOPd V3 Web Interface

StallPOPdV4
☰

- 🏠 Welcome and User Tutorial
- 📍 Your System of Interest
- 📊 Matrix Situation
- 📍 Geographical Area
- 📊 Potential Treatment Strategies
 - Density Dependent System
 - Density Independent System
- 📌 The Take Away
- 📄 Download My Results

Initiate your Geographical Area

Enter the characteristics of target area for population treatment(s). Once you like your entries, proceed to the Potential Treatment Strategies tab to view computational results.

Enter the geographical expanse of the area
 Area is defined in square kilometers.
The initial (example) area represents a critical habitat unit in the Mojave Desert, California, USA (K. Holcomb, unpublished data).

Enter the current density of individuals in the area
 Density is defined as the number of individuals per square kilometer.
The initial (example) density represents that of common raven in a critical habitat unit in the Mojave Desert, California, USA (K. Holcomb, unpublished data).

Enter the target density of individuals in the area
 Target density is defined as the individuals per square kilometer.
Target density for common ravens is 0.4 individuals per square kilometer from Coates, P.S., S.T. O'Neil, B.E. Briscoe, M.A. Roca, P.J. Jackson, J.B. Grwno, K.B. Howe, A.M. Meyer, L.J. Foster, D.J. Delehanty. 2020. 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. *Biological Conservation* 243: 108409.

$$\mathbf{L} = \begin{bmatrix} 0 & 0 & a_{13} \\ a_{21} & (a_{22}) & (a_{23}) \\ 0 & a_{32} & a_{33} \end{bmatrix}$$

<https://cwhl.vet.cornell.edu/tools/stallpopd>

StallPOPdV4
Wildlife Health Lab at Cornell University

Hanley et al. *accepted*

Density Reset and Maintenance Removal

Discussion

Area	Take Required to Reset Density	Annual Take Required to Maintain $\lambda \leq 0.99$	2020 Take	2021 Take
CI	0	54.91	60	28
FIM	0	358.55	188	114
FK	2636	232.6	1005	445
OR	134	54.57	294	104
SC	1484	302.75	393	357
JT	355	57.12	105	188
CH	0	538	0	122
	4609	1598.5	2045	1358

Density Reset and Maintenance Removal

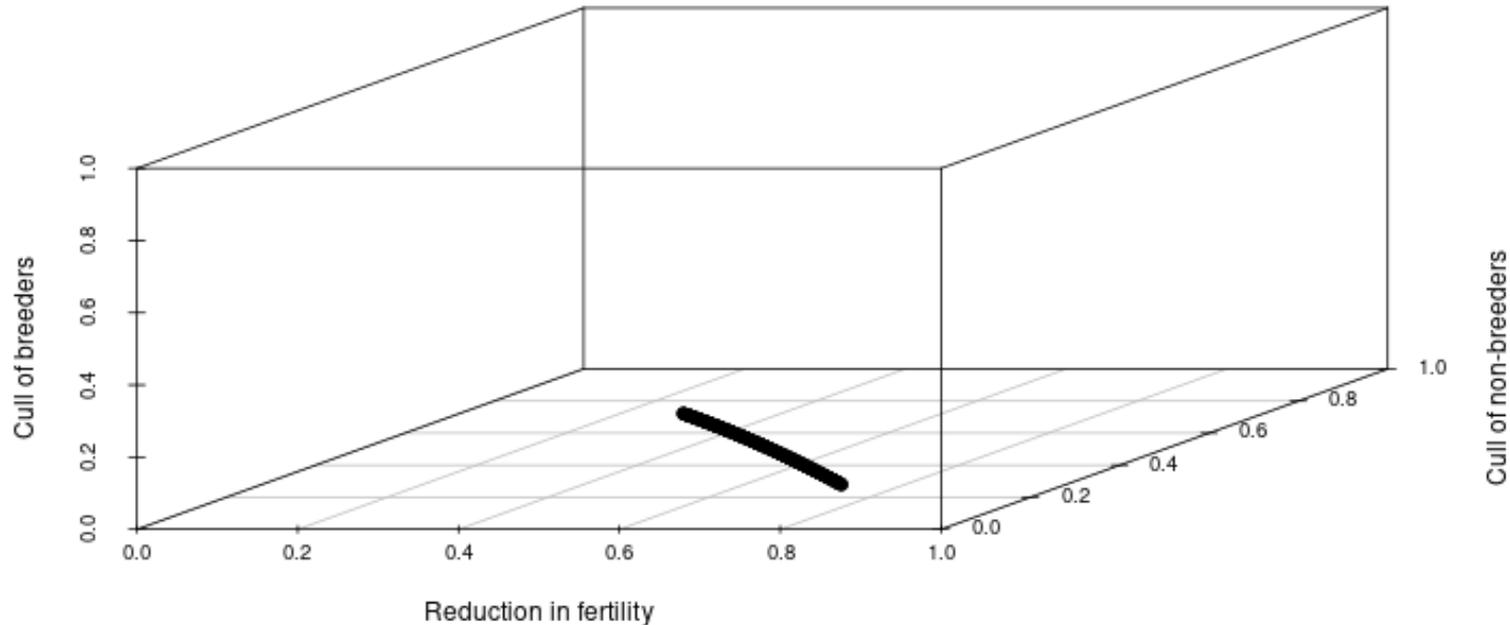
Discussion



Reset					
Strata	Eggs/ Hatch Year	Non- Breeders	Breeders	2020 Totals	Total Take Required
FK-2020	1,486	531	2,132	4,149	
FK-Target	542	193	778	1,513	
Take Target	944	338	1,354		2,636
2020 Take	1027	0	59		1,086
Strata	Eggs/ Hatch Year	Non- Breeders	Breeders	2020 Totals	Total Take Required
FK-2021	1,486	531	2,132	4,149	
FK-Target	542	193	778	1,513	
Take Target	944	338	1,354		2,636
2021 Take	426	0	7		433
Maintenance					
Strata	Eggs/ Hatch Year	Non- Breeders	Breeders	2020 Totals	Total Take Required
FK-202x	542	193	778	1,513	
FK-Target	407	174	700	1,280	
Take	136	19	78		233

Maintenance Removal Rates

Hanley et al. *accepted*



in this population matrix model:

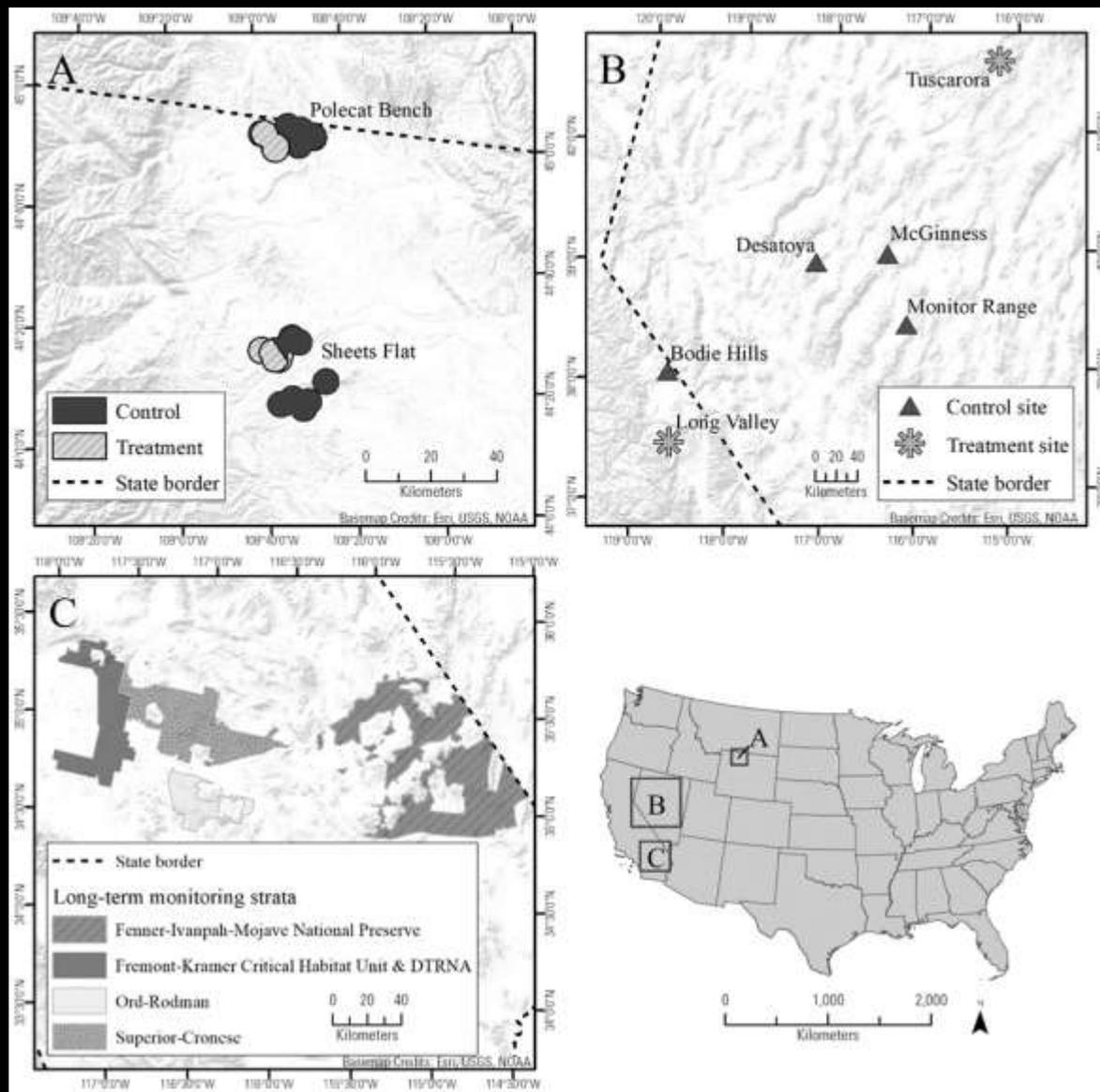
	[,1]	[,2]	[,3]
[1,]	0.0	0.00	0.78
[2,]	0.4	0.00	0.00
[3,]	0.0	0.64	0.96

to reduce the growth rate to 1.

Note: Every 3-D coordinate shown in the line on this graph constitutes a solution that produces a growth rate of one.

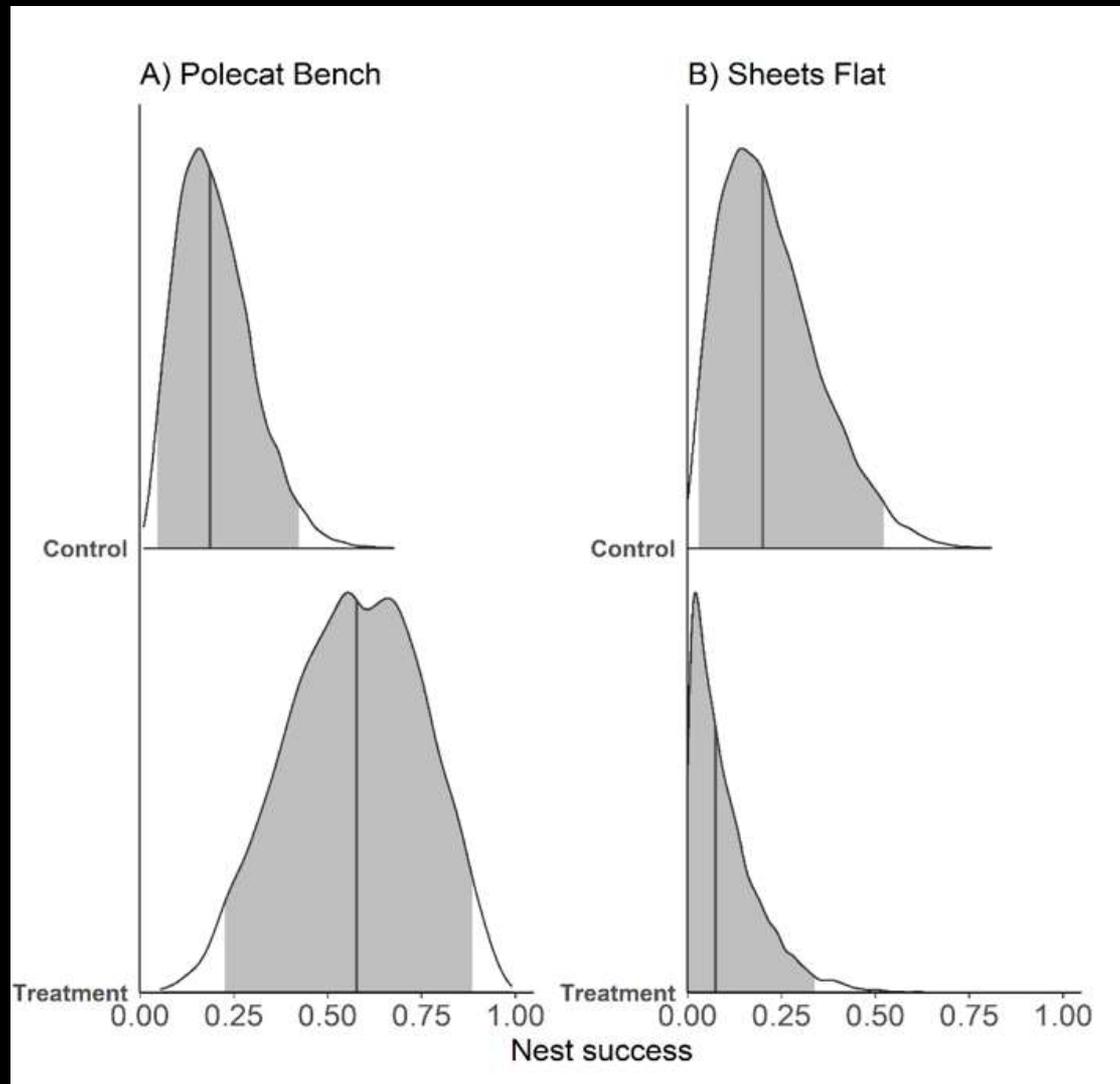
Raven Reproduction Manipulation Case Studies

Results



Raven Nest Removal on Great Sagegrouse Nest Success

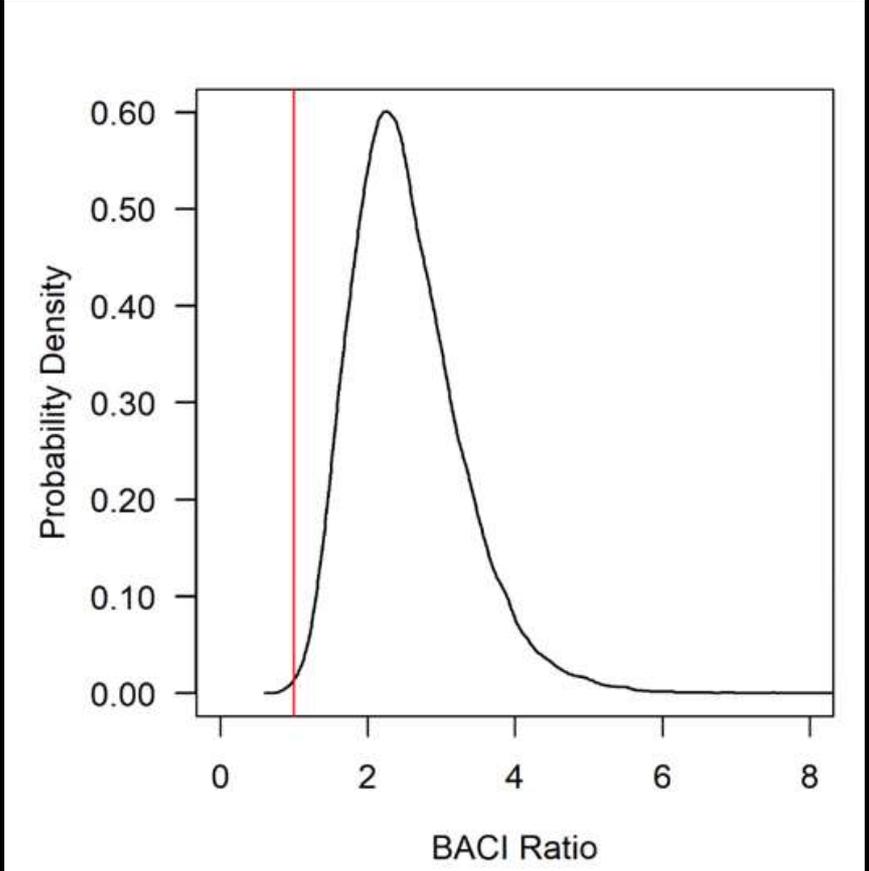
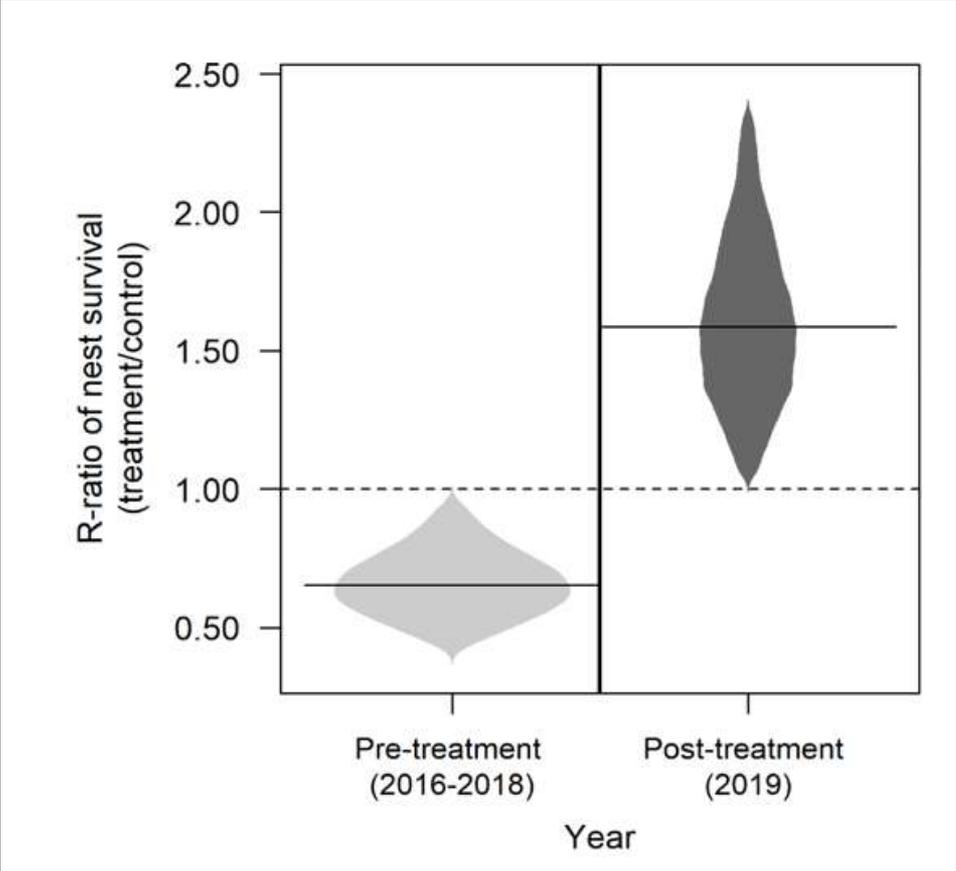
Results



Sanchez et al. *in review*

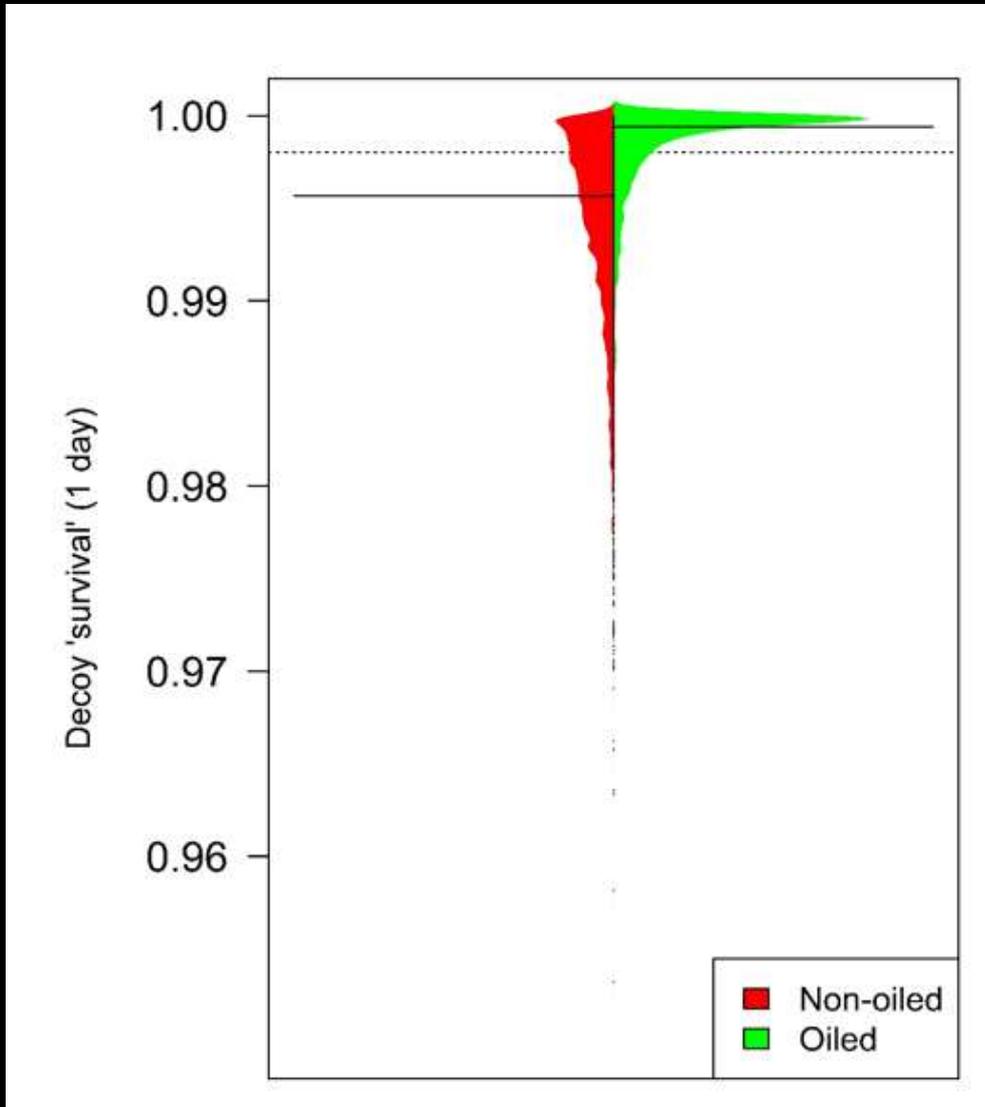
Raven Egg Addling on Great Sagegrouse Nest Success

Results



Sanchez et al. *in review*

Raven Egg Addling on Great Sagegrouse Nest Success



Acknowledgments

