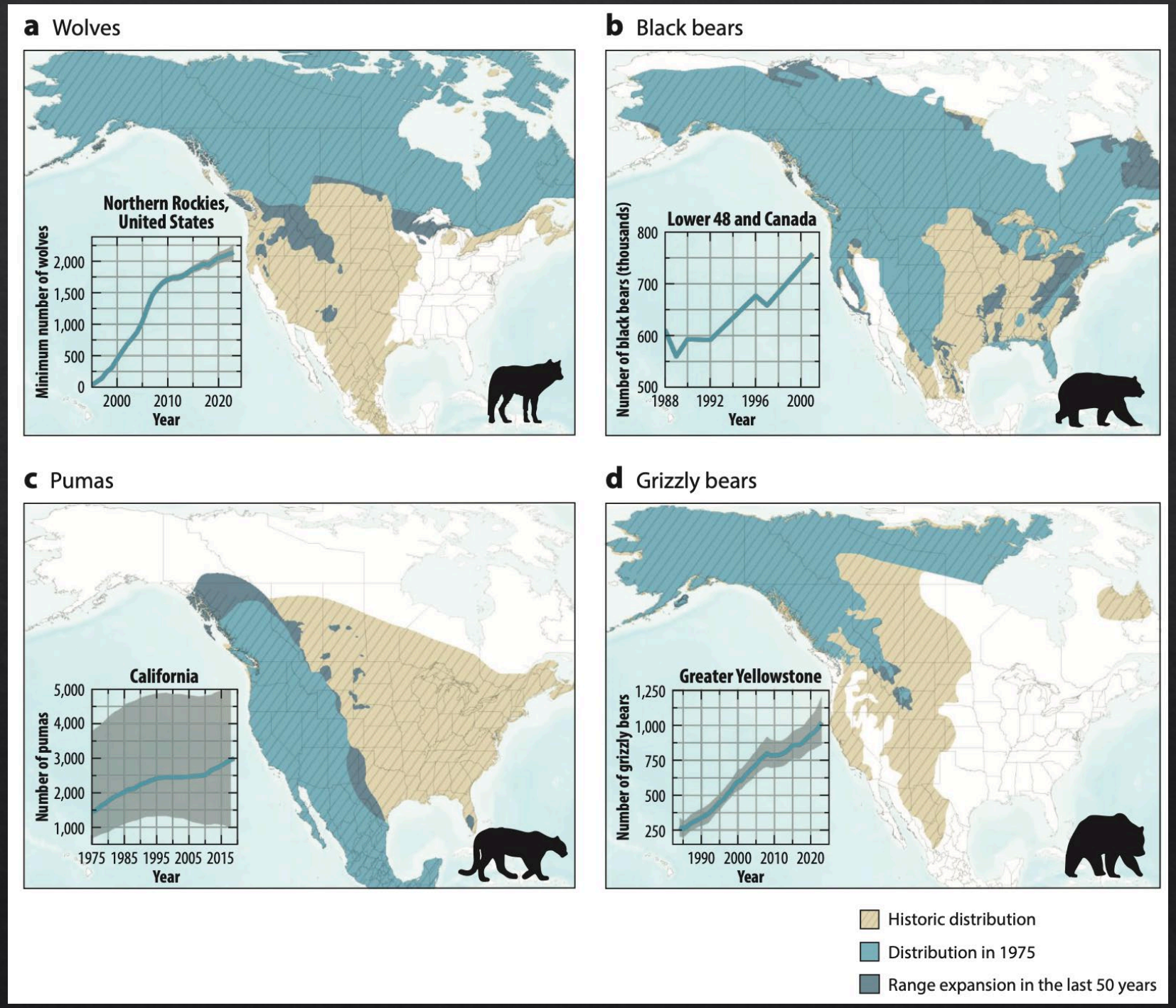
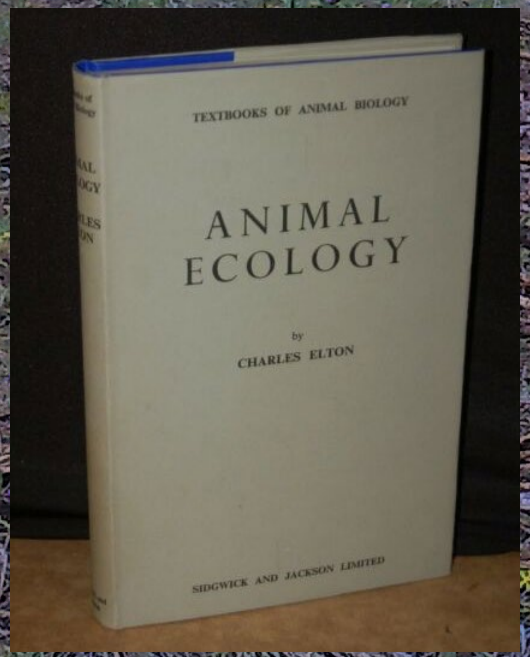
THE ECOLOGICAL IMPACTS OF LARGE CARNIVORE RECOVERY IN NORTH AMERICA

Taal Levi

Department of Fisheries, Wildlife, and Conservation Sciences, Oregon State University


a Wolves
Northern Rockies, United States
Minimum number of wolves
2,000
1,500
1,000
500
0
2000
2010
2020
Year
b Black bears
Lower 48 and Canada
Number of black bears (thousands)
800
700
600
500
1988
1992
1996
2000
Year
c Pumas
California
Number of pumas
5,000
4,000
3,000
2,000
1,000
1975 1985 1995 2005 2015
Year
d Grizzly bears
Greater Yellowstone
Number of grizzly bears
1,250
1,000
750
500
250
1990 2000 2010 2020
Year
Historic distribution
Distribution in 1975
Range expansion in the last 50 years



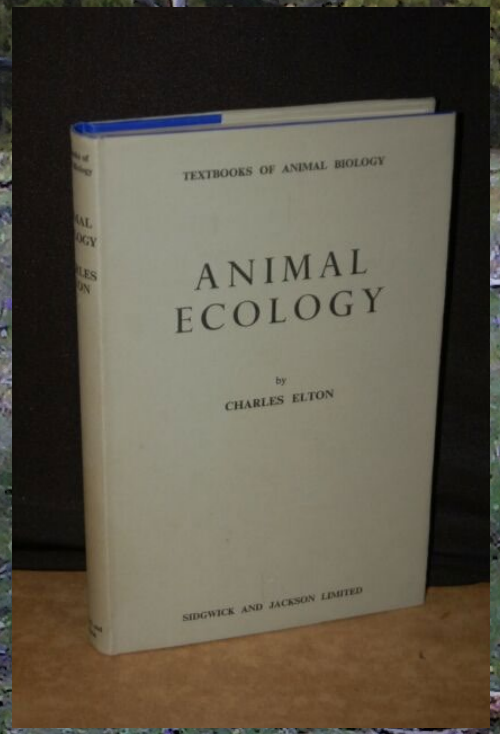
FOREWORD

CHARLES ELTON'S INFLUENCE IN ECOLOGY

By Sir ALISTER HARDY

Elton was, and still is, essentially a naturalist, so, as I have said, he turned in the opposite direction; he was determined to apply the scientific method to living animals, not, however, by laboratory analyses, but by studying them under the natural conditions of their own habitats.

Elton in fact set out to turn natural history into science, and that, of course, is what ecology is: the quantitative and experimental study of living organisms in relation to their environments.



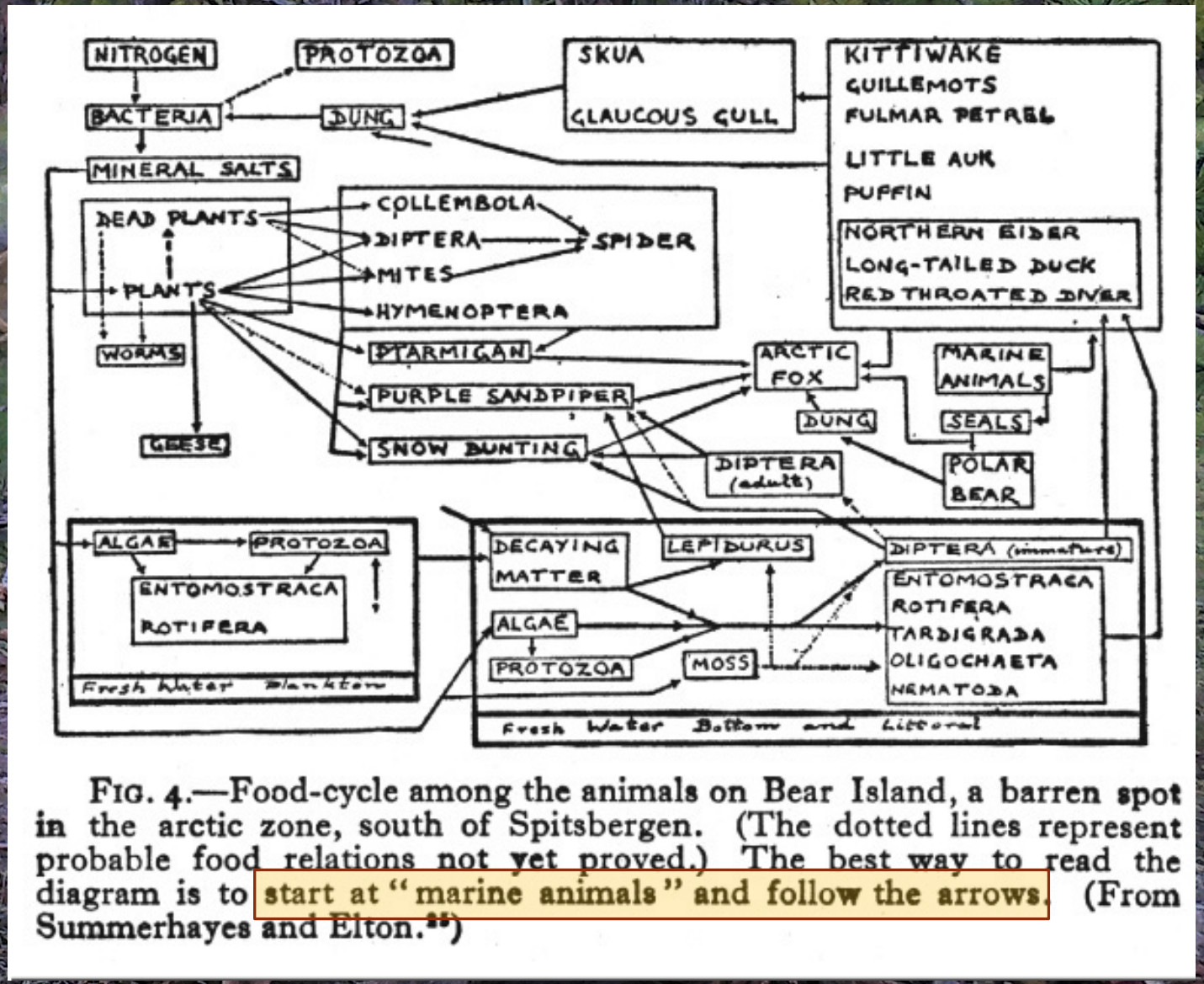
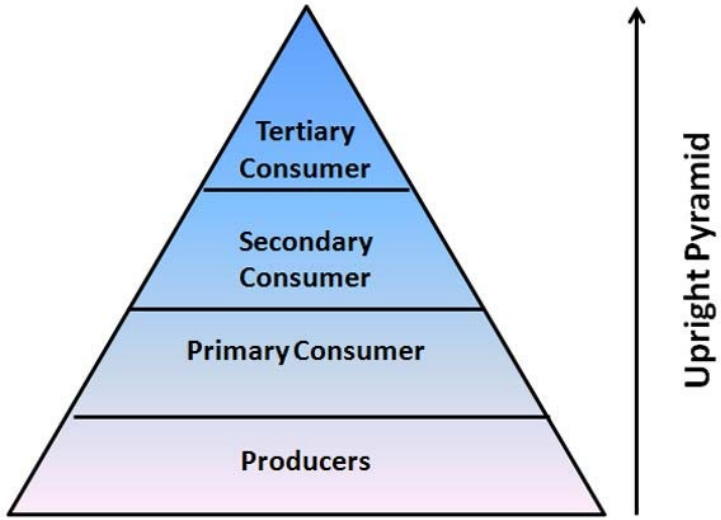
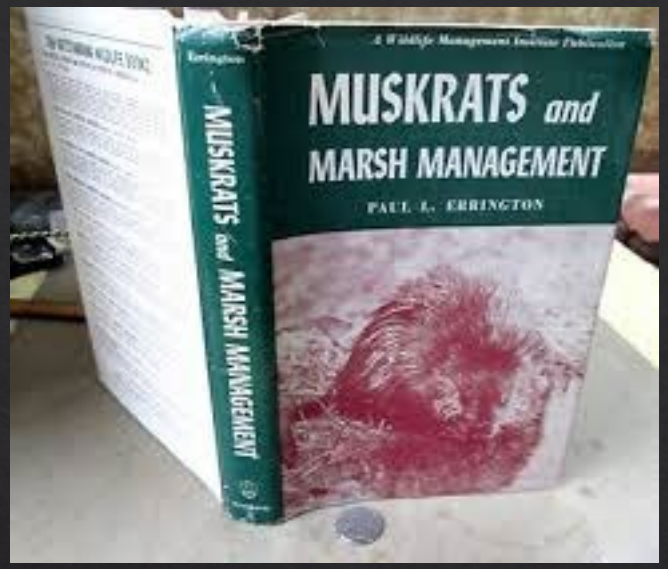


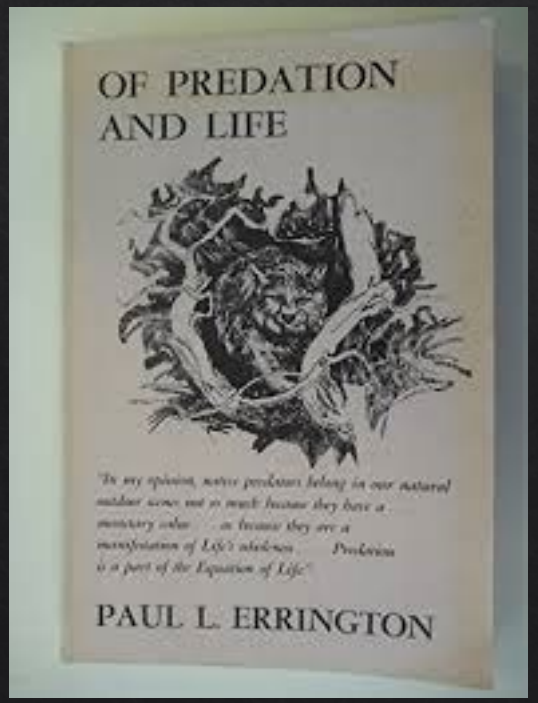
FIG. 4.—Food-cycle among the animals on Bear Island, a barren spot in the arctic zone, south of Spitsbergen. (The dotted lines represent probable food relations not yet proved.) The best way to read the diagram is to start at "marine animals" and follow the arrows. (From Summerhayes and Elton.[35])



Pyramid of Numbers

Paul Errington (1930s-1960s)



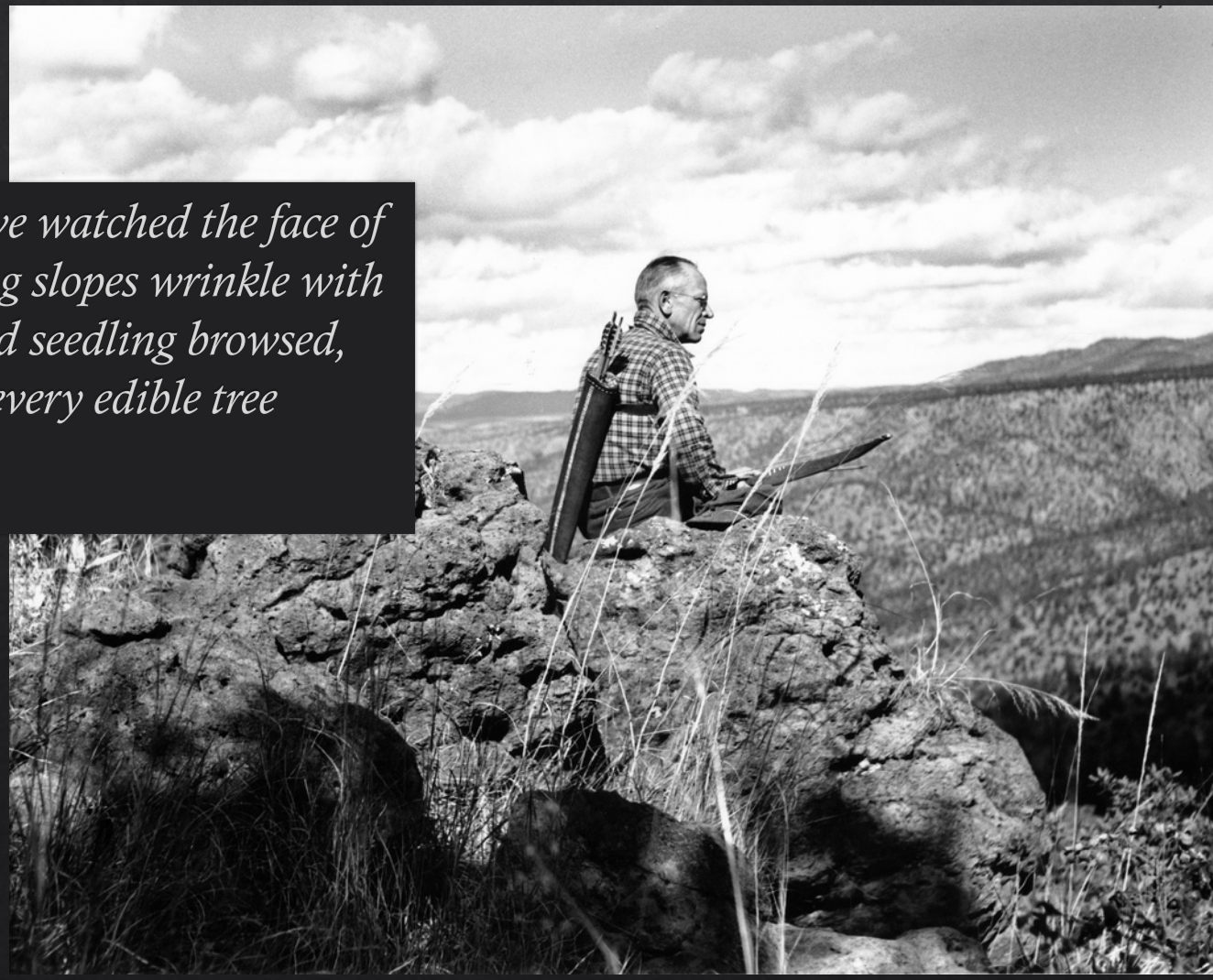


Predators remove a "doomed surplus" of weakened individuals, those in marginal habitat, subdominant or socially excluded, etc.

Predation mortality is largely compensatory, not additive.

Aldo Leopold and Deer on Kaibab Plateau

I have lived to see state after state extirpate its wolves. I have watched the face of many a newly wolfless mountain, and seen the south-facing slopes wrinkle with a maze of new deer trails. I have seen every edible bush and seedling browsed, first to anaemic desuetude, and then to death. I have seen every edible tree defoliated to the height of a saddlehorn.



Leopold, 1949

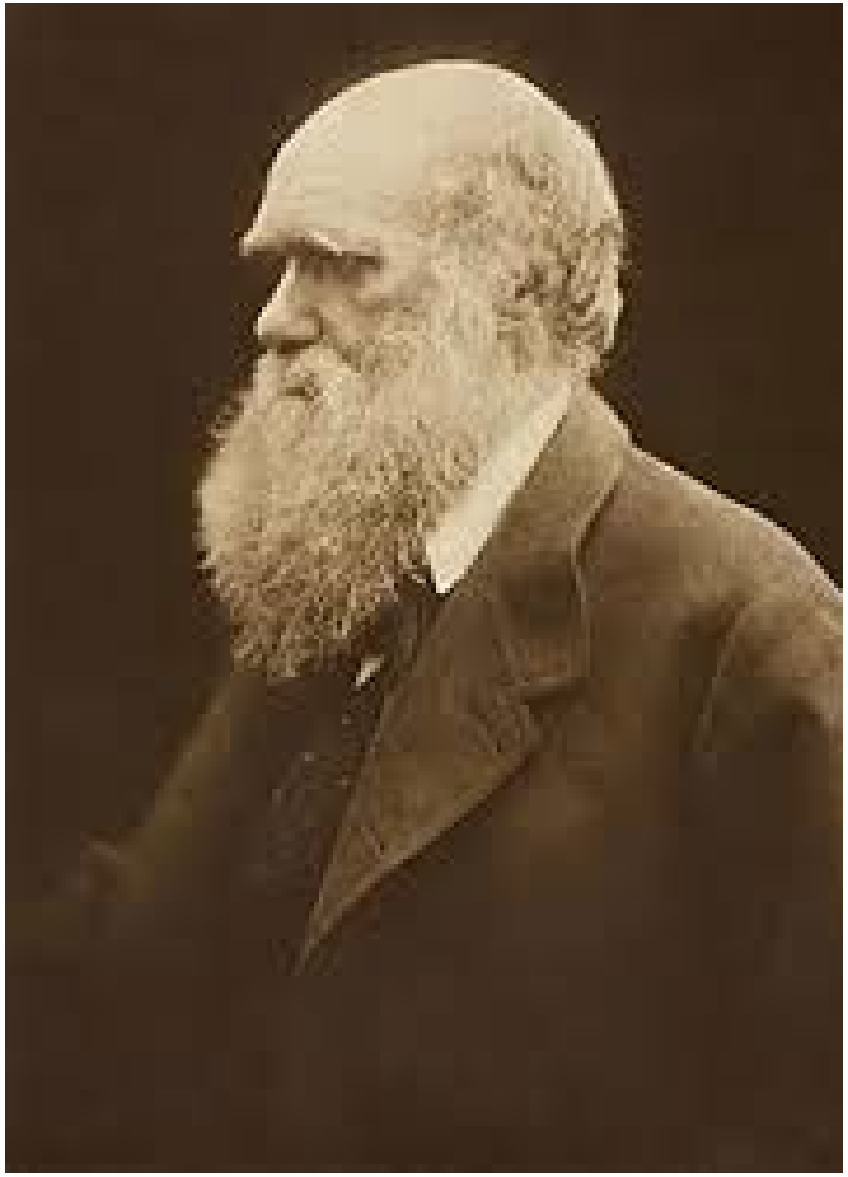
Vol. XCIV, No. 879 The American Naturalist November–December, 1960

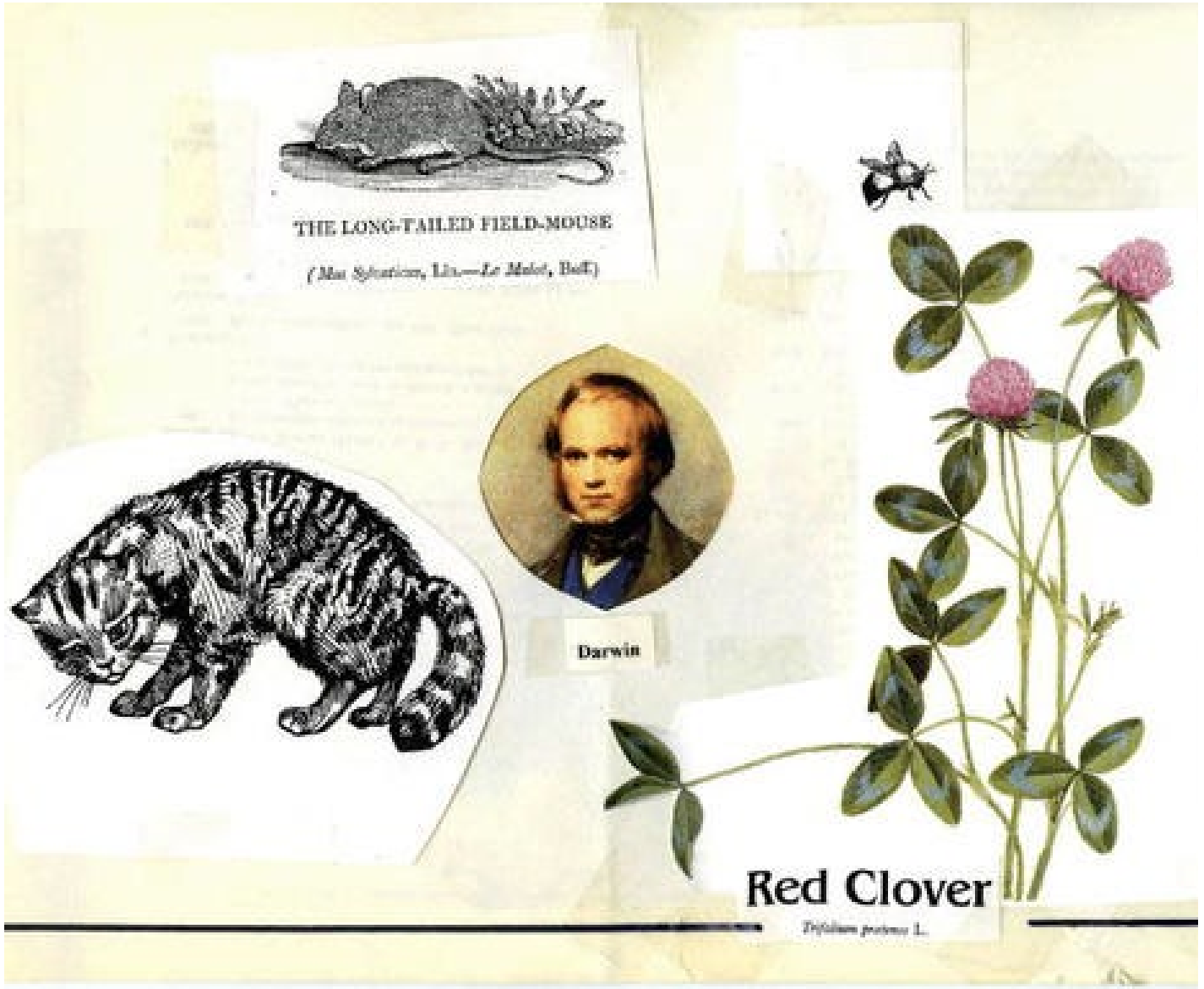
COMMUNITY STRUCTURE, POPULATION CONTROL, AND COMPETITION

NELSON G. HAIRSTON, FREDERICK E. SMITH, AND LAWRENCE B. SLOBODKIN

Department of Zoology, The University of Michigan, Ann Arbor, Michigan

The Green World Hypothesis:
The world is green because higher trophic levels control herbivore abundance



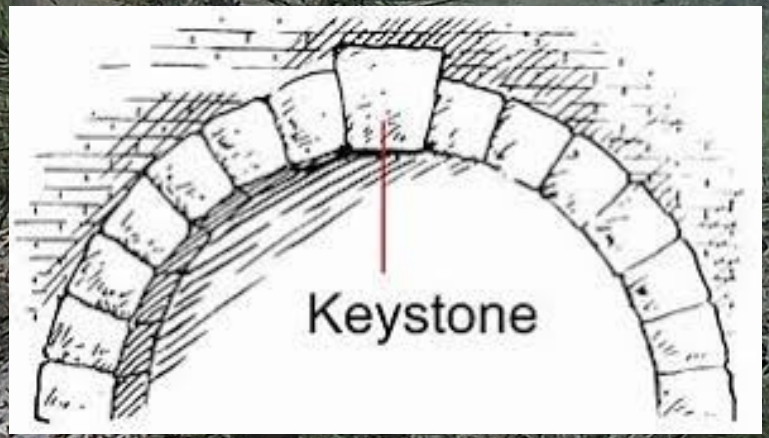

THE LONG-TAILED FIELD-MOUSE
Darwin
Red Clover

Vol. 100, No. 910 The American Naturalist January–February, 1966

FOOD WEB COMPLEXITY AND SPECIES DIVERSITY

ROBERT T. PAINE

Department of Zoology, University of Washington, Seattle, Washington



THE EFFECTS OF GRAZING BY SEA URCHINS, *STRONGYLOCENTROTUS* SPP., ON BENTHIC ALGAL POPULATIONS[1]

Robert T. Paine
Department of Zoology, University of Washington, Seattle 98105
and
Robert L. Vadas[2]
Department of Botany, University of Washington, Seattle 98105

1969

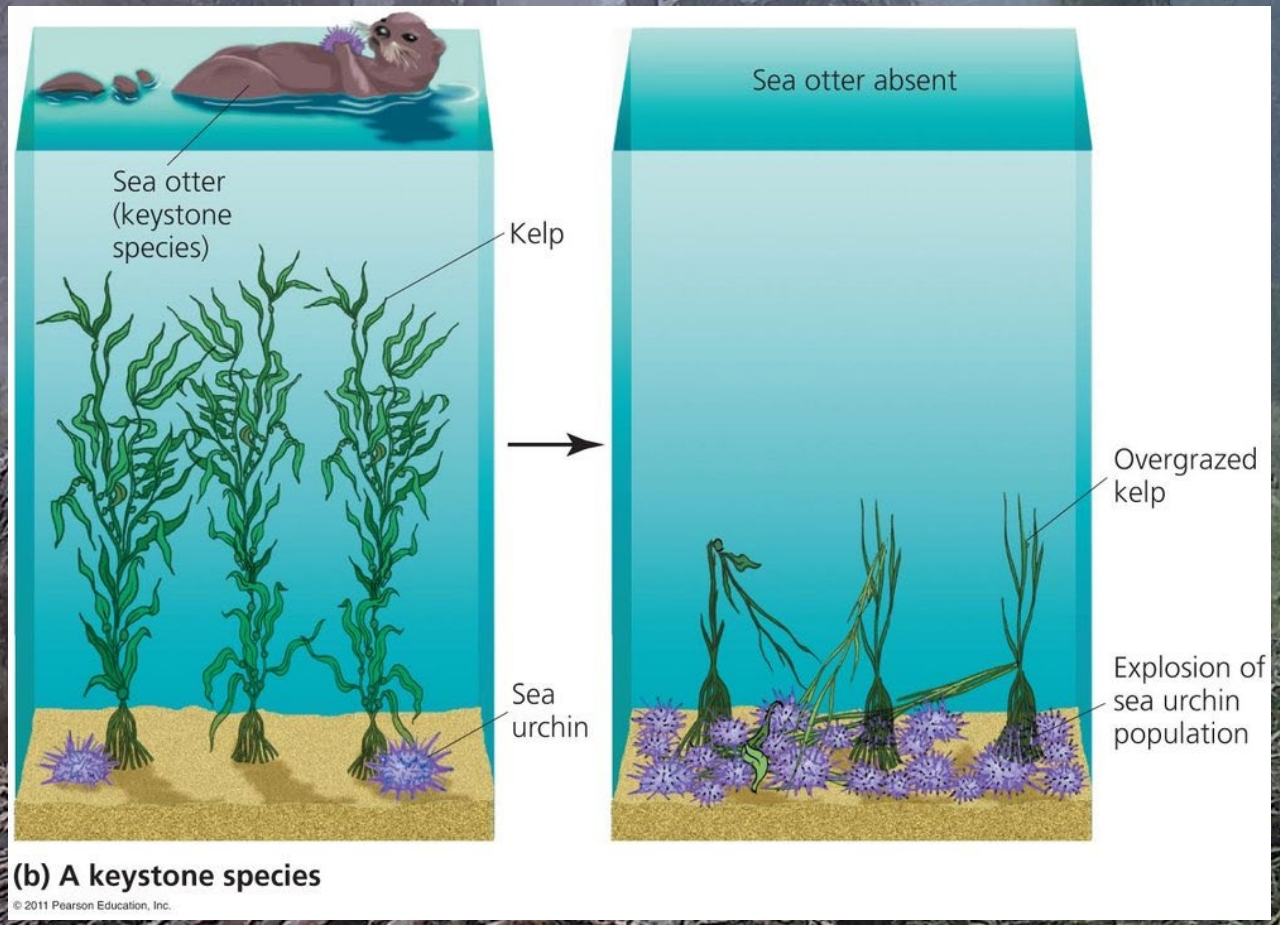
Science
Current Issue | First release papers | Archive | Abou
HOME > SCIENCE > VOL. 185, NO. 4156 > SEA OTTERS: THEIR ROLE IN STRUCTURING NEARSHORE COMMUNITIES

REPORT

Sea Otters: Their Role in Structuring Nearshore Communities

JAMES A. ESTES AND JOHN F. PALMISANO Authors Info & Affiliations

1974



Criticism: Are trophic cascades all wet?

Strong 1992

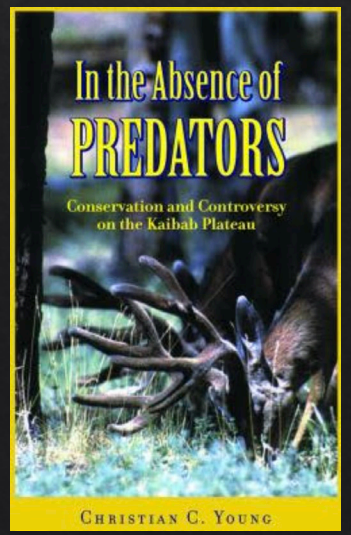
Largemouth bass → Planktivorous Fish → Zooplankton → Phytoplankton

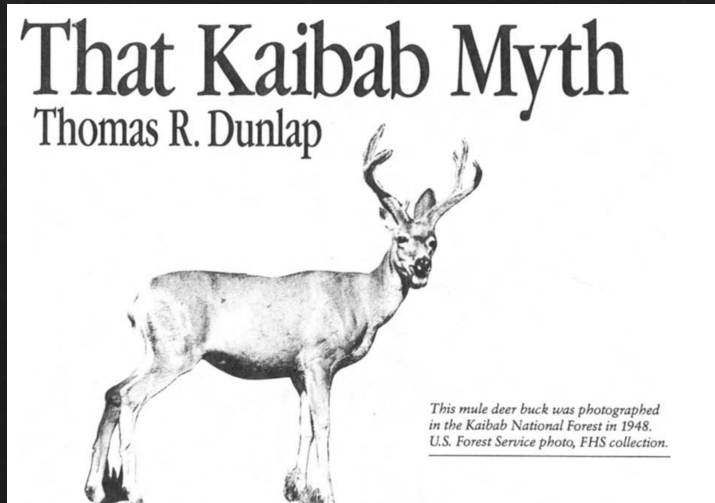
Carpenter et al. 1985
Strong 1992

Questioning the Kaibab Plateau Story

Many authors, most famously Graeme Caughley (1970)

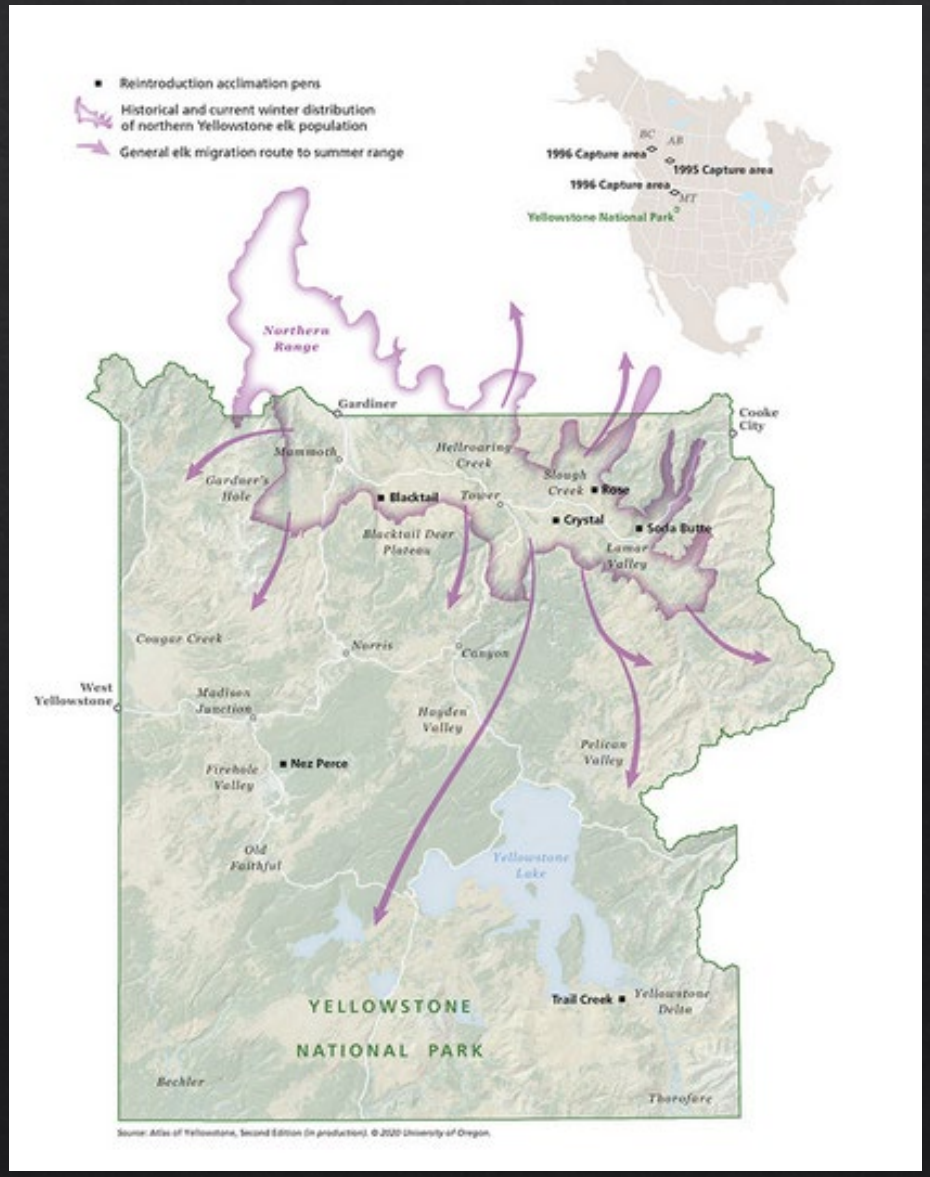
- There was no discrete predator removal event and wolves had been absent long before deer increase
- From 1880s – 1906, when Roosevelt established the Grand Canyon National Game Preserve, sheep and cattle **severely overgrazed** the plateau
- Livestock removed by executive order, providing bottom-up release
- Kaibab becomes a "parable" to articulate Leopold's evolving land ethic and his argument that predators are essential to ecosystems.



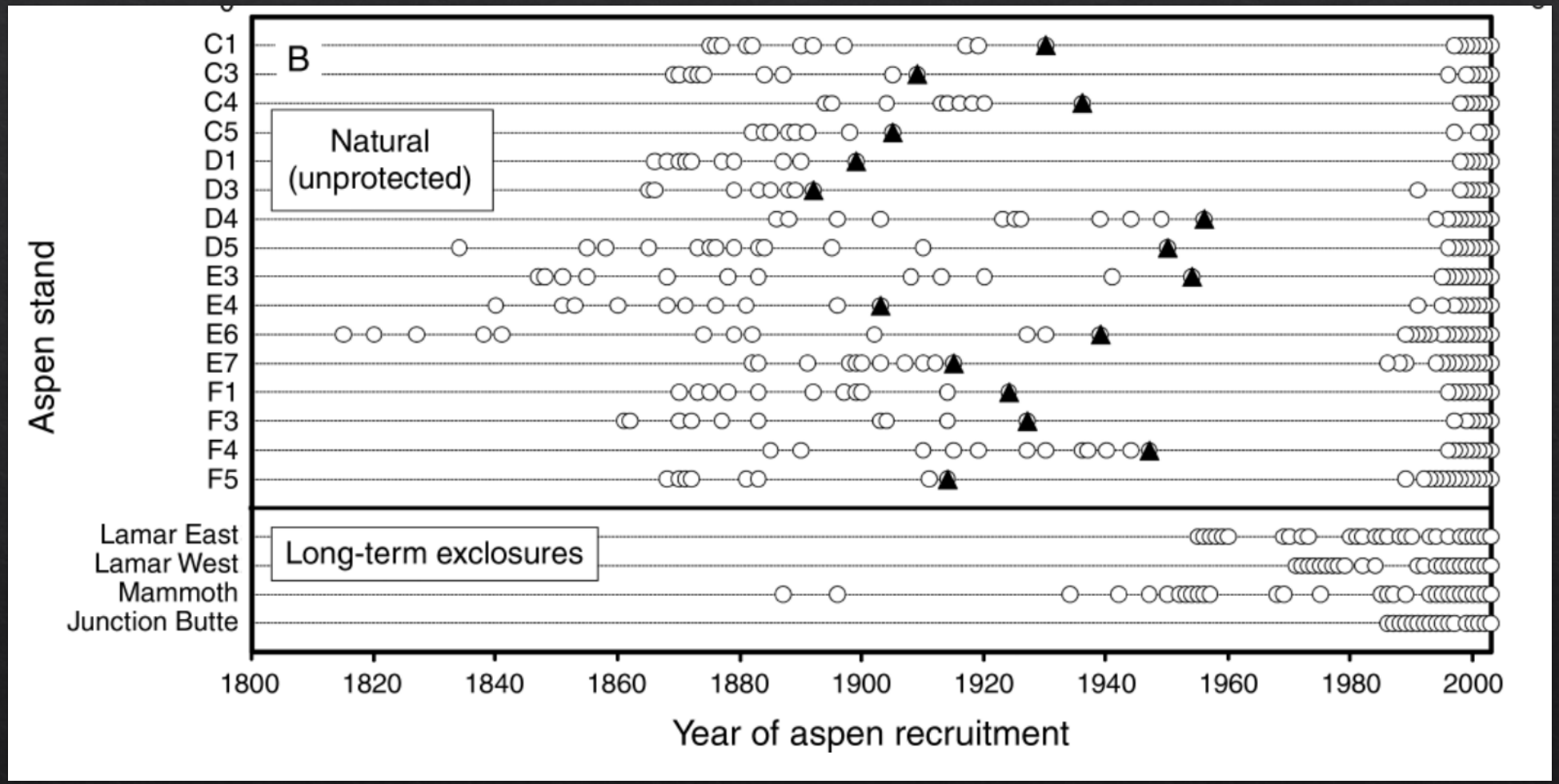


Did Wolves Transform Yellowstone National Park?

Introduced 1995/1996



No aspen recruitment

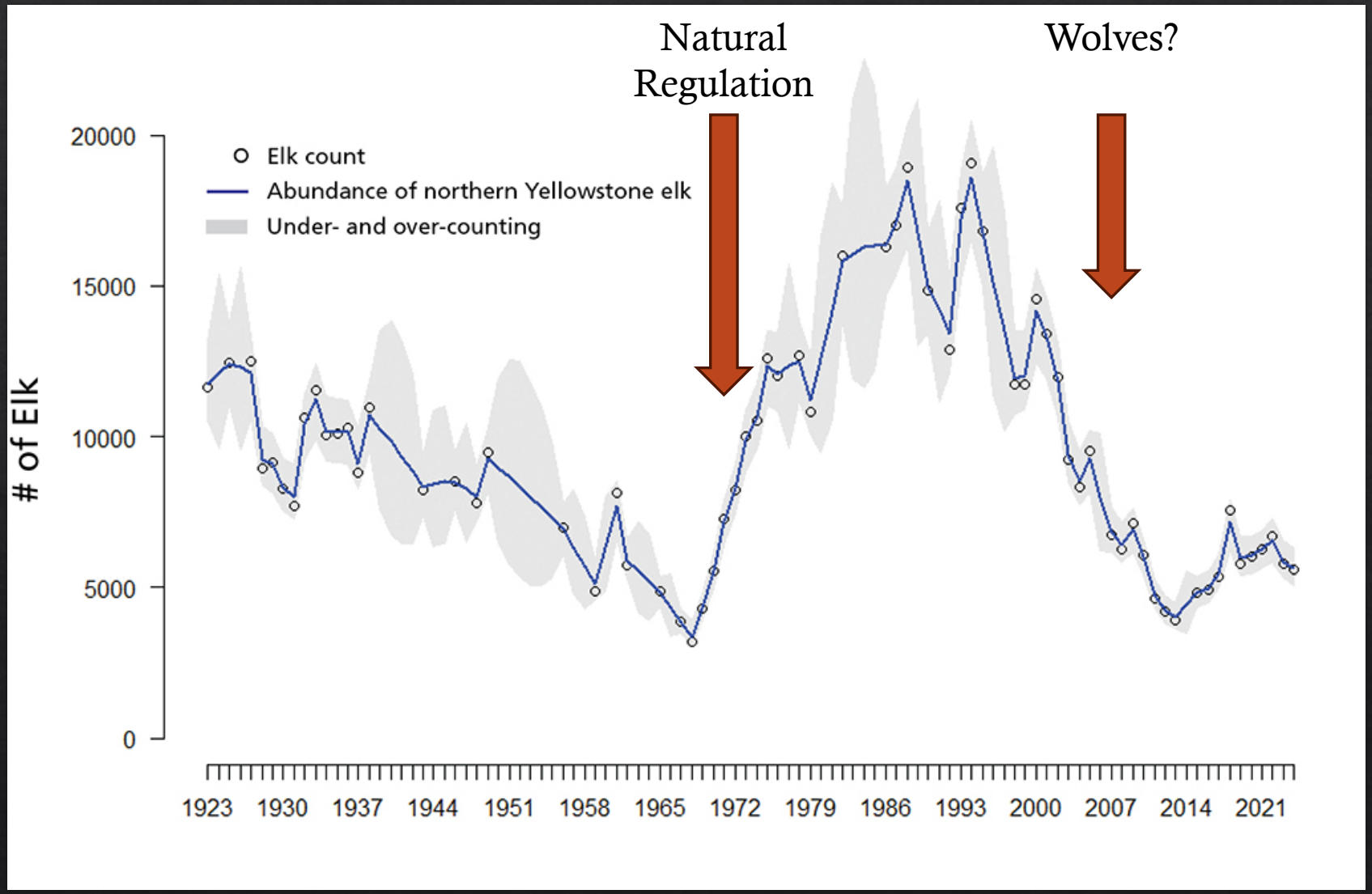


Kauffman et al. 2010

Wolves as drivers of trophic cascades?

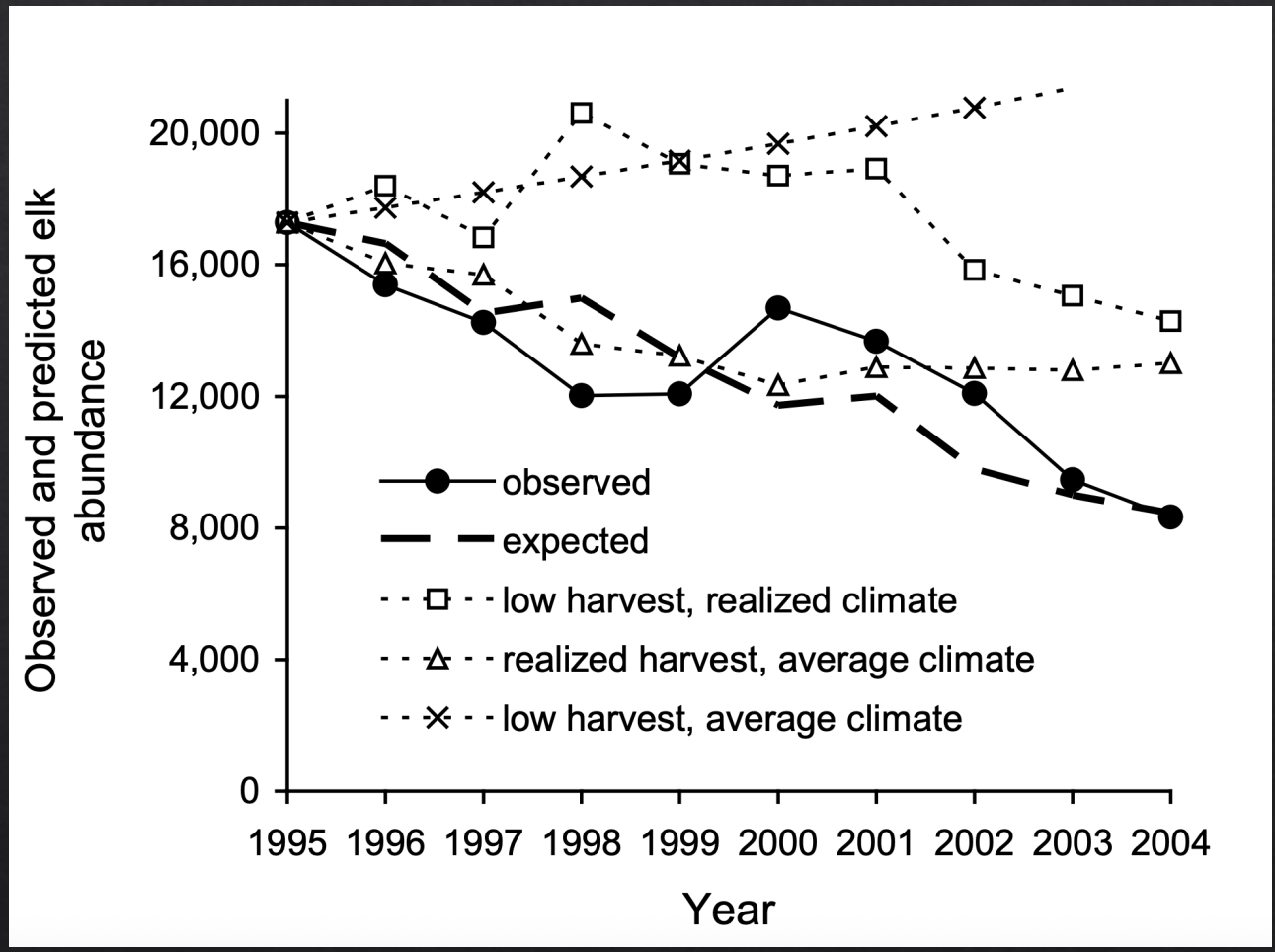
Ripple & Larsen 2000
Ripple et al. 2001
Ripple & Beschta 2003

Northern Range Elk



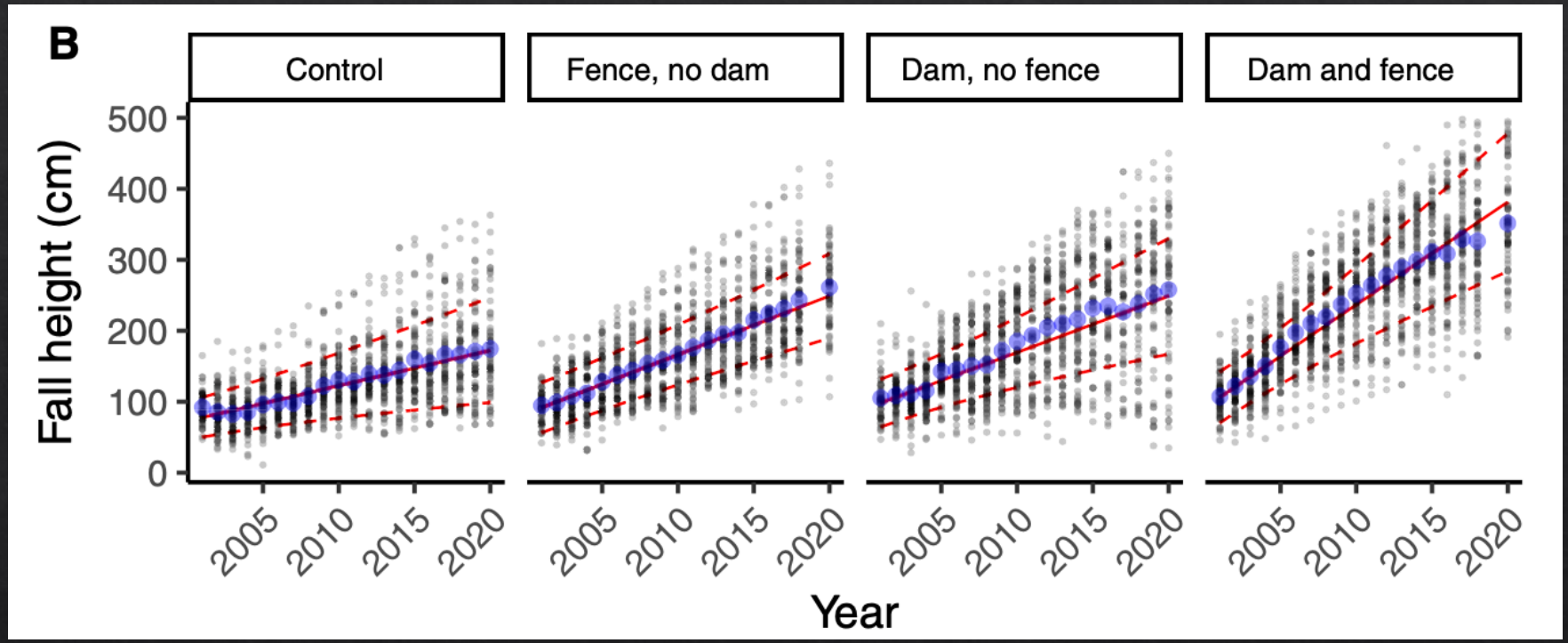
What caused elk to decline from 1995-2004?

- Elk declined by 8.1% annually
- Aggressive cow harvest (mostly) and climate explained this decline
  - >7500 elk harvested in first three years
- In most years between 1998 and 2004, cougars killed a larger proportion of the elk population than did wolves (Metz et al.2020, Ruth et al. 2019)
- Bears are dominant calf predator and elk dynamics are better explained by variation in calf survival
- Wolves mostly killed calves and old adults—the modal age of a wolf-killed adult female elk was approximately 16 years, compared to just 4 years for hunter-killed (MacNulty et al. 2020).



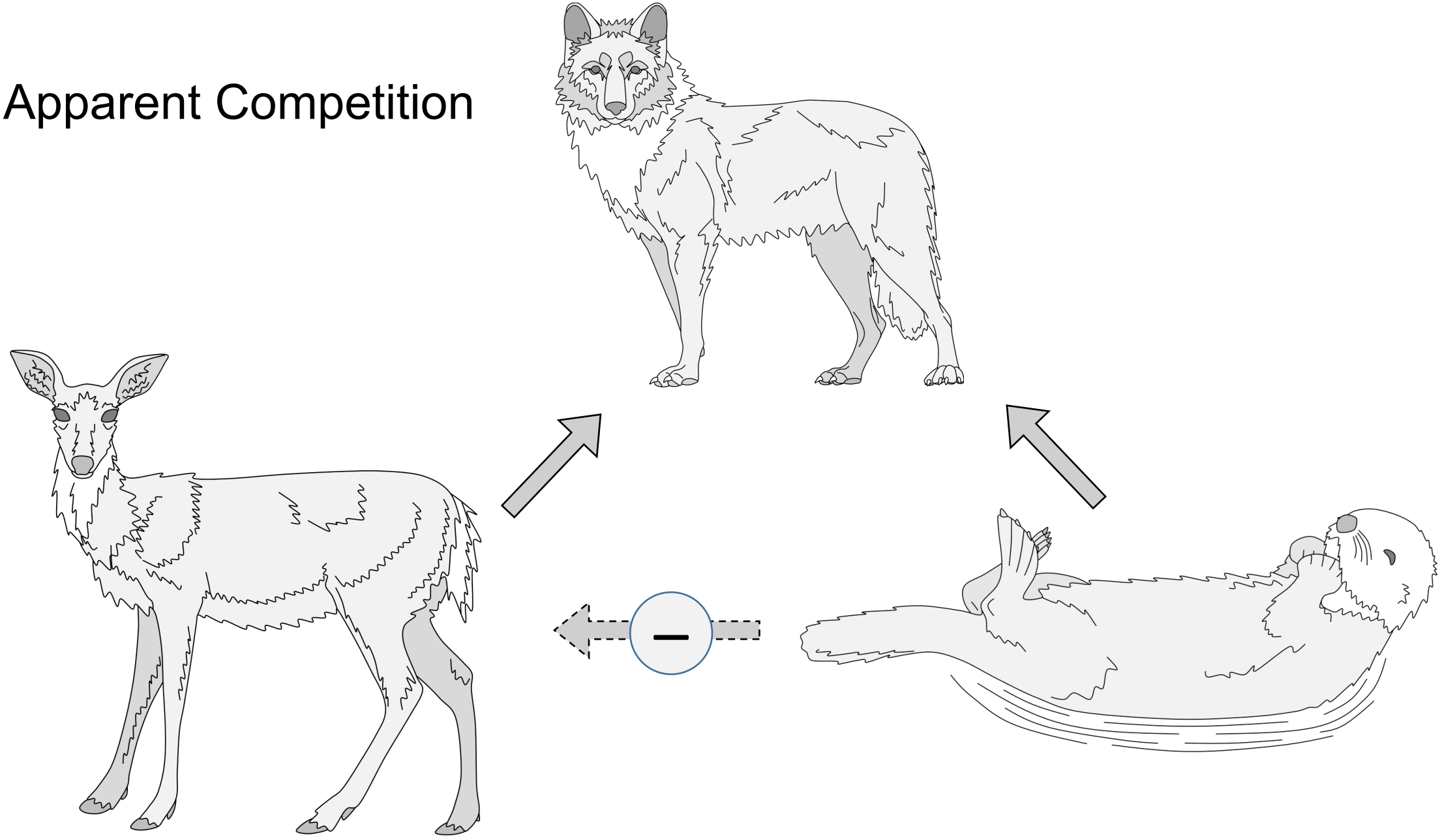
Vucetich et al. 2005

Did the decline of elk cause widespread willow recovery?



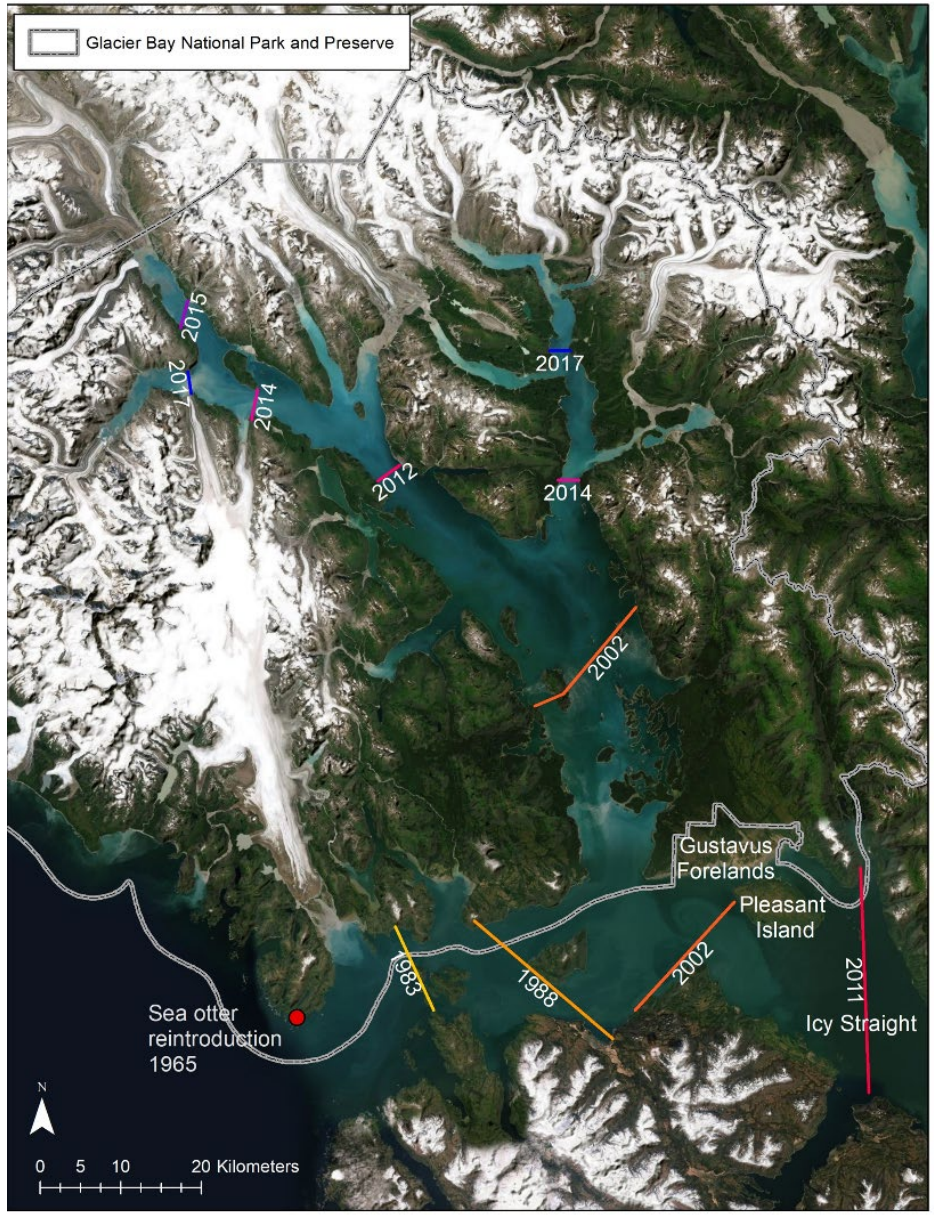
Hobbs et al. 2024

Apparent Competition



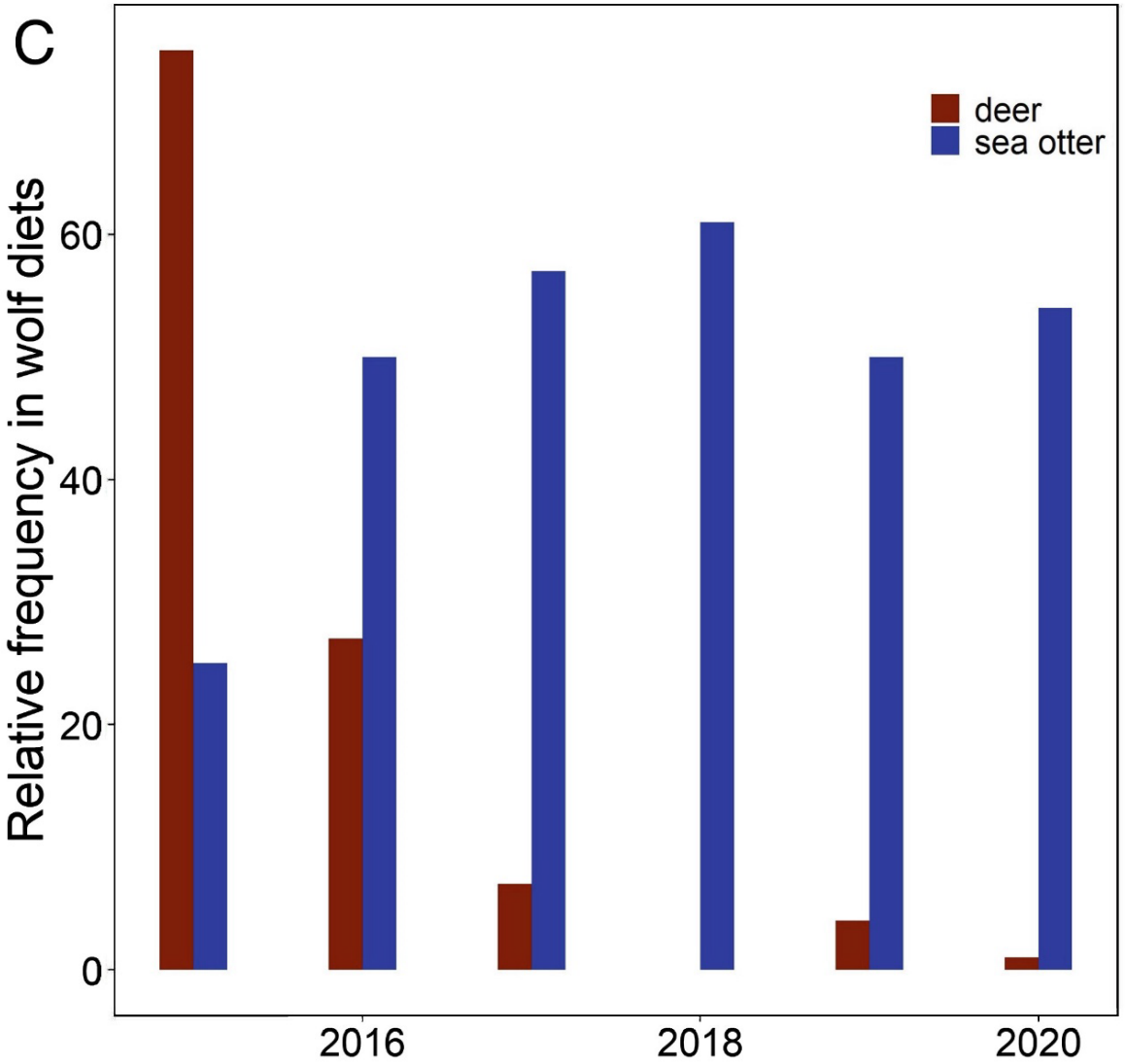

ALASKA DEPT OF
FISH & GAME

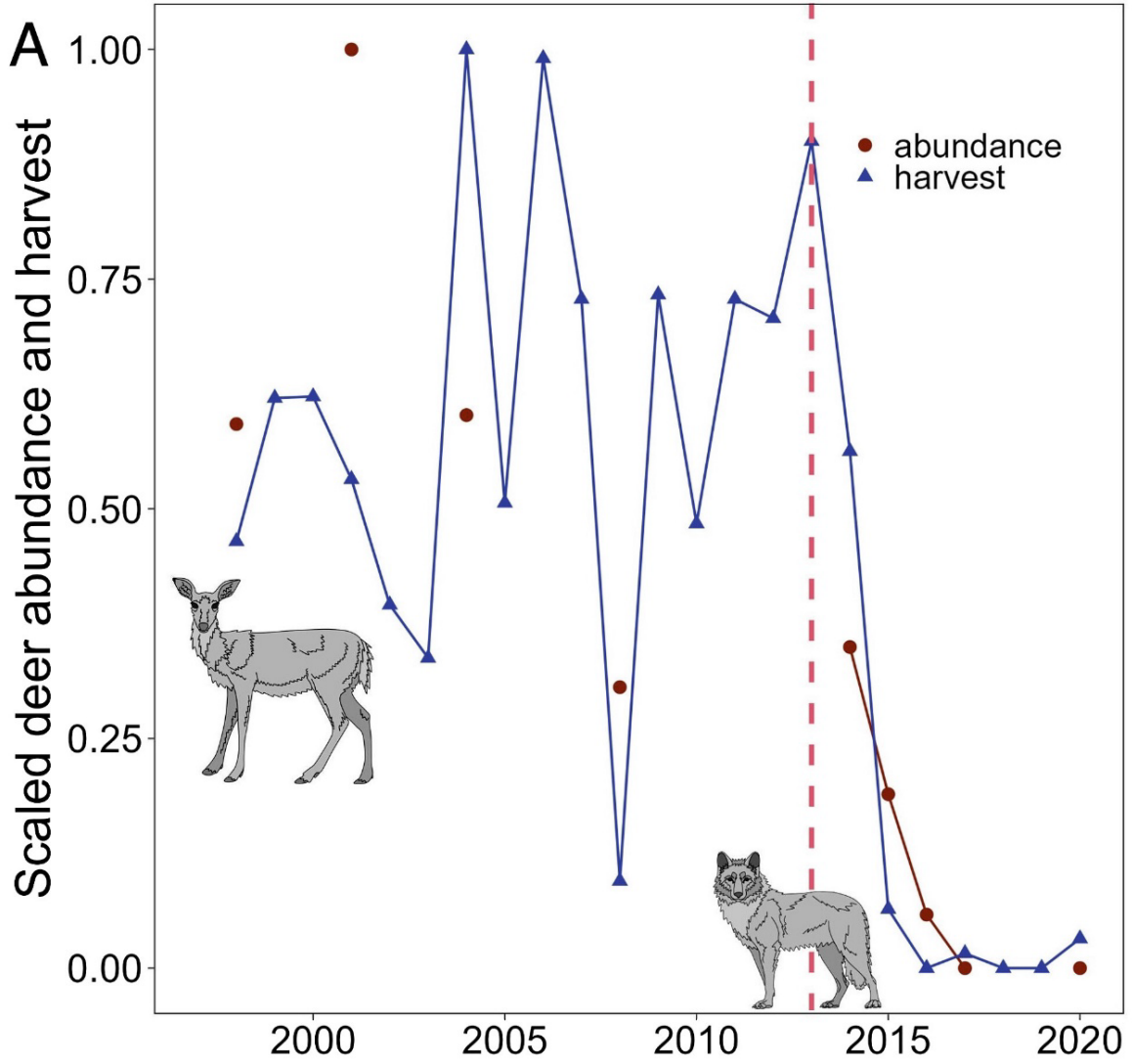
Sea otter recovery



Roffler, G.H., Eriksson, C.E., Allen, J.M., Levi, T., 2023. Recovery of a marine keystone predator transforms terrestrial predator–prey dynamics. *Proceedings of the National Academy of Sciences*

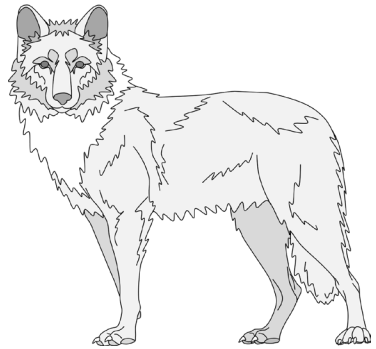
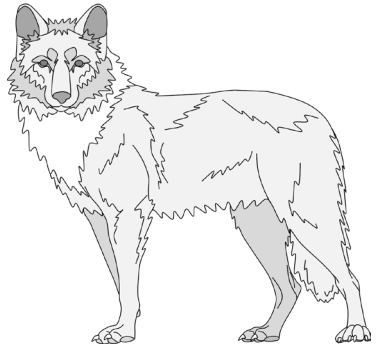
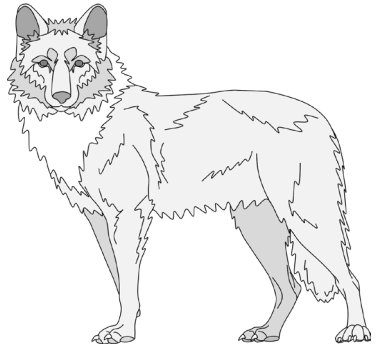
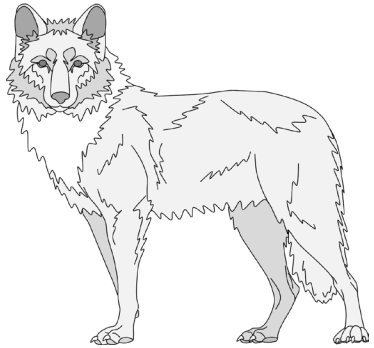
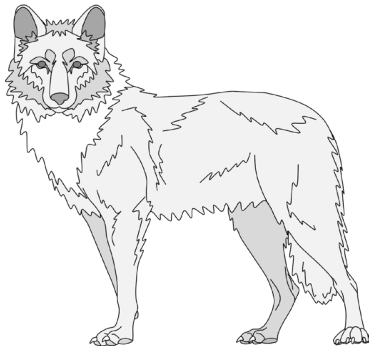
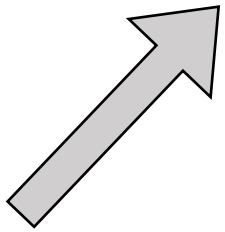
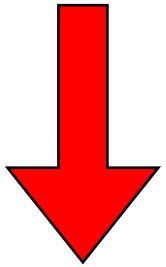
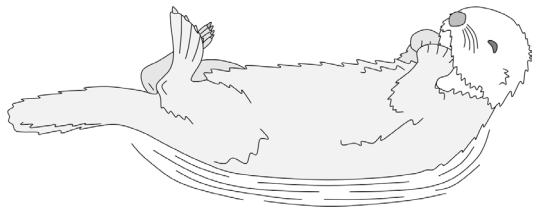
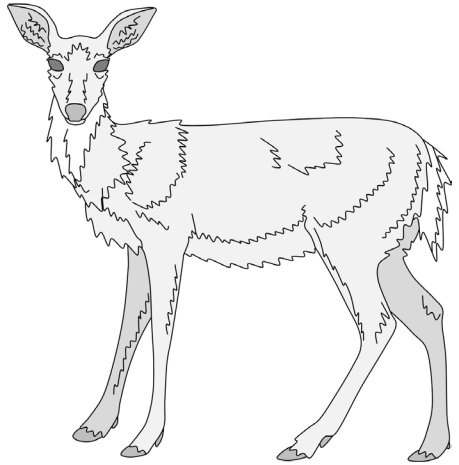
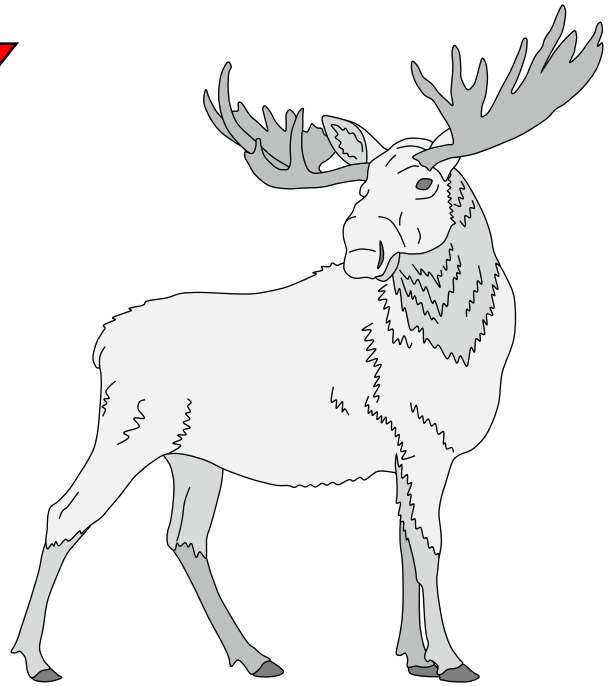
Sea otter recovery facilitates collapse of deer on Pleasant Island





Roffler, G.H., Eriksson, C.E., Allen, J.M., Levi, T., *2023*. Recovery of a marine keystone predator transforms terrestrial predator–prey dynamics. Proceedings of the National Academy of Sciences

Was this the historical baseline?


Sea
Gates of the Arctic
National Park
RUSSIA
Kotzebue
Kobuk Valley
National Park
Bering Strait
ALASKA
Nome
Fairbanks
CANADA
Wrangell-St. Elias
National Park
Wasilla
Palmer
Anchorage
Valdez
2022
2022-2024
Glacier Bay
National Park
Cordova
Bethel
Kenai
Lake Clark
National Park
Juneau
Bering
Sea
Homer
2023-2024
Kenai Fjords
National Park
Petersburg
Wrangell
Sitka
2021
Gulf of Alaska
Ketchikan

EXPERIMENTAL MOOSE REDUCTION LOWERS WOLF DENSITY AND STOPS DECLINE OF ENDANGERED CARIBOU

INTRODUCTION

Moose and white-tailed deer populations have **increased** in western north America due to **climate change and forestry**

This has also **increased predators** that are causing the **decline and extirpation of woodland caribou**

Serrouya, R., McLellan, B. N., van Oort, H., Mowat, G., & Boutin, S. (2017). Experimental moose reduction lowers wolf density and stops decline of endangered caribou. *PeerJ*, *5*, e3736.

TREATMENT AREA
6500 km²

Moose reduction

Caribou stabilized

REFERENCE AREA
11500 km²

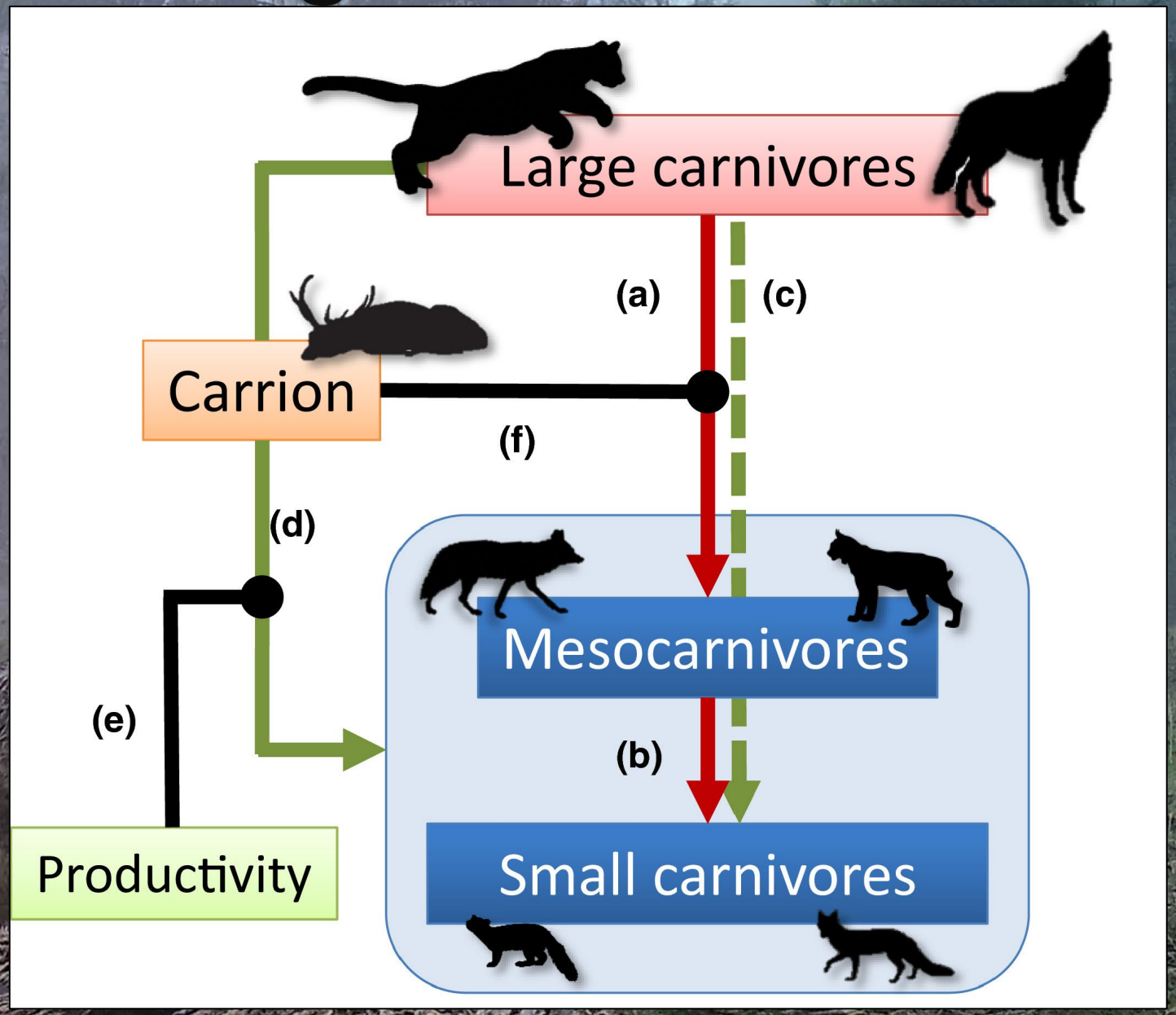
No intervention

Caribou decline continued

RESULTS

Following the moose reduction, **the largest caribou population stabilized**, whereas in the reference area caribou populations continued to decline.

Interactions among carnivores



ECOLOGY LETTERS

Ecology Letters, (2020) **23**: 902–918 doi: 10.1111/ele.13489

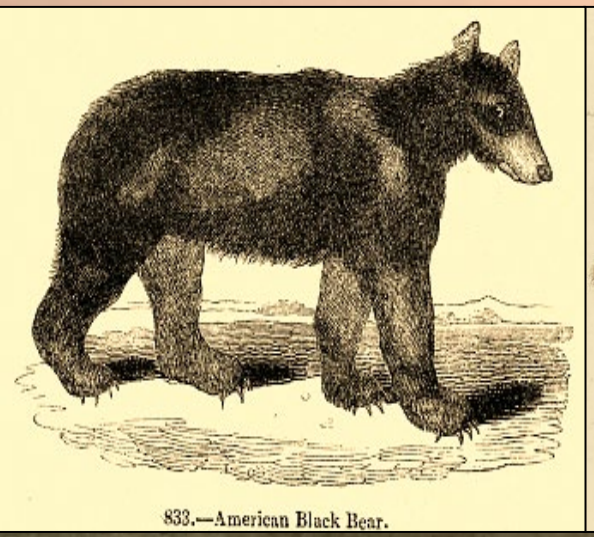
REVIEW AND SYNTHESES

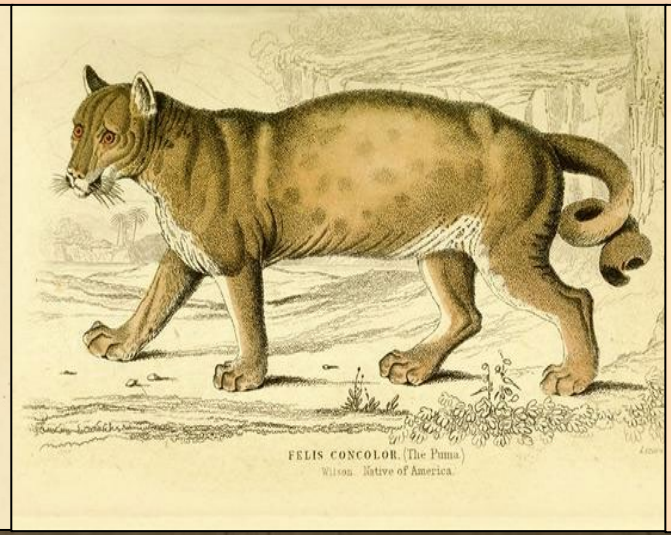
Enemies with benefits: integrating positive and negative interactions among terrestrial carnivores

Laura R. Prugh* and Kelly J. Sivy

School of Environmental and Forest Sciences, University of Washington, Seattle, WA 98195, USA

Risk-reward tradeoffs in Eastern Oregon carnivore communities



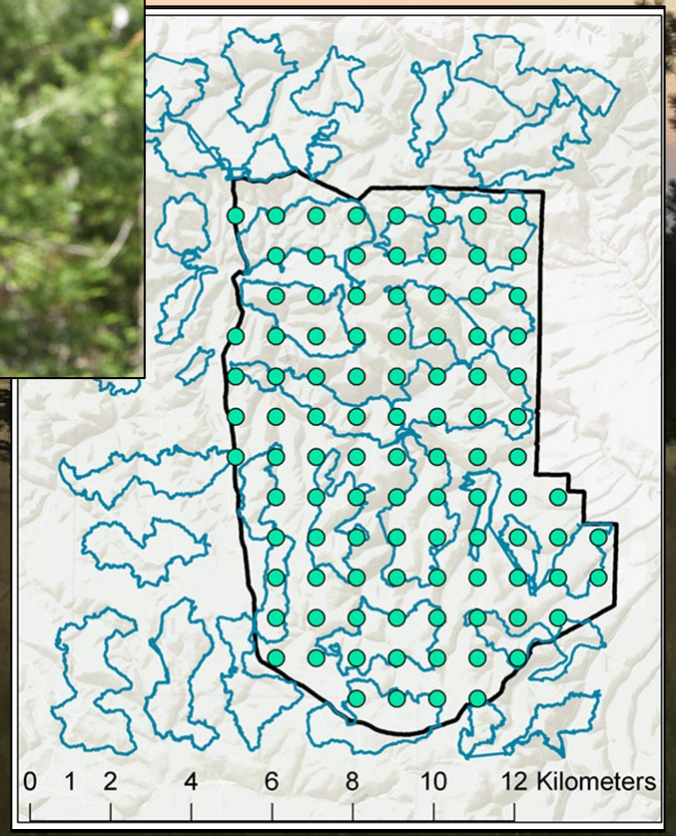


Scats

> 1200 carnivore scats collected

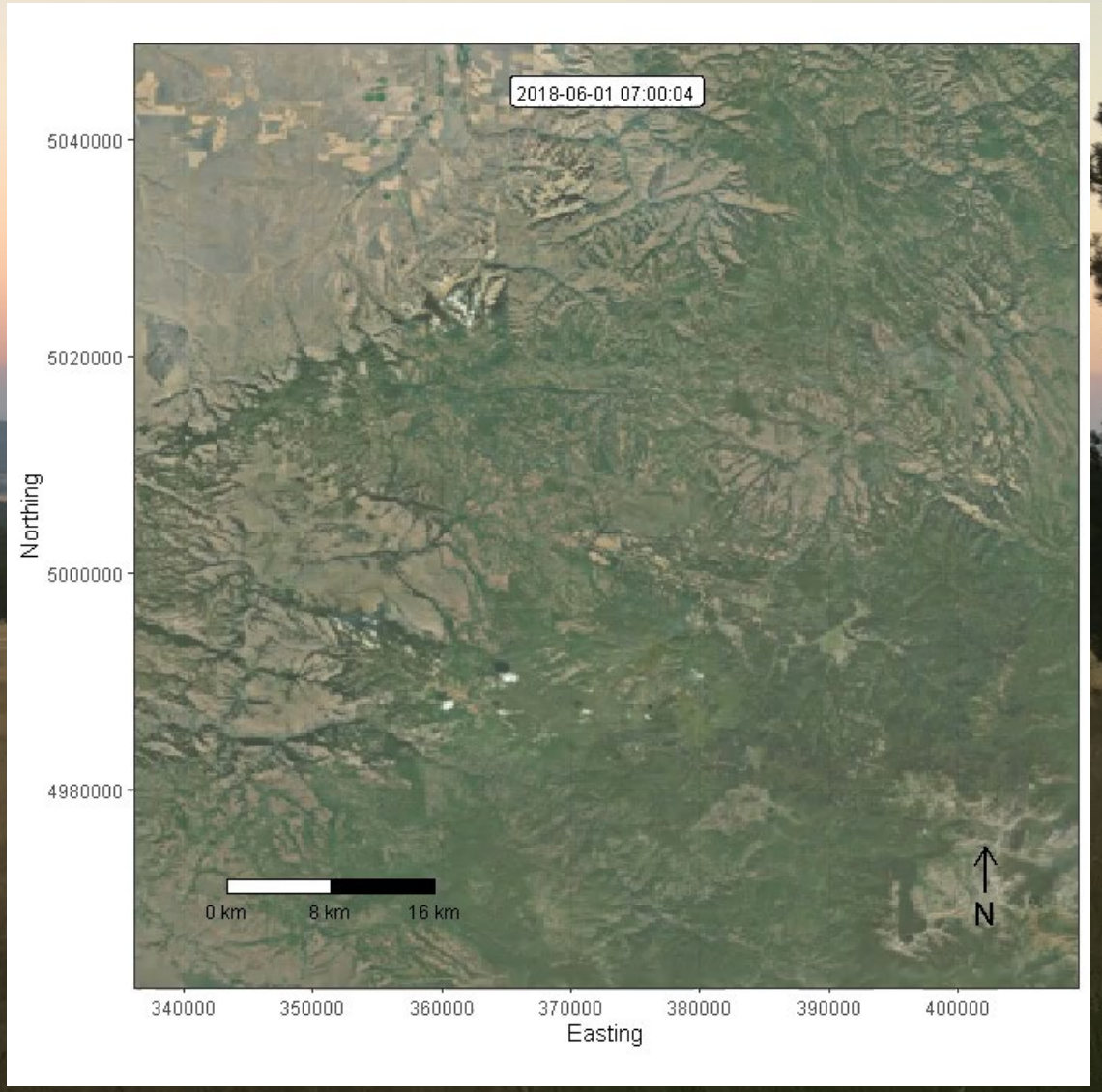
Scats

Trail cameras



> 1200 carnivore scats collected

GPS collars



> 50 carnivores GPS collared (17 cougar, 17 coyote, 11 bears, 6 bobcats)

Cougar kill site investigations

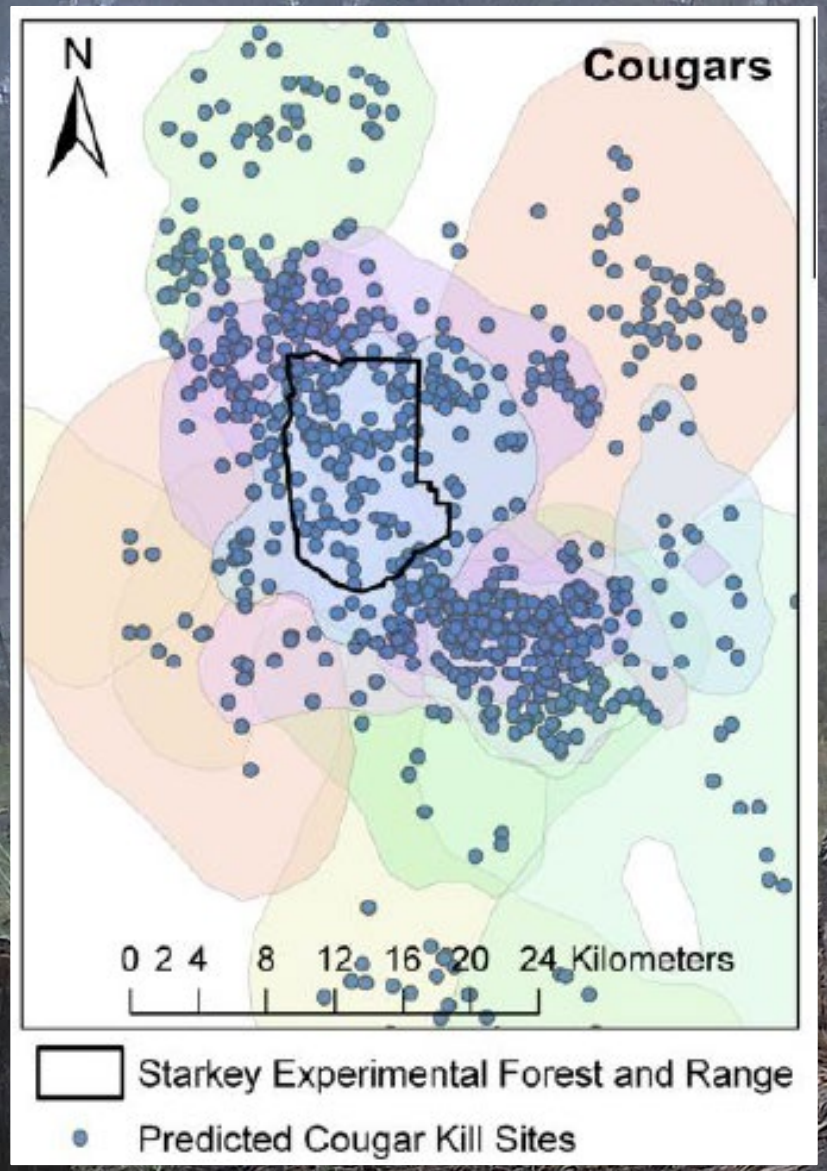

Bushnell
33°F 0°C
03-14-2020 07:18:29

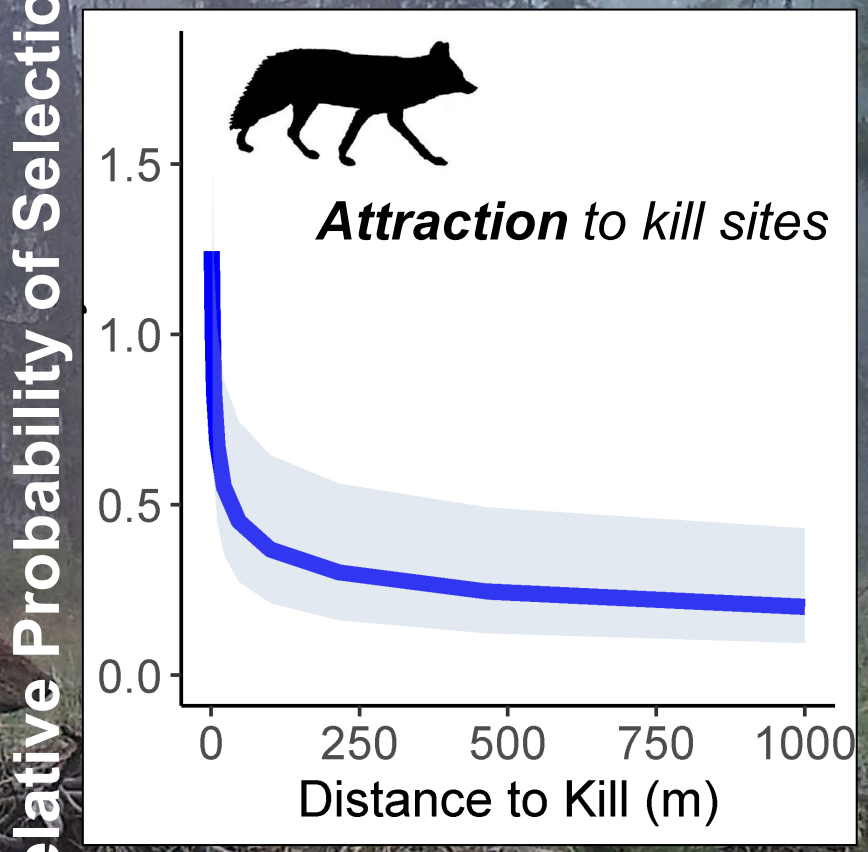

Bushnell
86°F 30°C
08-09-2020 12:02:32

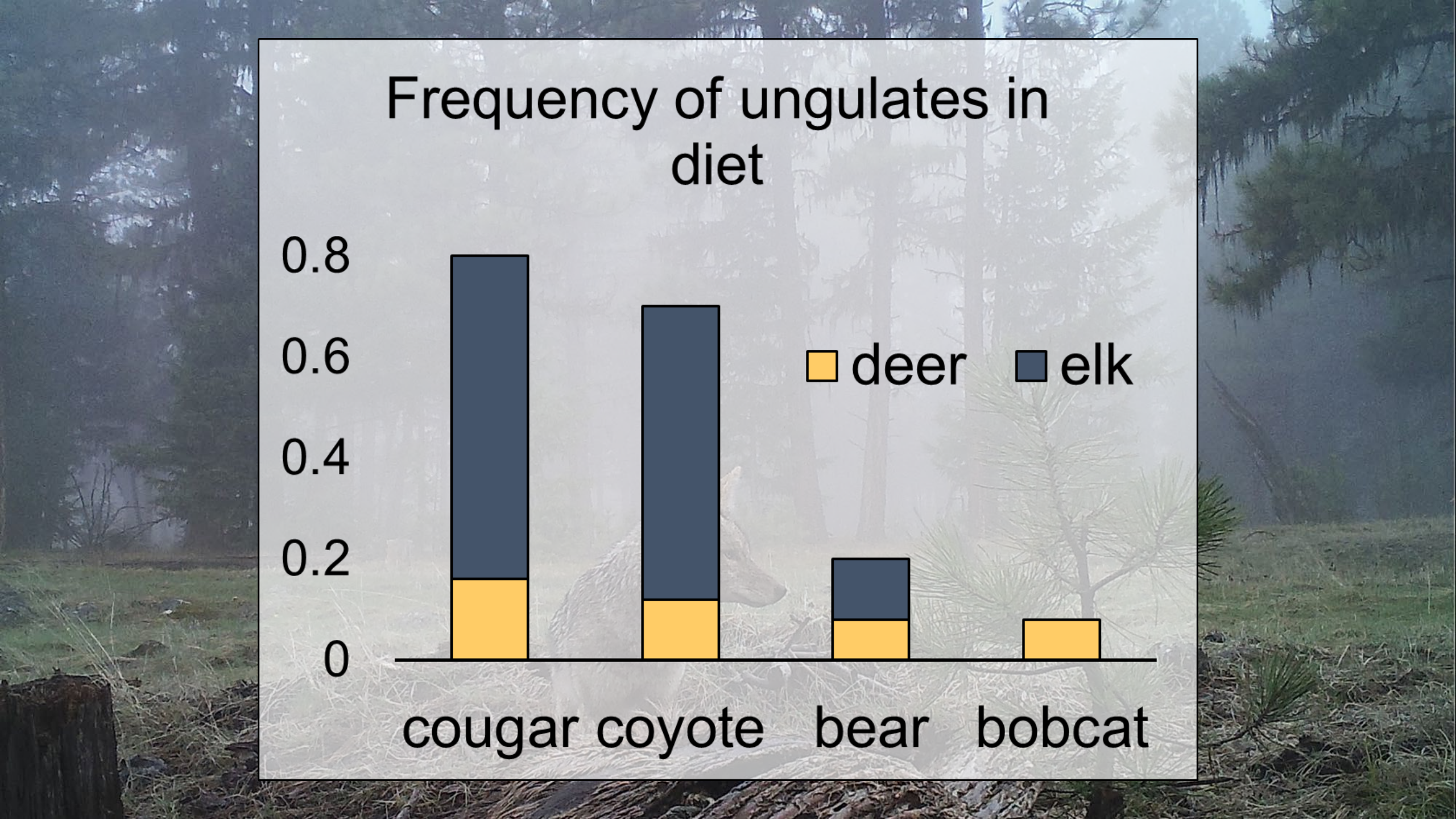

Bushnell
57°F 13°C
04-23-2020 17:11:03

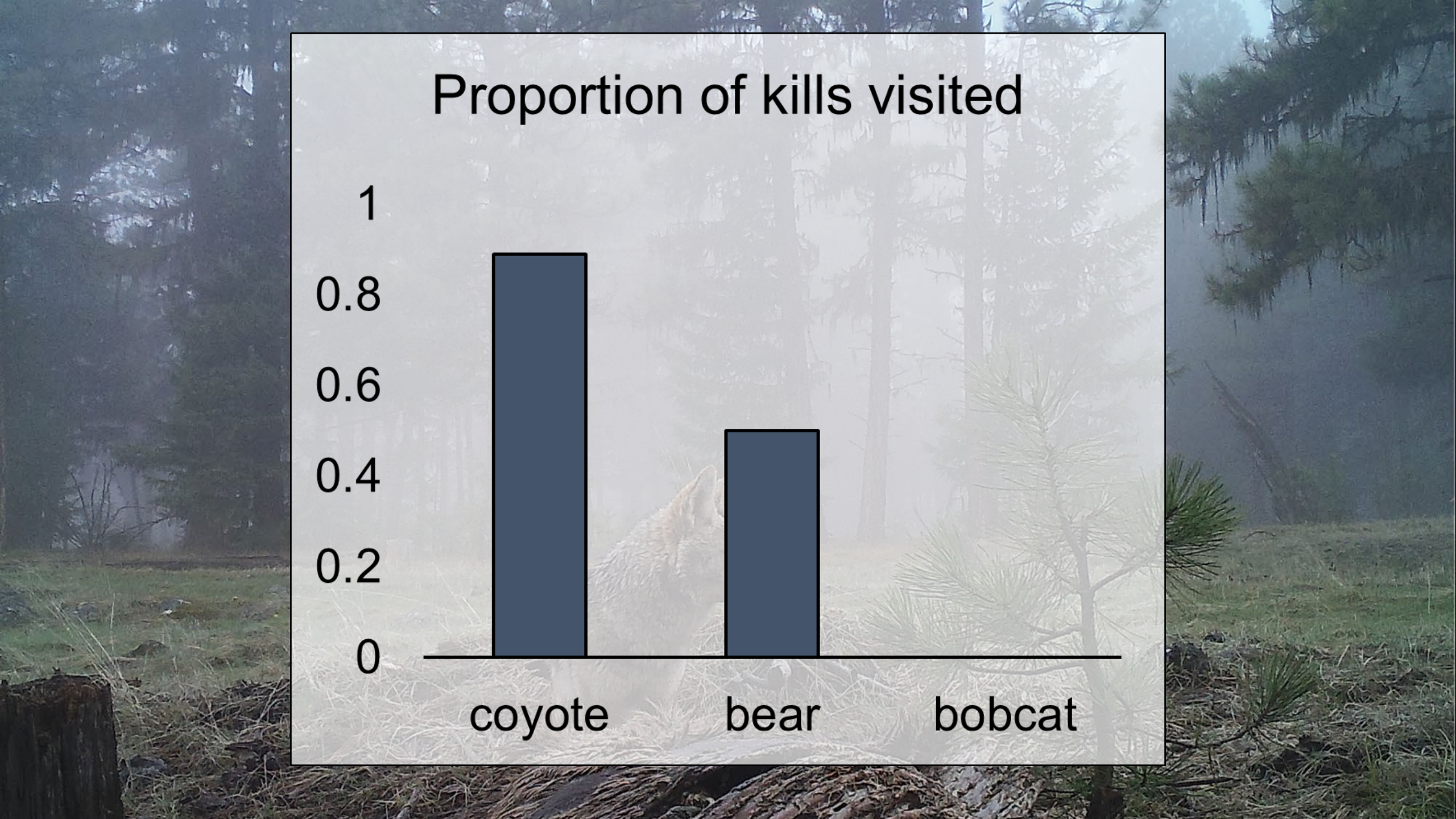

2020-06-30 19:35:33 M
62°F
HYPERFIRE 2 COVERT
RECONYX

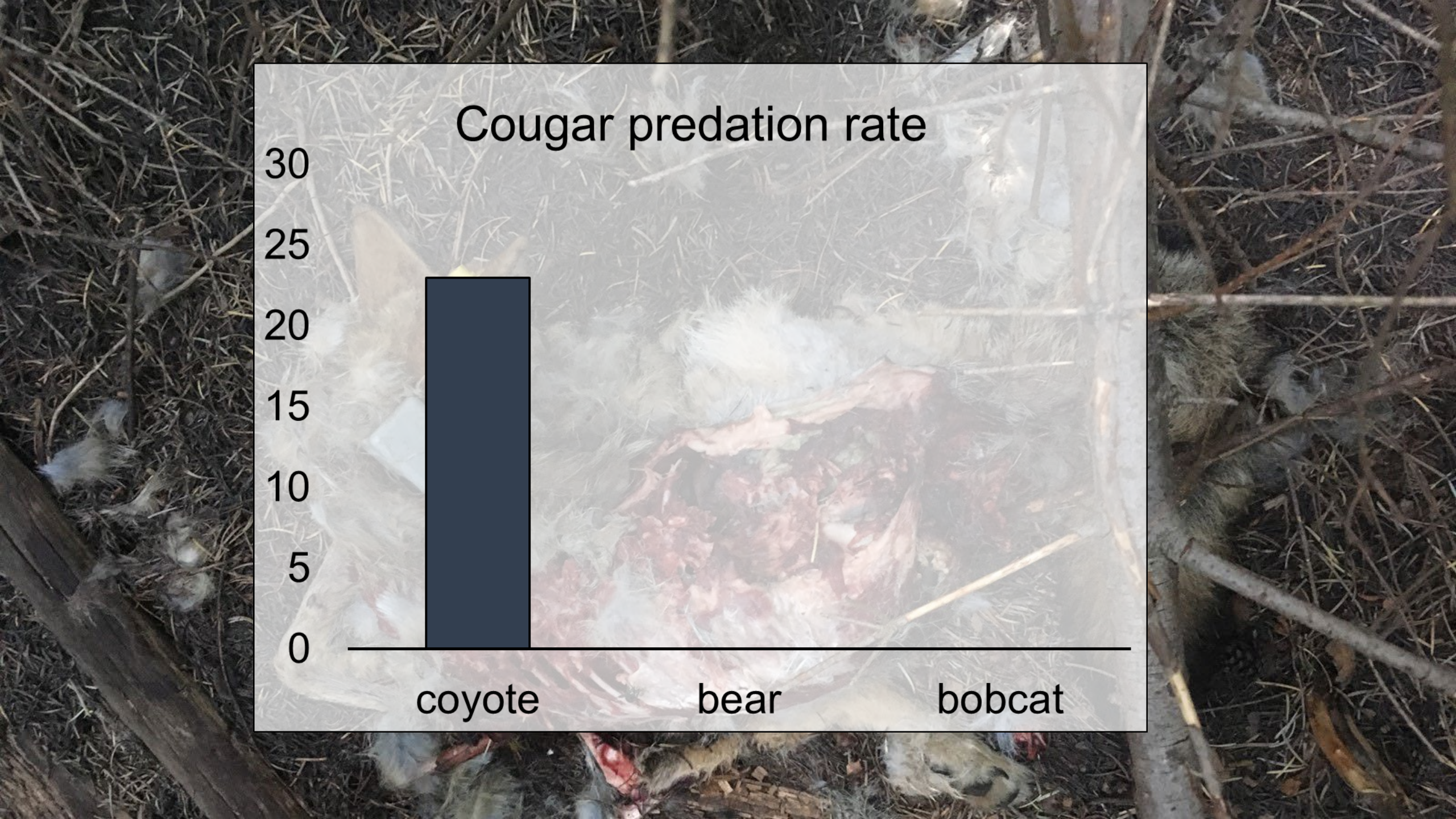
Coyotes strongly attracted to kill sites






Frequency of ungulates in diet
0.8
0.6
0.4
0.2
0
deer
elk
cougar
coyote
bear
bobcat


Proportion of kills visited
1
0.8
0.6
0.4
0.2
0
coyote
bear
bobcat


Cougar predation rate
30
25
20
15
10
5
0
coyote
bear
bobcat

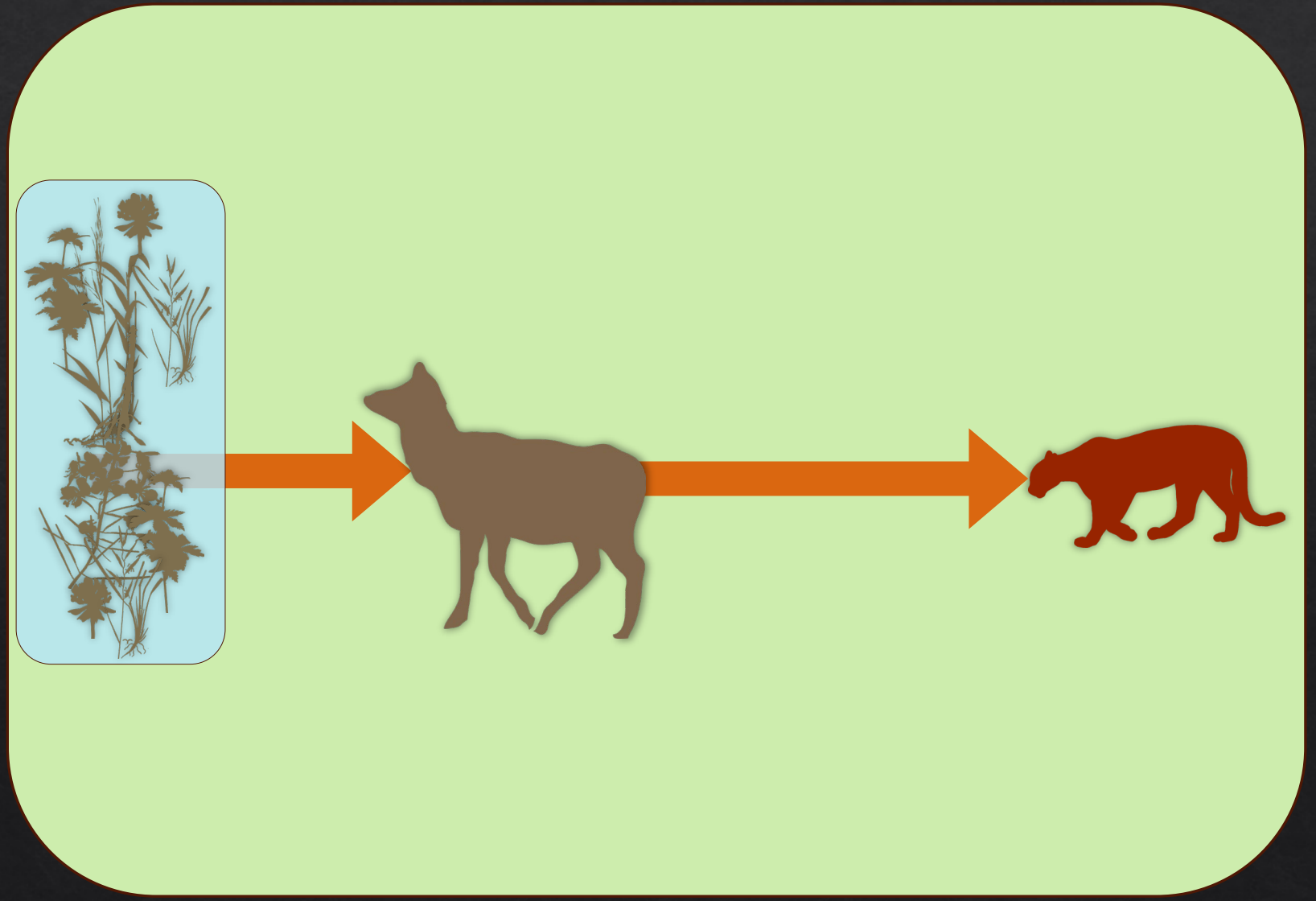
Enemies Without Benefits


23.50 inHg
35°F
04/09/2022 05:10PM CAM 127

Can we make sense of complex webs of interactions?

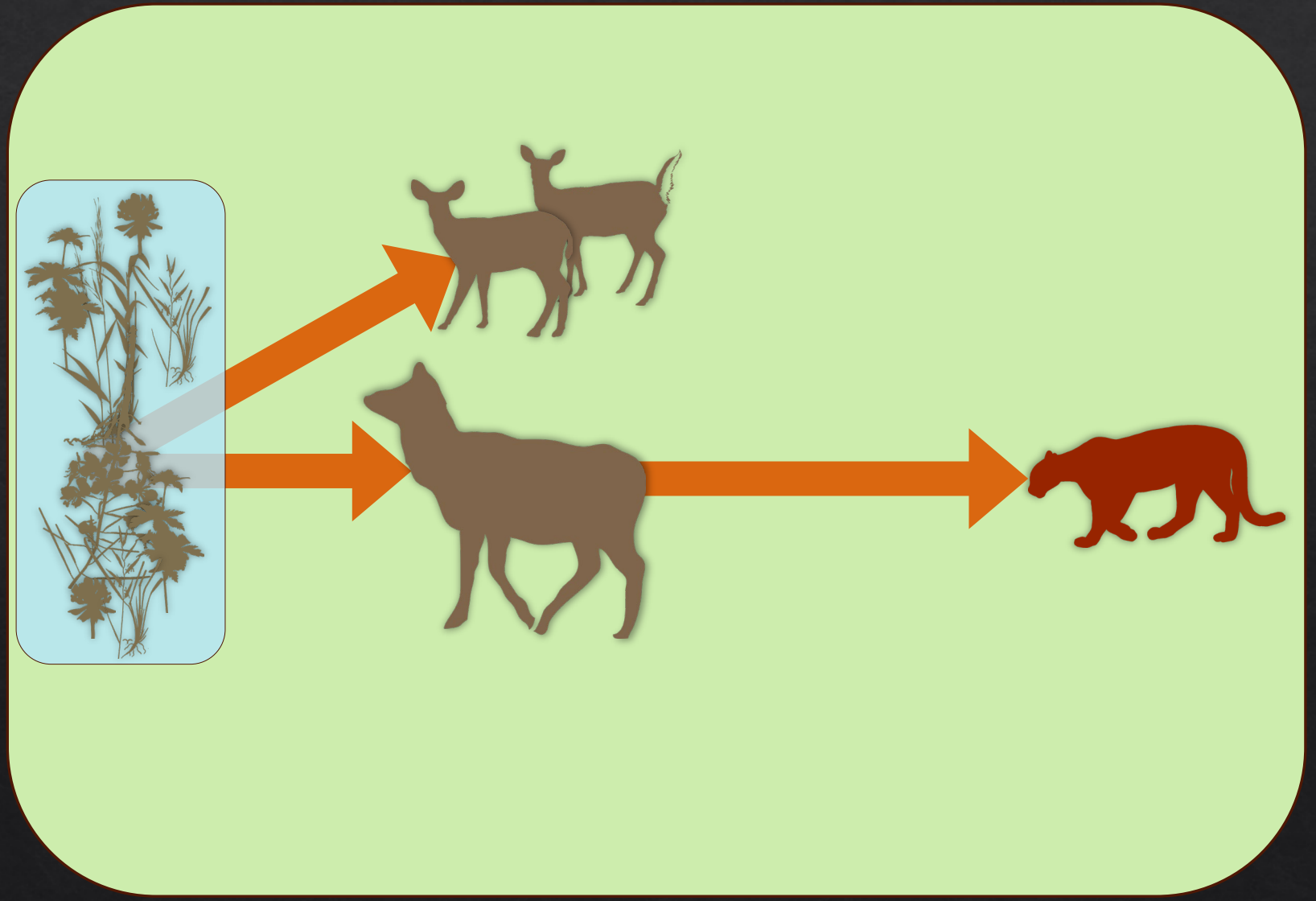
Community hypotheses

- Predation



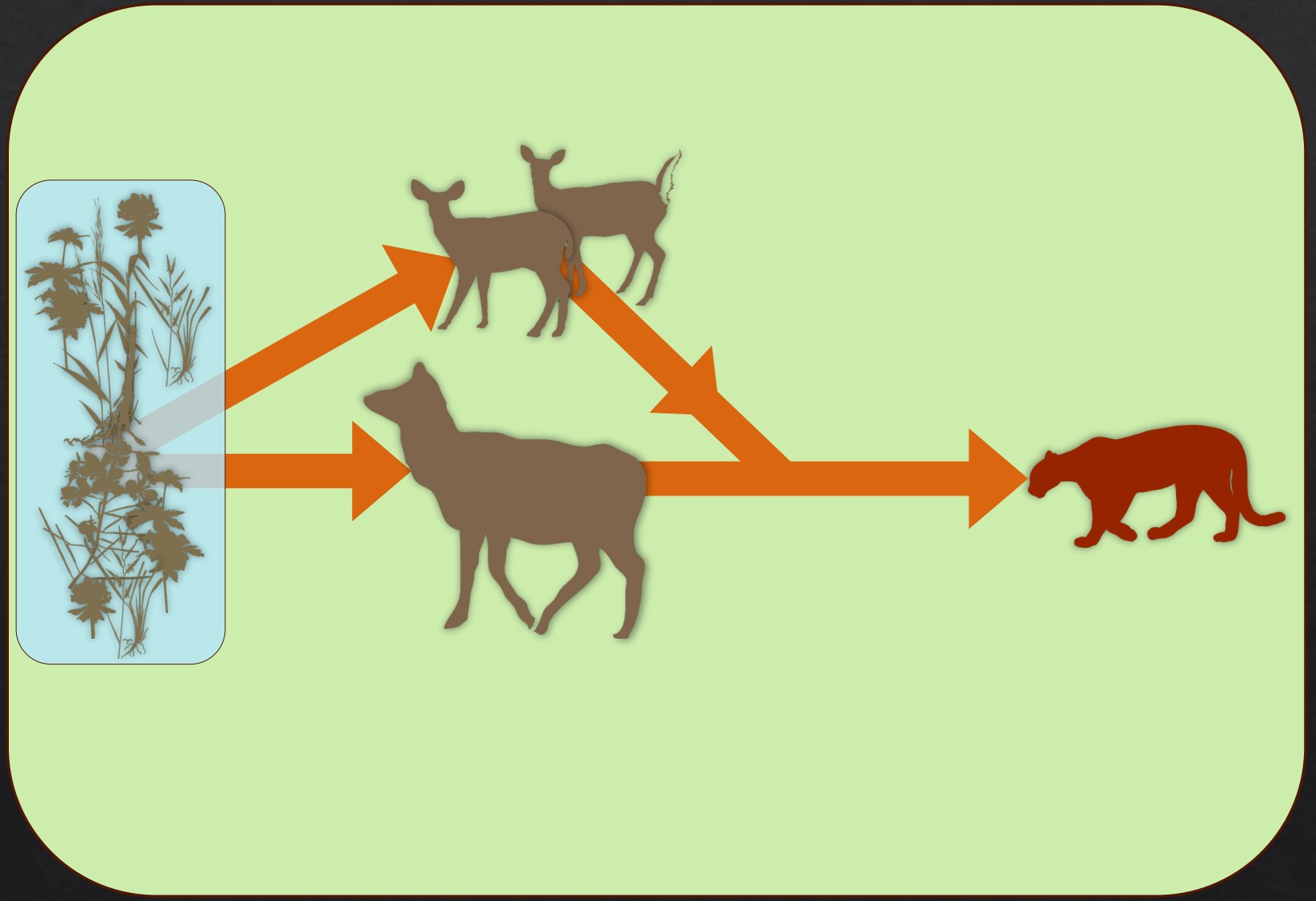
Community hypotheses

- Predation
- Competition



Community hypotheses

- Predation
- Competition



Community hypotheses

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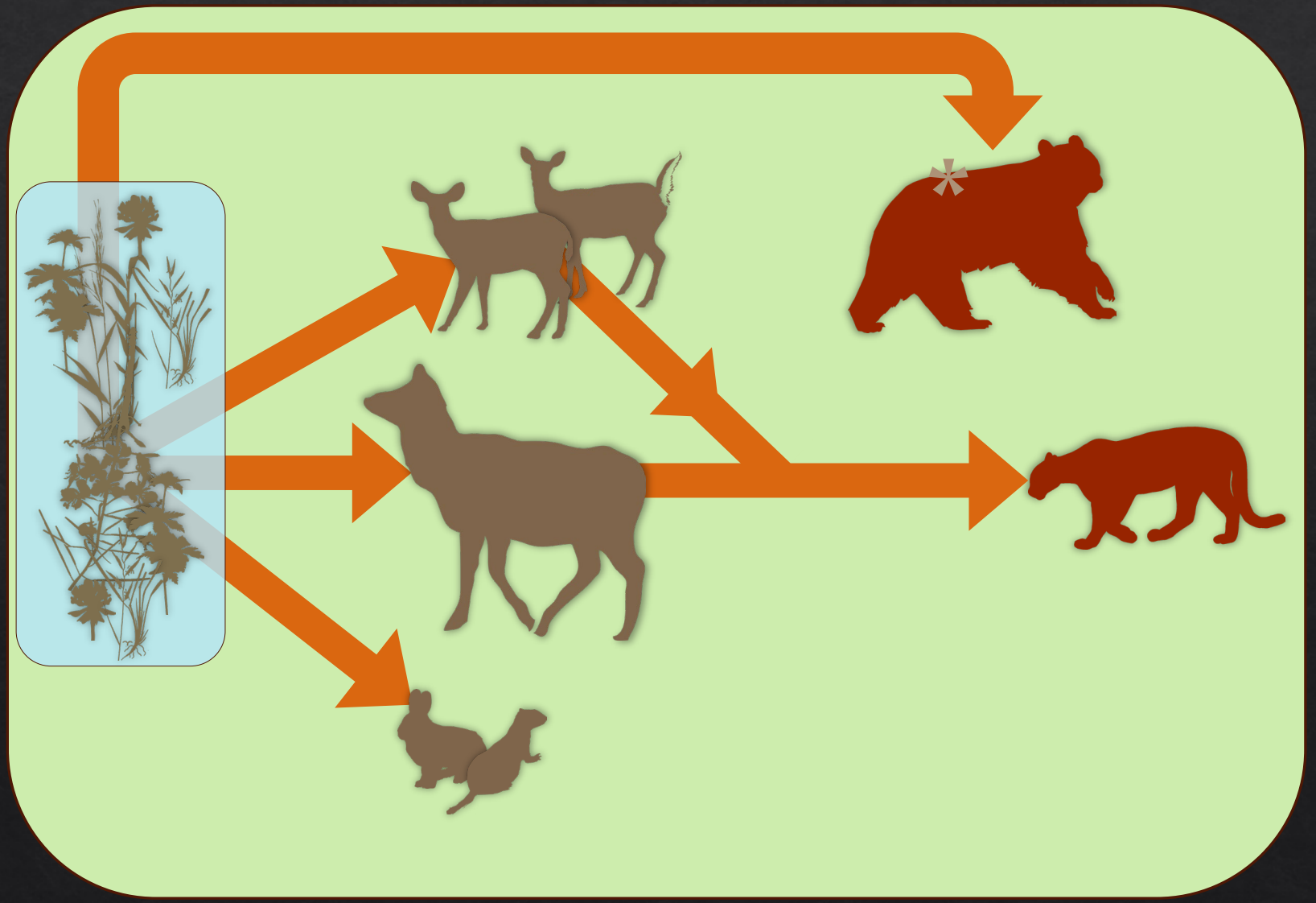

Community hypotheses

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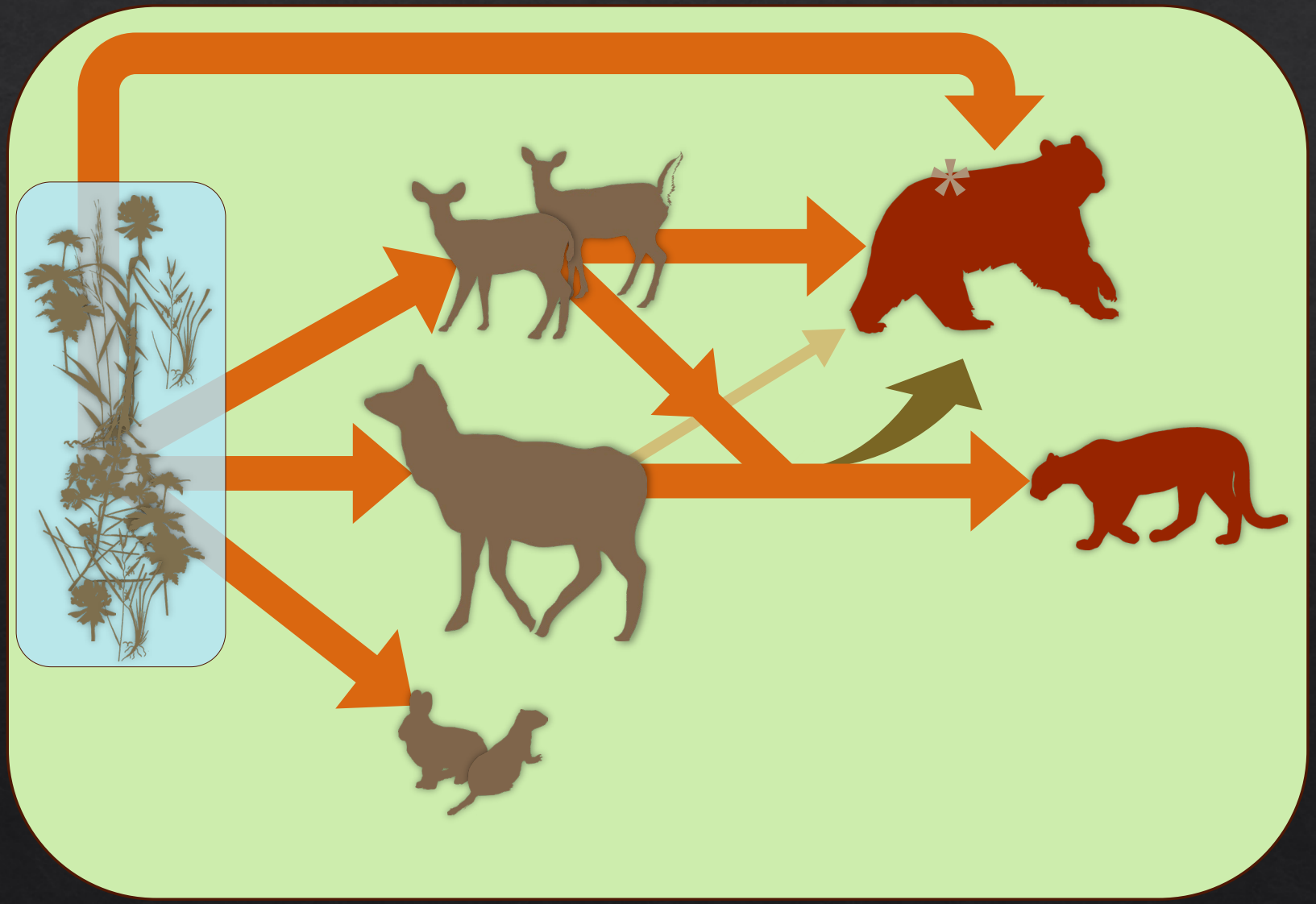
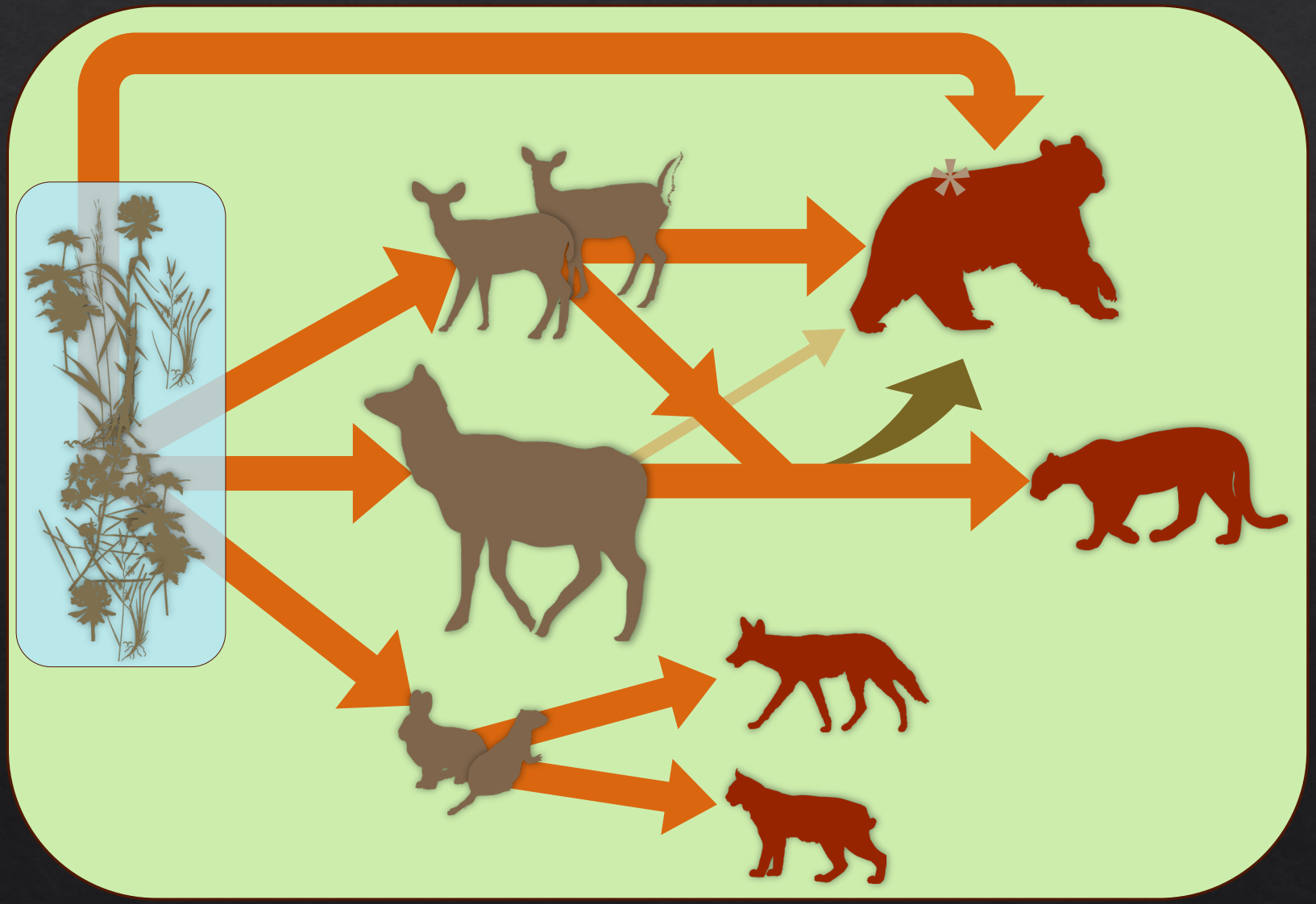


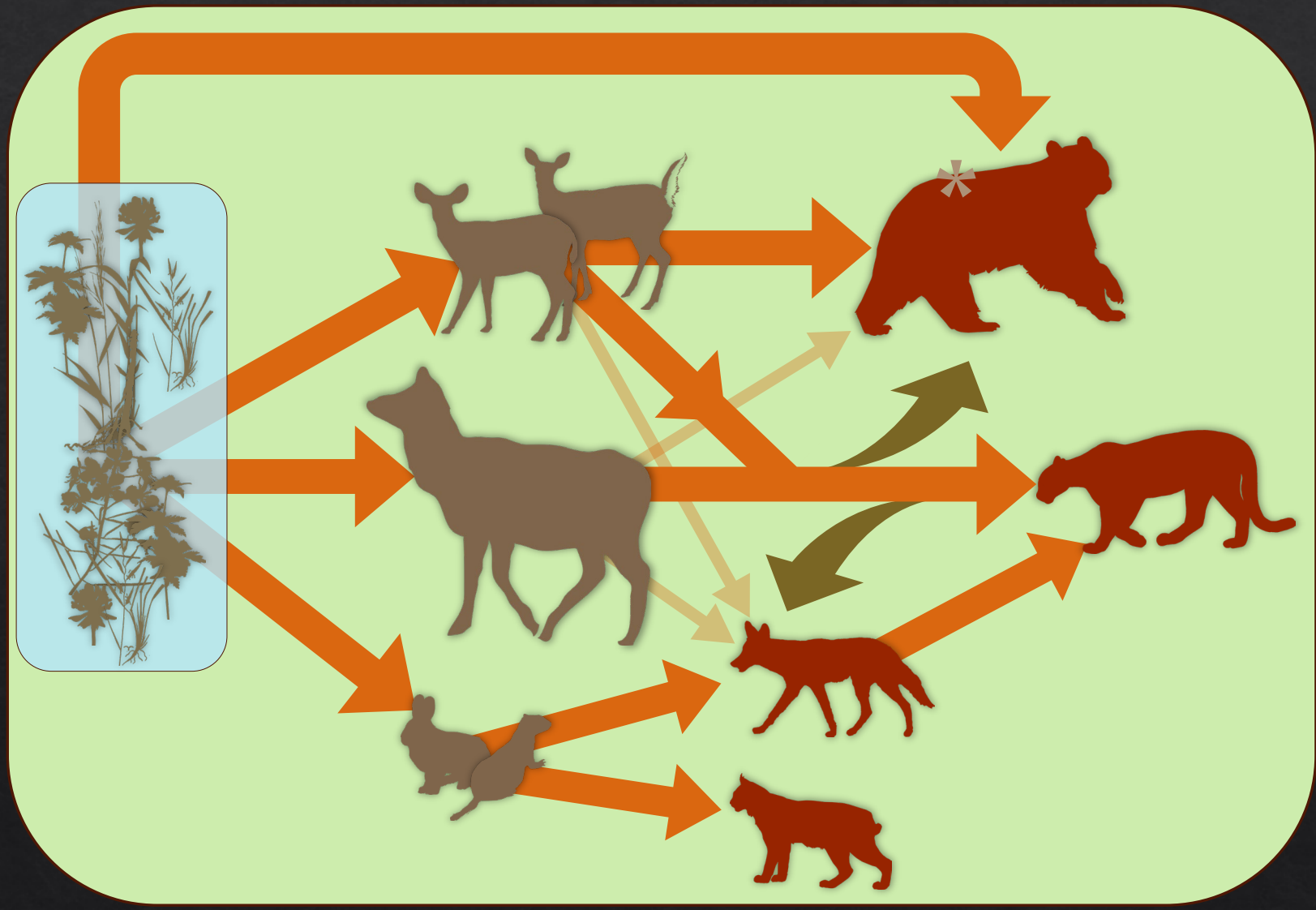
Community hypotheses

- Predation
- Competition



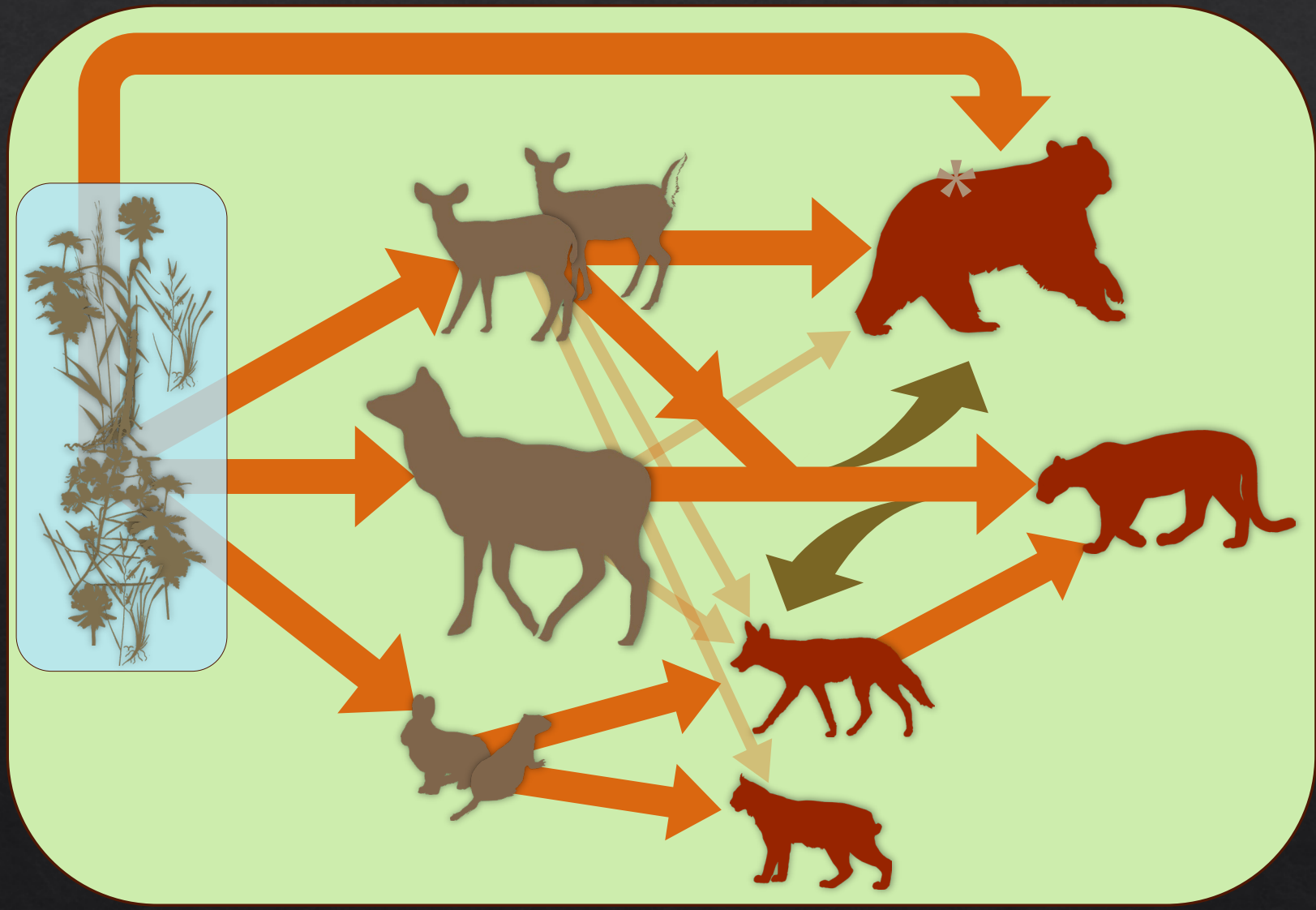
Community hypotheses

- Predation
- Competition
- Multi-step effects

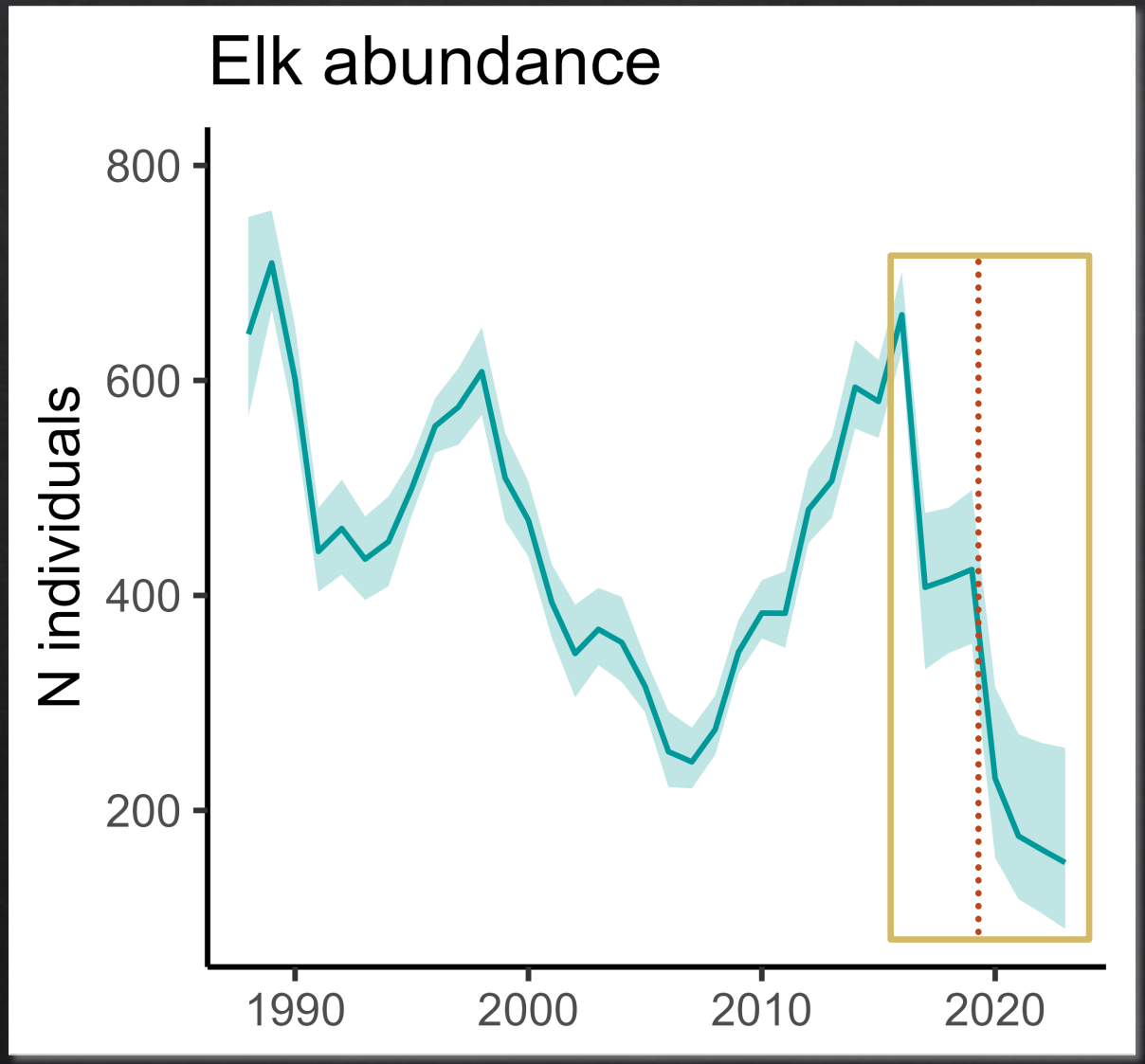


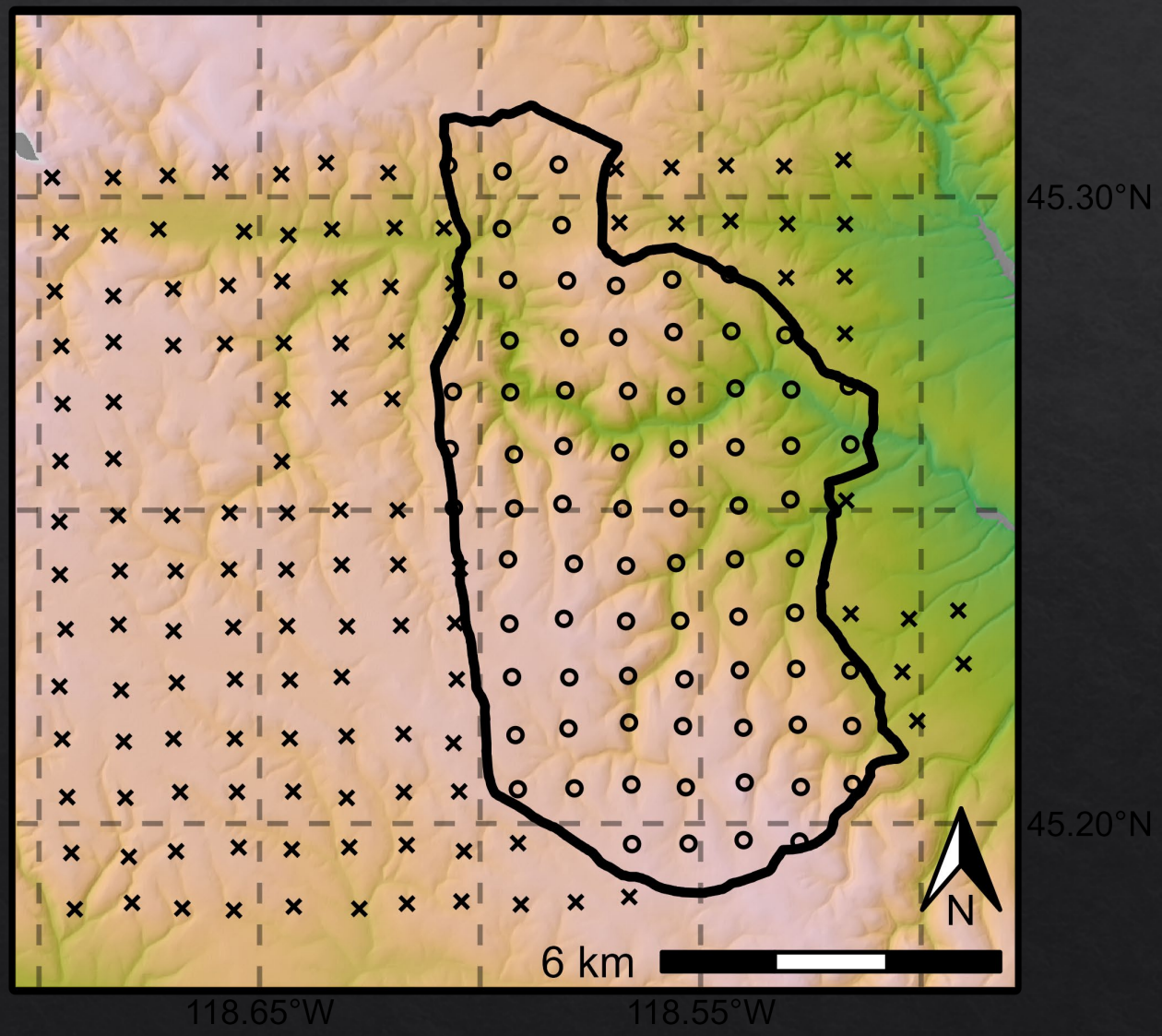
Community hypotheses

- Predation
- Competition
- Multi-step effects

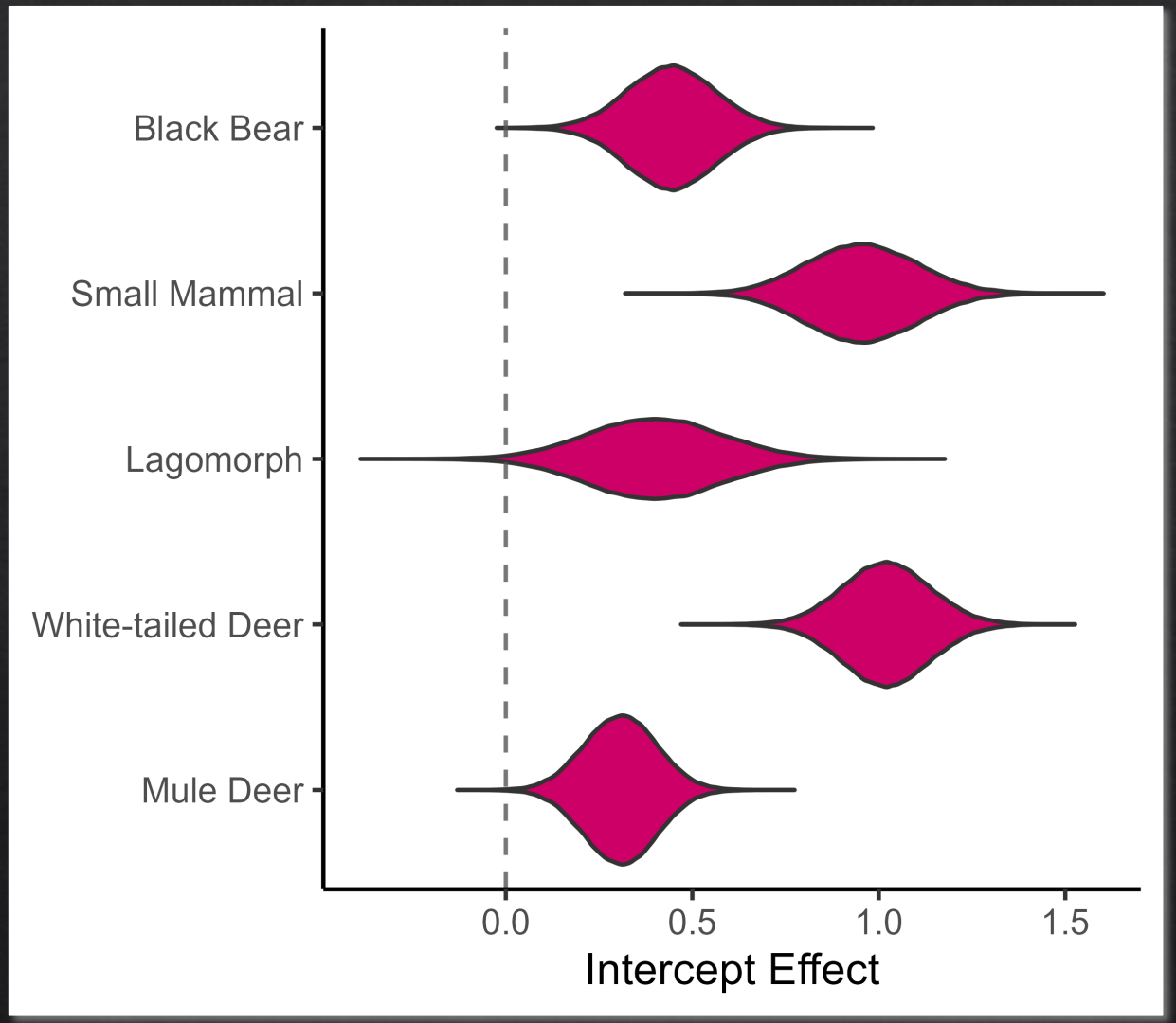


Experimental Reduction of Elk





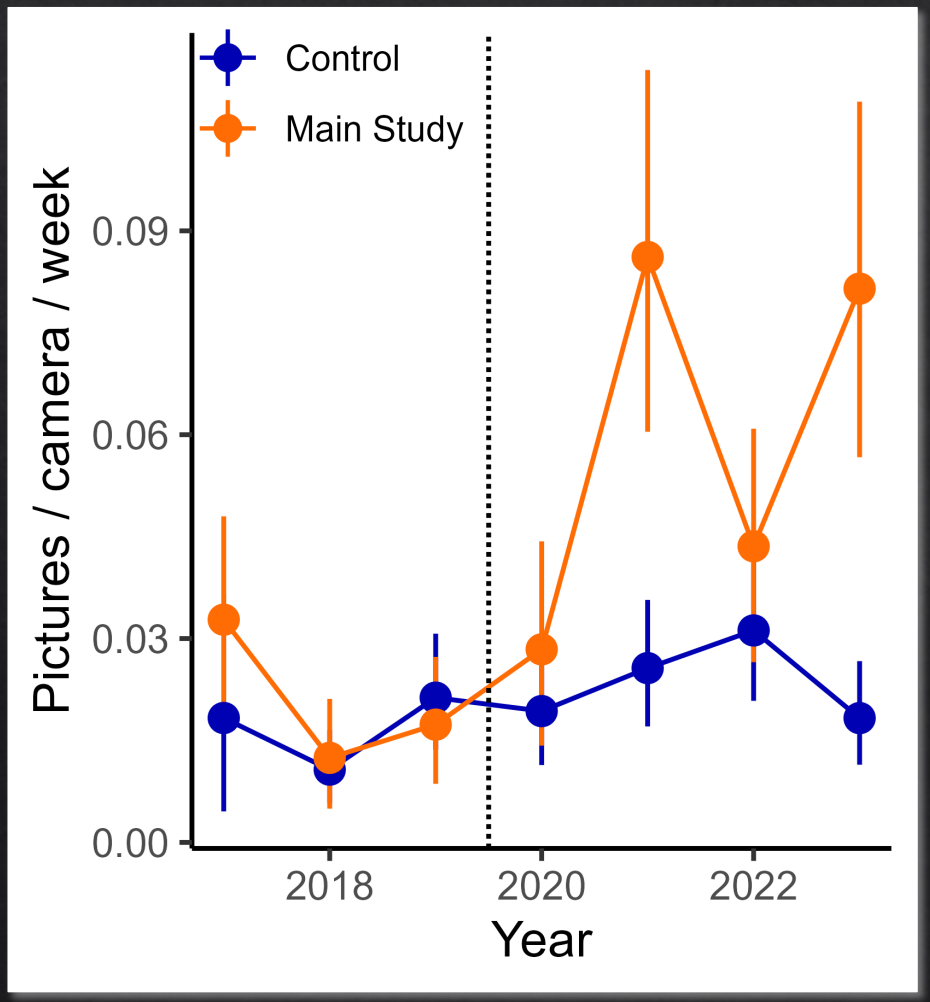
Broad Release of Competitors



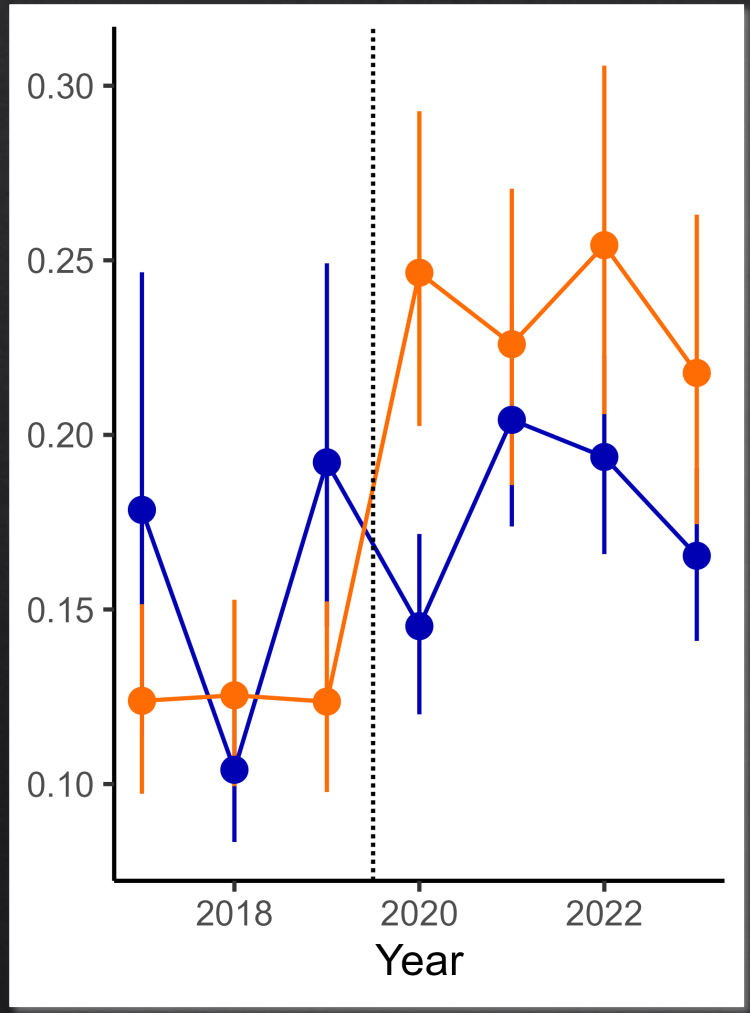
Deer

Control = no elk removal
Main Study = elk removal

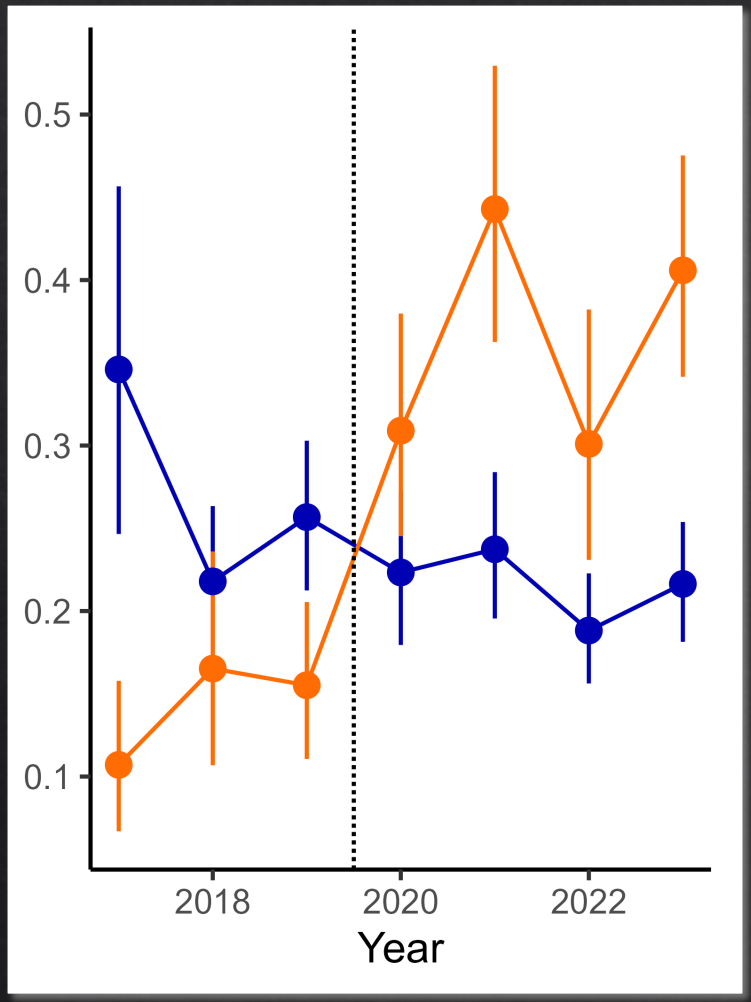
Bobcats



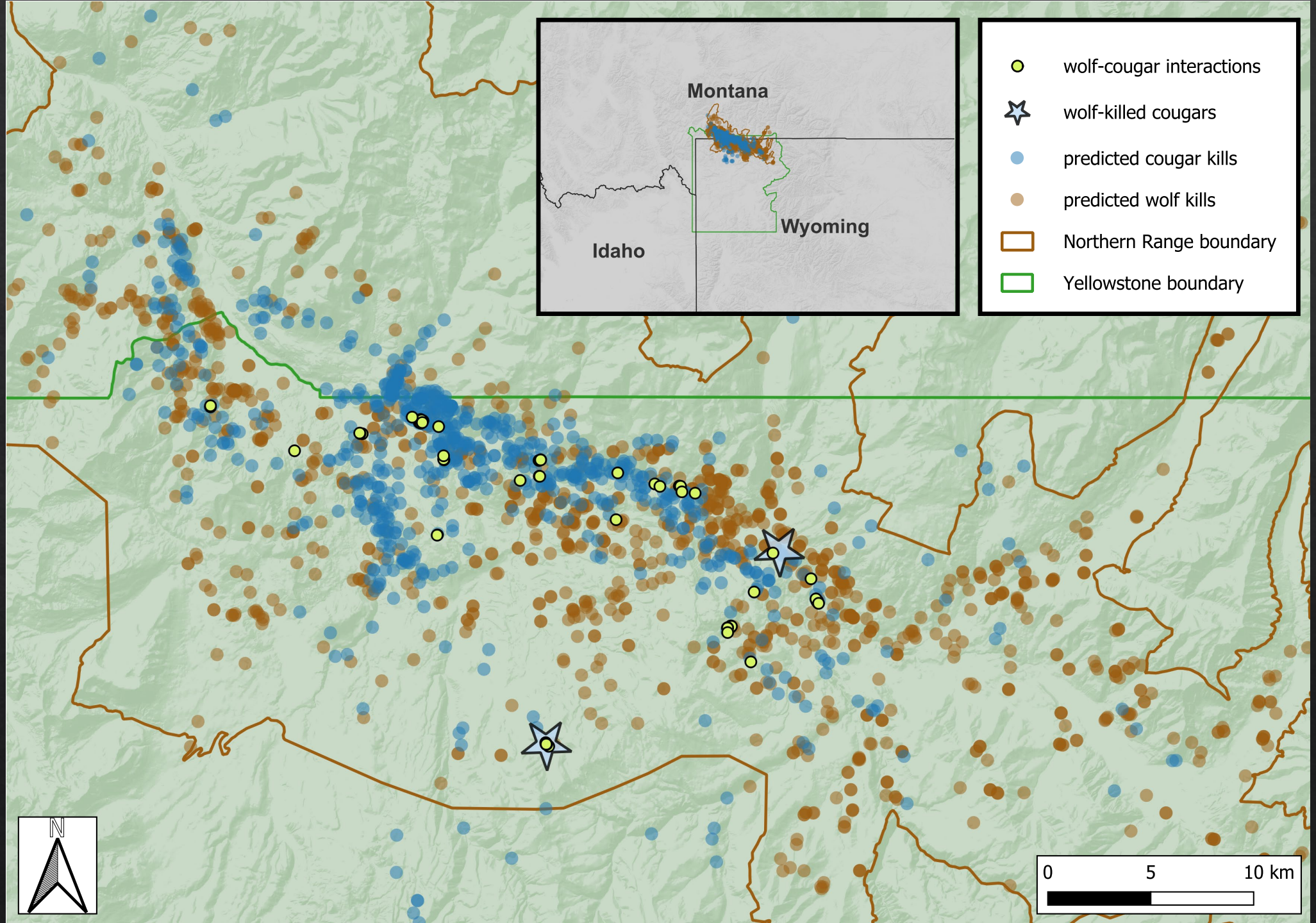
Black bears



White-tailed deer

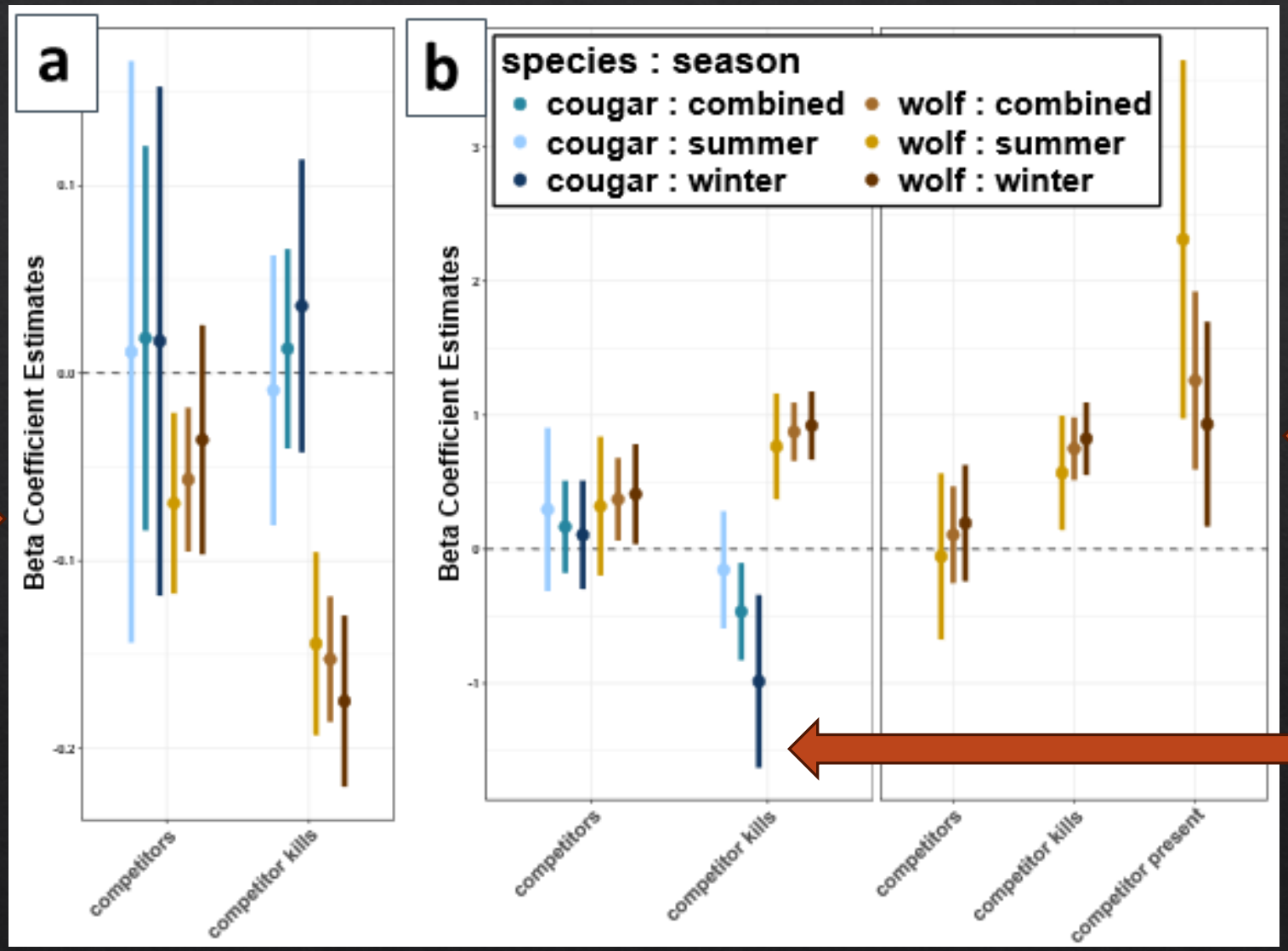


1. Species interactions are complex
2. Unraveling complexity is challenging with observational data
3. Experiments can be much stronger


Montana
Idaho
Wyoming
wolf-cougar interactions
wolf-killed cougars
predicted cougar kills
predicted wolf kills
Northern Range boundary
Yellowstone boundary
N
0
5
10 km

Island Wolf Project – 2024-2027

Wolves move toward cougars and their kills



Wolves encounter cougar kills much more often than expected, especially fresh kills with cougars present

Cougars encounter wolf kills less than expected by chance