Prey diversity and season mediate trophic overlap between cougars and wolves in anthropogenic ecosystems

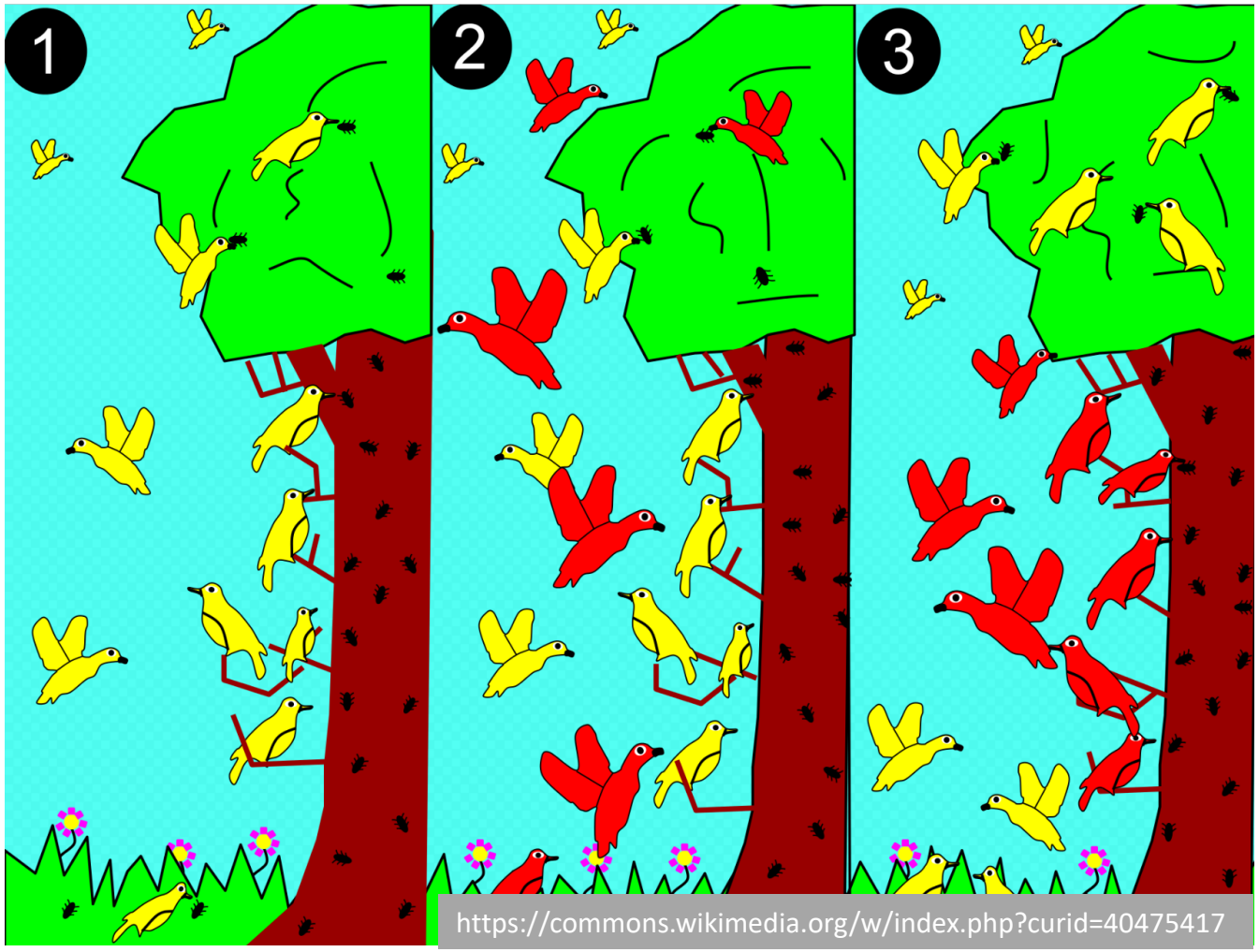
Lauren Satterfield, Thomas Newsome, Briana Abrahms, Jennifer Allen, Brian Kertson, Taal Levi, Anna Nisi, Laura Prugh, Ellie Reese, Andrew White, Aaron J. Wirsing

WDFW Commission Meeting
Virtual
Friday, December 9, 2022, 1:40 – 2:40 pm

University of Washington
School of Environmental and Forest Sciences
Predator Ecology Lab
Lsatter@uw.edu

Background

- Competitive Exclusion Principle: two species with identical niches cannot coexist indefinitely
- Competition, if present, drives niche partitioning



https://commons.wikimedia.org/w/index.php?curid=40475417

(Gause 1934, Levin 1970)

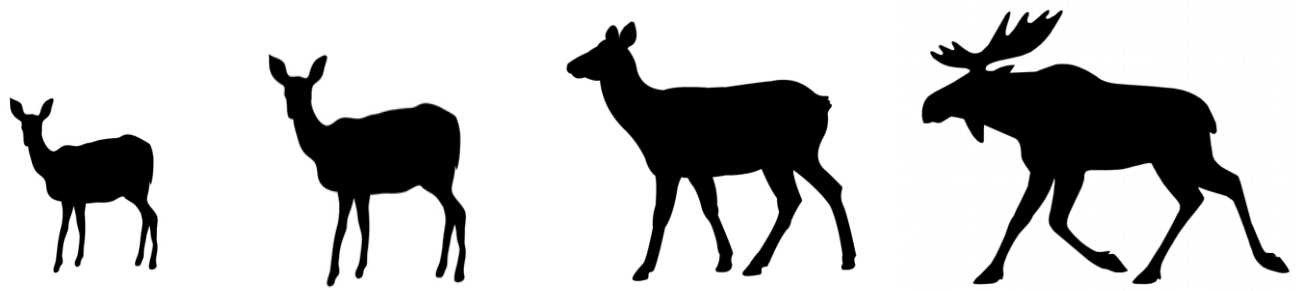
Background

- Most studies on trophic cascades are single predator/single prey
- Most ignore predator-predator interactions
- Predator-predator interactions may mediate trophic impacts on prey
- Multi-predator landscapes influence prey in divergent ways
- Fewer studies from managed landscapes

(Thurber and Peterson 1993, Ripple and Beschta 2003, Ritchie et al. 2012, Hughes et al. 2013)

- Wolves are recolonizing WA after an 80-year absence
- Timeline:
  - **Pre-1900s:** Co-occurrence of cougars and wolves in Washington
  - **1930's:** Wolves extirpated by settlers
  - **Late 1900's:** Cougars remain as sole top predator
  - **2008:** Confirmed first wolf breeding pack in 80 years
  - **2021:** At least 206 wolves, 33 known packs, 19 successful breeding pairs

- **How will the co-occurrence of cougars and wolves and affect Washington's ungulate prey populations?**
- White-tailed deer, mule deer, elk, moose



(WDFW et. al. 2022)

Introduction

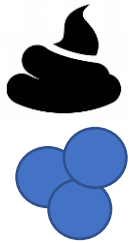
Goal: Investigate indicators of dietary competition between cougars (*Puma concolor*) and wolves (*Canis lupus*)

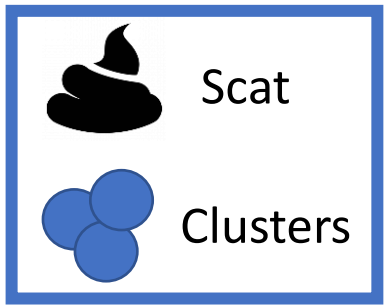
Objectives:

- Fully characterize diets of wolves and cougars
- Compare dietary overlap between existing cougars and recolonizing wolves
- Explore dietary differences between study areas and season

Data:

- Scat metabarcoding (genetic diet analysis)
- GPS cluster investigations





Introduction

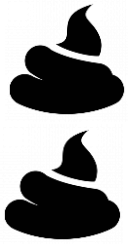
Hypothesis:

- Increased prey diversity provides greater opportunity for dietary partitioning

Image: https://www.evolvingsciences.com/

Introduction

Predictions:



- If competition exists, expect more dietary partitioning in the Northeast (higher Net Primary Productivity)
- If competition exists, expect more dietary partitioning in summer vs winter (more prey species available in summer)

Field Methods

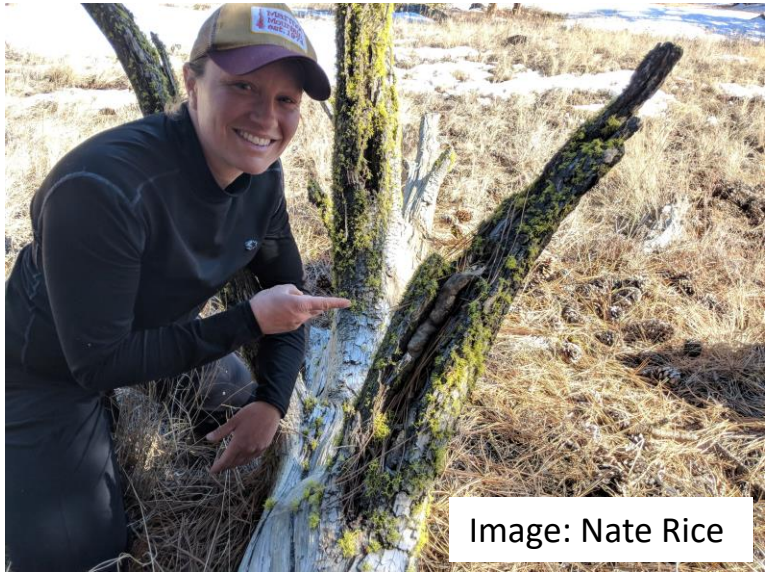
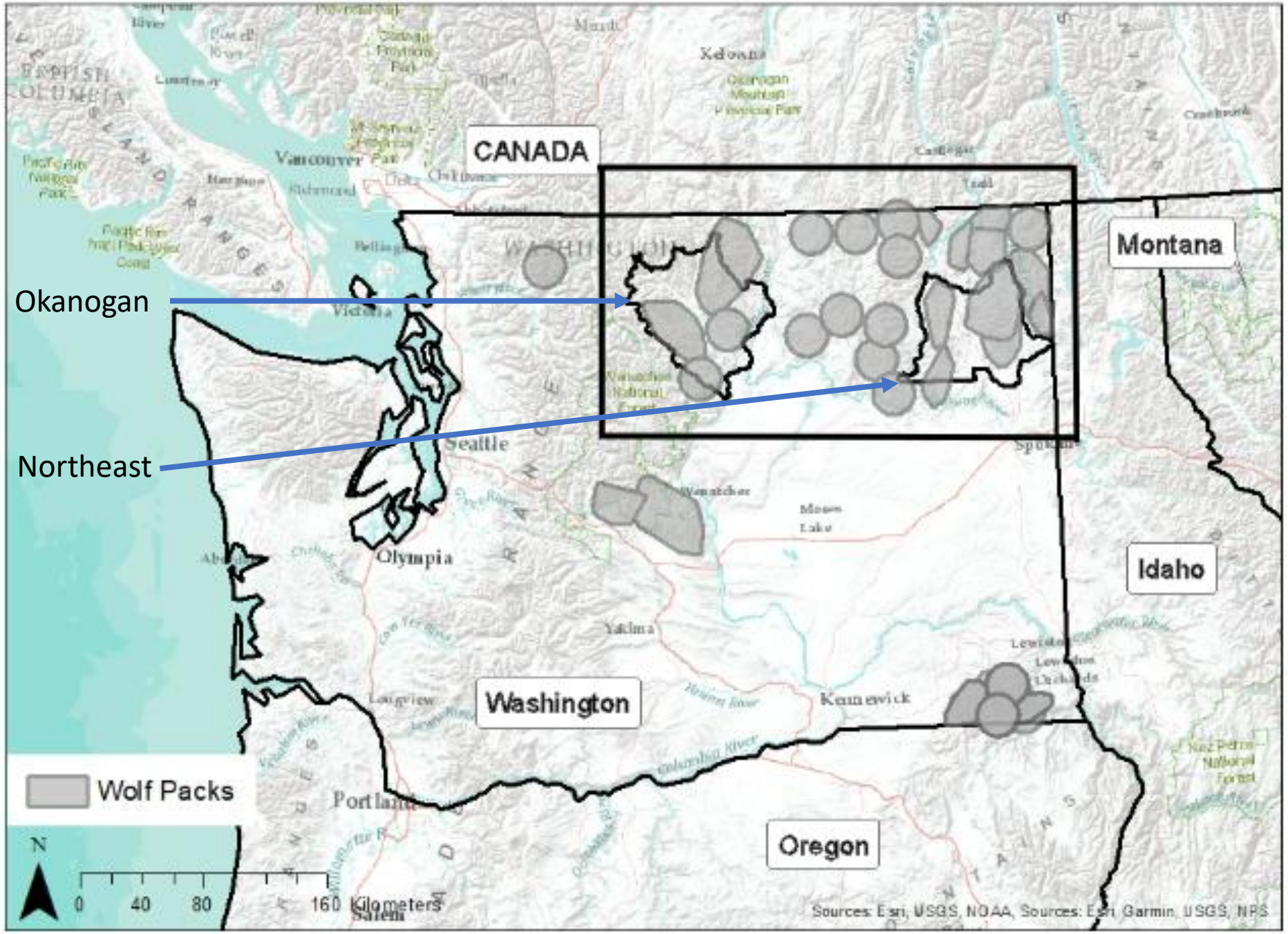
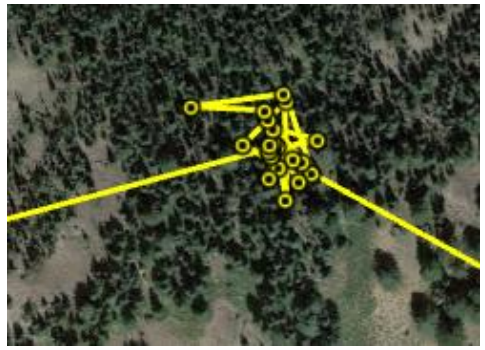
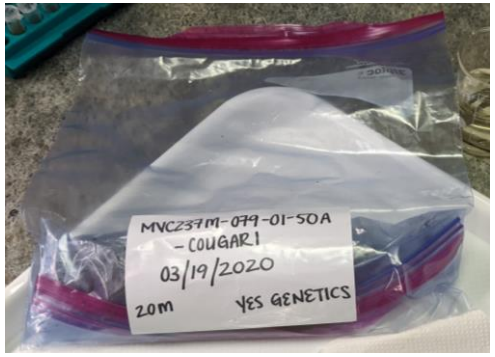


Image: Nate Rice

Field Methods







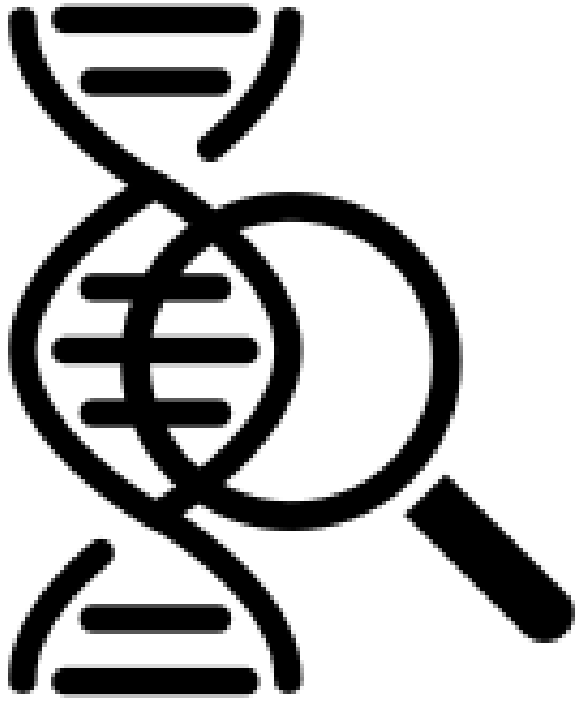
- Cougars and wolves GPS-collared as part of the collaborative Washington Predator-Prey Project
  - 60 cougars (NE: 34, OK: 26)
  - 16 wolves (NE: 14 (4 packs), OK: 5 (2 packs)

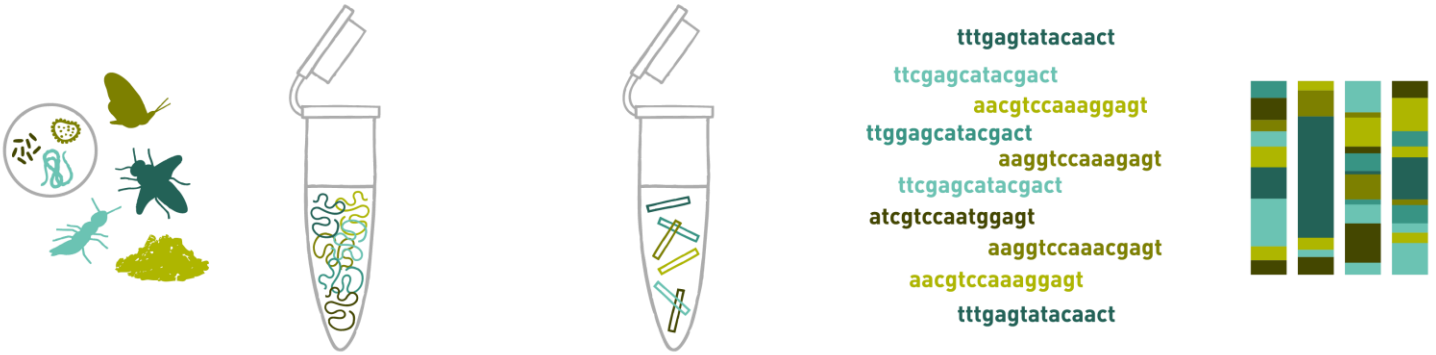
- Scat data collection occurred from 2017-2020
  - Summer: June 1 – December 14
  - Winter: December 15 – May 31

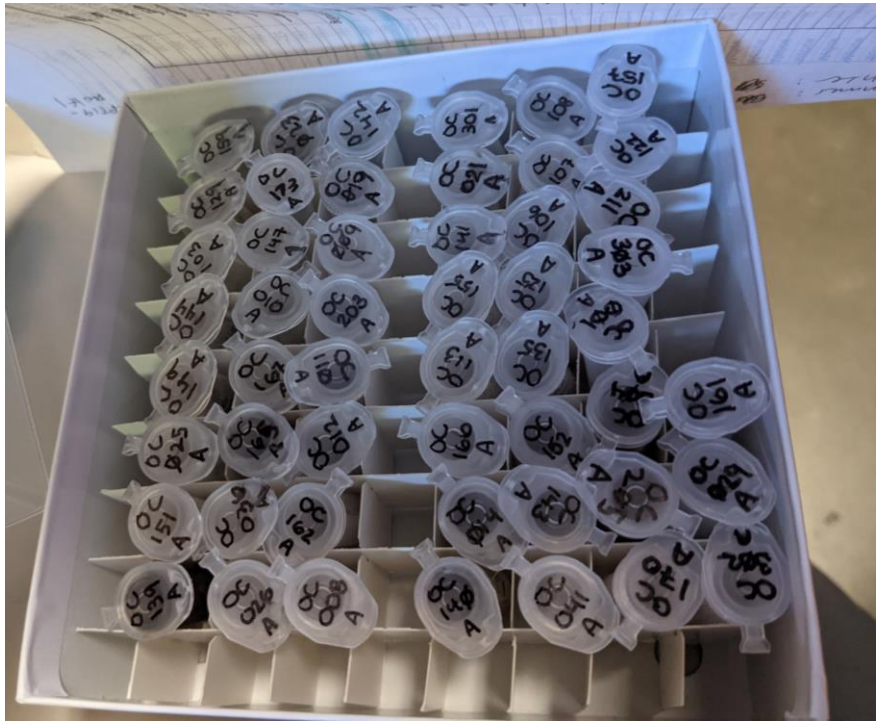
- Suspected cougar and wolf scat collected
  - At GPS clusters with carcasses
  - At GPS clusters without carcasses (i.e., bedsites)
  - Opportunistically while hiking to and from GPS cluster sites

- Collected whole, stored frozen and double-bagged

Lab Methods





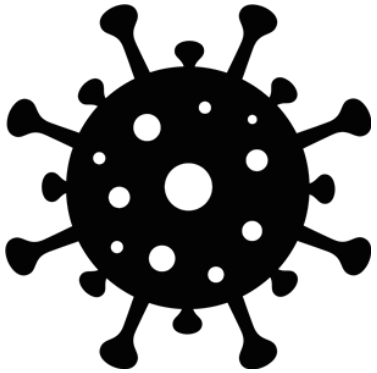


- Why use metabarcoding?
  - Bulk sequencing of multiple species simultaneously
  - Sensitive method - detects rare species
  - Works well on new and old scats
  - Ability to identify depositor species *along with* prey species
- Our analysis:
  - 12S region of the vertebrate mitochondrial genome
  - Three replicate samples
  - Follow-up PCR analysis for *Canis* spp. and *Odocoileus* spp.

(e.g., Thomas et al. 2016; Deagle et al. 2018; Massey et al. 2019, Massey et. al. 2021)

Lab Methods

- Trained UW undergraduate student in genetic lab methods
- Tubed scats during summer 2021
- Many COVID protocols



- Lab preparation:
  - Thawed scats overnight
  - Selected three scat “subsections”
  - Broke scats subsections open
  - Sampled a lentil-sized piece from the middle of each subsection
  - Three subsamples per centrifuge tube
  - Collected a main (A) and backup (B) set of tubed samples

Lab Methods

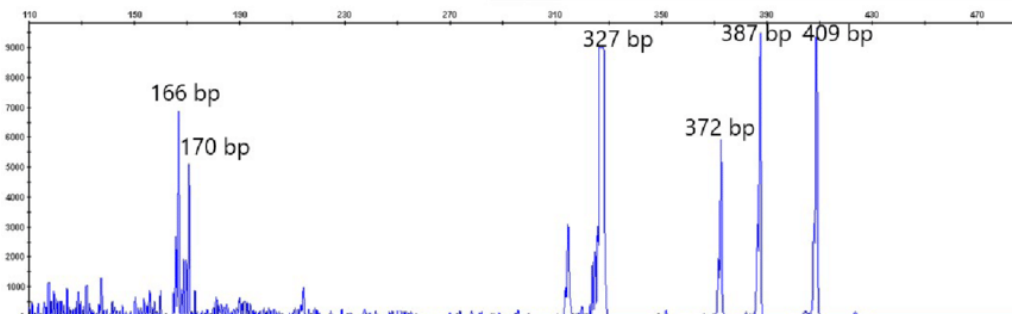
Metabarcoding:

- Levi Genetics Lab – Oregon State University
- Removed results where the relative read abundance (RRA) was <0.5% of sample
- Required 2 of 3 sample replicates to be successful to include sample results
- Matched species using GenBank (https://www.ncbi.nlm.nih.gov/genbank/)

Analysis to differentiate *Odocoileus virginianus* from *O. hemionus*:

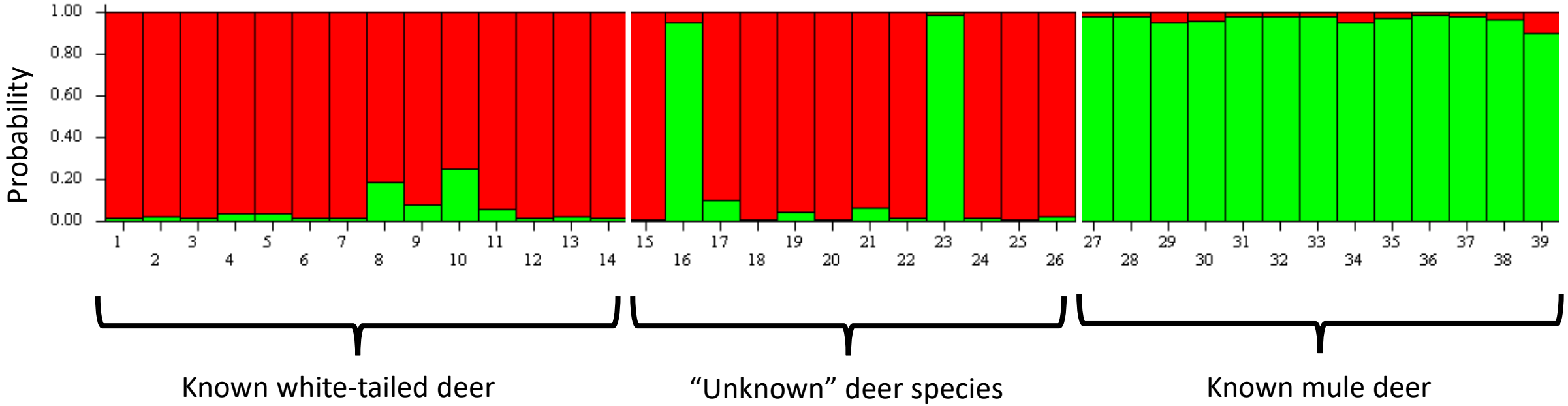
- Collaboration with UW SEFS Genetics Lab to develop primer set
- Primers adapted from previous work (Latch et al. 2008, Lindsay and Belant 2007)
- Primer set also tests for elk (*Cervus canadensis*) and moose (*Alces alces*)
- Combined species and sex ID primers together

- Process:
  - DNA extraction
  - Polymerase Chain Reaction (PCR)
  - Fragment analysis



Cervid Primers – *Odocoileus* spp. Analysis

- Used Bayesian program Structure to differentiate between unknown target species
- Method showed strong differentiation between *Odocoileus* spp.
- Differentiation of sex also worked in the genetic multiplex



(Pritchard et al. 2000)

Statistical Methods

Statistical Methods

- Analyses
  - Percent frequency of occurrence (%FO) plots (primary prey by carnivore, study area, and season)
  - Pianka's Niche Overlap Index (dietary overlap index – prediction testing)
  - Shannon's Diversity Index (species diversity index – hypothesis testing)

Statistical Methods

- % Frequency of Occurrence (%FO): (events / total events) x 100%

- Pianka's Index (range 0 – 1)
  - Metric of dietary overlap between two species or groups j, *k*
  - O_{jk} = Pianka's Index value for dietary overlap between depositor species or groups *j* and *k*

$$O_{jk} = \frac{\sum_i^n P_{ij} \times P_{ik}}{\sqrt{\sum_i^n P_{ij}{}^2 \times \sum_i^n P_{ik}{}^2}}$$

  - P_{ij} = proportion of prey species *i* in the diet of depositor *j*
  - P_{ik} = proportion of prey species *i* in the diet of depositor *k*

- Shannon's Diversity Index (H) (range 0 – 1)
  - Metric of dietary diversity within depositor species or groups
  - Related to weighted geometric mean of the proportional abundances of the types

$$H = -\sum_{i=1}^{s} p_i \ln(p_i)$$

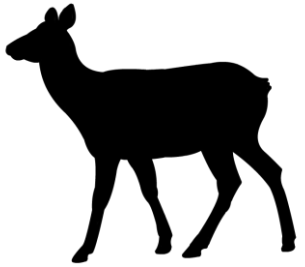
  - H = Shannon index value
  - p_i = proportion of a prey item found for *i*th prey species
  - s = number of prey species categories

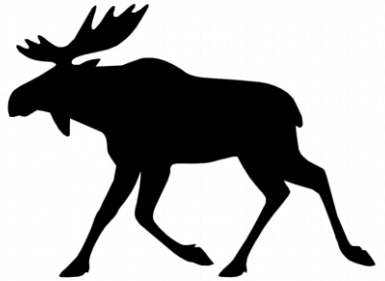
(Pianka 1973, 1974, Shannon 1948)

Statistical Methods

Simplified prey categories for analysis:

- Ungulates
  - White-tailed deer (*Odocoileus virginianus*)
  - Mule deer (*Odocoileus hemionus*)
  - Elk (*Cervis canadensis*)
  - Moose (*Alces alces*)
  - Deer Unknown Species
    - randomly assigned to white-tailed deer or mule deer by proportion of known samples in group (carnivore / study area / season)
- Non-Ungulates
  - Bird
  - Carnivore
  - Lagomorph
  - Small mammal
  - Medium mammal
  - Other
- Bootstrapped output dataset 10,000 to calculate results and generate 95% confidence intervals





Results

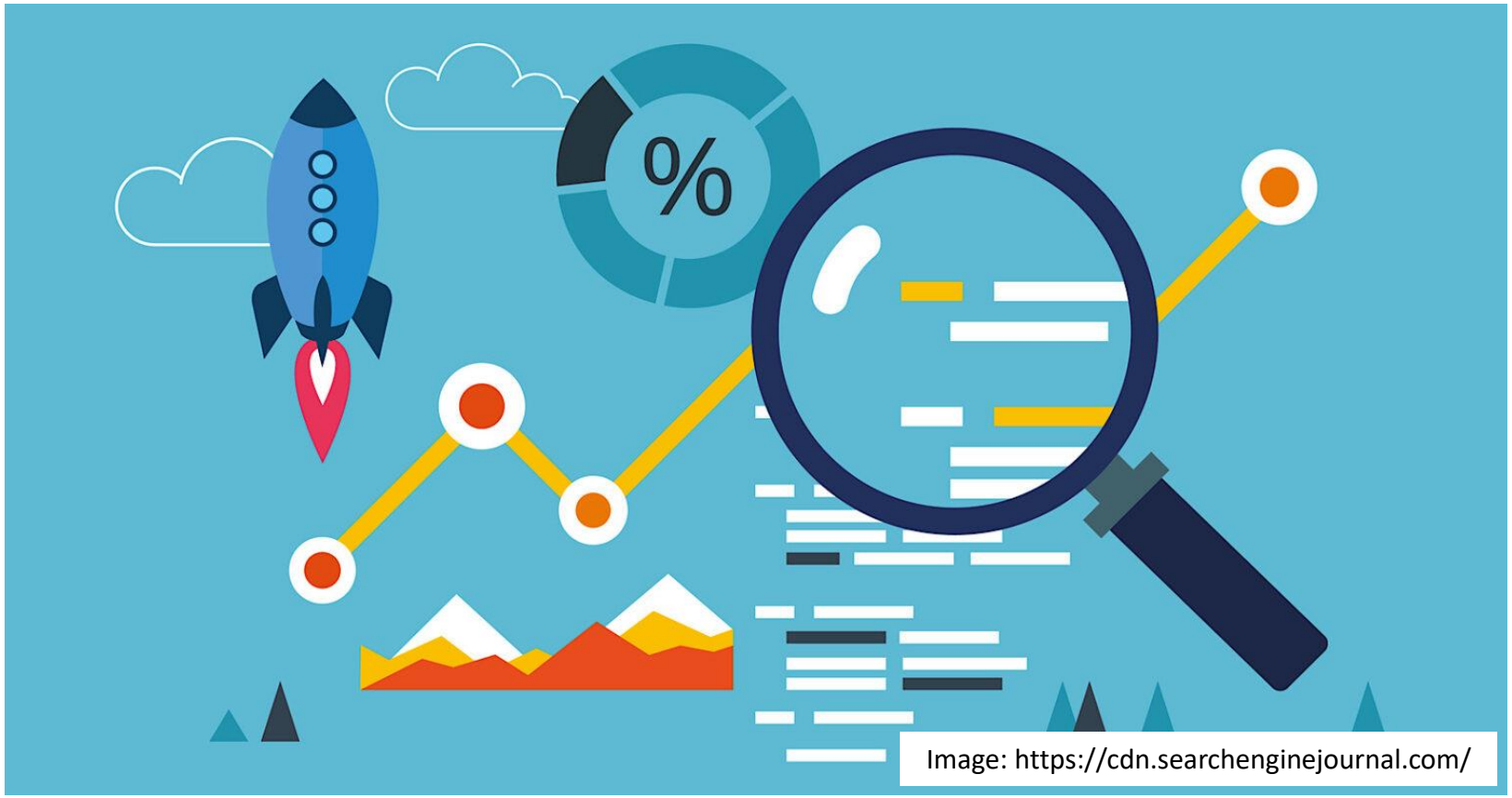


Image: https://cdn.searchenginejournal.com/

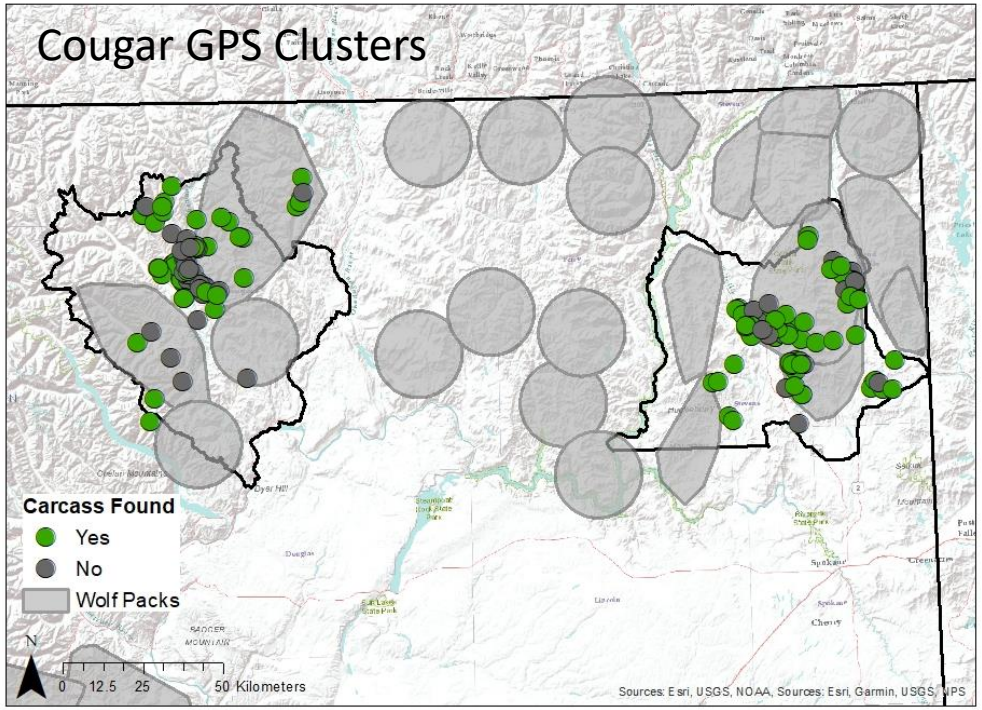
Scat Collection - Sample Sizes

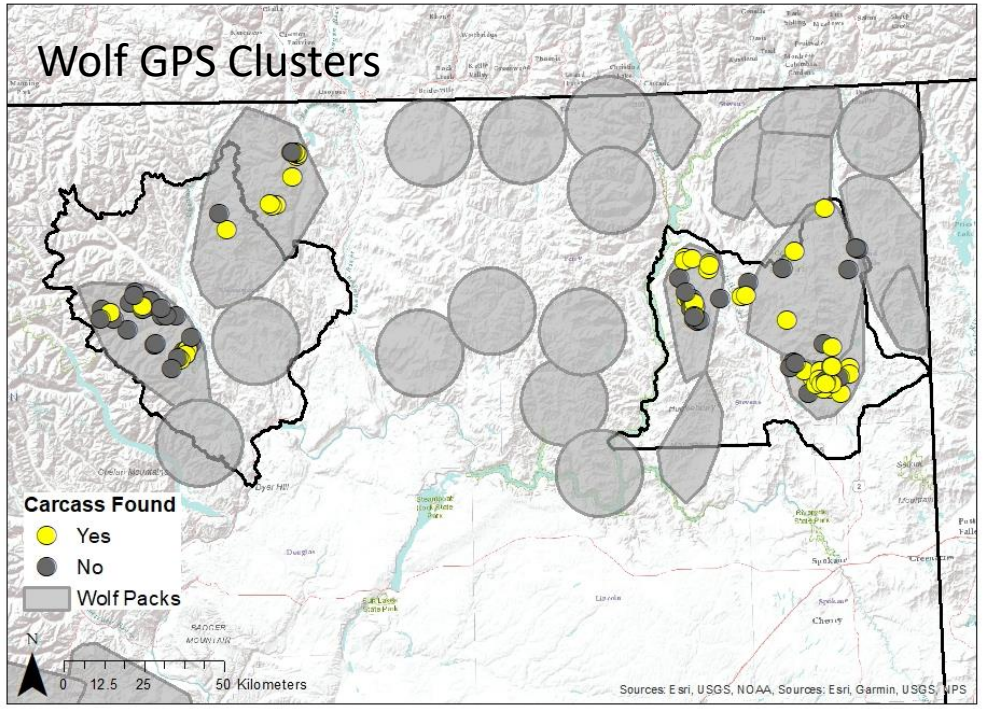
		Cougars			Wolves		
Study Area	**Season**	**Submitted**	**Amplified**	**Contained Prey**	**Submitted**	**Amplified**	**Contained Prey**
Northeast	Summer	50	41	**39**	55	56	**49**
Northeast	Winter	50	40	**40**	52	51	**44**
Okanogan	Summer	46	39	**37**	60	47	**38**
Okanogan	Winter	55	54	**46**	32	27	**23**
	Totals	201	174	**162**	199	181	**154**

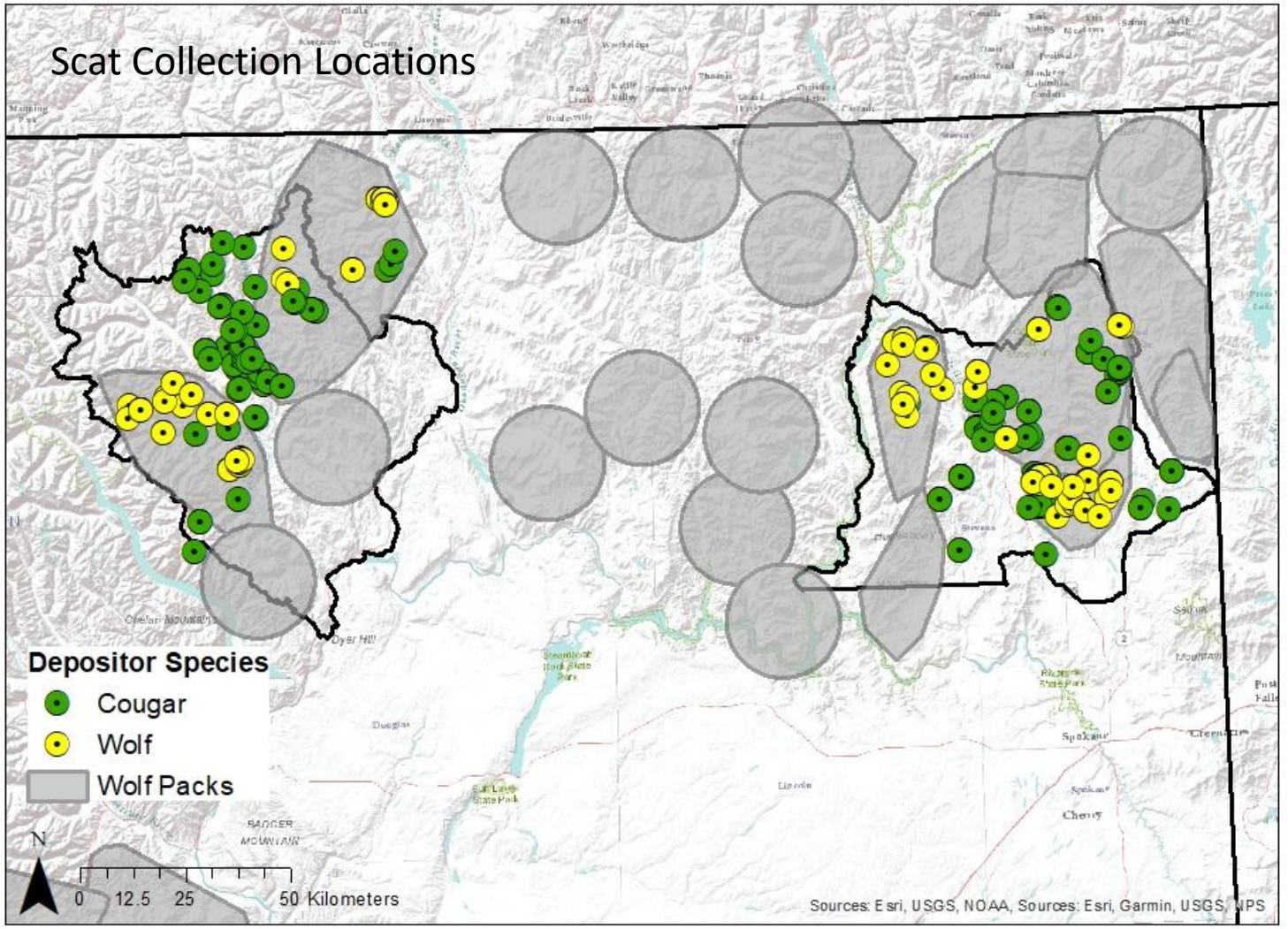
Scat Collection – Location Types

Species	Feeding Site (GPS Cluster)	Bedsite (GPS Cluster)	Opportunistic	Totals
Cougar	105 (64.8%)	39 (24.1%)	18 (11.1%)	**162**
Wolf	80 (51.9%)	60 (39.0%)	14 (9.1%)	**154**
Totals	185 (58.5%)	99 (31.3%)	32 (10.1%)	**316**

- Scats also collected at carcasses sites may represent carcass item plus any prey eaten immediately prior
- Scats collected at bedsites also allow a wealth of information
- Scats collected opportunistically more similar to traditional scat collection methods







- 400 scats collected total
- Samples collection somewhat reflects wolf and cougar collar data

Species Detected (Cougars)

Clusters

Scat

Cougar*
Livestock
Porcupine

Elk
Moose
Mule deer
White-tailed deer
Deer – Unknown Species

Beaver
Coyote
Grouse
Turkey
Raccoon
Snowshoe hare
Unknown Canid
Unknown Bird
Small Mammal

Bobcat
Domestic Cat
Shrew
Squirrel

Species Detected (Wolves)

Clusters

Scat

Unknown Canid
Domestic Dog
Dumpsite
Magpie
Marmot
Skunk

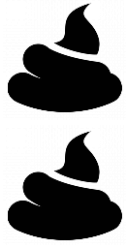
Elk
Moose
Mule deer
White-tailed deer
Deer – Unknown Species

Grouse
Snowshoe hare
Turkey
Livestock

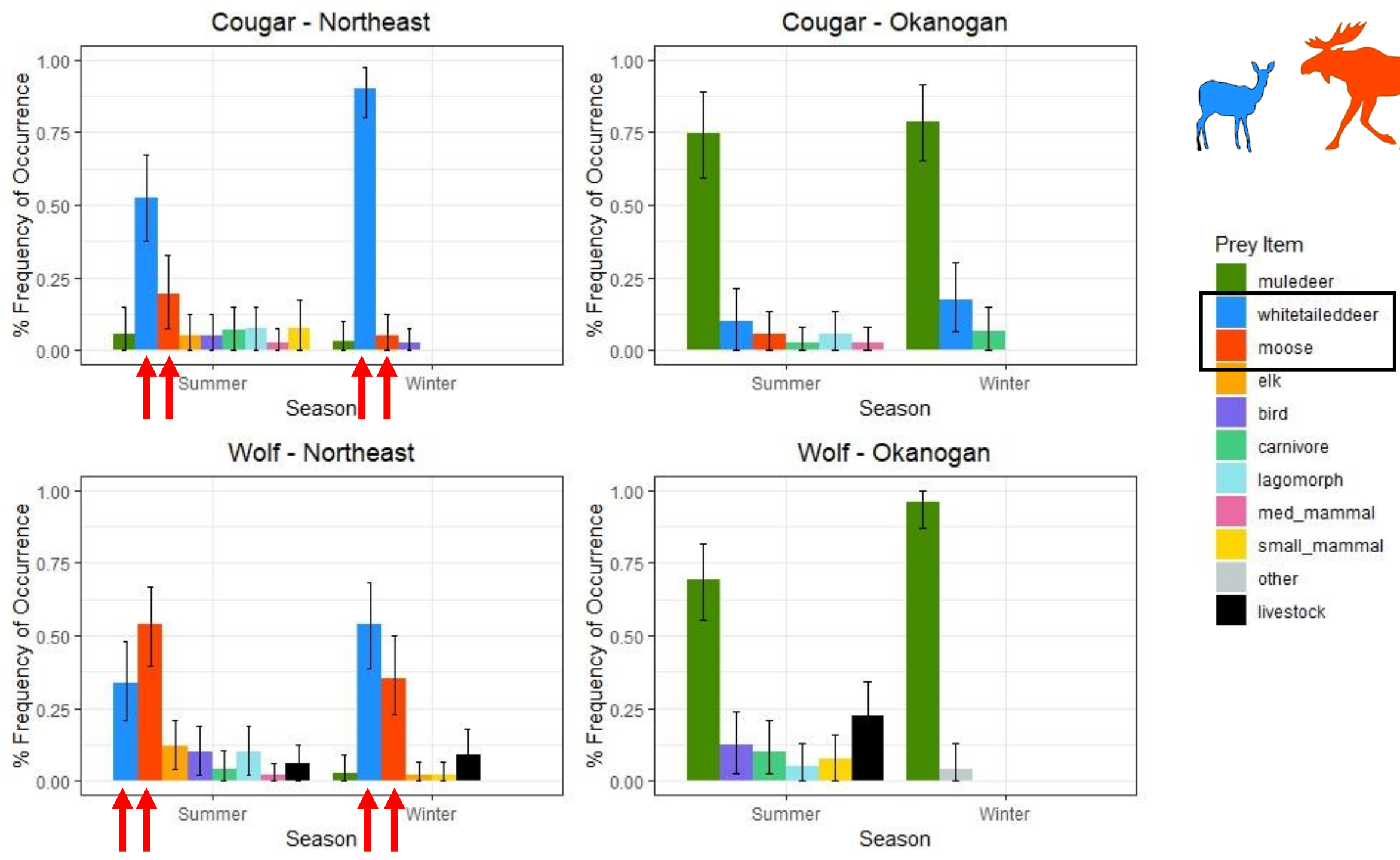
Beaver
Other Bird
Black Bear
Bobcat
Chipmunk
Fish
Flying squirrel
Vole

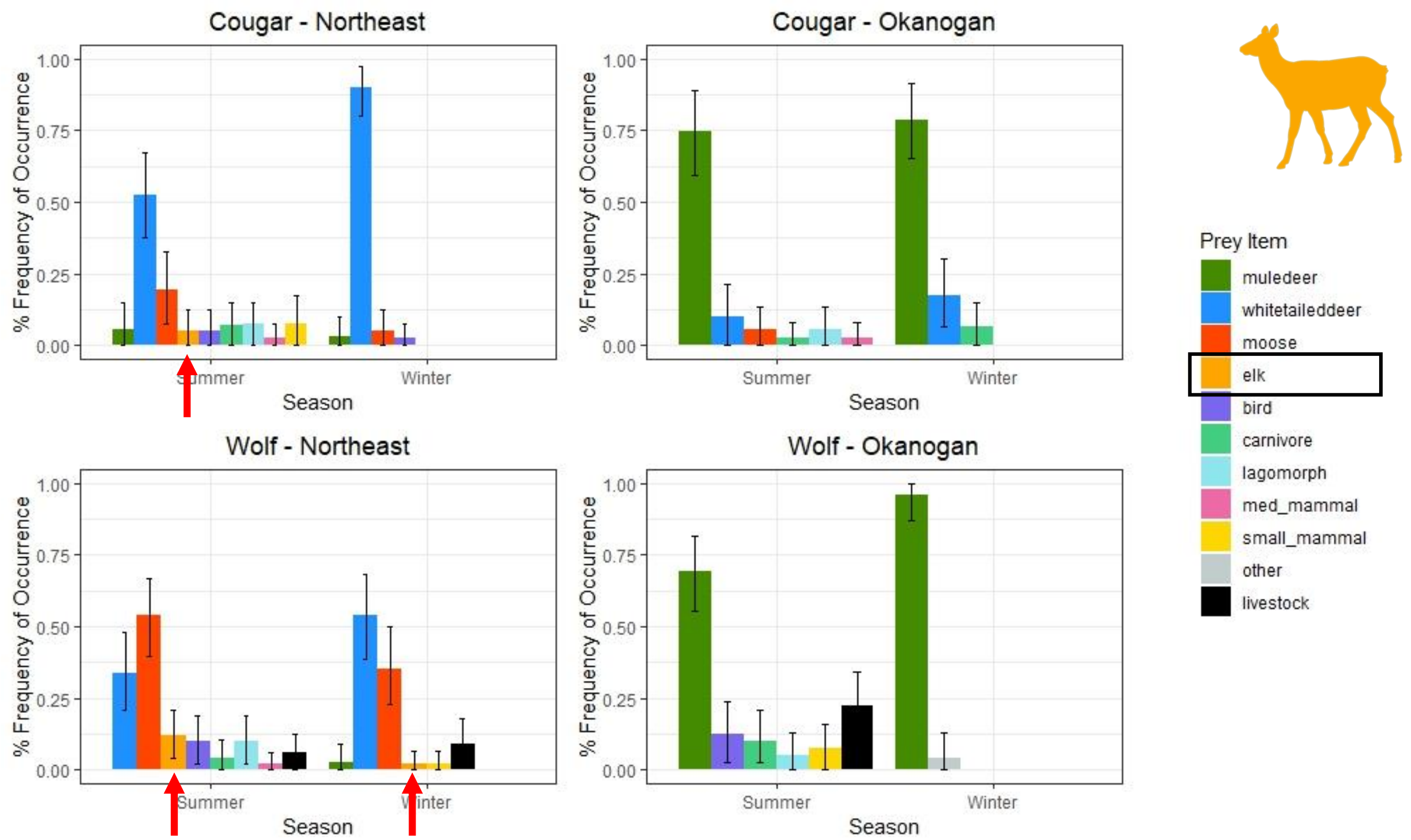
Results

Predictions:



- If competition exists, expect more dietary partitioning in the Northeast
- If competition exists, expect more dietary partitioning in summer vs winter


Cougar - Northeast
Cougar - Okanogan
Wolf - Northeast
Wolf - Okanogan
% Frequency of Occurrence
1.00
0.75
0.50
0.25
0.00
Summer
Winter
Season
Prey Item
muledeer
whitetaileddeer
moose
elk
bird
carnivore
lagomorph
med_mammal
small_mammal
other
livestock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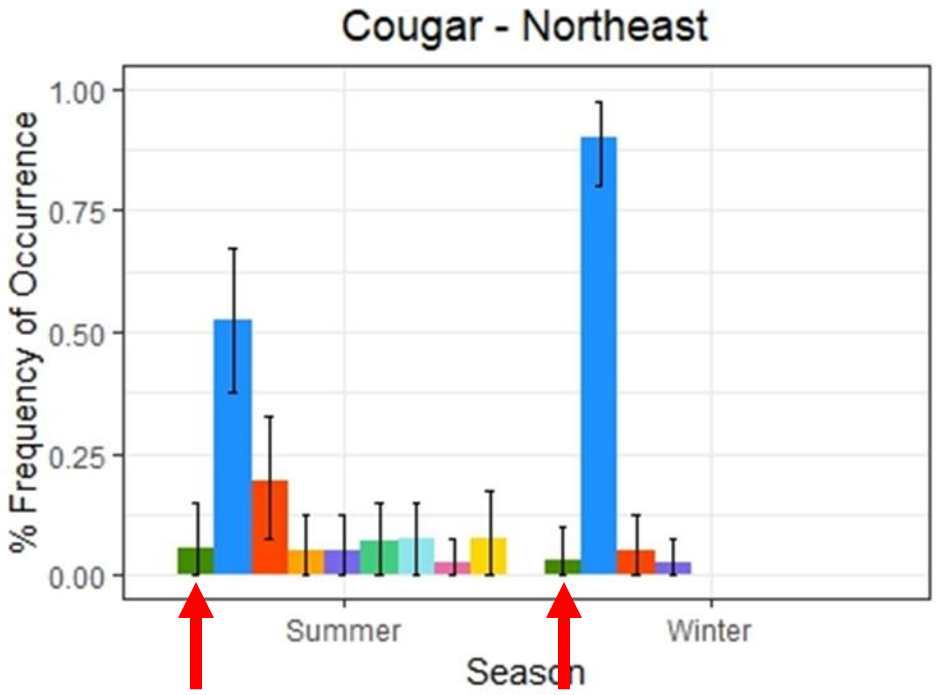
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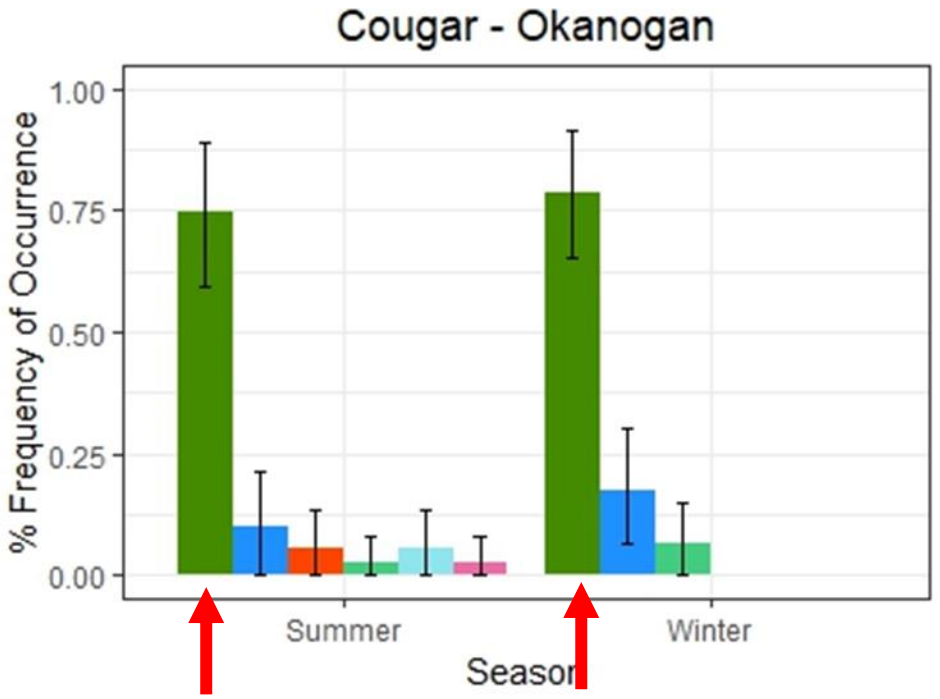
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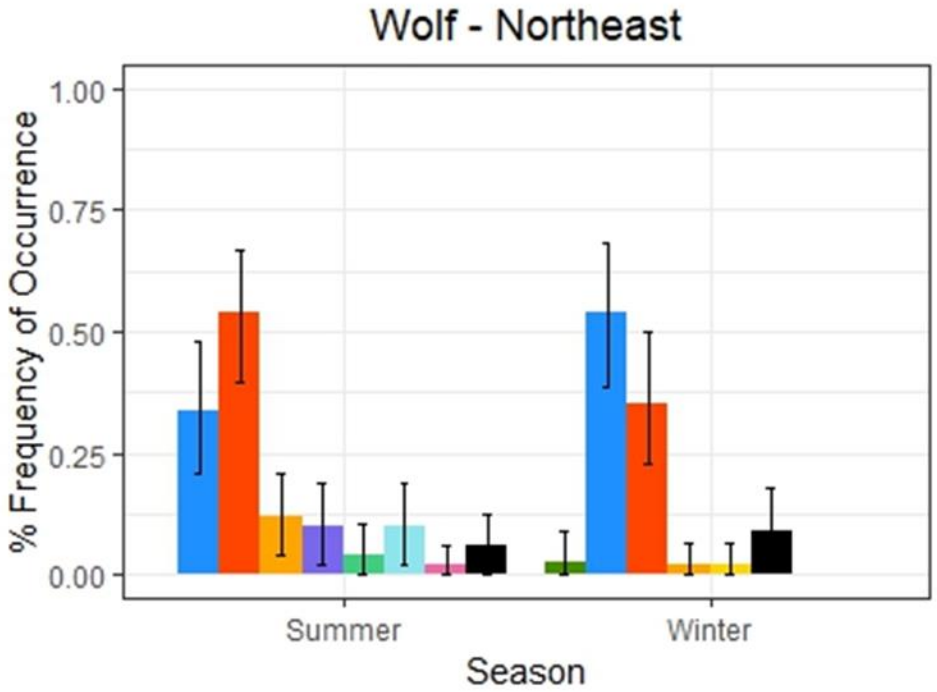
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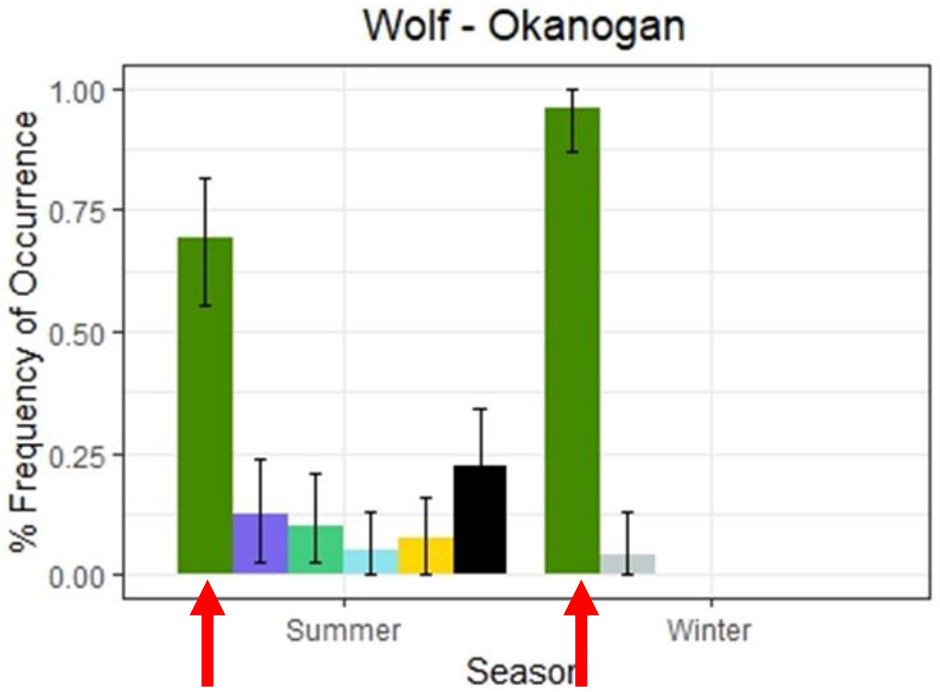
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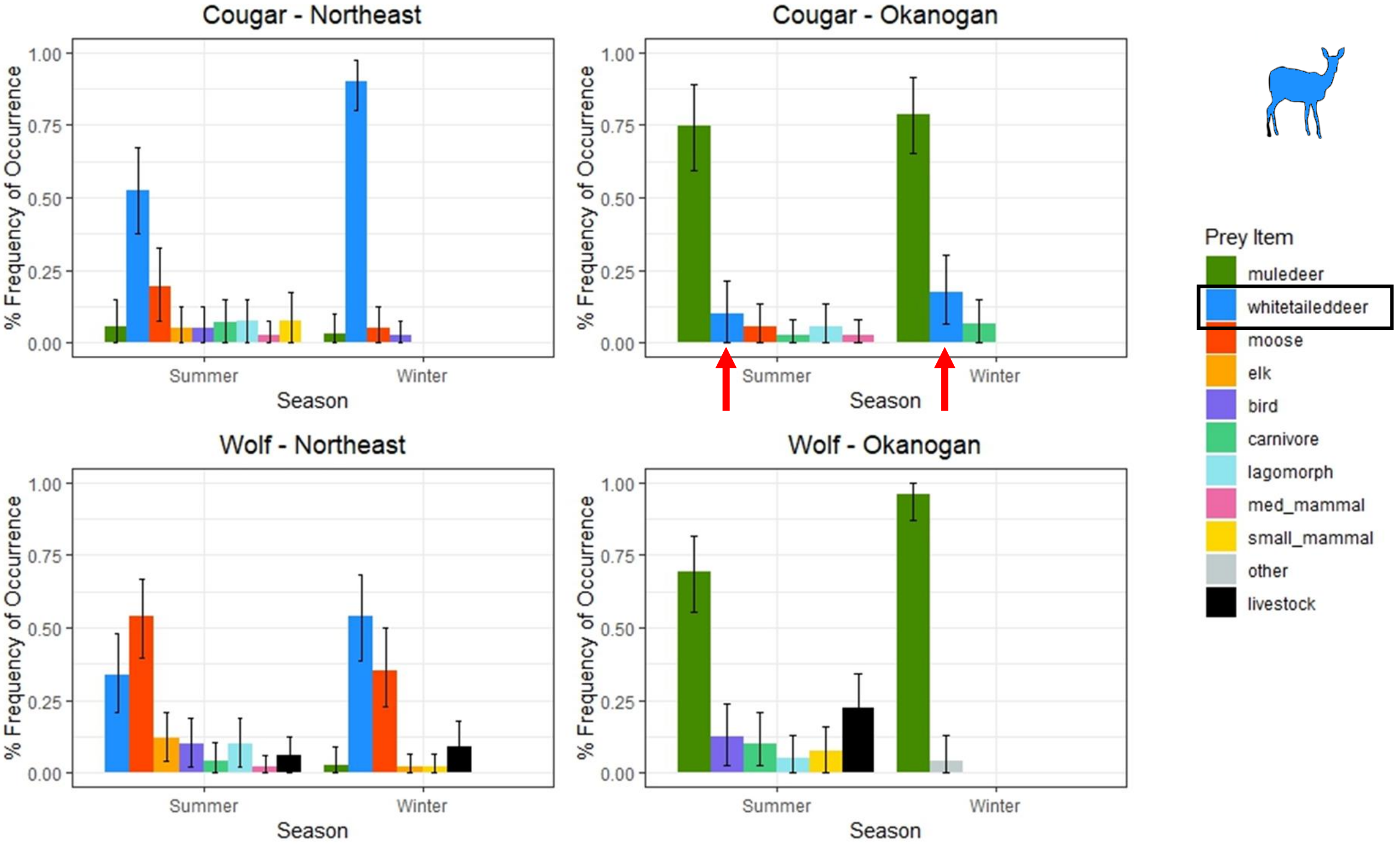
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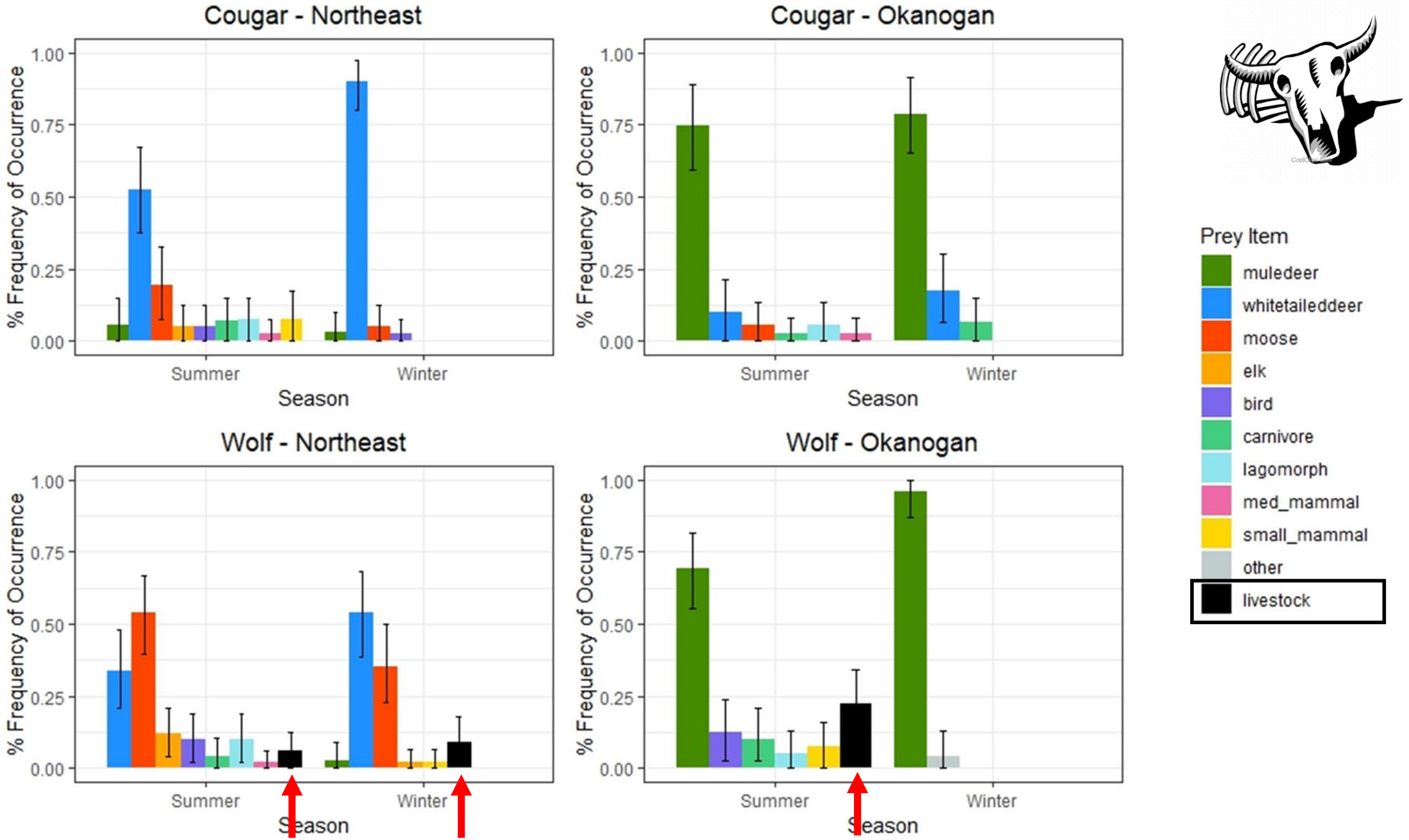
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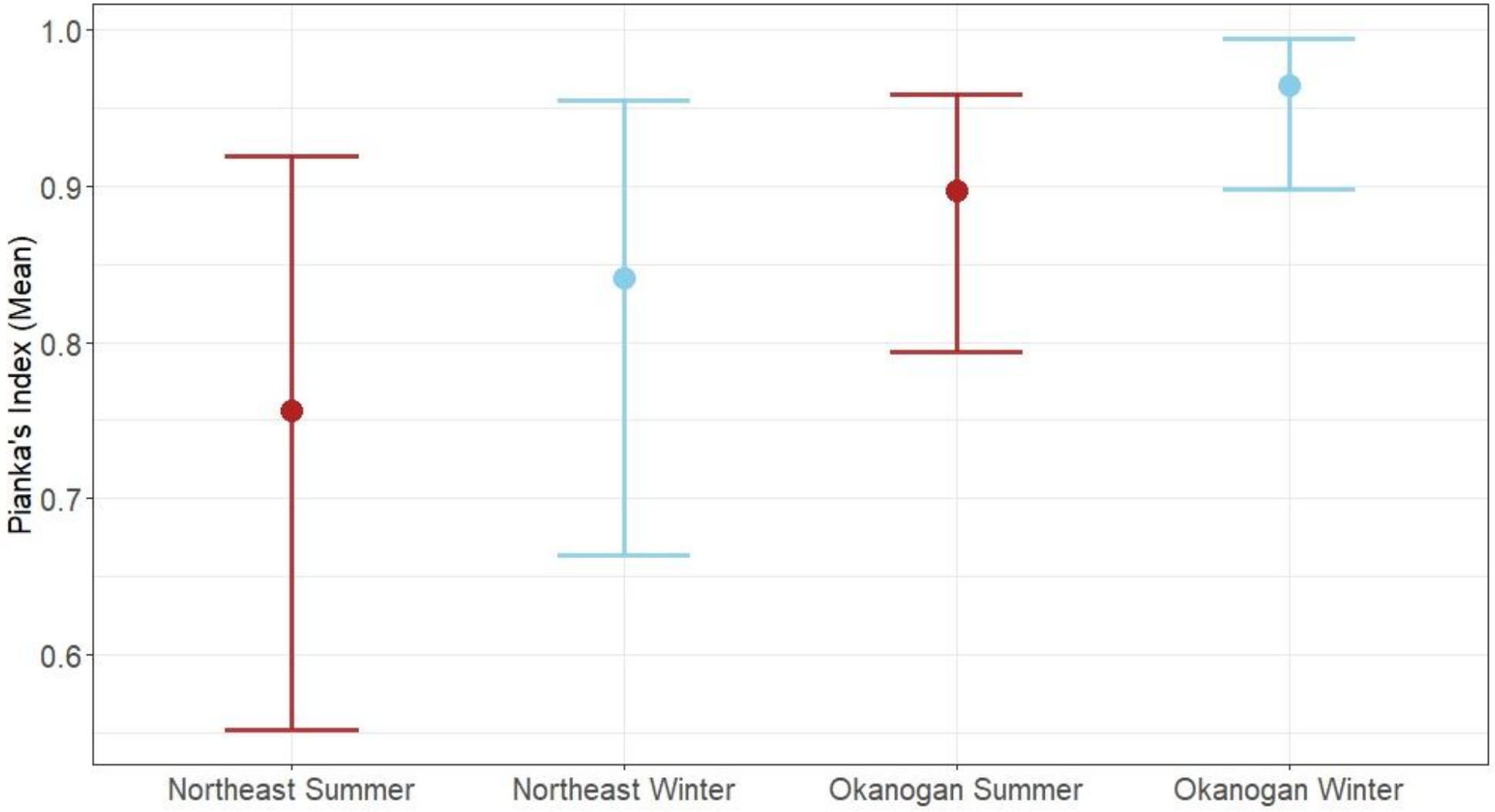
Pianka's Index



Pianka's Index	Northeast Summer	Northeast Winter	Okanogan Summer	Okanogan Winter
Mean (95% CI)	0.756 (0.552, 0.919)	0.841 (0.664, 0.955)	0.897 (0.794, 0.958)	0.965 (0.899, 0.994)

Results

Hypothesis:

- Increased prey diversity provides greater opportunity for dietary partitioning

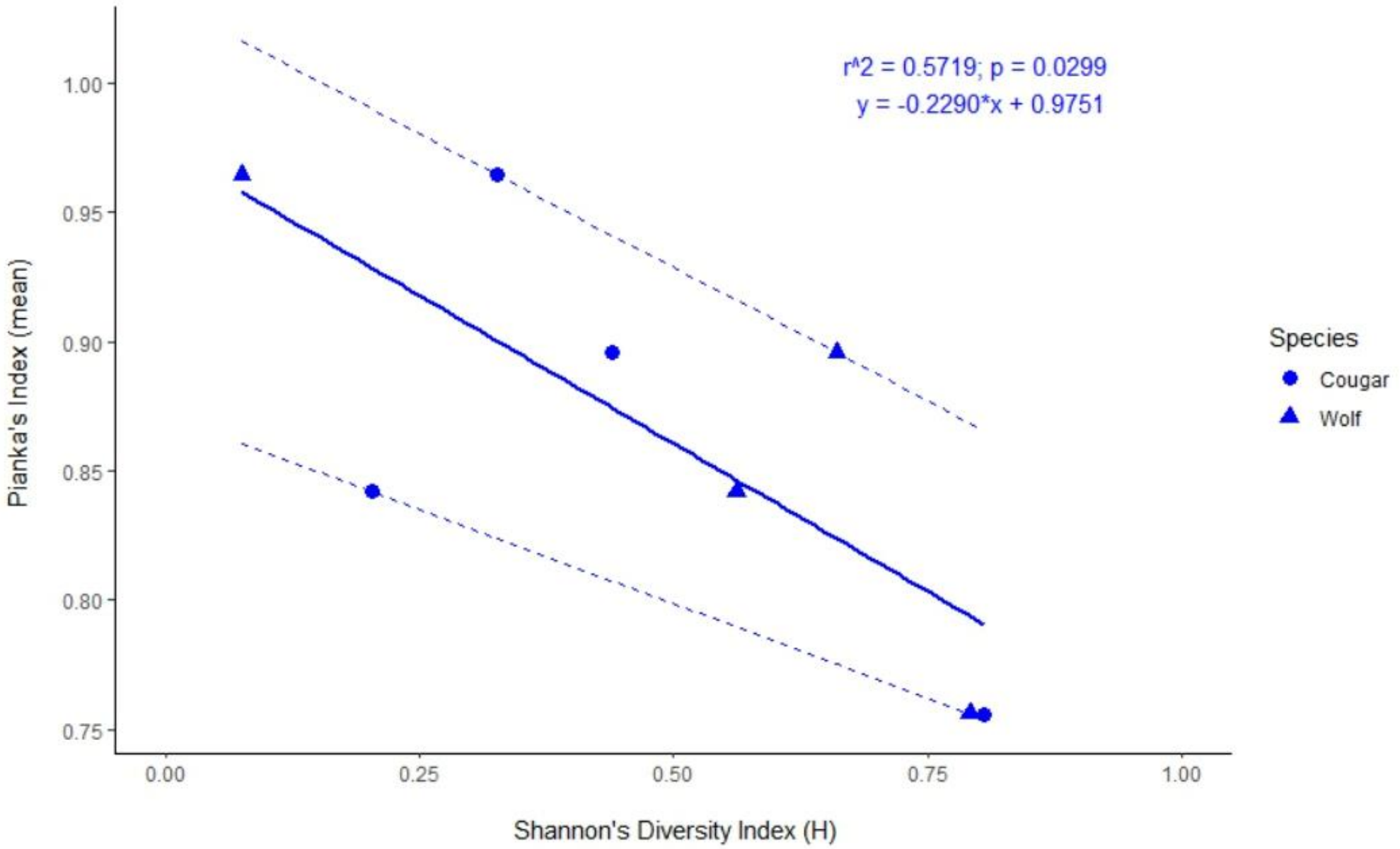
Predictions:

- If competition exists, expect more dietary partitioning in the Northeast
- If competition exists, expect more dietary partitioning in summer vs winter




Hypothesis:

Increased prey species diversity (Shannon's H) provides greater opportunity for dietary partitioning (Pianka's Index)



Conclusions

- Overview
  - → Prey diversity mediates dietary overlap between wolves and cougars
  - → Season may also play a role in mediating dietary overlap
  - → Areas or times of reduced prey diversity (Okanogan, Winter) have higher dietary overlap in use of of prey species
  - → Areas of higher prey diversity (Northeast) have less dietary overlap in use of prey sex within prey species

- Data consistent with hypothesis - inverse relationship between prey species diversity and dietary niche overlap

- Trends indicate that prey species niche partitioning between wolves and cougars occurs:
  - → (i) in the Northeast more than the Okanogan in both seasons
  - → (ii) in the summer more than winter in both study areas

Conclusions

Final Remarks:

- Collection of scat makes cluster investigation more efficient and results in higher-quality data, makes use of “bedsite” cluster investigations
- Moose mediate dietary overlap between wolves and cougars in the Northeast seasonally
- White-tailed deer allow greater flexibility of cougar diets in Okanogan – Winter as compared to wolves
- Livestock allow greater flexibility of wolf diets in Okanogan - Summer

  → cluster data suggests that livestock use is mainly scavenging

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Thank You!

Seattle City Light

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- WPPP PIs and Graduate Students
- Predator Ecology Lab, Quantitative Ecology Lab, & Prugh Lab
- Lab Technicians/Interns, UW SEFS Genetics Lab, and OSU Levi Genetics Lab
- Field Technicians and Volunteers
- Hound Handlers
- Private Landowners

Washington Department of FISH and WILDLIFE

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

FOREST SERVICE
US
DEPARTMENT OF AGRICULTURE

WASHINGTON DEPARTMENT OF NATURAL RESOURCES

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