

Carnivore Complex Dynamics in Rocky Mountain National Park



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Main Goals

- Facilitate evolution and persistence of healthy populations of native species in Rocky Mountain ecosystems.
- Improve proper functioning and health of Rocky Mountain habitats and the National Park.
- Aid management of a healthier functioning ecosystem, which will improve ecosystem services for human communities.

Main Objectives

■ Research

- “Carnivore Complex”: carnivore guild, their main prey, and vegetation.
- Improve our understanding of community ecology and dynamics relative to hierarchical structure and trophic cascades within and emanating from the carnivore complex in temperate mountain ecosystems of N. America.
- Test and improve scientific methods for addressing single and multi-species questions *via* non-intrusive field techniques, such as remote camera-trapping, sign surveys, and genetic sampling.
- Generate rigorous data pre and post-wolf re-establishment.
- Produce density, abundance, and occupancy estimates along with habitat use of principal carnivore and prey species as well as primary productivity and vegetative community structure in critical habitats relative to habitat disturbance, human activity, and climate change.

Main Objectives

- Conservation

- Provide rigorous scientific information for management and conservation plans.
- Increase public education and awareness of natural ecological processes via information on community ecology, thereby improving visitor experiences and support for ecosystem and Park-wide conservation.

A priori Sampling Design -- Transects

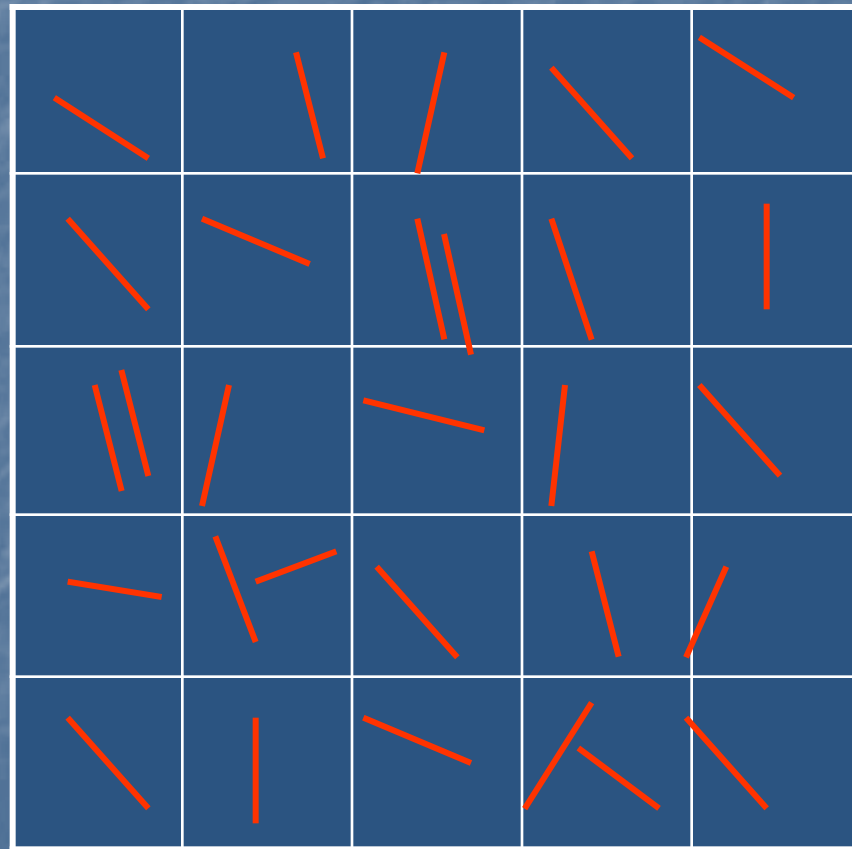
* Stratified-random sampling by site and habitat type

Fully-randomized

- * Sampling period
- * Location
- * Transect selection
- * Bearing (direction)

+

Semi-replication of
transects, habitat types,
conditions, etc.



64 km² grid
2 x 2 km cells

A priori Sampling Design - Camera Trapping

- * Stratified-random sampling by site and habitat type

Trapping Period: 4 sets x 8 weeks/set

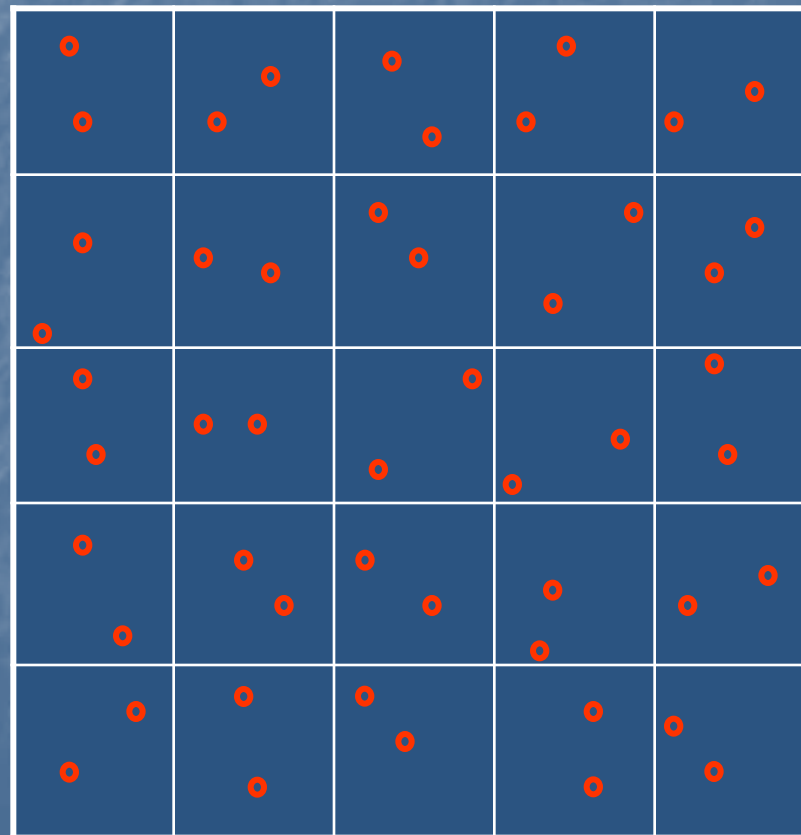
Fully-randomized

- * Sampling period

- * Location

+

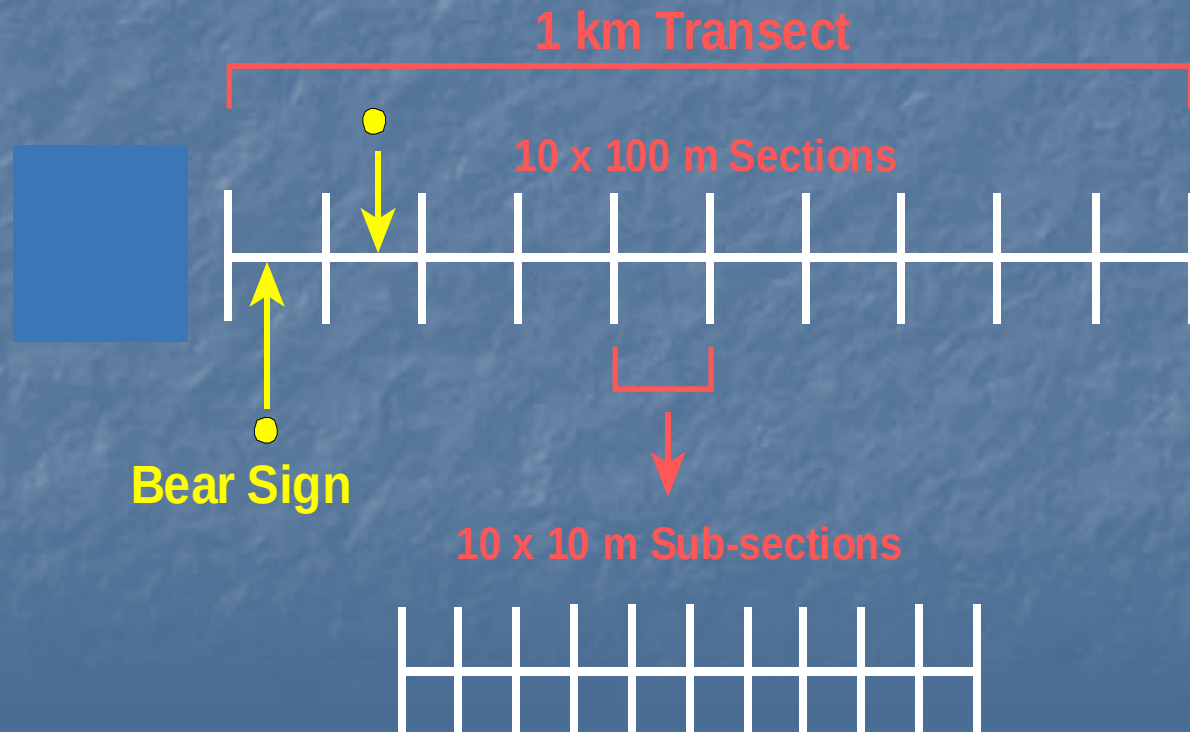
Semi-replication of
habitat types, conditions,
etc.



64 km² grid
2 x 2 km cells

Sign and Genetic Census

- a) Systematic censusing along 1000 m transects
- b) Distance Sampling



Site Occupancy Modeling

(MacKenzie et al. 2002, Royle & Nichols 2003, Augeri 2005)

Sign Surveys and Camera Trapping

- Based on: detection - non-detection (pres/absence) probabilities

(In this study): unique photo or sign events

Example: detection history of 1101:

$$\psi \times ((p[1])(p[2])(1-p[3])(p[4]))$$

Test: Asymptotic Quadratic Chi-square

Model Evaluation: Akaike Information Criteria (AIC)





Carnivore Complex Study

Preliminary Results

- 1) Camera Trapping: 5,760 hours
- 2) Sign Surveys: 33 km

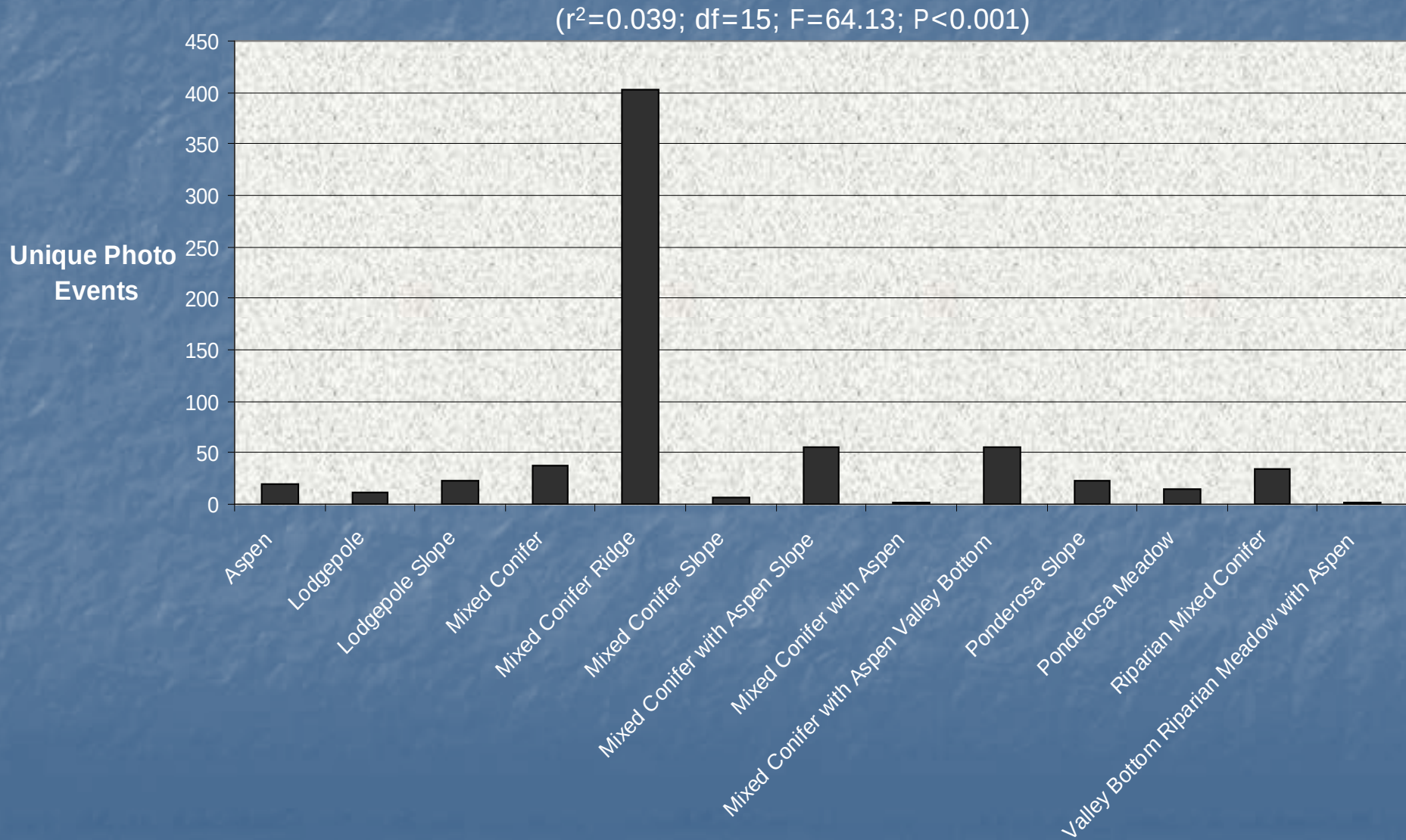
Current Main Carnivores



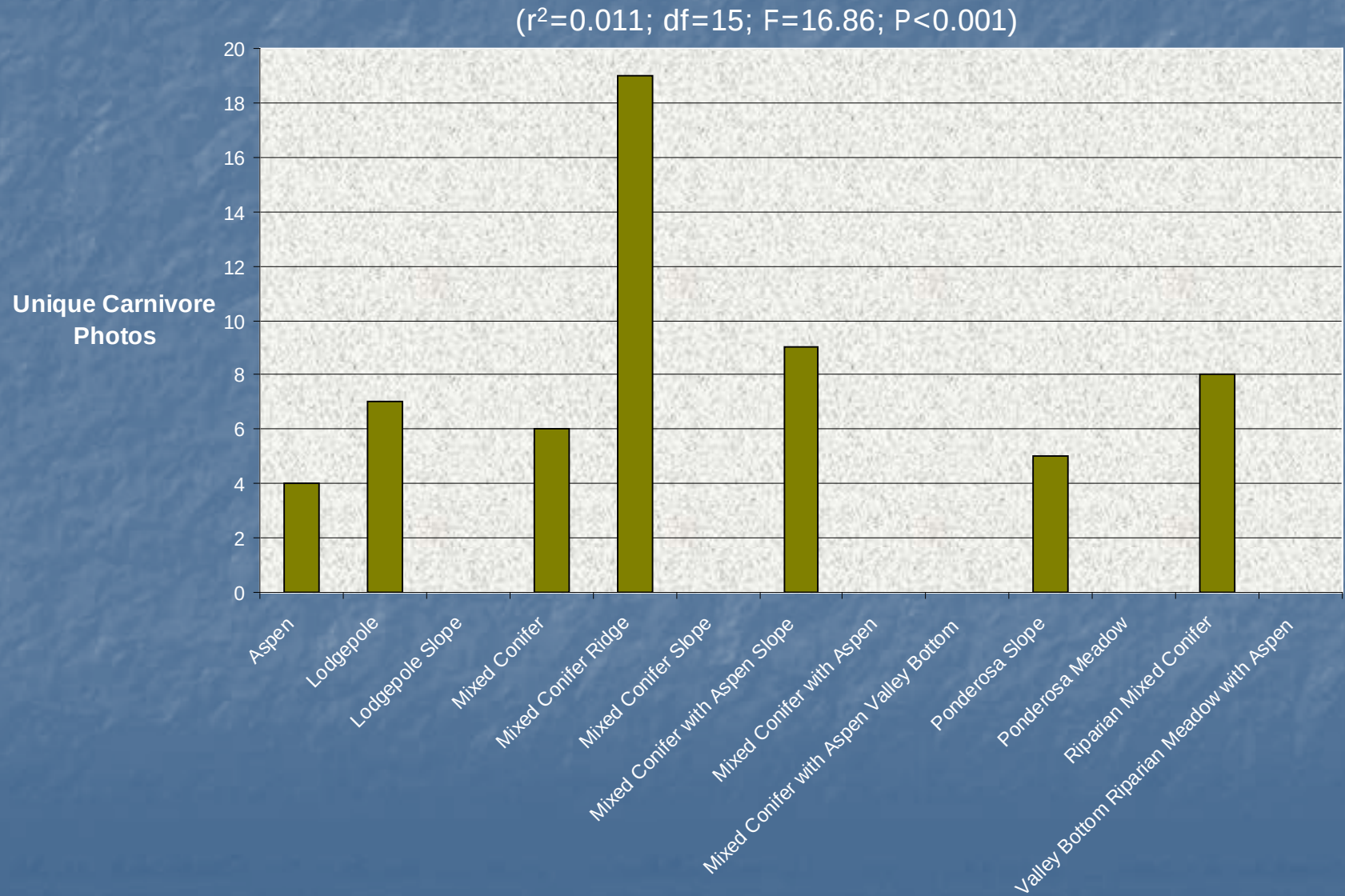
Unique Photo Events of All Species Captures

Subject	Total Unique Events
American Robin	1
Northern Flicker	2
Steller's Jay	1
Uinta Chipmunk	8
Bighorn Sheep	3
Bird (unknown species)	7
Black Bear	14
Bobcat	15
Cottontail Rabbit	21
Coyote	6
Dark-eyed Junco	1
Domestic Dog	6
Elk	16
Golden Mantled Ground Squirrel	2
Human	424
Magpie	1
Moose	1
Mouse	6
Mt Lion	9
Mule Deer	55
Rabbit	1
Red Fox	7
Red Squirrel	76
Snowshoe Hare	10
Striped Skunk	8
Unknown	4
Wild Turkey	2

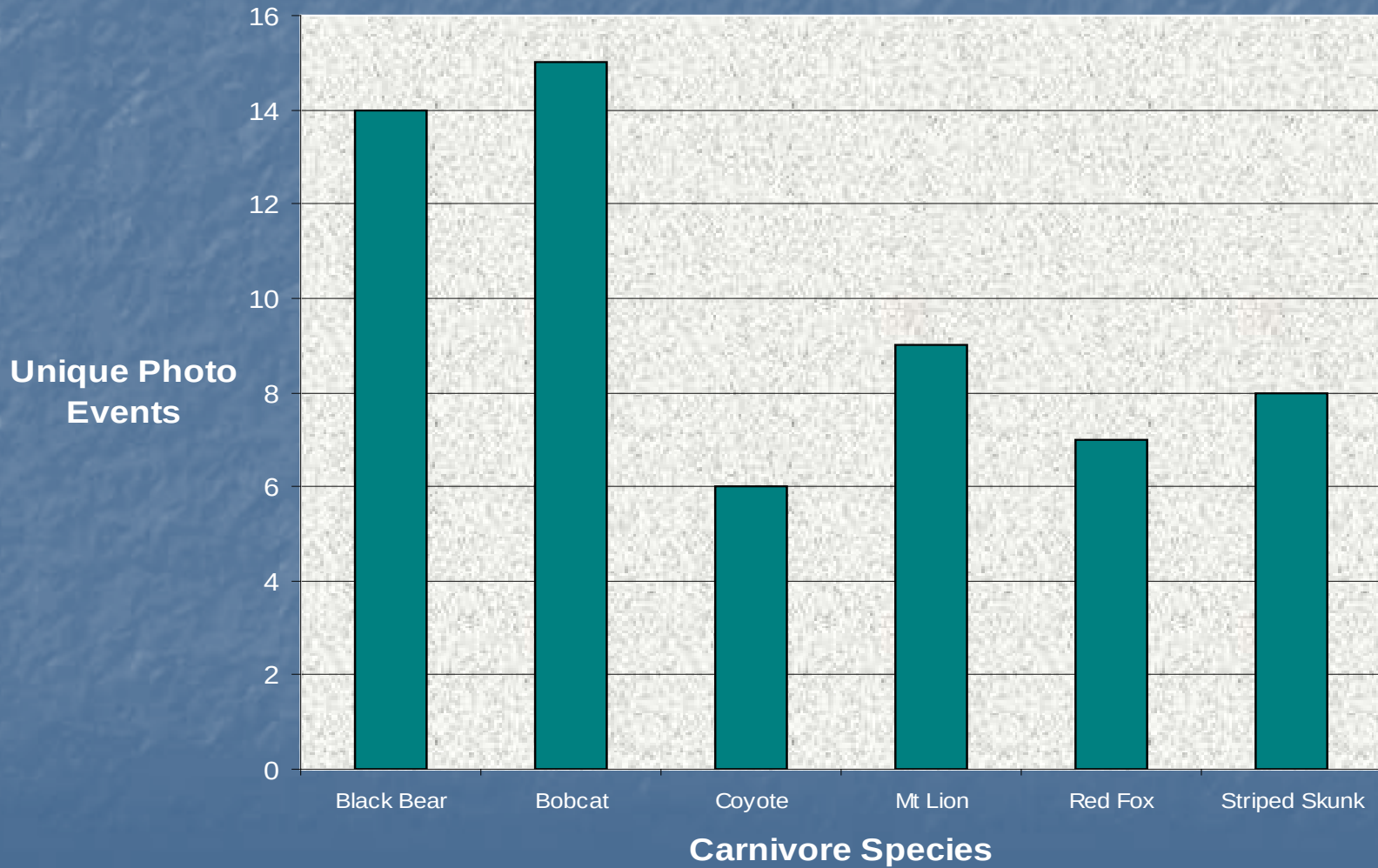
Unique Photo Events for All Species vs. Habitat Type



Unique Carnivore Photo Events by Habitat Type



Unique Carnivore Photo Events



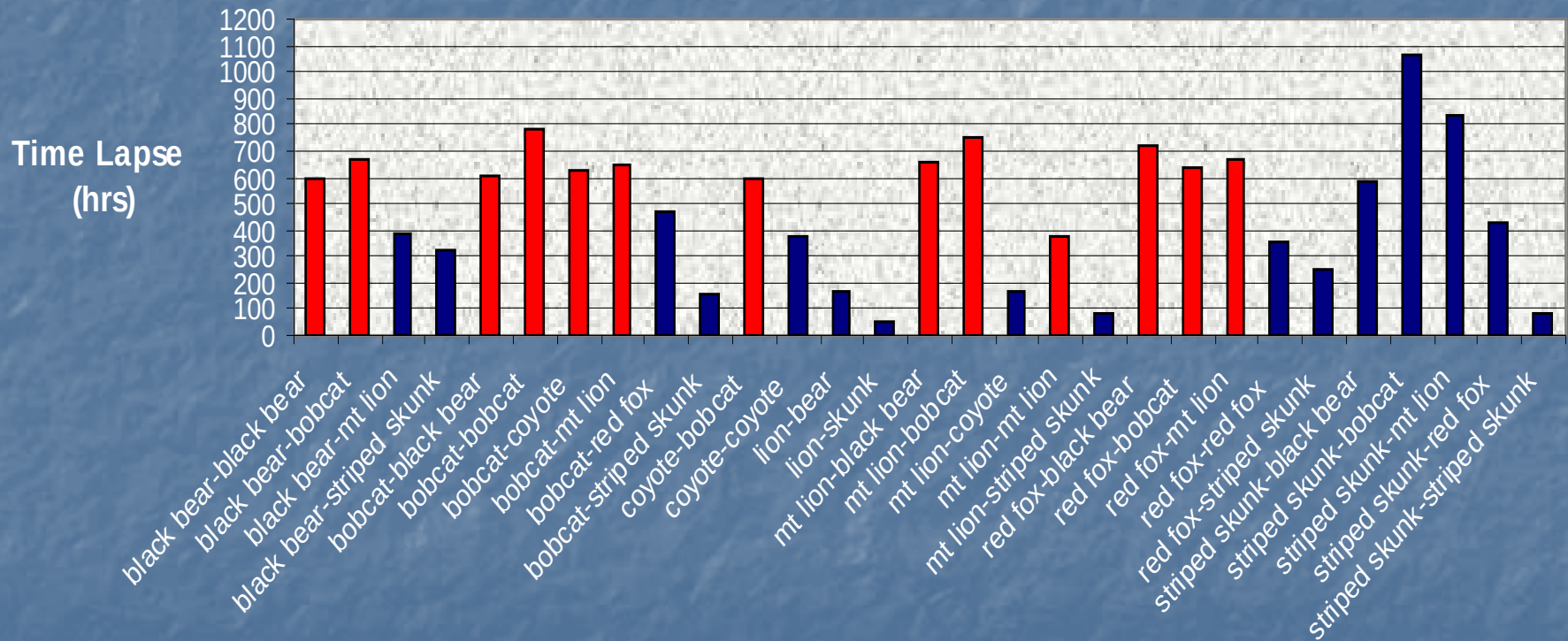
Temporal Variation in Landscape Use

Mean Time Lapse Between Photos at Same Site

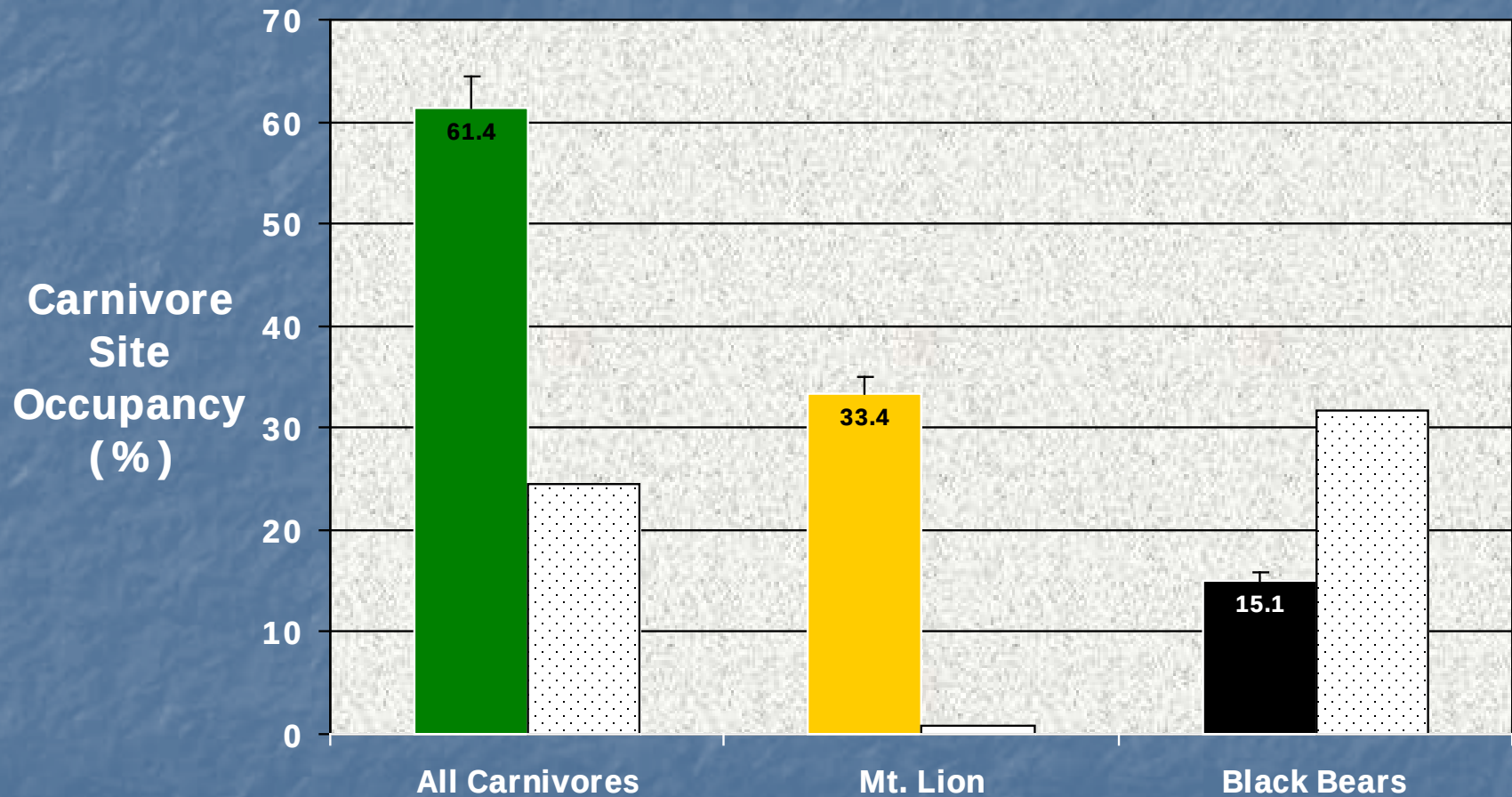
Group	Mean Time Lapse (hrs)	Significance
Carnivore - Human	91.02	$r^2=0.131$; $F=75.04$; $p<0.001$
Prey - Human	179.22	$r^2=0.015$; $F=7.7$; $p<0.0057$
Carnivore - Carnivore	583.64	$r^2=0.347$; $F=265.49$; $p<0.001$
Carnivore - Prey	165.46	$r^2=0.026$; $F=13.17$; $p<0.0003$

Temporal Variation Among Carnivores

($r^2=0.347$; $F=265.49$; $p<0.001$)



Carnivore Site Occupancy



Black Bear Density

- R. Baldwin (2007): 0.0129 bears/km⁻² (90% CI: 0.016 – 0.0241)
 - Telemetry and Occupancy
- Current Study (2007): 0.016 bears/km⁻² (95% CI: 0.05 - 0.027)
 - Camera trapping and Occupancy









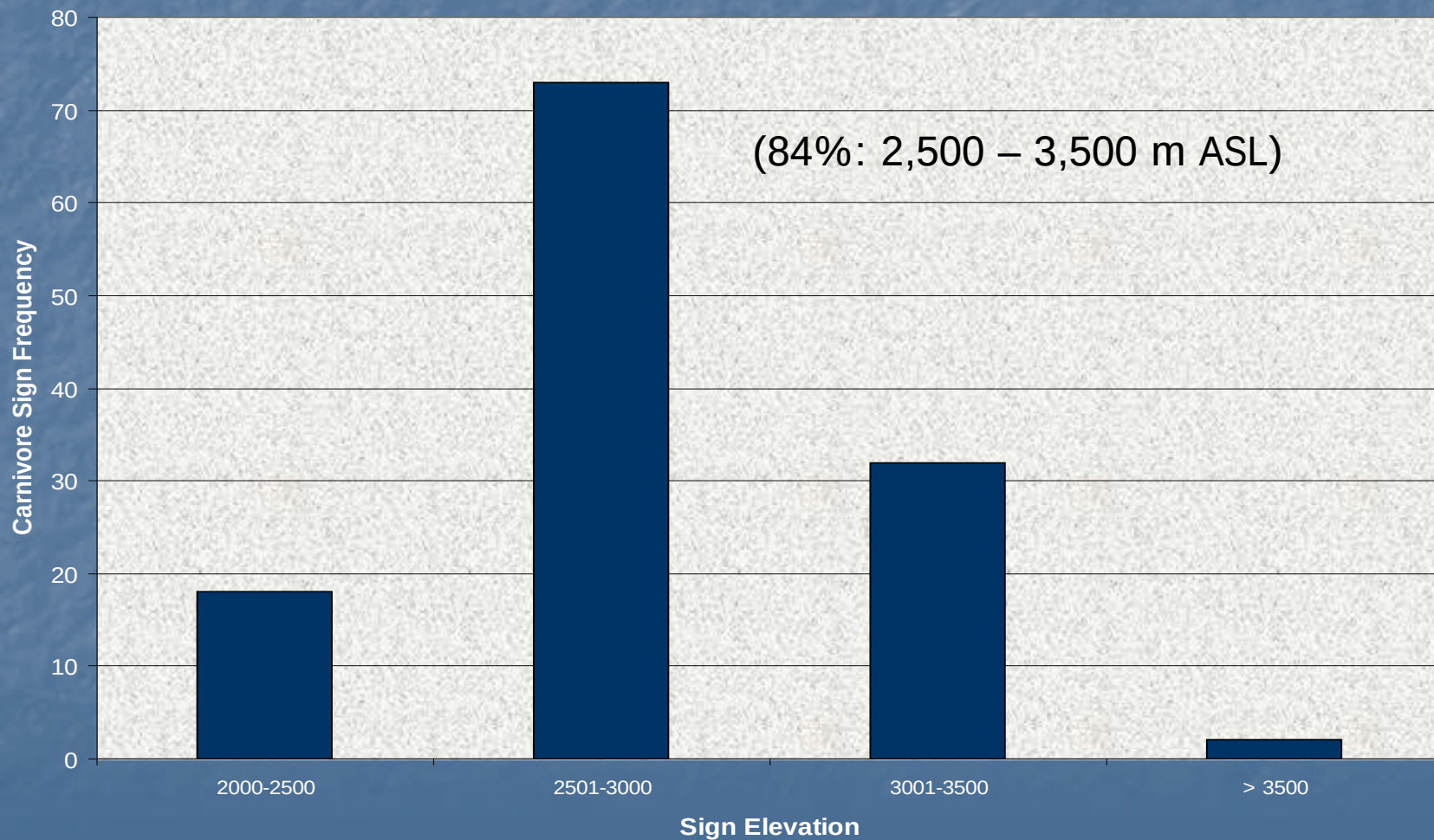


Unique Sign Events of All Species by Habitat Type

Habitat	Prey Presence	Carnivore Presence
Arid Hillside	4	0
Arid Lodgepole	95	0
Aspen Meadow, Ponderosa	87	6
Lodgepole	198	1
Meadow Willow	52	7
Mixed Conifer	203	1
Mixed conifer with aspen	248	1
Mixed conifer with Aspen and Juniper	91	2
Open Fir and Cedar	12	0
Open Fir and Pine	34	6
Open Ponderosa	266	37
Pine Fir Slope	470	39
Ponderosa and Fir Forest	90	0
Ponderosa Spruce Fir	85	3
Riparian and Mixed Conifer with Aspen	75	0
Riparian Slopes	58	1
Rock Grass sc Conifer	42	0
Rocky Creek Bank	50	0
Rocky Mixed Slope	5	2
Spruce Fir	215	26
Totals	2380	132

Carnivore Presence by Elevation & Habitat

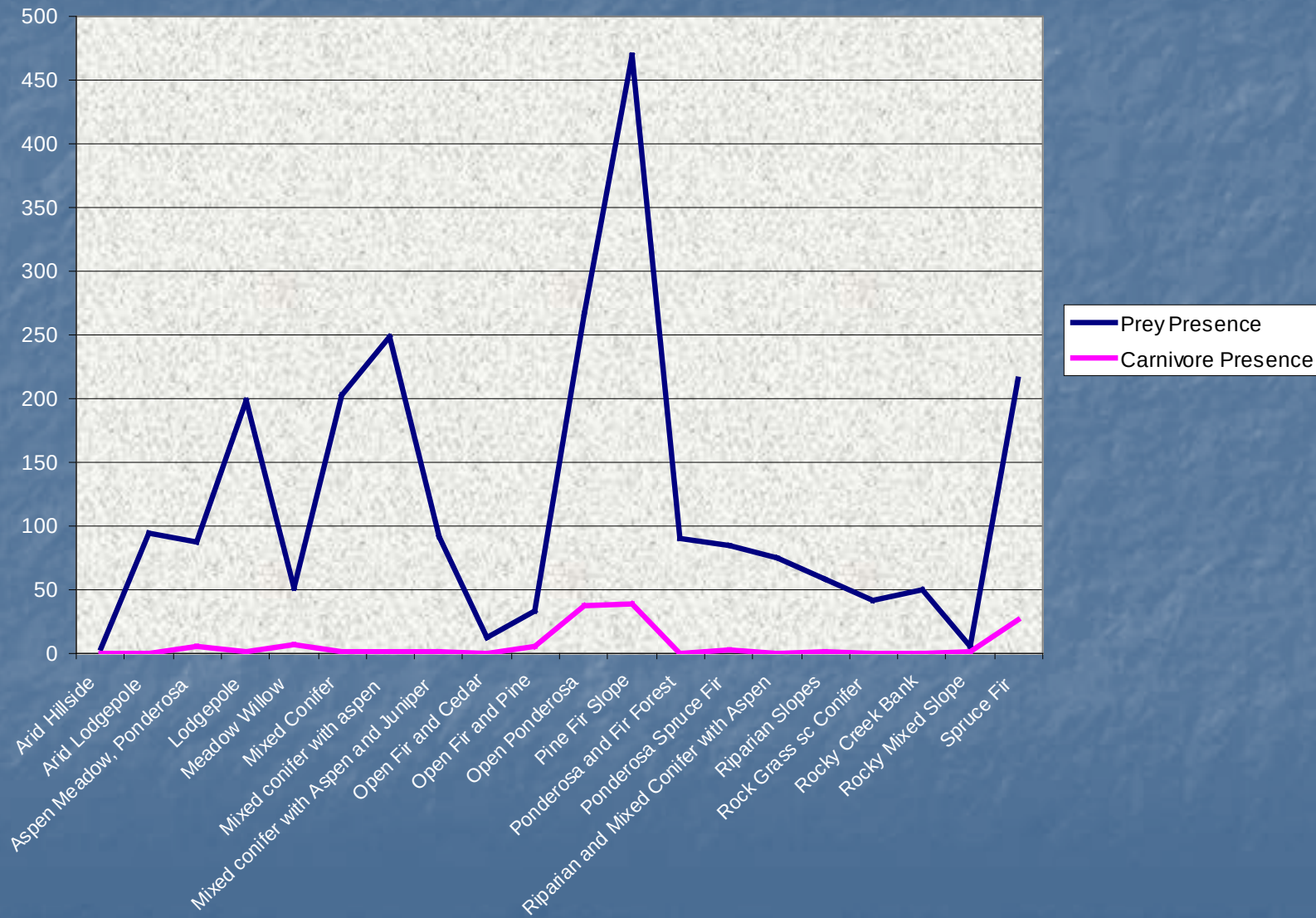
($r^2=0.442$; $df=13$; $F=6.96$; $P<0.001$)



Carnivore and Prey Presence vs. Habitat Types

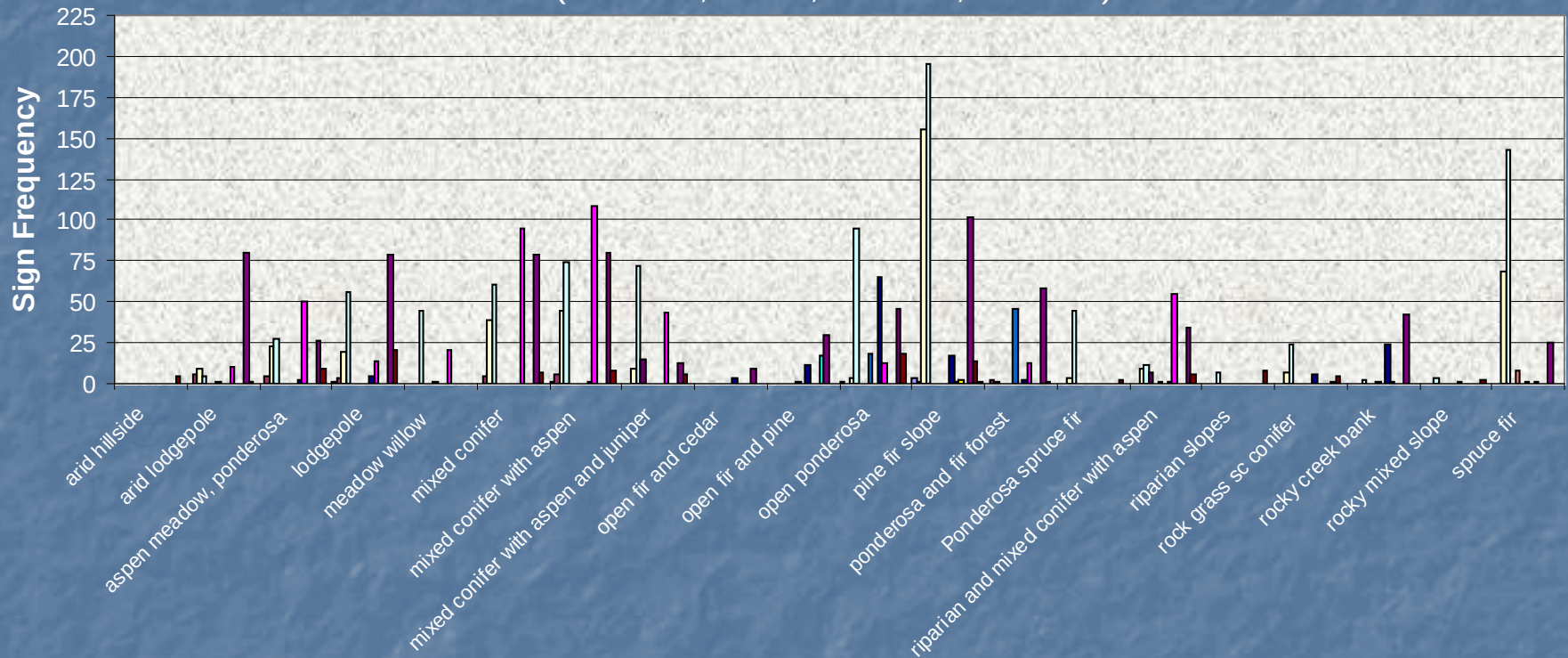
(Pearson's $r=0.218$; $\chi^2=0.219$)

Carnivore & Prey
Sign Frequency



Prey Species by Habitat Type

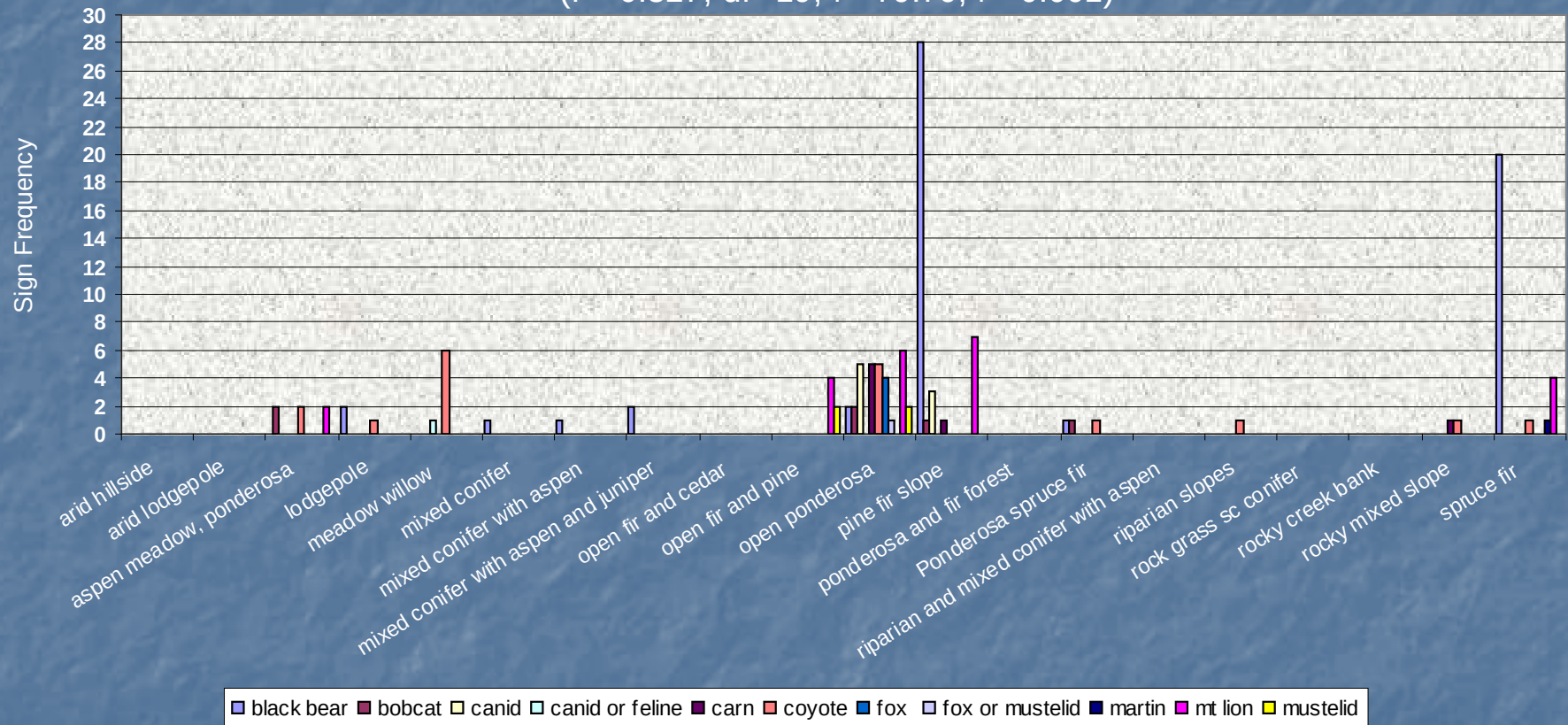
($r^2=0.083$; $df=19$; $F=14.87$; $P<0.001$)



■ bighorn
 ■ chipmunk
 ■ deer
 ■ elk
 ■ ground sql
 ■ moose
 ■ mouse
 ■ porcupine
 ■ rabbit
 ■ rodent
 ■ snake
 ■ snhare
 ■ sql
 ■ ungulate
 ■ vole

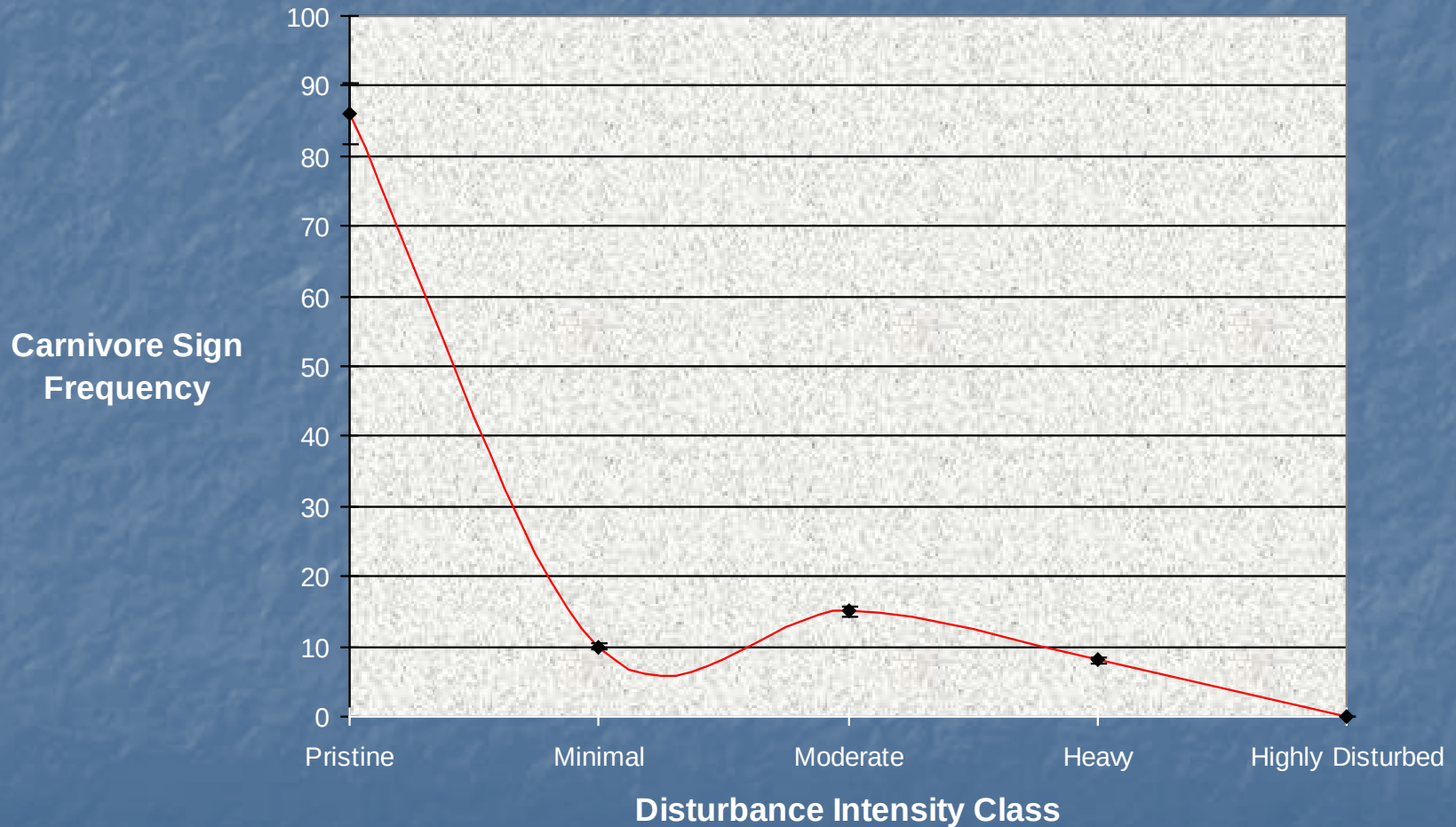
Carnivore Species by Habitat Type

($r^2=0.327$; $df=19$; $F=79.76$; $P<0.001$)



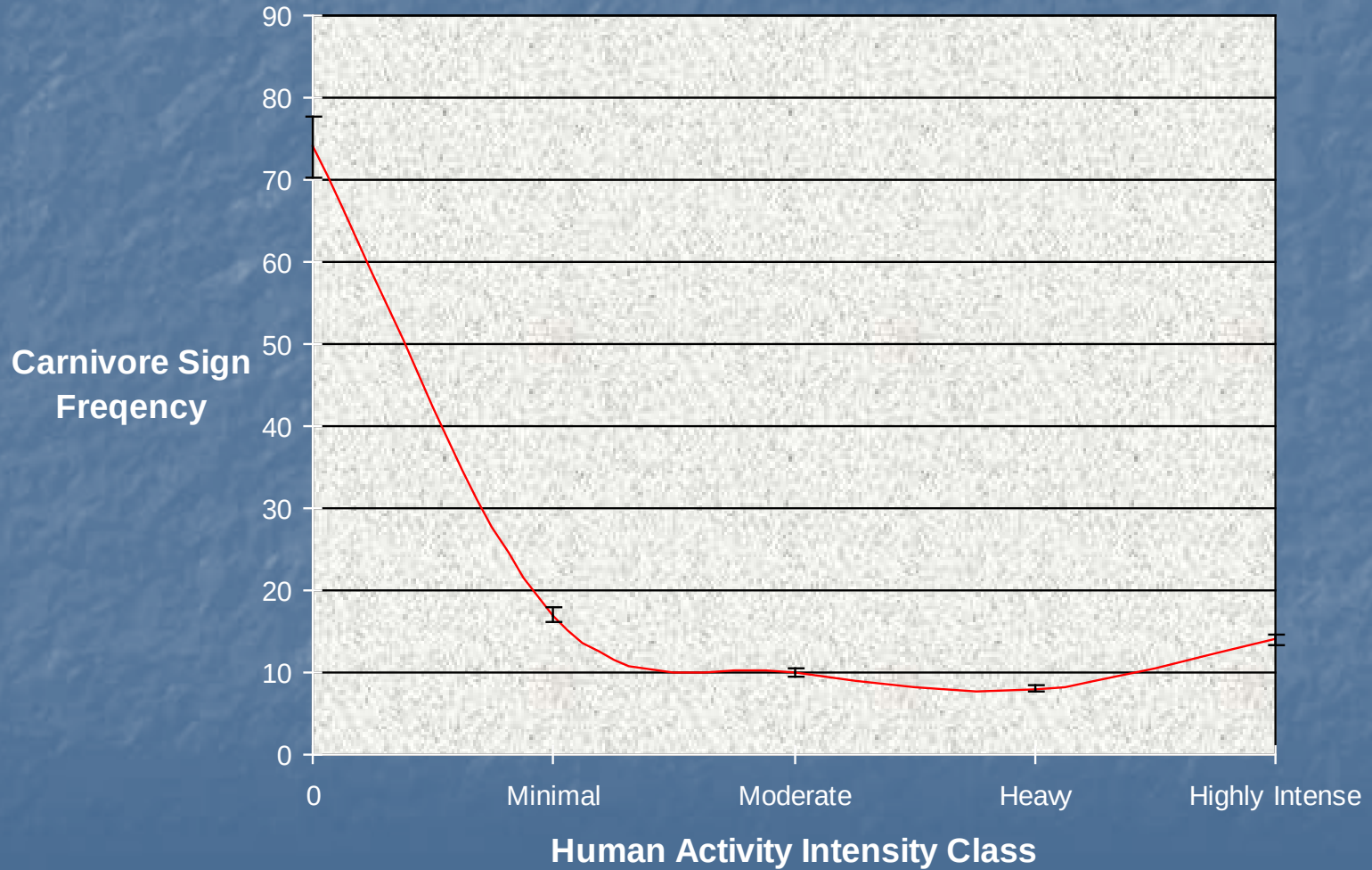
Carnivore Presence vs. Habitat Disturbance

73 % ($r^2=0.232$; $df=4$; $F=11.57$; $P<0.001$)



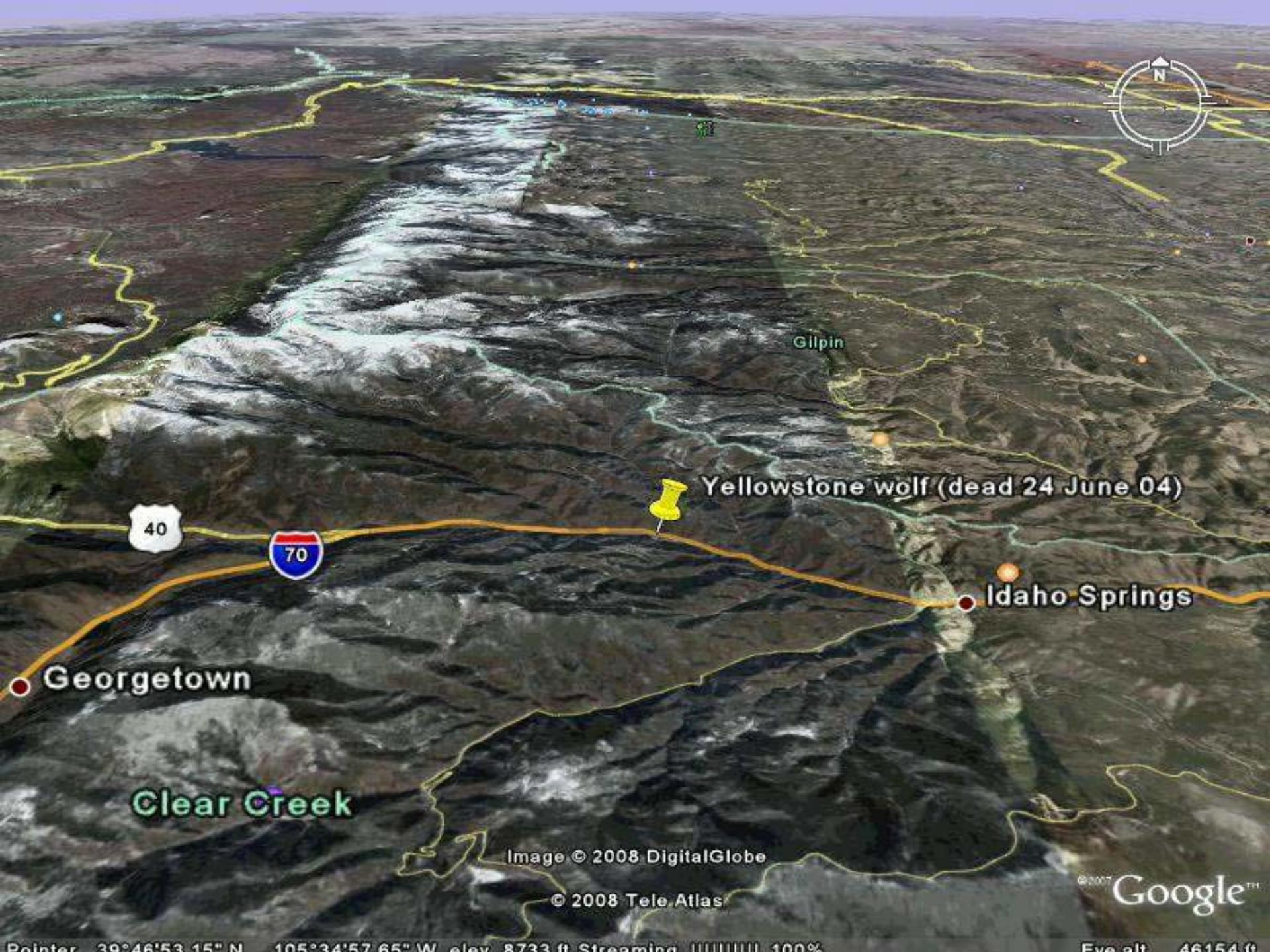
Carnivore Presence vs. Human Activity

61% ($r^2=0.211$; $df=4$; $F=8.07$; $P<0.001$)



Are Wolves in Colorado??





Yellowstone wolf (dead 24 June 04)

Gilpin

Idaho Springs

Georgetown

40

70

Clear Creek

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Video of Wolf Near Walden Colorado, 16 February 2007



Wolfsighting (video 16 Feb 07)

Walden, CO

Steamboat Springs, CO

40

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Pointer 40°33'14.57" N 106°32'45.36" W elev 8648 ft Streaming ||||| 100%

Eye alt 25.56 mi



Rainbow Lakes Campground   Wolf Pair Sighting (14 October 2007)

 Eldora

Image © 2008 DigitalGlobe

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Wolf sighting video (17 Feb 07)

Wolf sighting (4 Dec 07)

Longs Peak

Estes Park

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Image © 2008 DigitalGlobe

Pointer 40°18'15.78" N 105°34'42.03" W elev 9509 ft Streaming 100%

Eye alt 31950 ft

Unique Sign Events of Key Genus/Species in Study Area

Bighorn sheep	6
Black bear	57
Bobcat	6
Canid	8
Canid or feline	1
Carnivore (unknown)	7
Chipmunk	28
Coyote	18
Deer	389
elk	862
Fox	4
Fox or mustelid	1
Ground squirrel	22
Martin	1
Moose	8
Mouse	69
Mt lion	23
Mustelid	4
Porcupine	1
Rabbit	137
Rodent	424
Snake	2
Snowshoe hare	17
Squirrel	704
Ungulate	111
Vole	1
Wolf / Wolf-hybrid	2



Wolf sighting (4 Dec 07)



Image © 2008 DigitalGlobe

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Pointer 40°21'12.48" N 105°35'25.94" W elev 8022 ft Streaming ||||| 100%

Eye alt 10590 ft



Wolf print (17 Jan 08)



Wolf track set (25 Jan 08)

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Pointer 40°21'11.03" N 105°35'49.50" W elev 8035 ft Streaming 100%

Eye alt 10294 ft



Wolf print (17 Jan 08)



Wolf track set (25 Jan 08)



Wolf sighting (4 Dec 07)

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Pointer 40°21'11.03" N 105°35'49.50" W elev 8035 ft Streaming ||||| 100%

Eye alt 10294 ft



Wolf pack tracks (March 08)

Wolf sighting (video 17 Feb 07)

Wolf print (17 Jan 08)

Wolf sighting (4 Dec 07)

Wolf track set (25 Jan 08)

Wolf Pair Sighting (14 October 07)

Yellowstone wolf (dead 24 June 04)

Preliminary Conclusions

- These methods work well. They are valid, realistic, practical and provide rigorous data on these species in these temperate mountain habitat types.
- Occupancy modeling, including for density estimates, is valid and can provide critical information for management and conservation of key species, including rare/endorsangered/threatened species.
- Carnivores appear to be selecting 3 main habitat types between 2,500 – 3,500 m ASL:
 - Pine-fir slope
 - Open Ponderosa
 - Spruce-fir
- There appears to be an insignificant correlation between the presence of some carnivores and prey.
- Carnivores in RMNP appear to be avoiding areas with moderate – high habitat disturbance and moderate – high human activity.
- Carnivores in RMNP appear to be selecting areas with high degrees of refugia cover.
- Carnivores appear to be adjusting temporally among each other.
- Wolves?????