

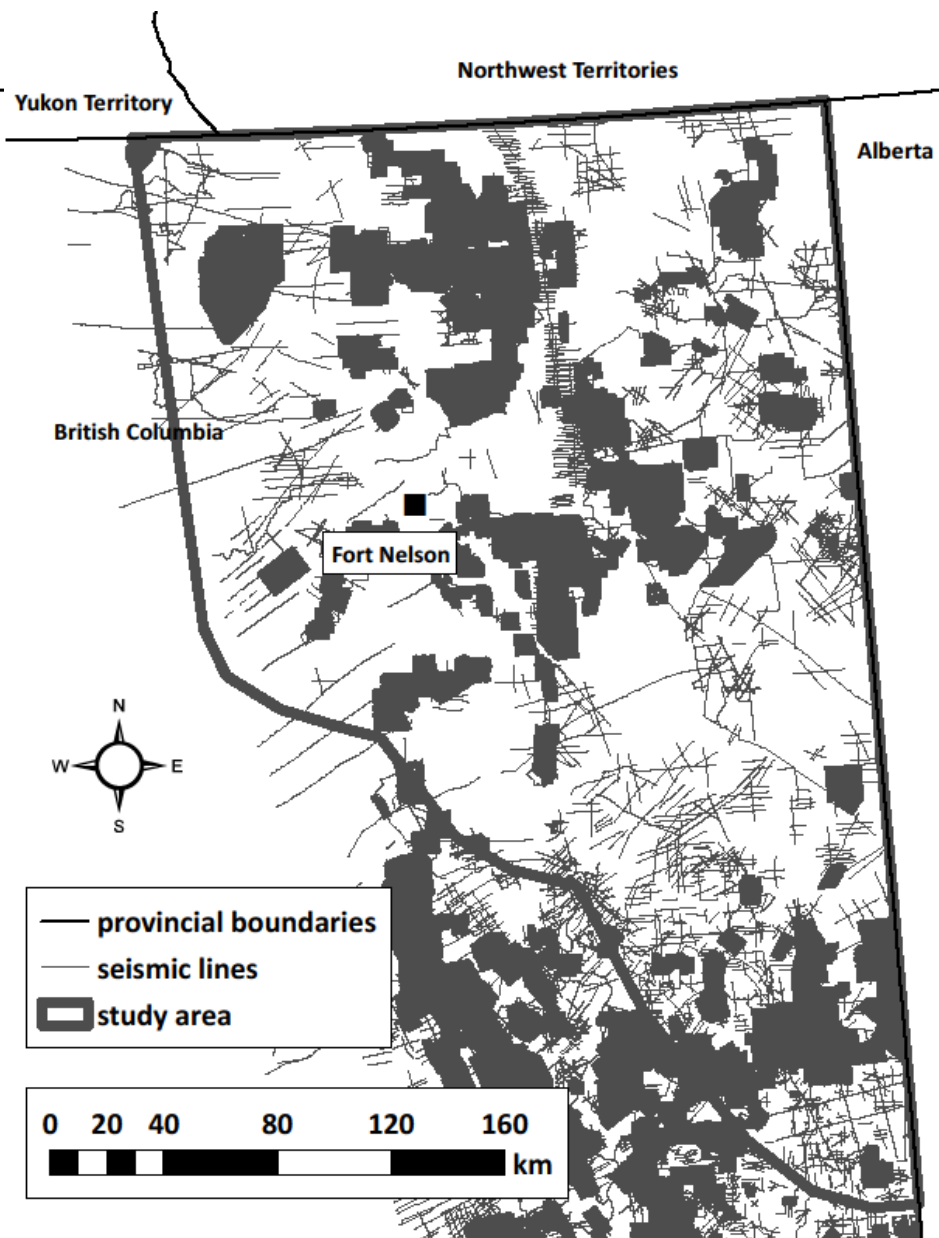
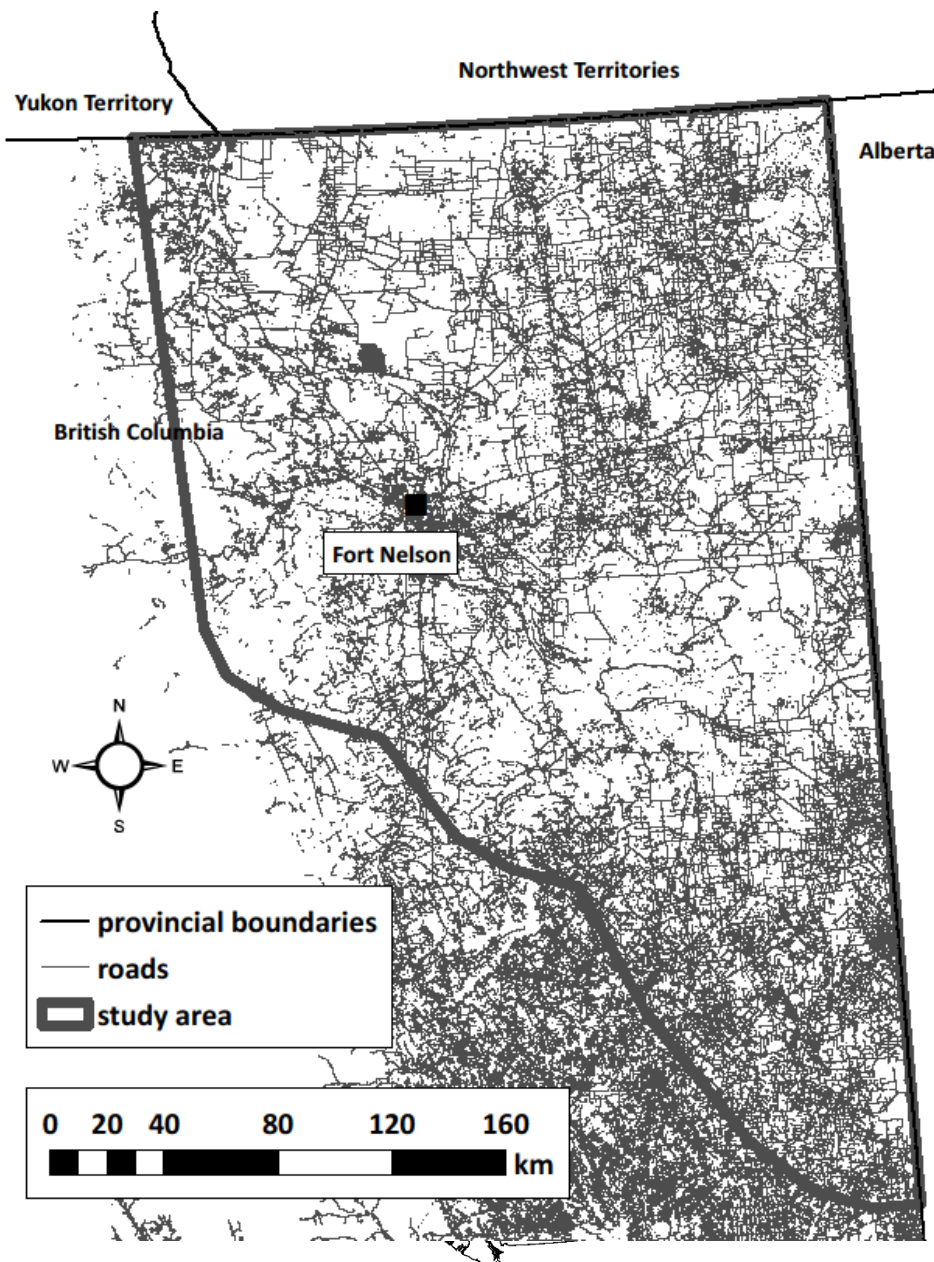
Understanding the influence of disturbance, moose, and wolves on boreal caribou



Photo: Brad Culling

By Matt Mumma¹
Mike Gillingham¹
Chris Johnson¹
Kathy Parker¹

¹Ecosystem Science & Management,
University of Northern
British Columbia

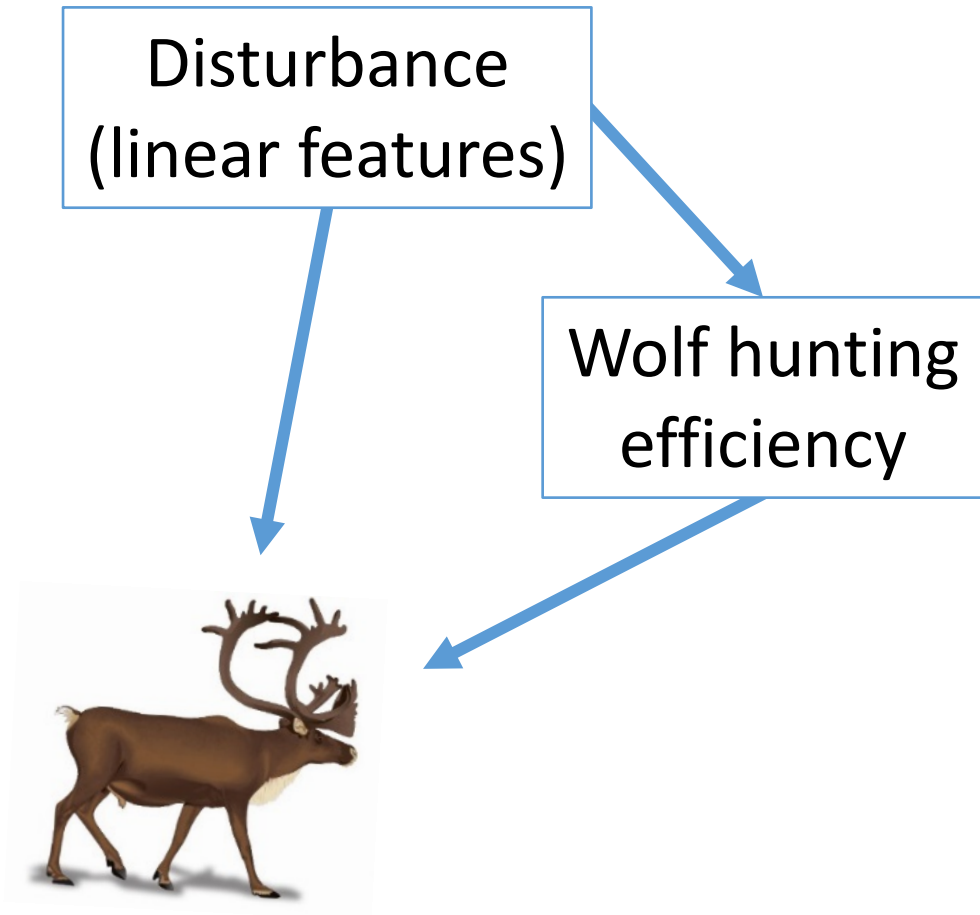


Direct and indirect effects

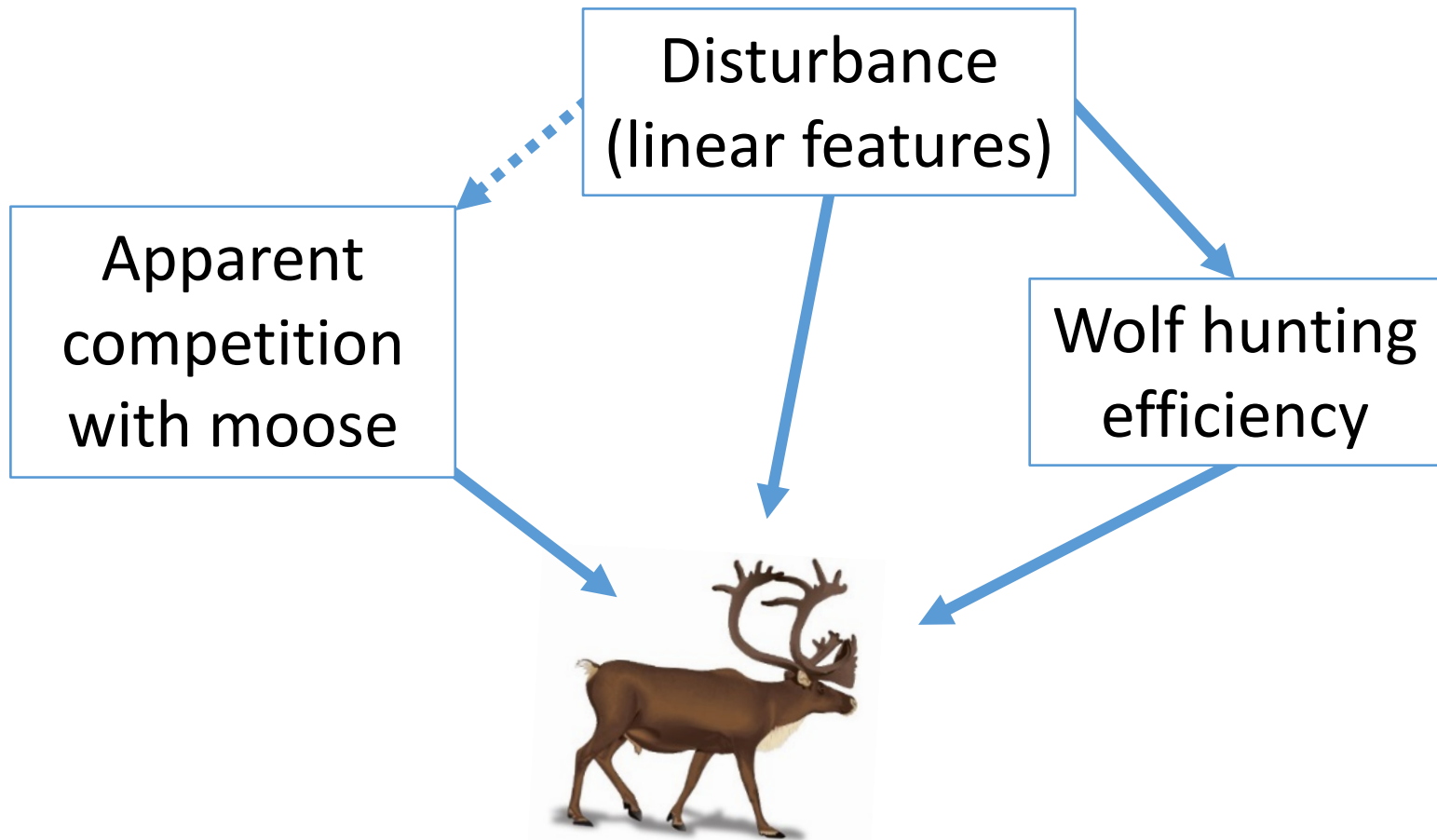
Disturbance
(linear features)



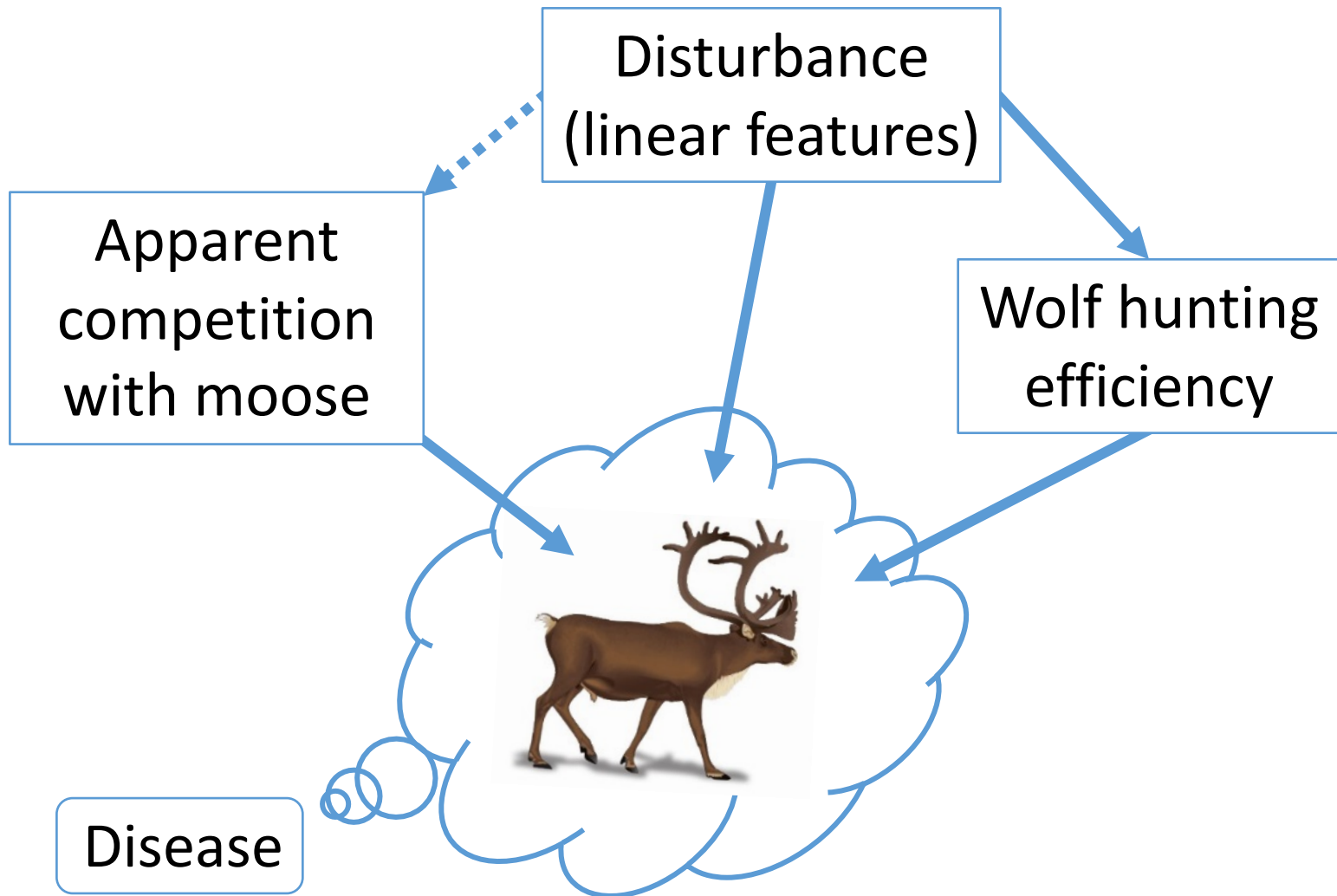
Direct and indirect effects



Direct and indirect effects



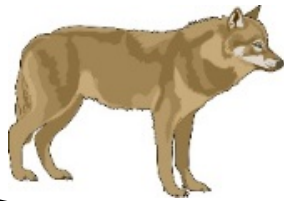
Direct and indirect effects



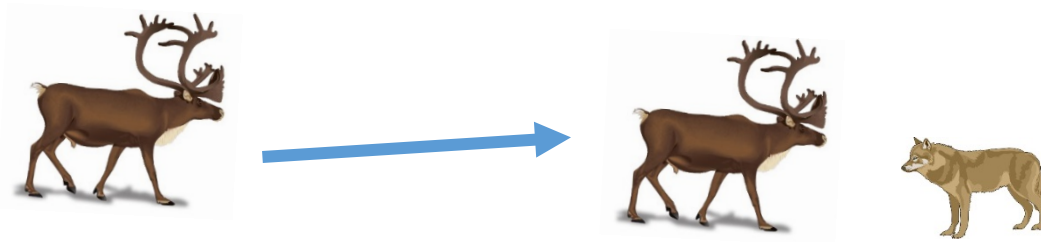
Questions

- 1) How do linear features influence predation risk for caribou?
- 2) How do caribou respond to linear features?
- 3) How do moose respond to linear features?
- 4) How does the presence of linear features influence moose selection of caribou habitats?

1) How do linear features influence predation risk for caribou?

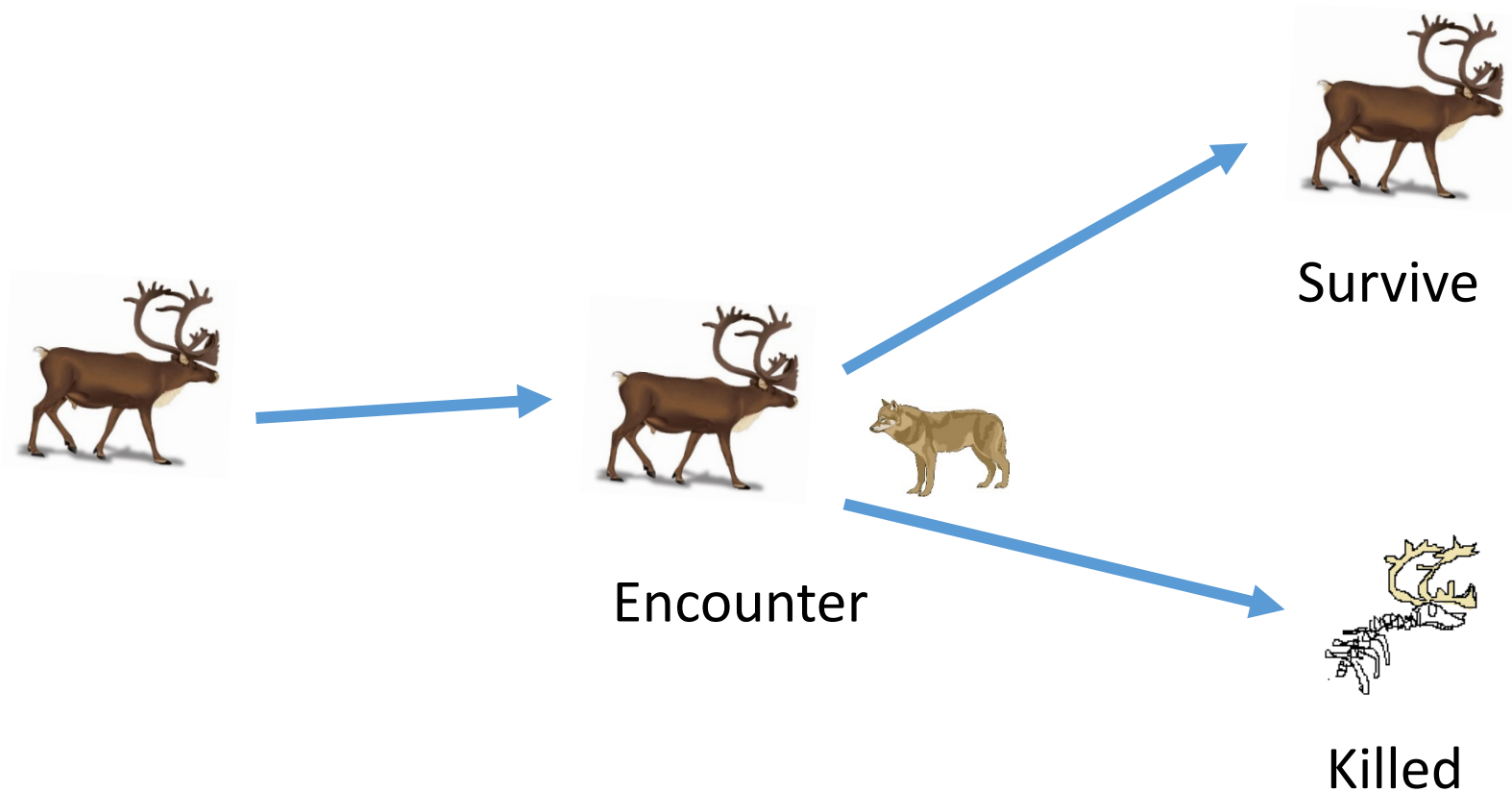


Mechanisms of predation risk

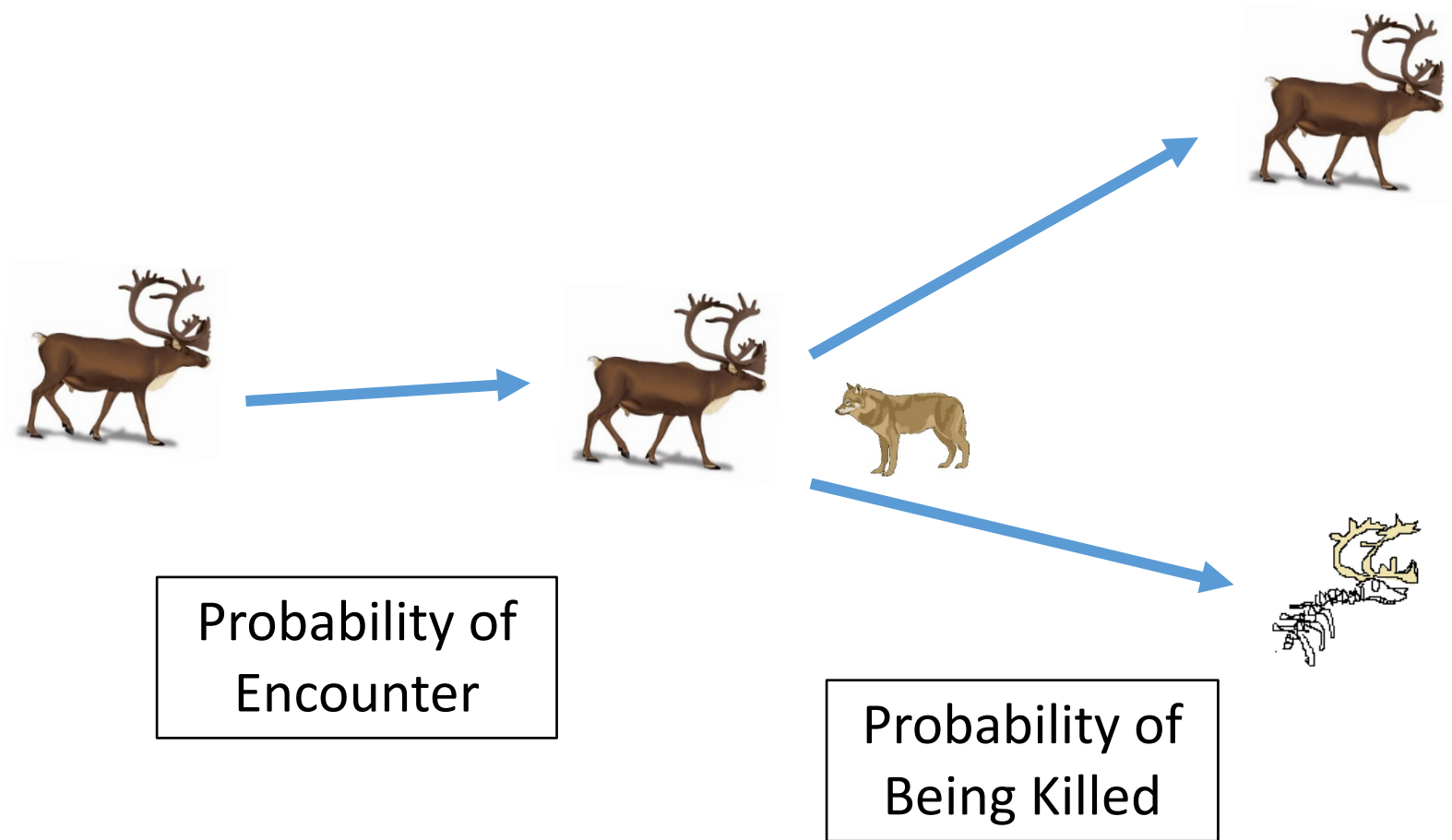


Encounter

Mechanisms of predation risk

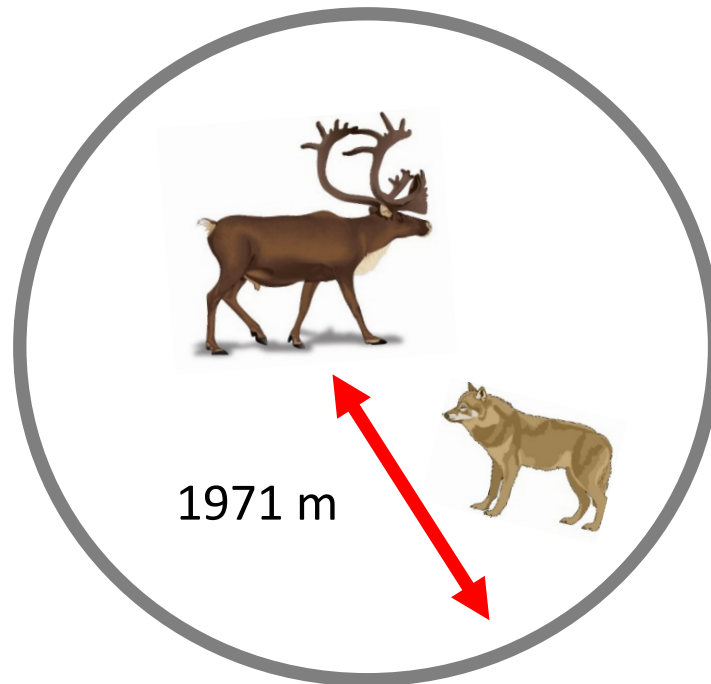


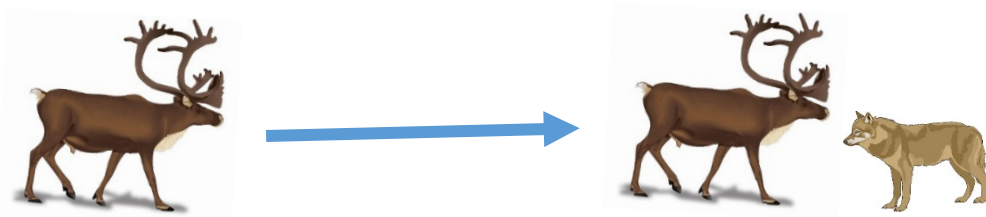
Mechanisms of predation risk



Identified potential caribou-wolf encounters

- 107 caribou and 28 wolves
- 112 encounter (caribou within *1971 m of collared wolf)
 - *1971 m ~ mean 24 h caribou movement distance

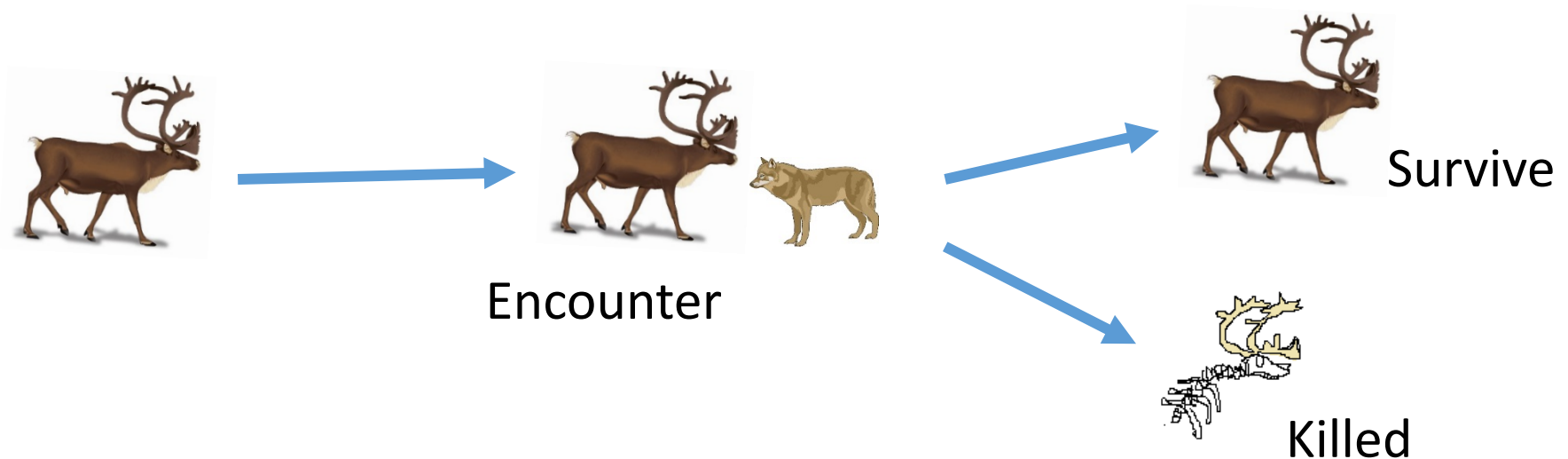




Encounter

Probability of encounter

- Compared caribou locations and potential caribou-wolf encounters using logistic regression



Probability of encounter

- Compared caribou locations and potential caribou-wolf encounters using logistic regression

Probability of being killed

- Compared potential caribou-wolf encounters and caribou mortality sites attributed to wolves using logistic regression

1) Linear features and risk

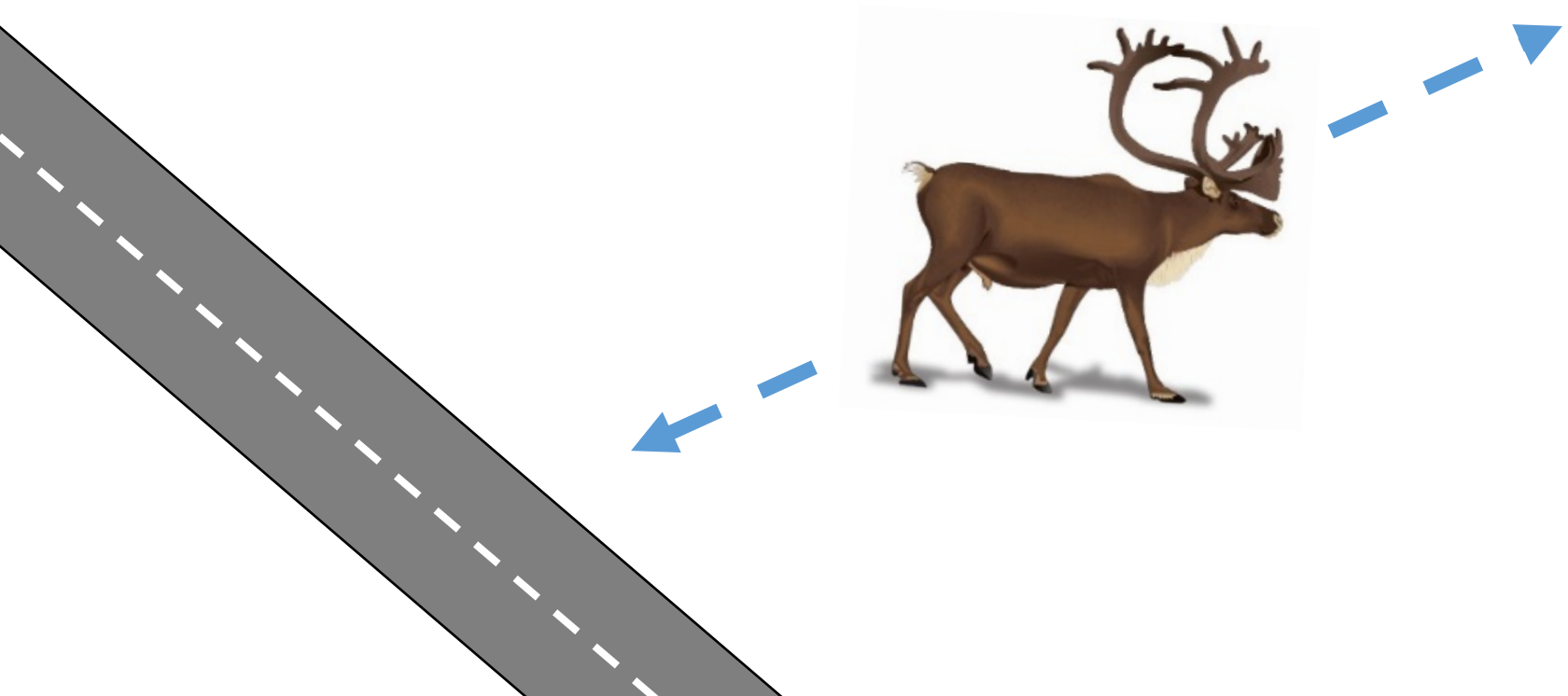
		summer		winter	
prob. encounter		β	se	β	se
	prop. hardwood swamp	0.980	0.941	1.352	0.493
	prop. bog	1.162	0.412	0.792	0.426
	elevation	-5.938	2.690	-2.705	0.828
	road density	1.791	1.307		
	seismic density	1.998	0.868		
	dist. to roads			-5.181	1.805
	dist. to seismic			-3.369	1.467
prob. being killed		β	se	β	se
	prop. swamp	3.970	1.864	0.528	1.582
	prop. bog			-2.633	1.211
	prop. fen			-2.056	1.423
	edge density	-3.208	1.381		
	terrain roughness	2.414	1.718		

1) Linear features and risk

		summer		winter	
prob. encounter		β	se	β	se
	prop. hardwood swamp	0.980	0.941	1.352	0.493
	prop. bog	1.162	0.412	0.792	0.426
	elevation	-5.938	2.690	-2.705	0.828
	road density	1.791	1.307		
	seismic density	1.998	0.868		
	dist. to roads			-5.181	1.805
	dist. to seismic			-3.369	1.467
prob. being killed		β	se	β	se
	prop. swamp	3.970	1.864	0.528	1.582
	prop. bog			-2.633	1.211
	prop. fen			-2.056	1.423
	edge density	-3.208	1.381		
	terrain roughness	2.414	1.718		

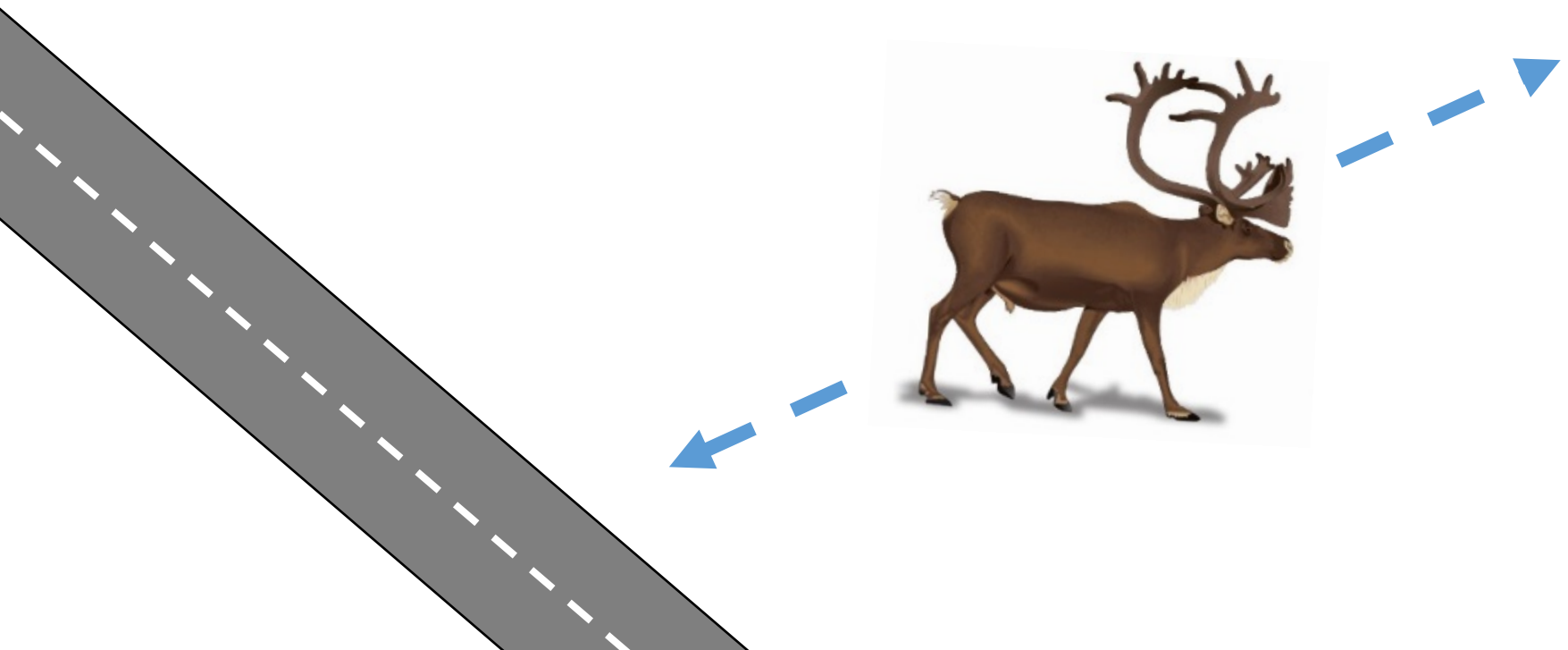
Latham et al. 2011
Whittington et al. 2011

2) How do caribou respond to linear features?



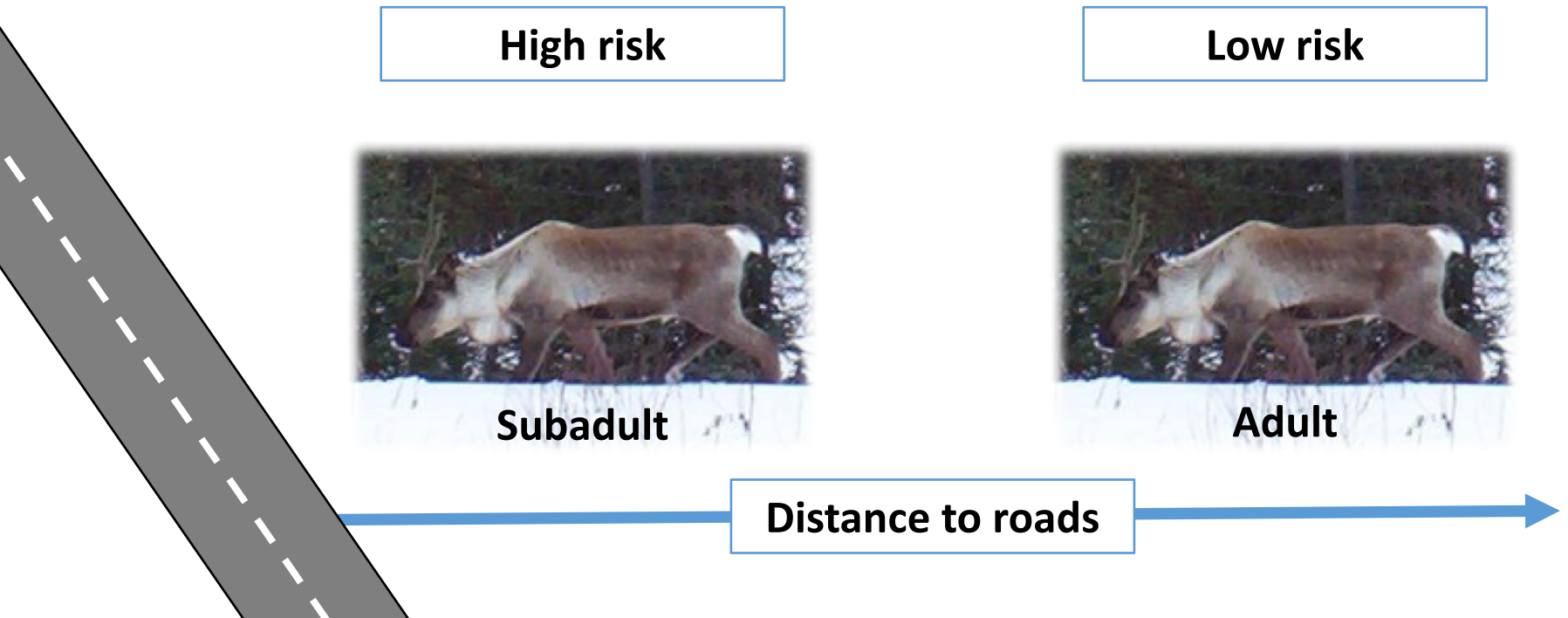
Built resource selection functions to
evaluate caribou responses to roads
and seismic lines

$$w(x) = \exp(\beta_1 x_1 + \beta_2 x_2 + \dots + \beta_n x_n)$$



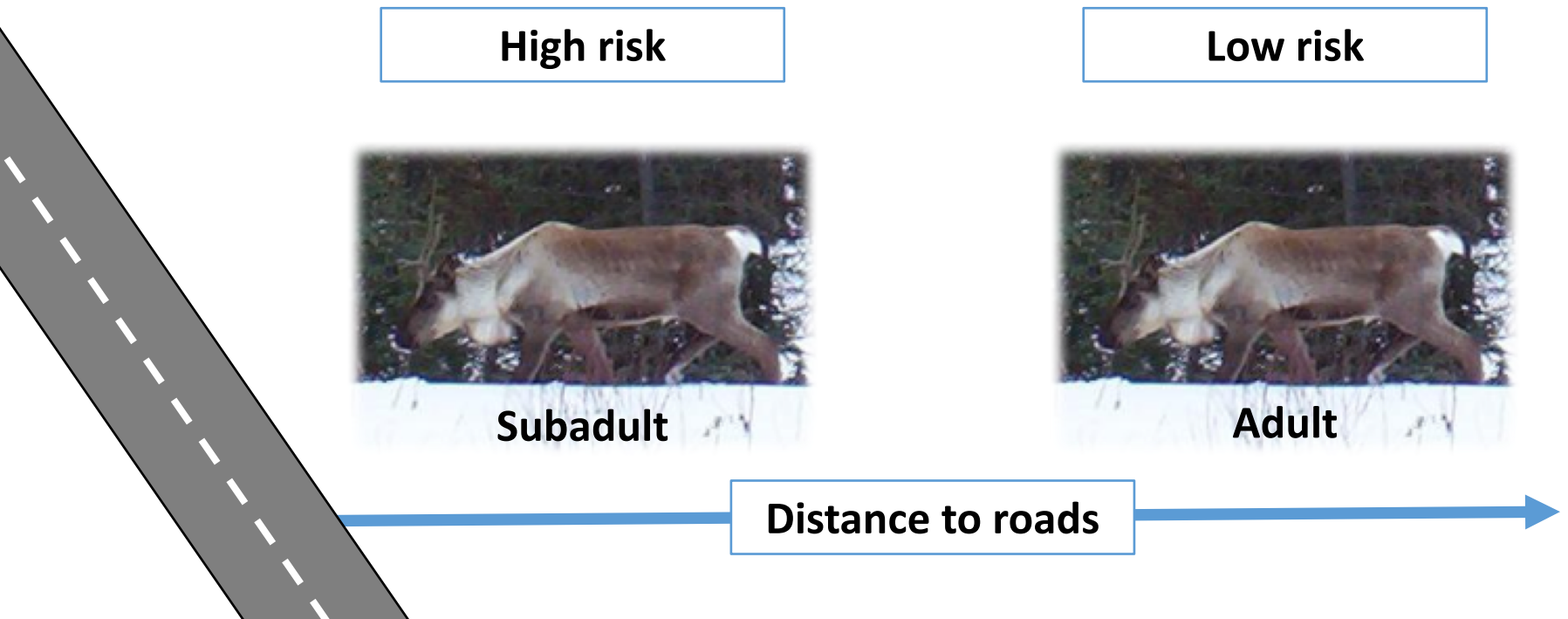
2) Caribou responses to linear features

- Young adults (<5 yrs) demonstrated less avoidance of roads and seismic lines in comparison to mature adults

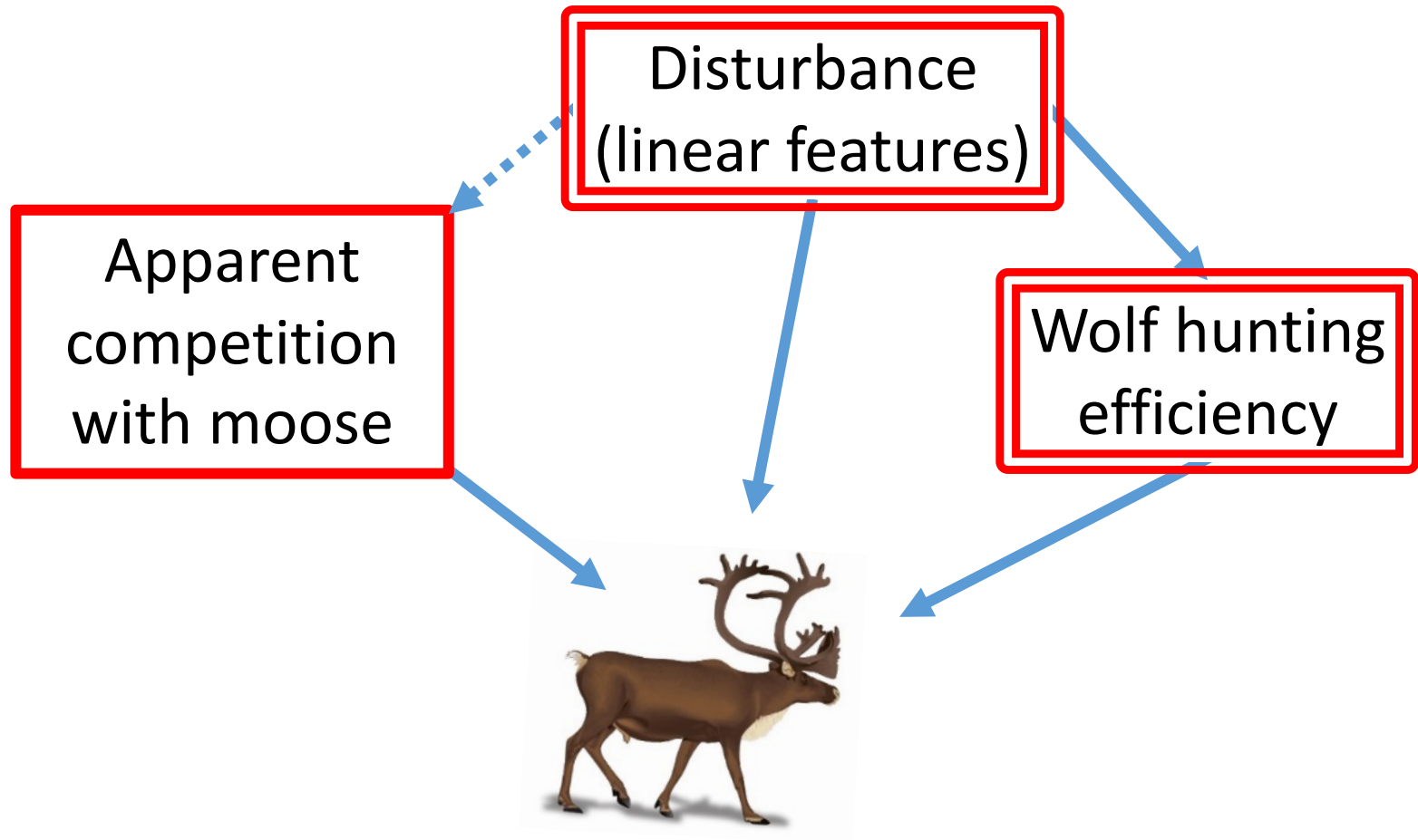


2) Caribou responses to linear features

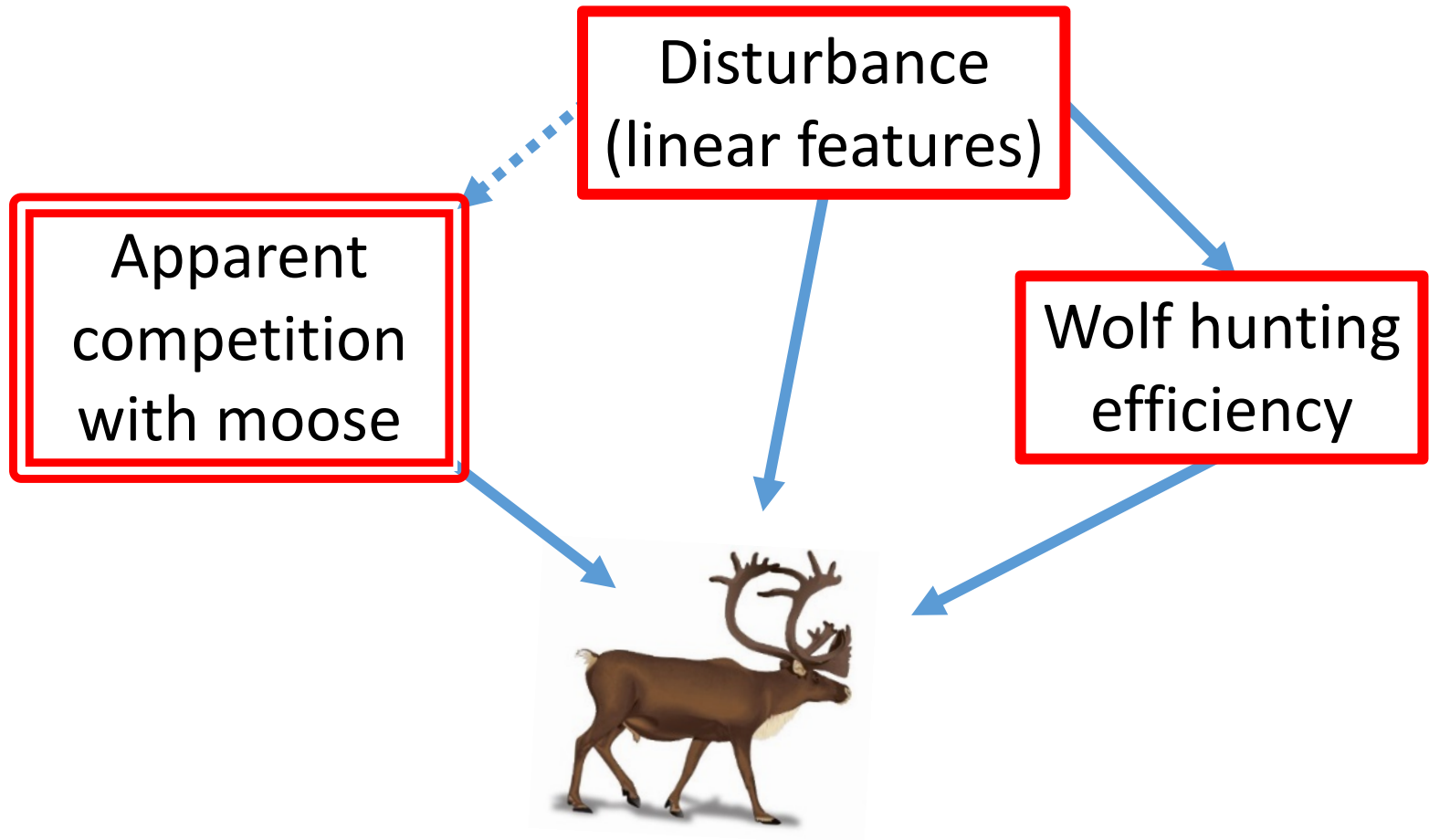
- Young adults (<5 yrs) demonstrated less avoidance of roads and seismic lines in comparison to mature adults
- Survival was not increased for mature adults



Direct and indirect effects



Direct and indirect effects



3) How do moose respond to linear features?

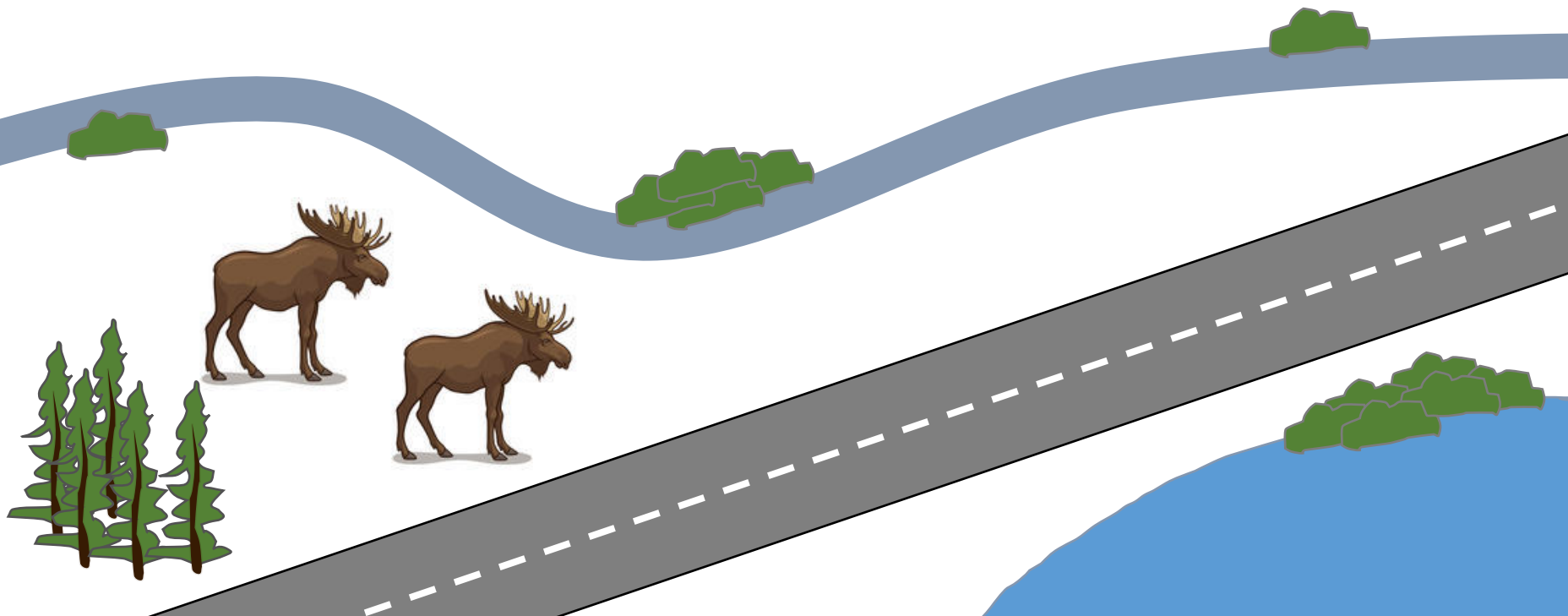


Photo: Brad Culling

Built resource selection functions

$$w(x) = \exp(\beta_1 x_1 + \beta_2 x_2 + \dots + \beta_n x_n)$$

- Season and sex



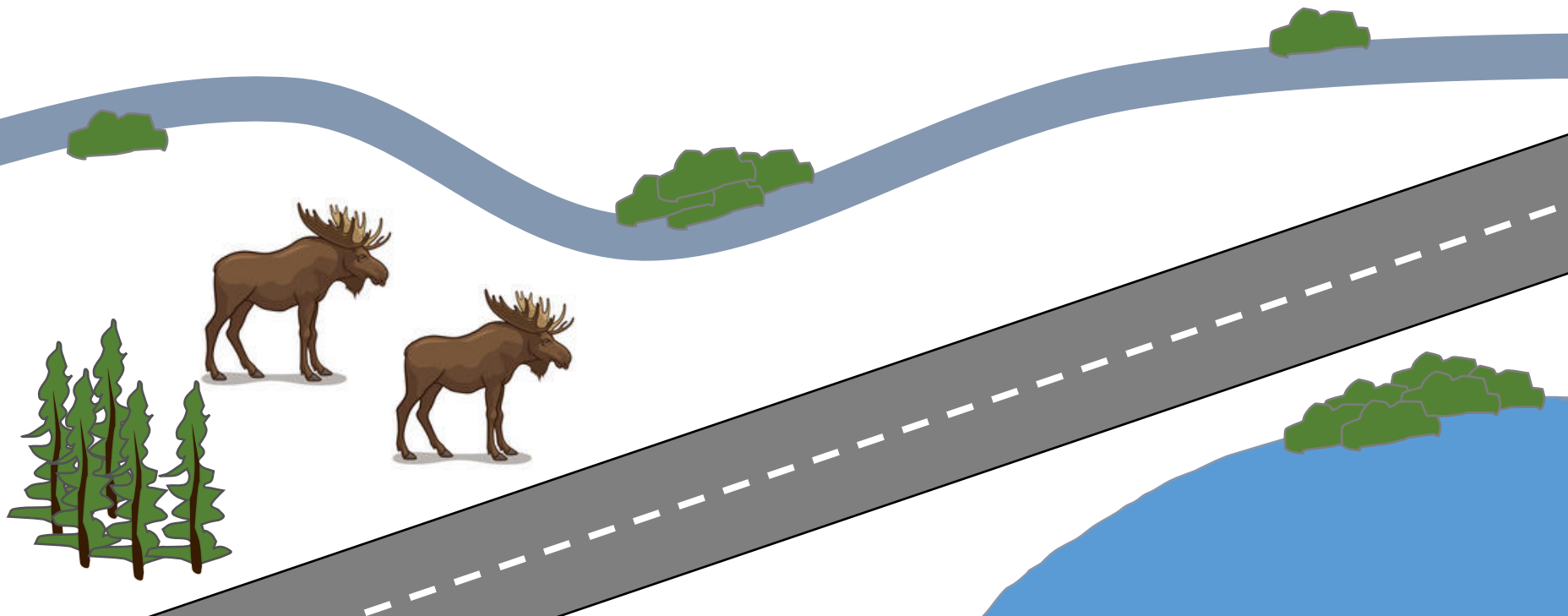
3) Roads and seismic lines

Season	Near roads		Near seismic lines	
	Female	Male	Female	Male
Calving	Avoided	Selected		
Late summer	Avoided		Selected	
Early winter			Selected	
Late winter	Selected	Avoided	Selected	Avoided

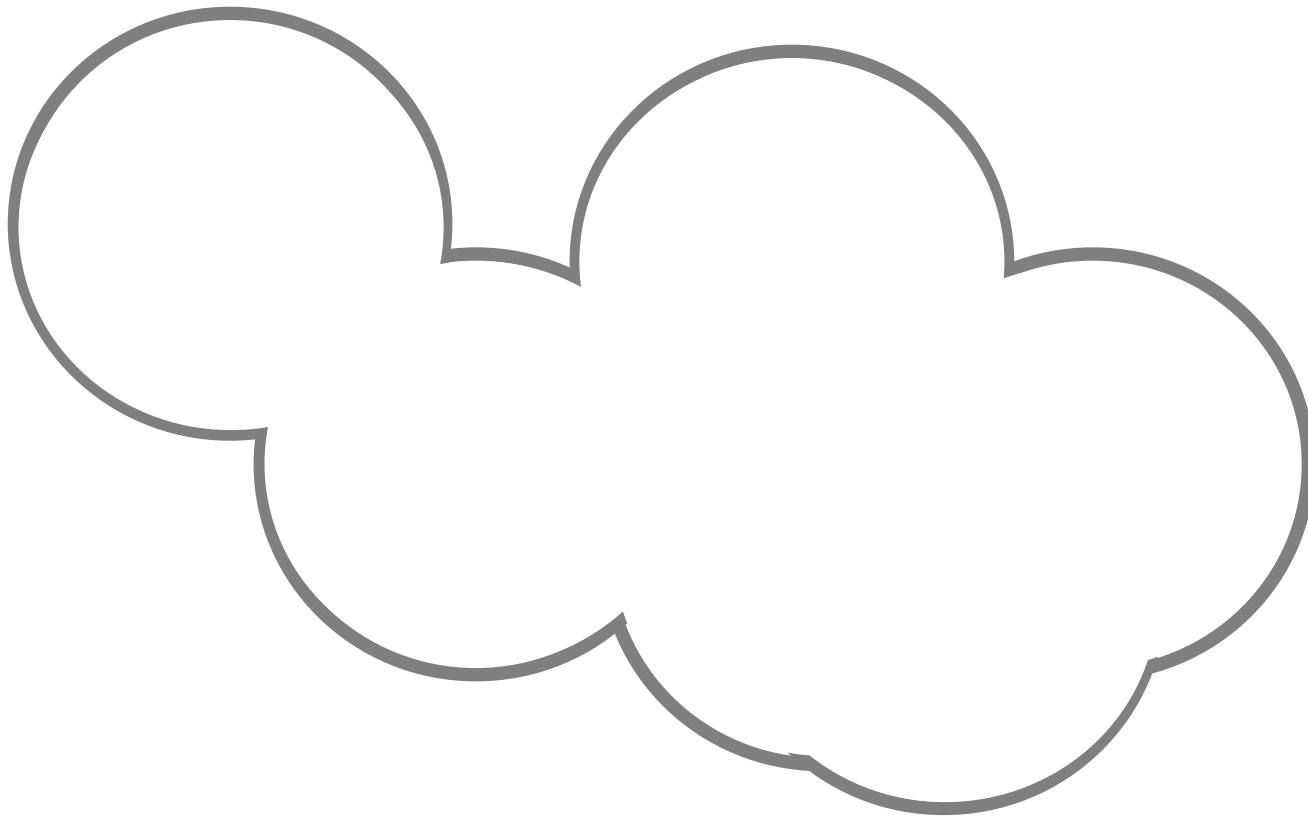
3) Roads and seismic lines

Season	Near roads		Near seismic lines	
	Female	Male	Female	Male
Calving	Avoided	Selected		
Late summer	Avoided		Selected	
Early winter			Selected	
Late winter	Selected	Avoided	Selected	Avoided

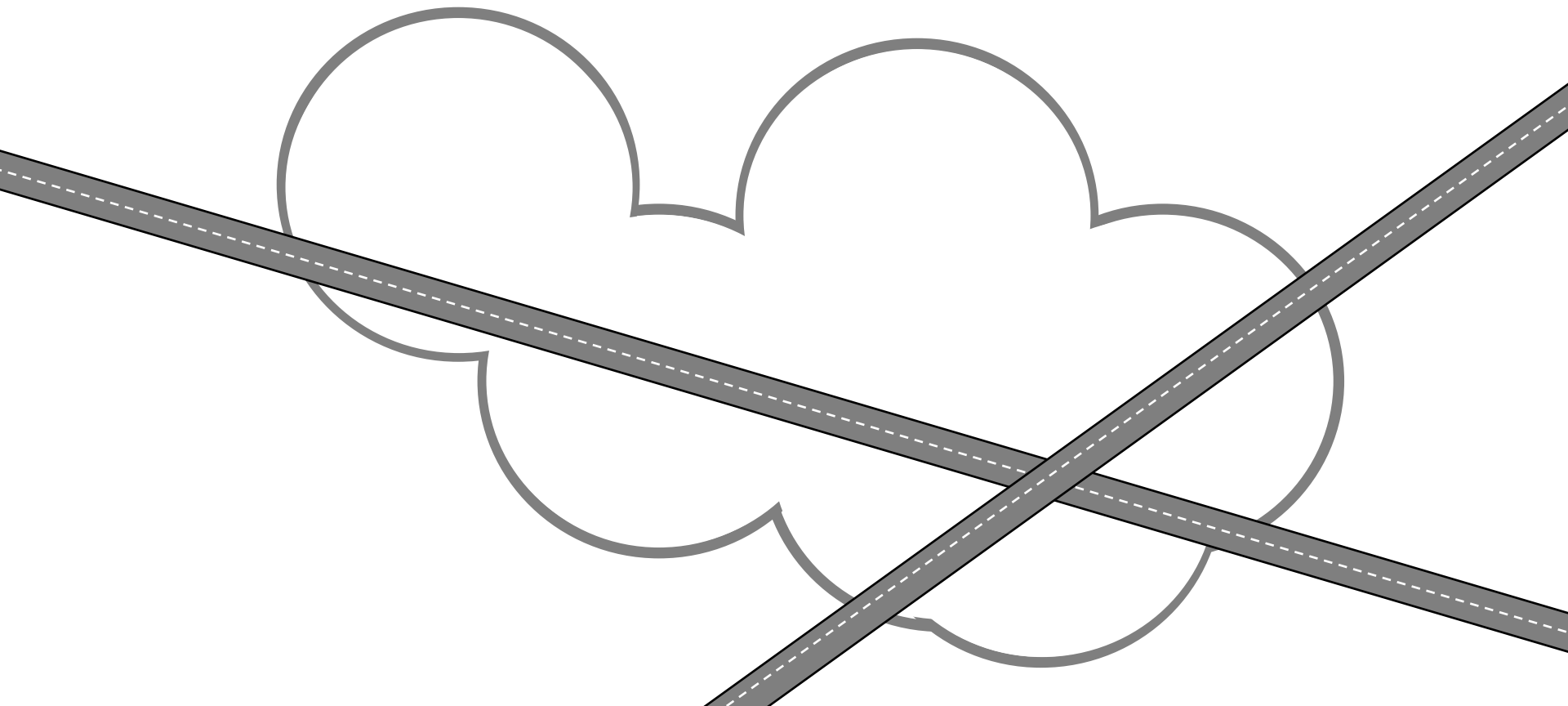
4) How does the presence of linear features influence moose selection of caribou habitats?



Estimated seasonal home ranges for each individual moose

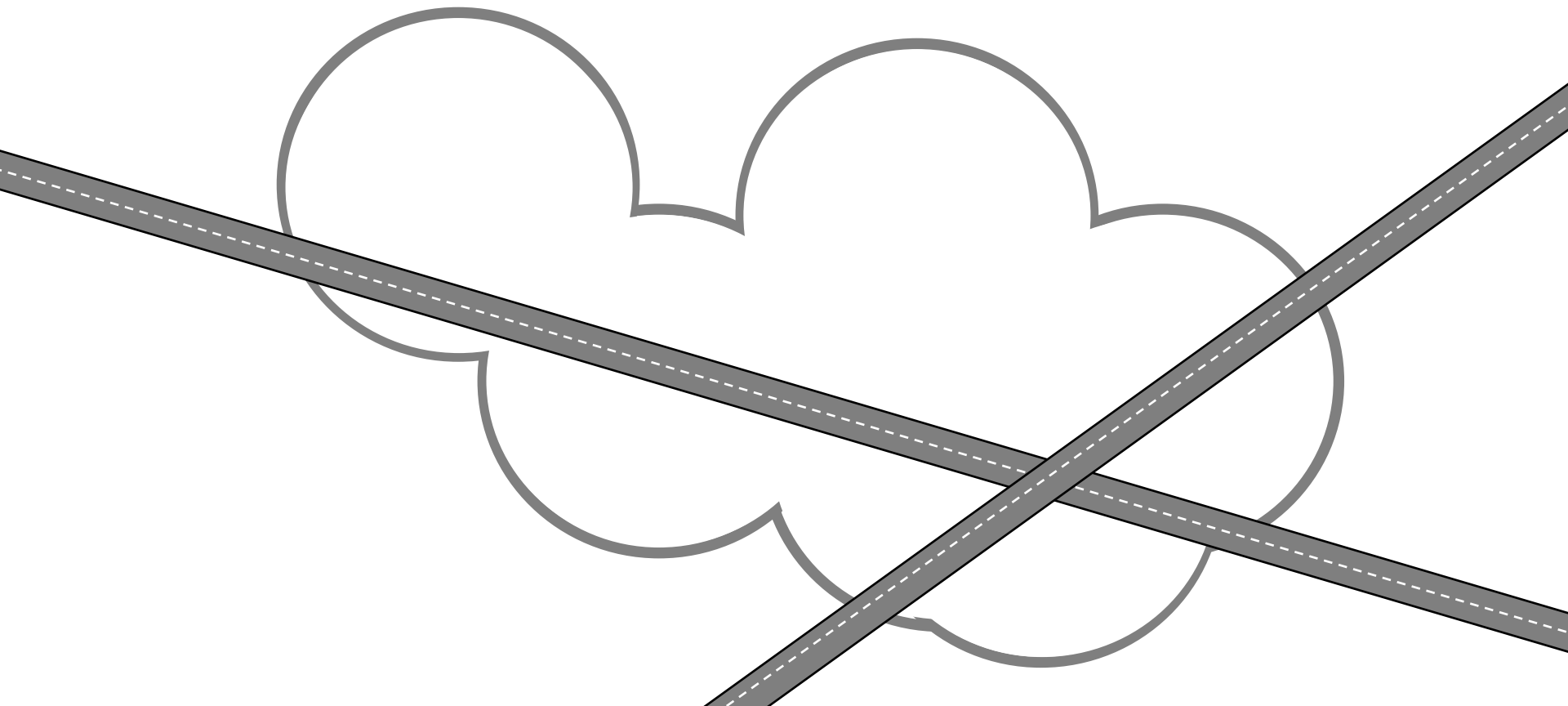


Calculated the density of roads and seismic lines within seasonal home ranges (HR)



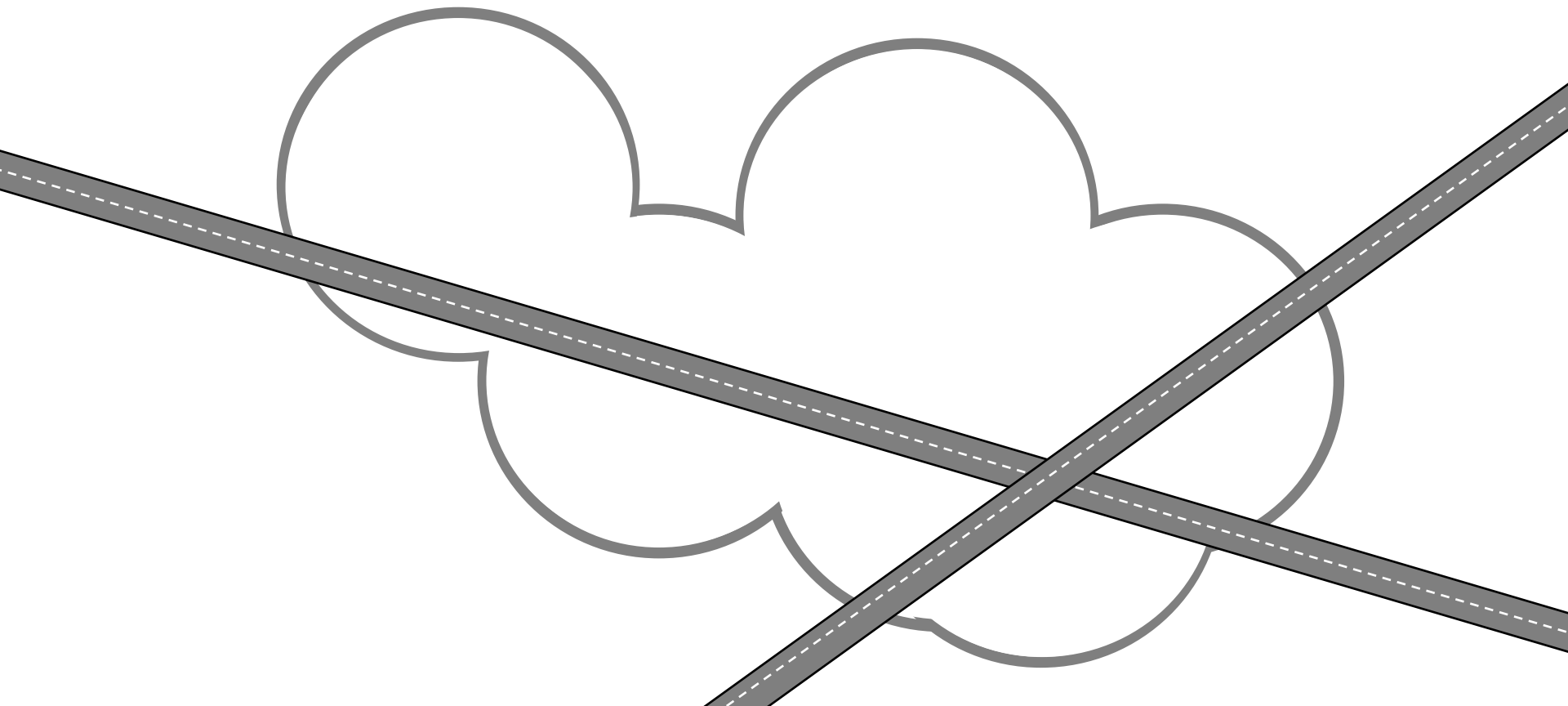
Resource selection functions (RSFs)

- $RSF = \text{base model} + (\text{seismic density HR} * \text{treed bogs})$
- $RSF = \text{base model} + (\text{road density HR} * \text{treed bogs})$



Resource selection functions (RSFs)

- $\text{RSF} = \text{base model} + (\text{seismic density HR} * \text{poor fens})$
- $\text{RSF} = \text{base model} + (\text{road density HR} * \text{poor fens})$



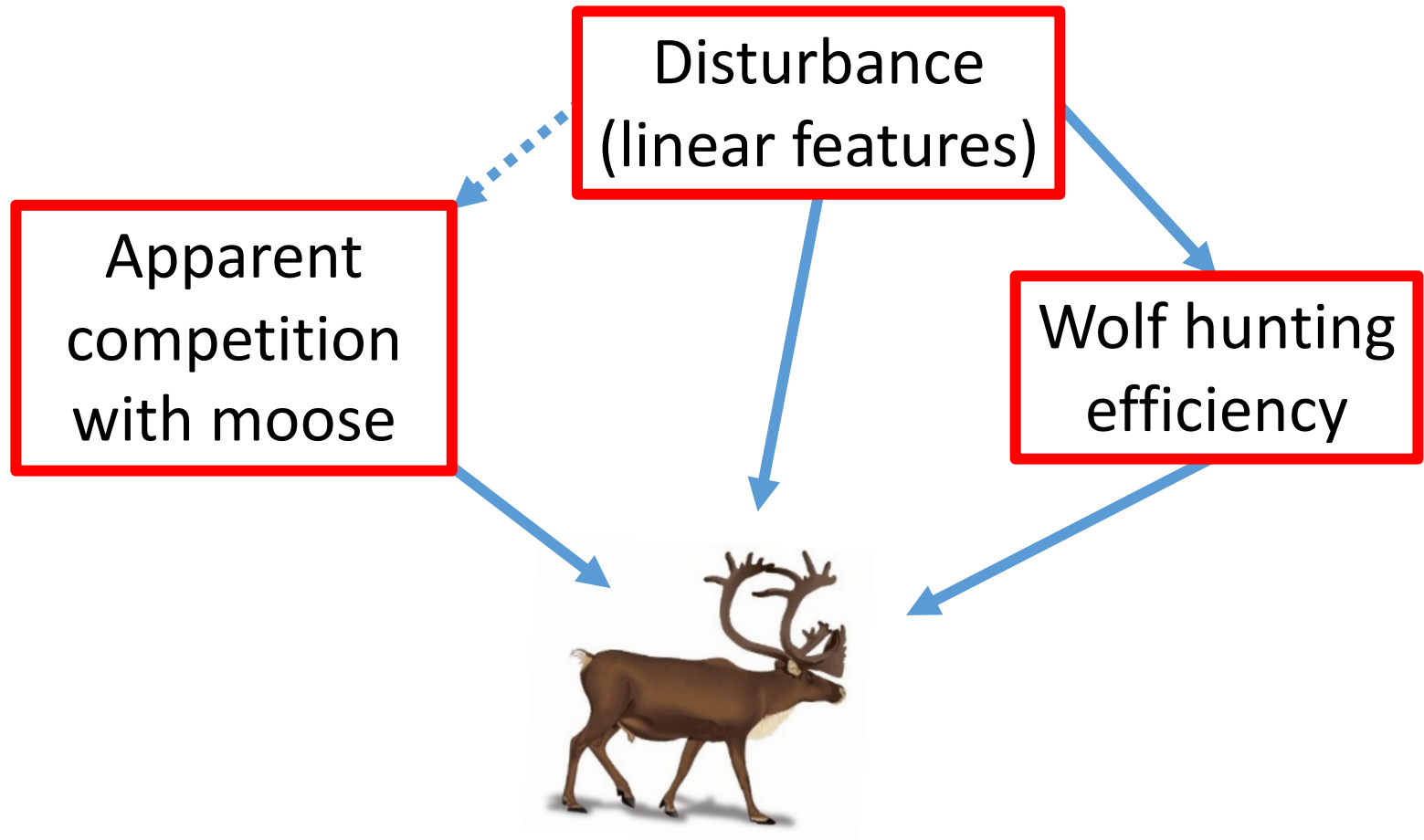
4) Linear features and treed bogs

Season	More roads		More seismic lines	
	Female	Male	Female	Male
Calving	Increased		Decreased	
Late summer		Decreased		Decreased
Early winter	Decreased	Decreased		
Late winter		Decreased		

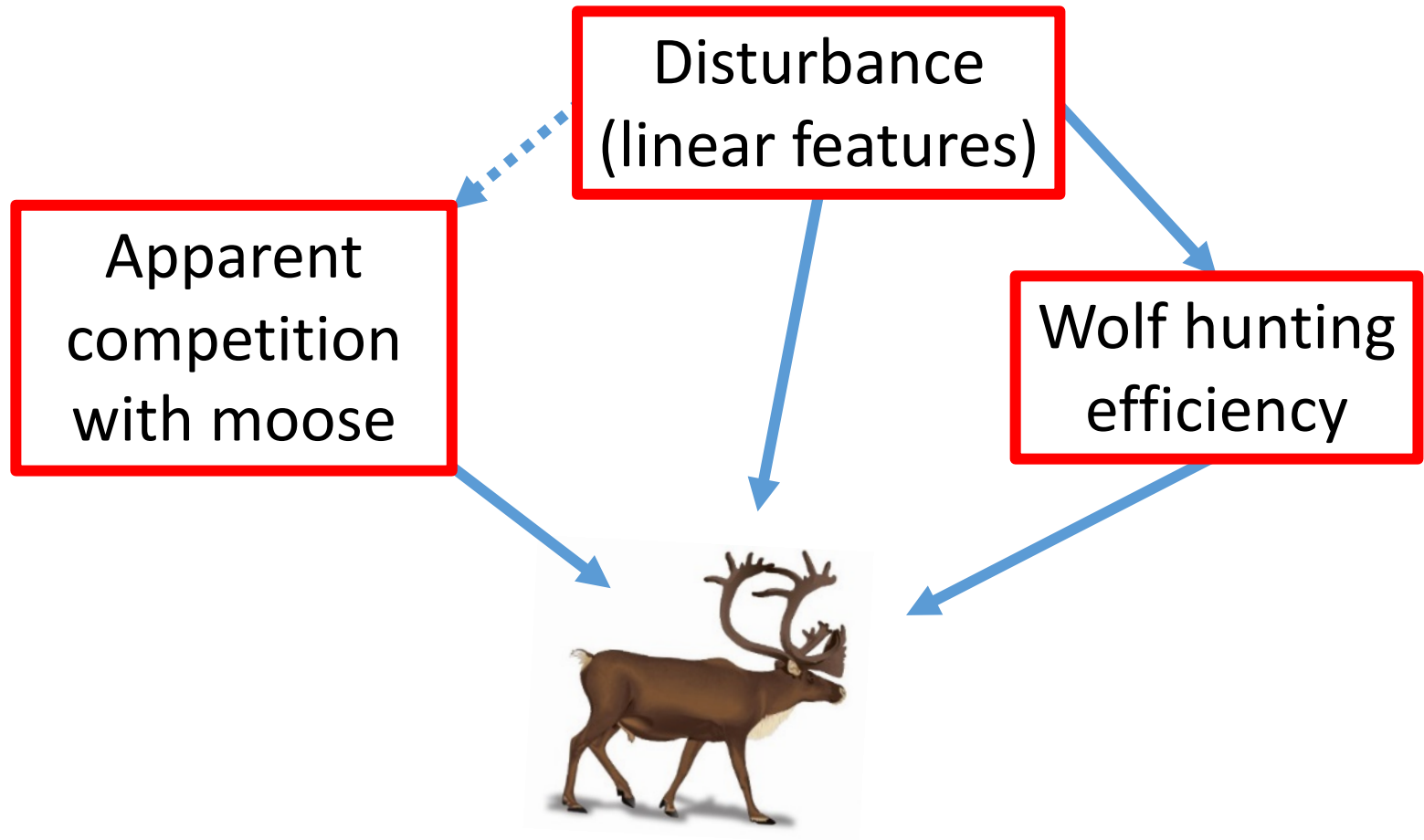
4) Linear features and poor fens

Season	More roads		More seismic lines	
	Female	Male	Female	Male
Calving	Increased			
Late summer		Decreased	Increased	
Early winter				
Late winter	Increased	Increased		

Direct and indirect effects



Direct and indirect effects on survival



Next steps – model caribou survival in relation to...

- Roads, seismic lines, and other disturbances
- Spatial overlap with moose

Next steps – model caribou survival in relation to...

- Roads, seismic lines, and other disturbances
- Spatial overlap with moose and beaver

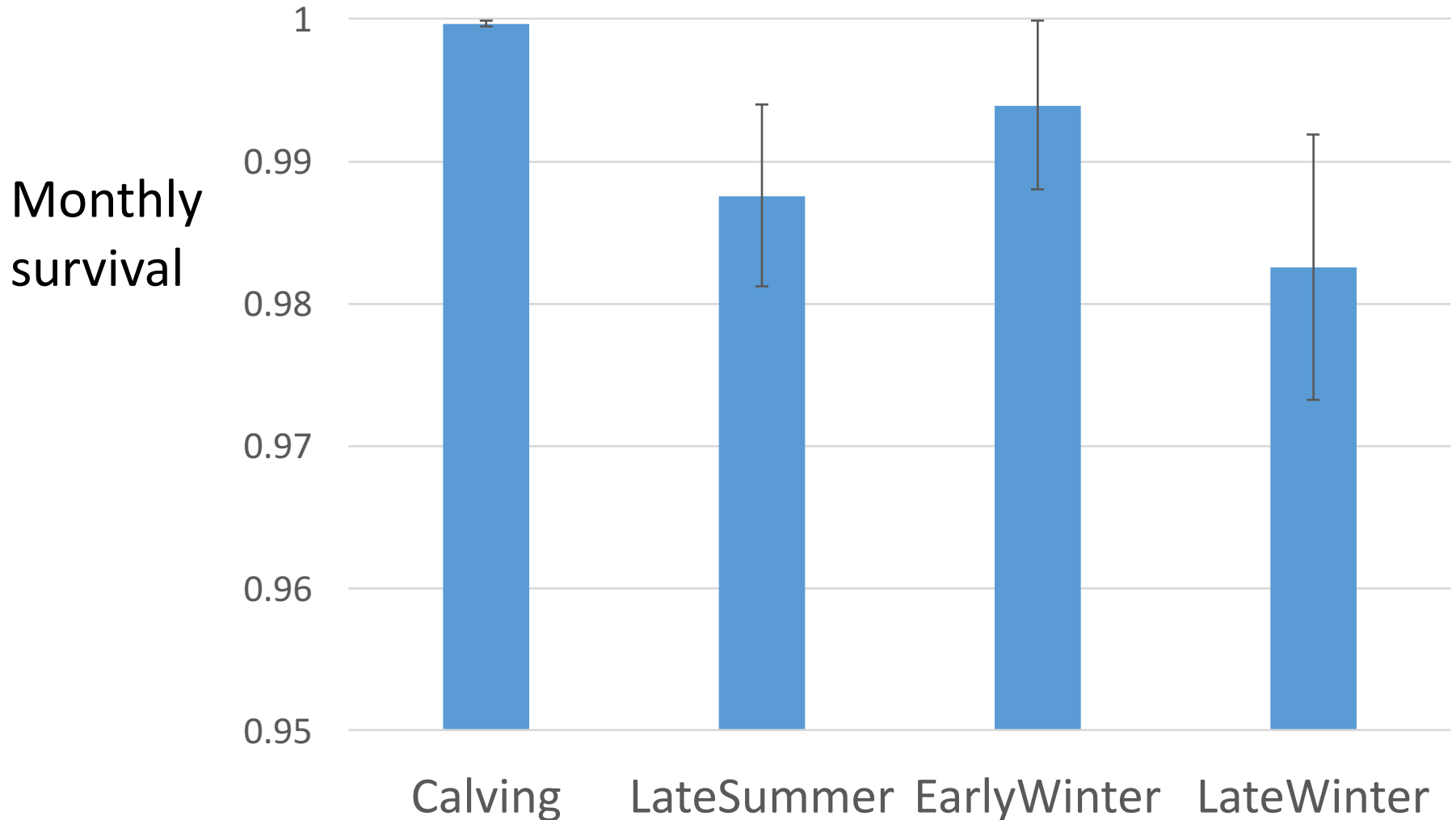
Next steps – model caribou survival in relation to...

- Roads, seismic lines, and other disturbances
- Spatial overlap with moose and beaver
- Wolf predation risk

Next steps – model caribou survival in relation to...

- Roads, seismic lines, and other disturbances
- Spatial overlap with moose and beaver
- Wolf predation risk
- Along with interactions

Boreal caribou survival by season

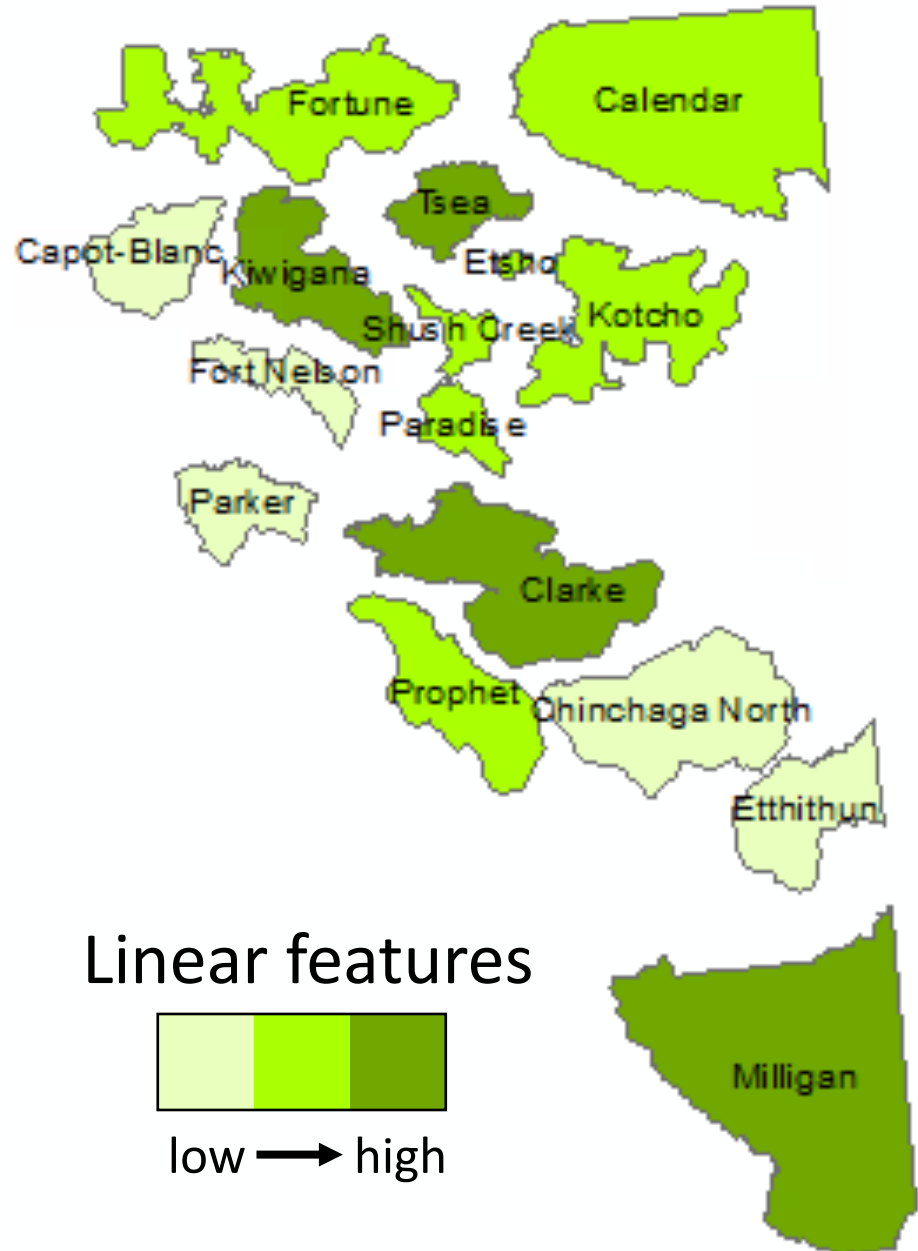


Next steps – model caribou survival in relation to...

- Roads, seismic lines, and other disturbances
 - Spatial overlap with moose and beaver
 - Wolf predation risk
 - Along with interactions
-
- Core- and individual-level analyses

Caribou cores







Core survival =

- Linear features and other disturbances
- Moose densities or distributions via RSFs
- Wolf densities or distributions via RSFs

Individual caribou survival

- Using cox-proportional hazard models
- Roads, seismic lines and other disturbances
- Spatial overlap with moose and beaver
- Wolf predation risk
- Along with interactions



Acknowledgments

Funding and Support	Other Contributors
Research and Effectiveness Monitoring Board	Megan Watters
British Columbia Oil and Gas Research and Innovation Society	Steve Wilson
 BC OGRIS BC Oil and Gas Research and Innovation Society	Ingebjorg Jean Hansen
	Shifting Mosaic Consulting
	Caslys Consulting
	Diversified Environmental Services
	Ducks Unlimited
	Bailey Helicopters
	Qwest Helicopters