Global population dynamics and climate change: Comparing species-level impacts on two contrasting large mammals

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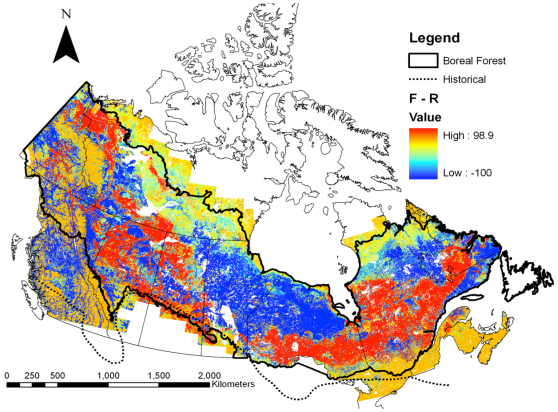
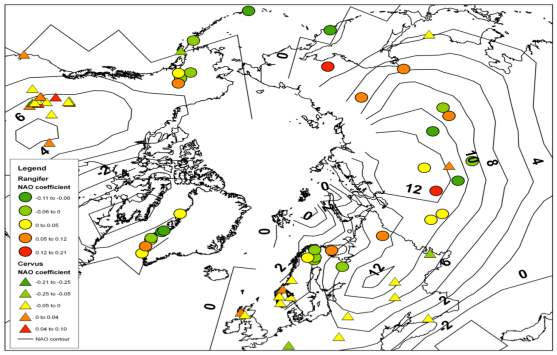
Q1: How do landuse and climatic change affect species' niche throughout their ranges?

Q2: How does climatic influence vary across a species' range and globally after accounting for biotic interactions?

Q3: How does the spatial scale of population synchrony vary with climate change?





Cervus vs. *Rangifer*

Similarities

- Generalists
- Circumpolar
- Ruminants dependent on spring phenology

- Winter snow accumulation negatively affects elk (Creel & Creel 2009)

- Fall and winter - prefer areas of high snowfall
- Summer - prefer cooler areas corresponding to lower prevalence of insects
- Trophic miss-match contributing to Caribou populations declines (Sharma et al. 2009; Vors & Boyce 2009)

State-space models of globally distributed *Cervus* and *Rangifer* populations offer insights into predictors of error

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Large herbivore population time-series

- Accurately counting open populations of large herbivores often impossible
- Estimates of abundance have inherent noise
- Two major sources of noise:
  - Observer error
  - Process variation

Bayesian state-space models

- MCMC hierarchical models
- Decompose time-series:
  - Growth parameters
  - Observation error
  - Process variation

Absence of studies analyzing predictors of process & observation error

Goals

1. Examine variation in magnitude of process and observation error among and between *Cervus* and *Rangifer* populations

2. Quantify contributions by ecological and methodological variables to process variation and observation error within and among *Cervus* and *Rangifer*

Goals

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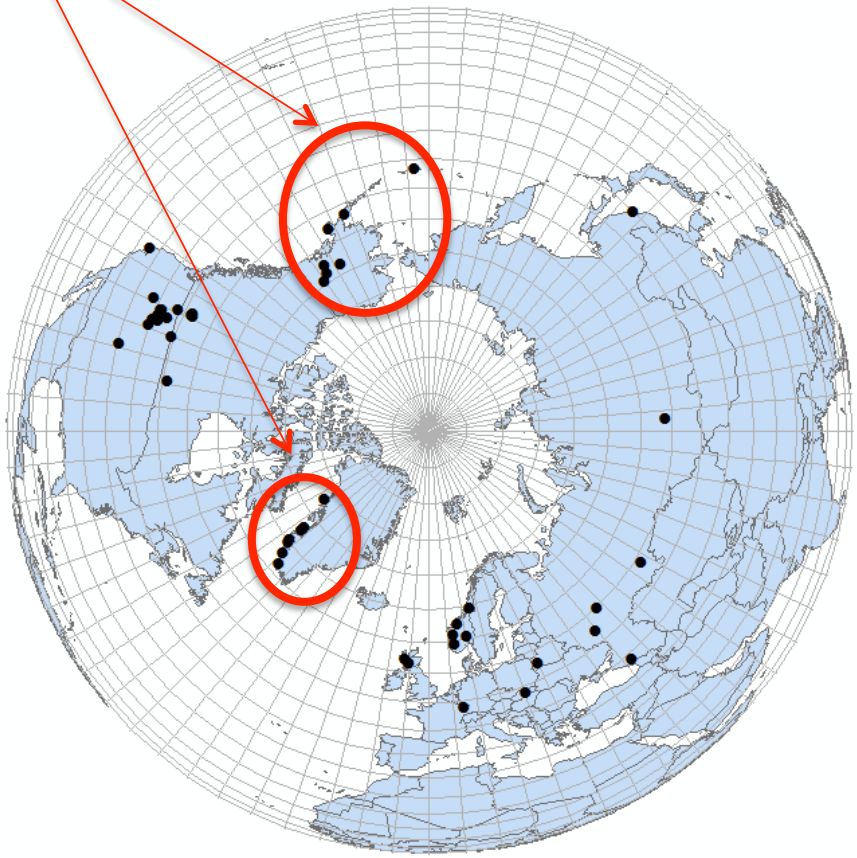
Globally distributed populations

34 *Cervus* populations
13 *Rangifer* populations



Time-series	*Cervus*	*Rangifer*
No. of years	12-46 (μ = 30)	15-74 (μ = 45)
% of missing years	0.03 - 0.22% (12 pops.)	0.04 - 0.43% (6 pops.)

State-space models

$$X_{i,t} = \beta_{i,0} + (1+\beta_{i,1})X_{i,t-1} + \varepsilon_{i,t} \quad (1)$$

$$Y_{i,t} \sim N(X_{i,t}, \tau_{i,t}) \quad (2)$$

$X_{i,t}$: time-series of $\log_e$ true abundances

$\beta_{i,0}$: rate of intrinsic population growth

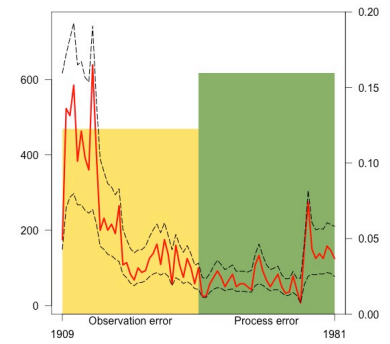
$\beta_{i,1}$: strength of direct density dependence

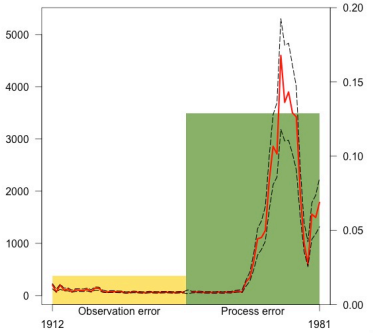
$\varepsilon_{i,t}$: process stochasticity

$Y_{i,t}$: observations

$\tau_{i,t}$: observation error

Rangifer


Observation error
Process error
1909
1981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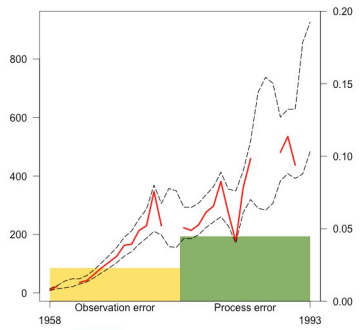
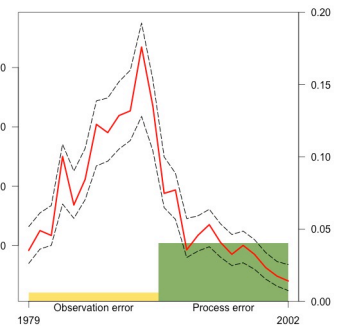
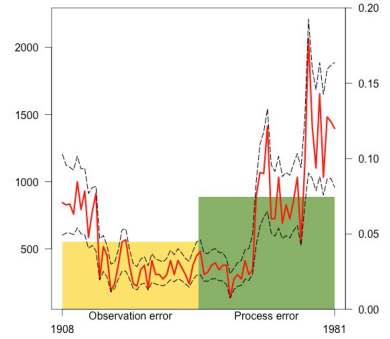
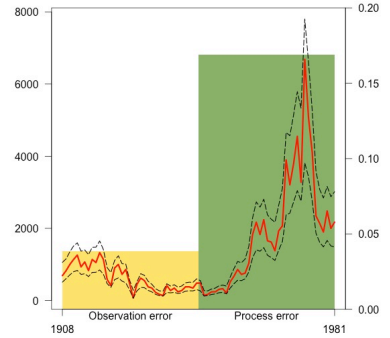
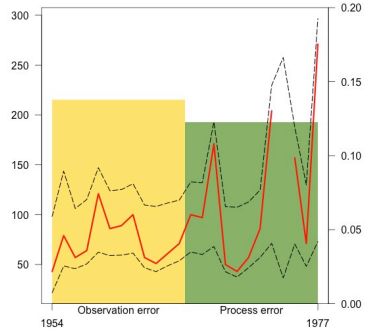
Process error
1912
1981

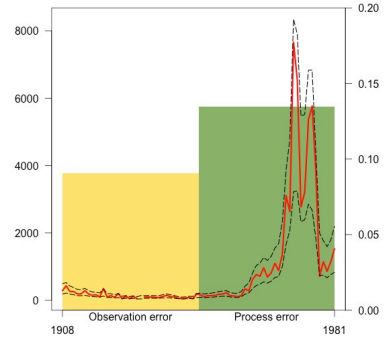

Observation error
Process error
1958
1993

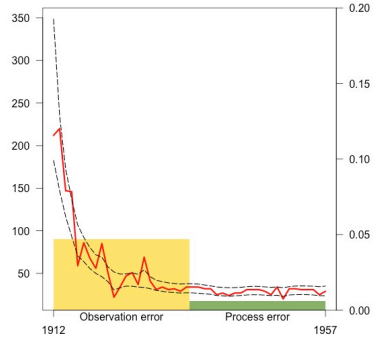

Observation error
Process error
1979
2002

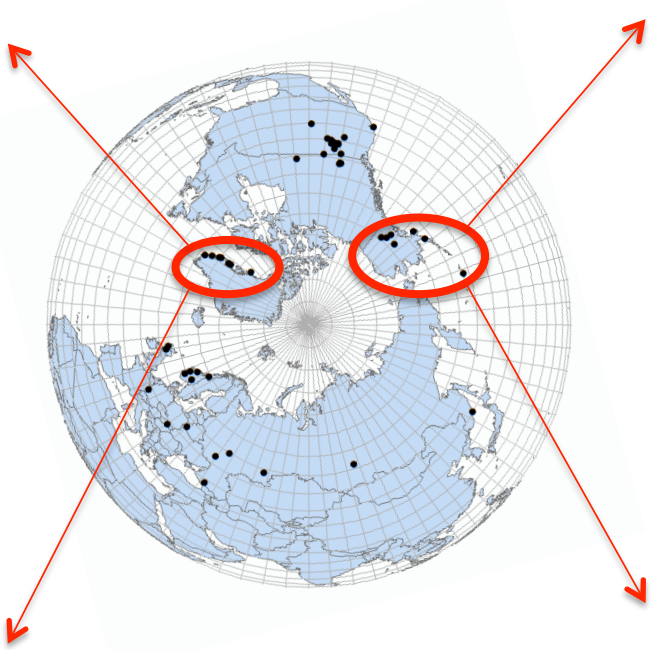

Observation error
Process error
1908
1981

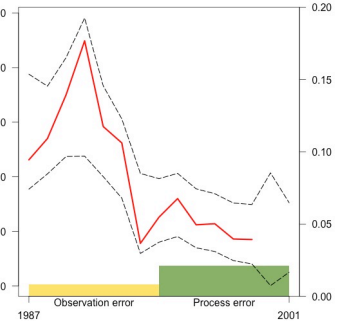

Observation error
Process error
1908
1981

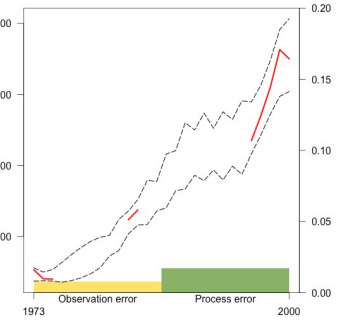

Observation error
Process error
1954
1977

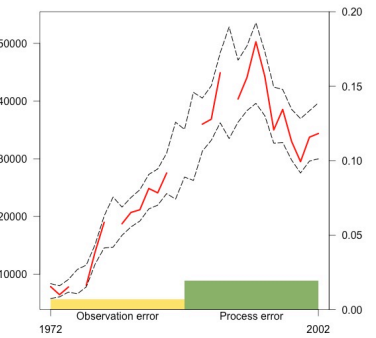

Observation error
Process error
1908
1981


Observation error
Process error
1912
1957




Observation error
Process error
1987
2001


Observation error
Process error
1973
2000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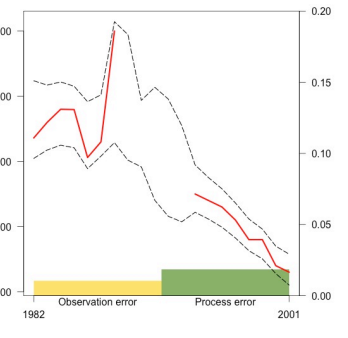
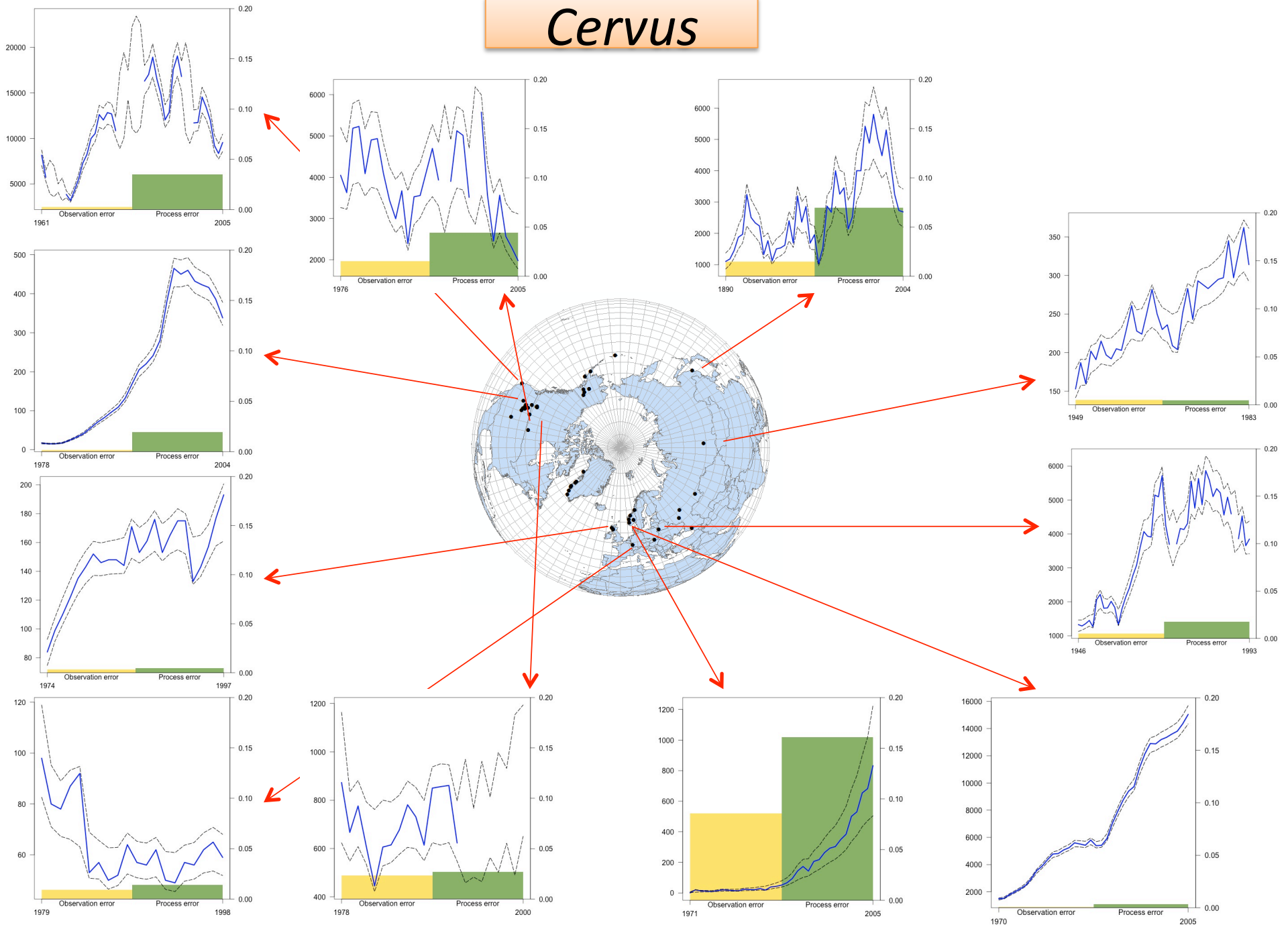
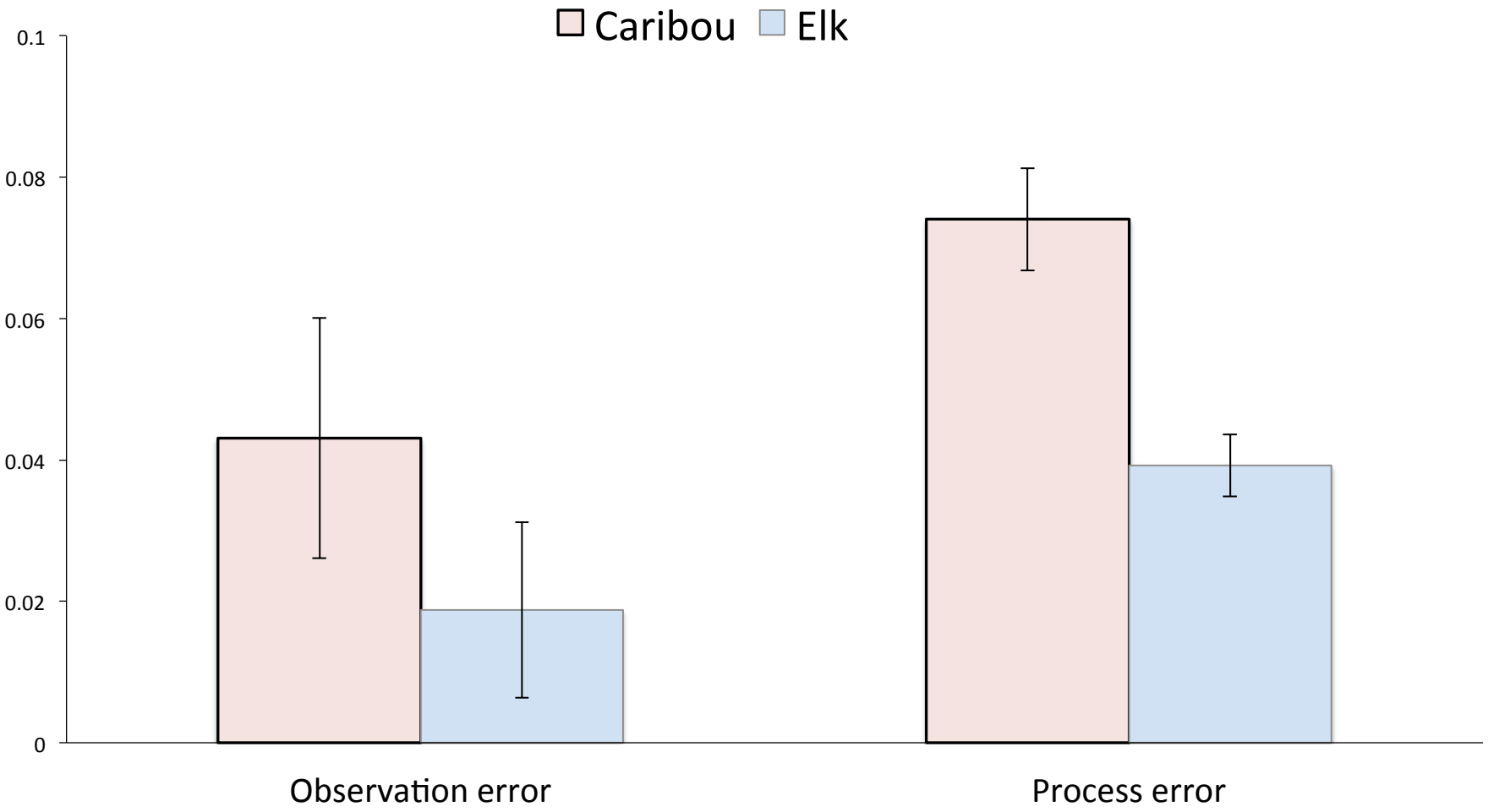
Process error
1972
2002


Observation error
Process error
1982
2001

Cervus


Observation error
Process error
1961
2005
1976
2005
1890
2004
1978
2004
1949
1983
1974
1997
1946
1993
1979
1998
1978
2000
1971
2005
1970
2005

Contrast in error between *Cervus* and *Rangifer* populations



Goals

2. Quantify contributions by ecological and methodological variables to process variation and observation error within and among *Cervus* and *Rangifer*

Predictors

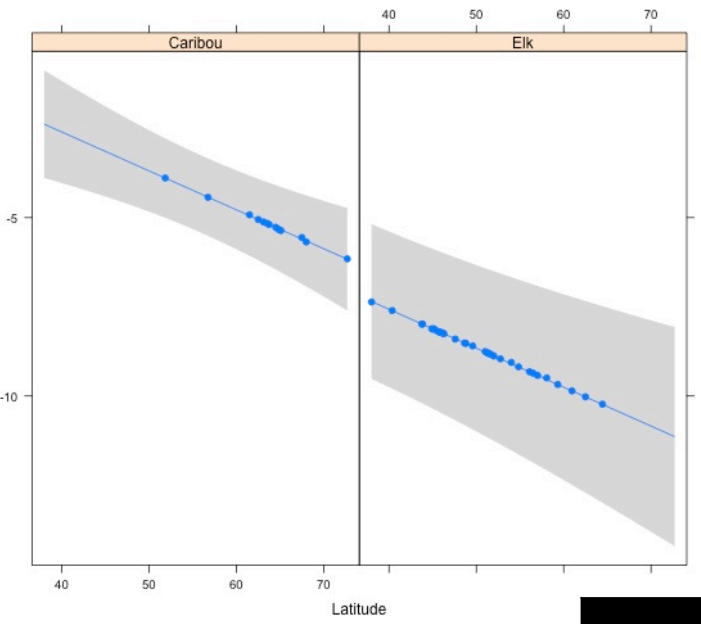
Methodological

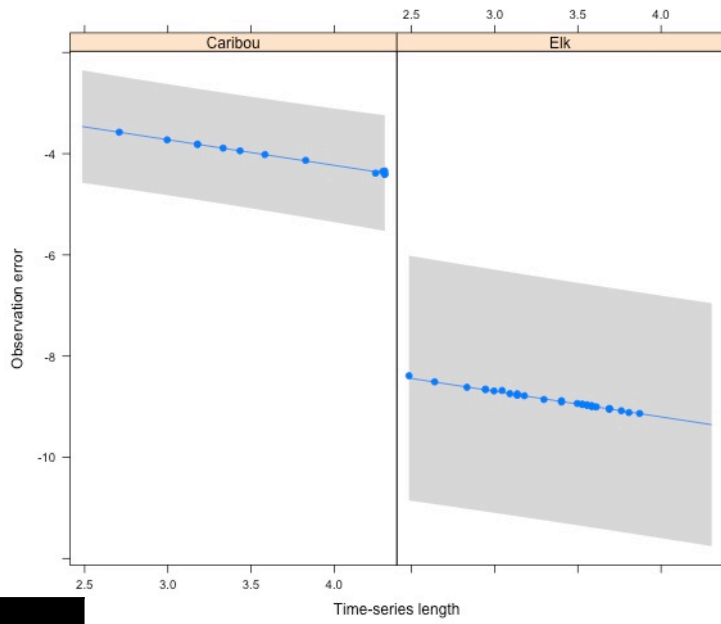
- species
- time series length
- proportion of missing data

Ecological

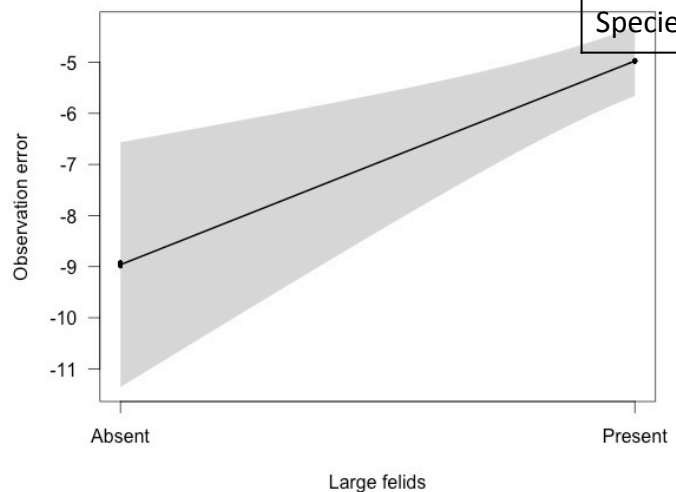
- latitude
- hunting
- predation: bears, large felids and wolves

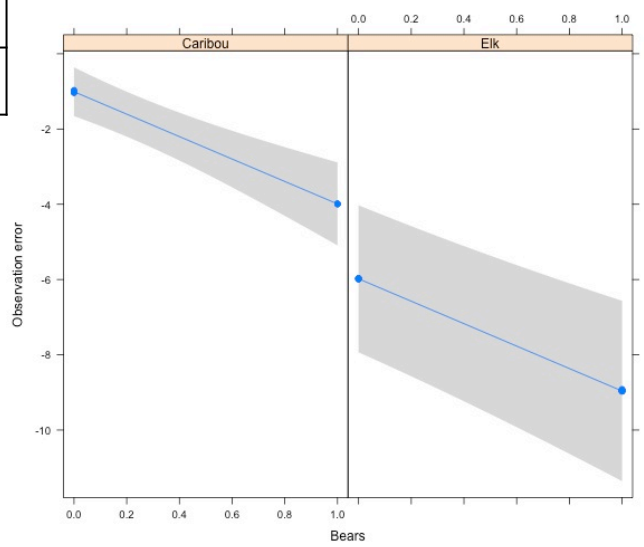
Observation error





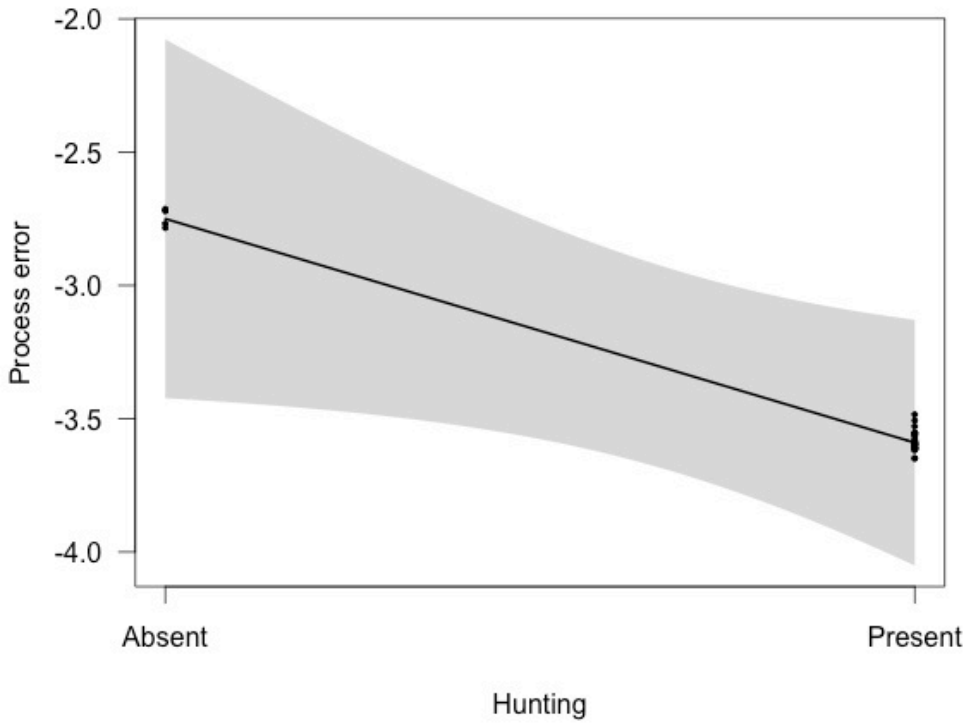
	Estimate	Std. Error	p
Latitude	-0.1	0.03	< 0.001
$\log_e$(Years)	-0.51	0.14	< 0.001
Large felids	3.98	1.16	0.001
Bears	-2.98	0.6	< 0.001
Species	-4.97	1.14	< 0.001

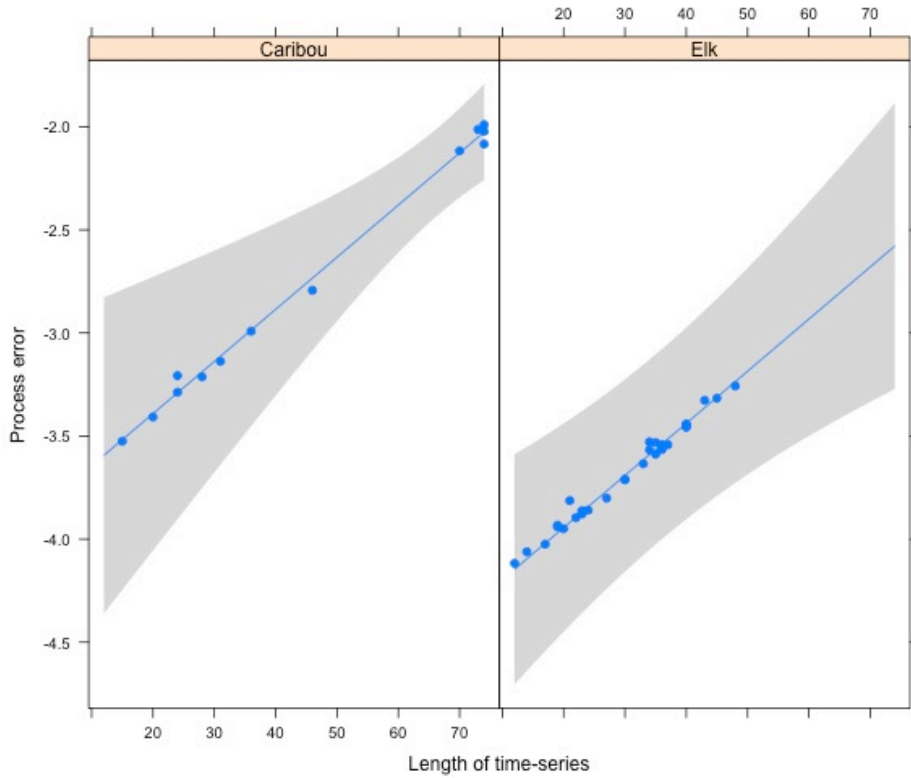




Process error

	Estimate	Std. Error	p
Length of time-series	0.03	0.01	< 0.001
Species	-0.55	0.34	0.11
Hunting	-0.84	0.42	0.05





Conclusions

- Process variation higher than observation error for most populations
- Error higher in *Rangifer* than *Cervus*
- Higher number of significant predictors of observation error

Open questions

- Does high process variation imply non-optimal population models?
- How do you correct/treat time-series with high observation error?