

While the wolf's away: modeling the dynamics of the moose population of the Forillon National Park in Gaspésie

15th CEF Symposium
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Supervised by Martin-Hugues St-
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(Parks Canada)

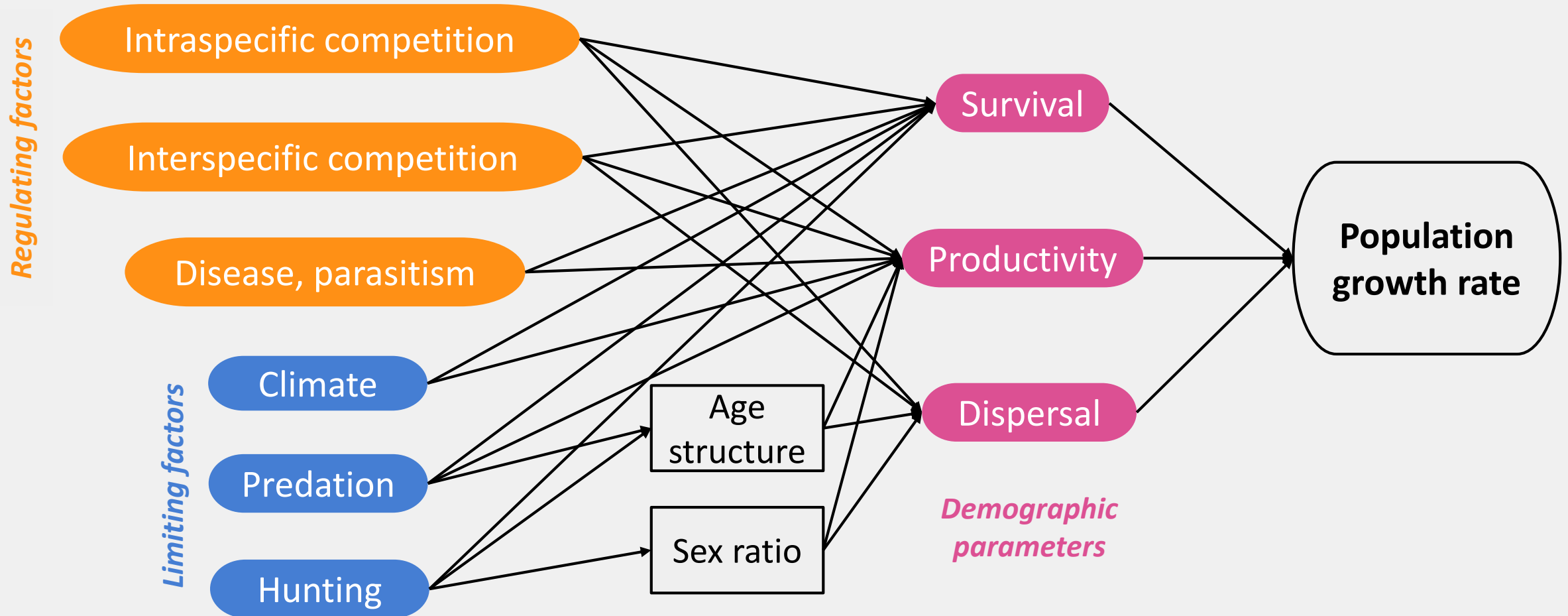


Parcs
Canada

Parks
Canada

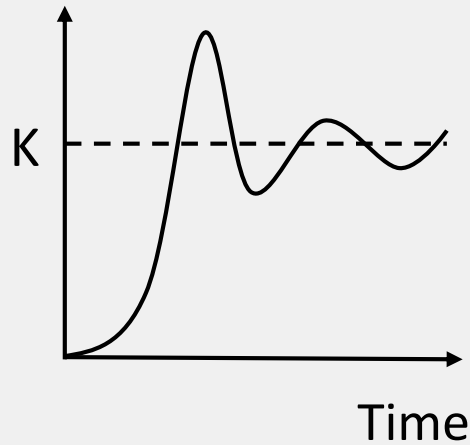


Influence of the environment on population numbers

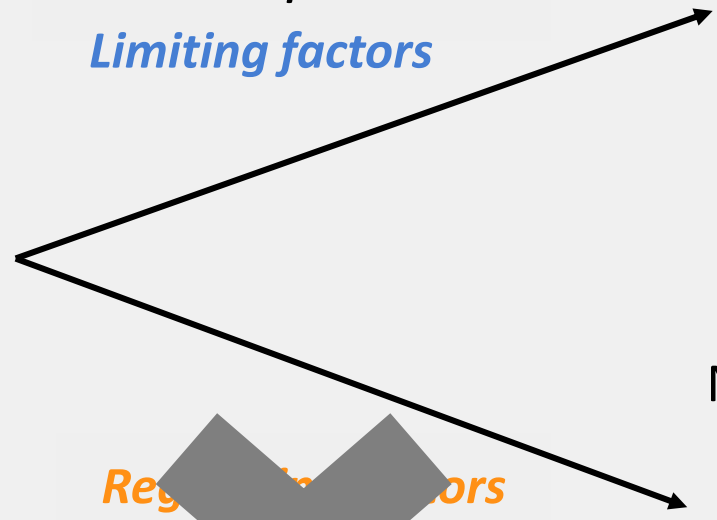


Carrying capacity

Number of individuals

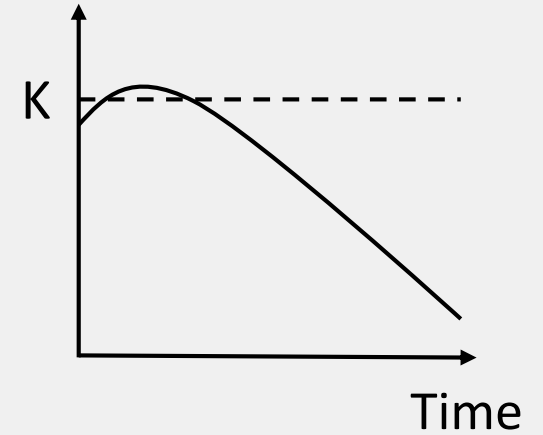


Regulating factors
+
Limiting factors

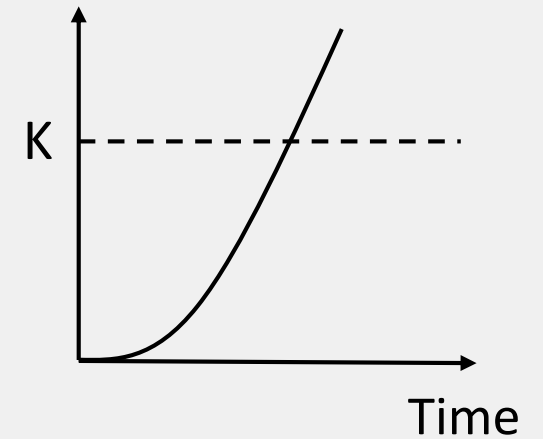


~~*Regulating factors*
+
Limiting factors~~

Number of individuals

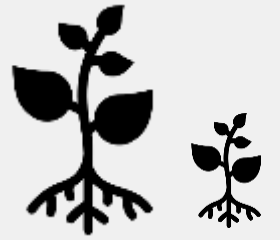
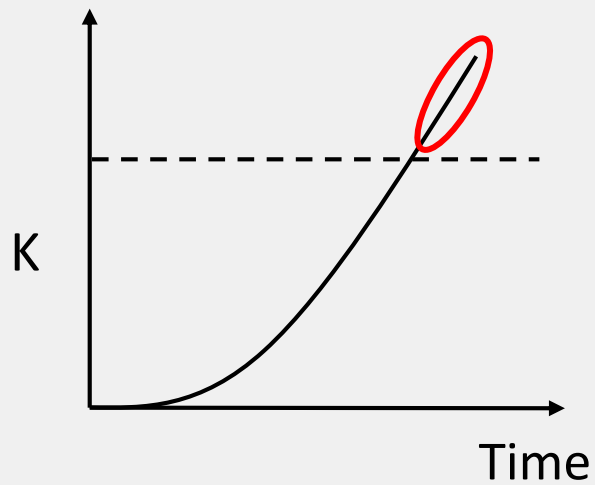


Number of individuals



High-density populations

Number of individuals



The case of moose

© Norbert Denis



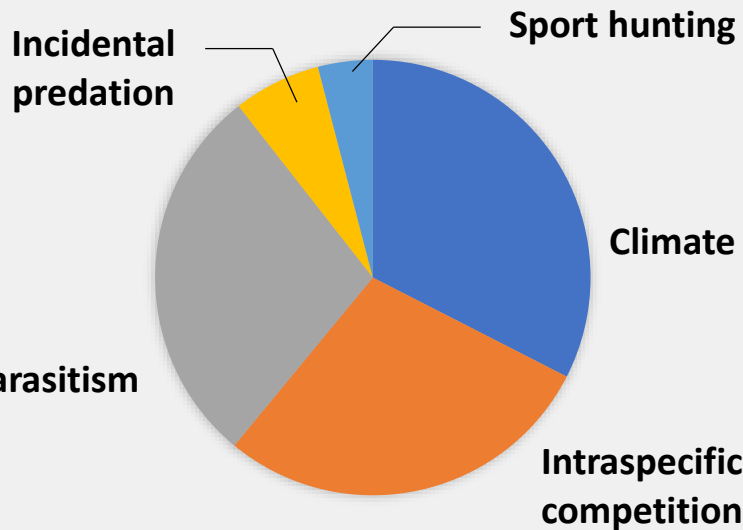
(Adapted from Timmermann & Rodgers, 2017)



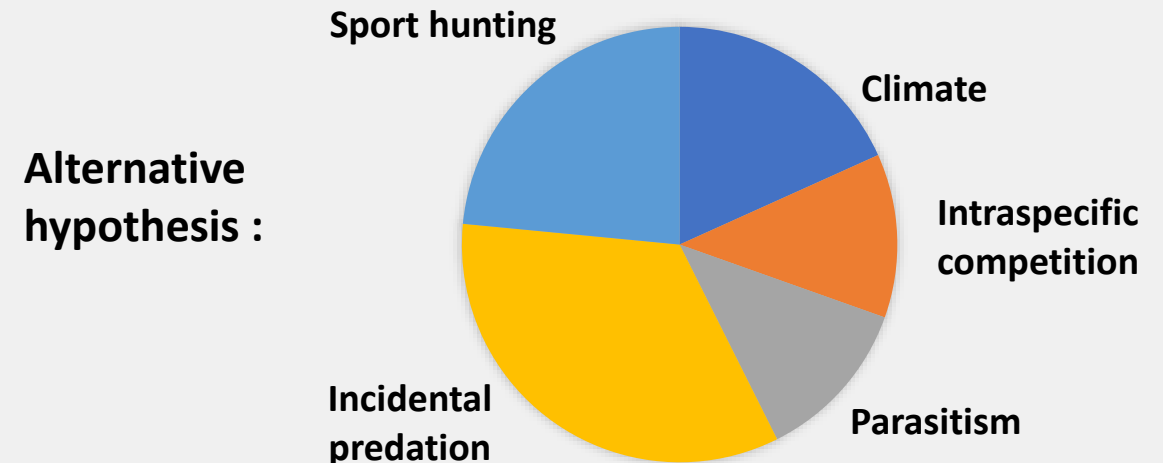
General objective : improve our understanding of the dynamics of high-density moose populations living in areas where no sport harvest nor logging occur, and where the main predator is absent

Sub-objective 1 : identify the factors that drive the dynamics of a high-density moose population living in a protected area meeting the above specifications

VARIATION OF THE POPULATION SIZE



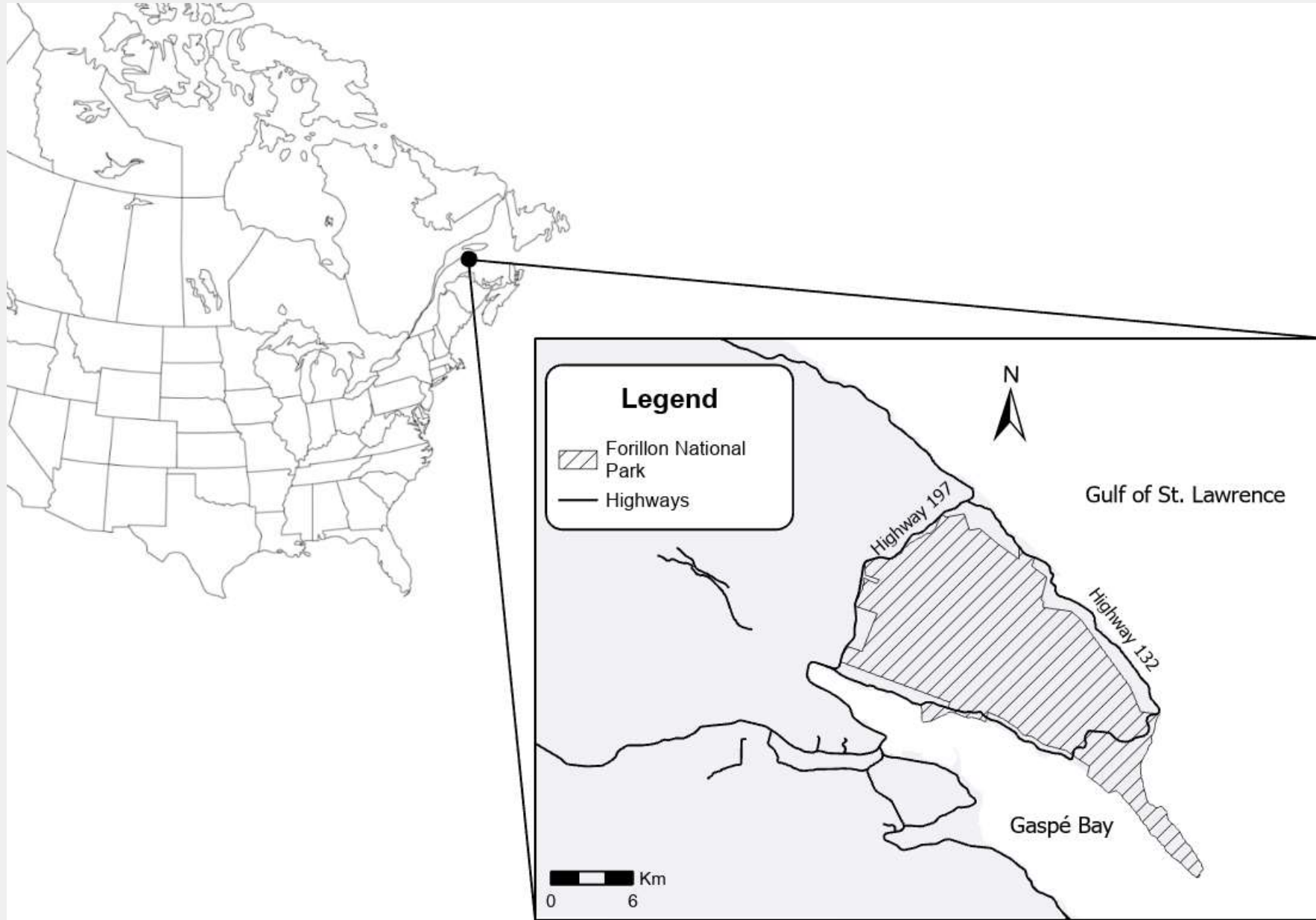
VARIATION OF THE POPULATION SIZE

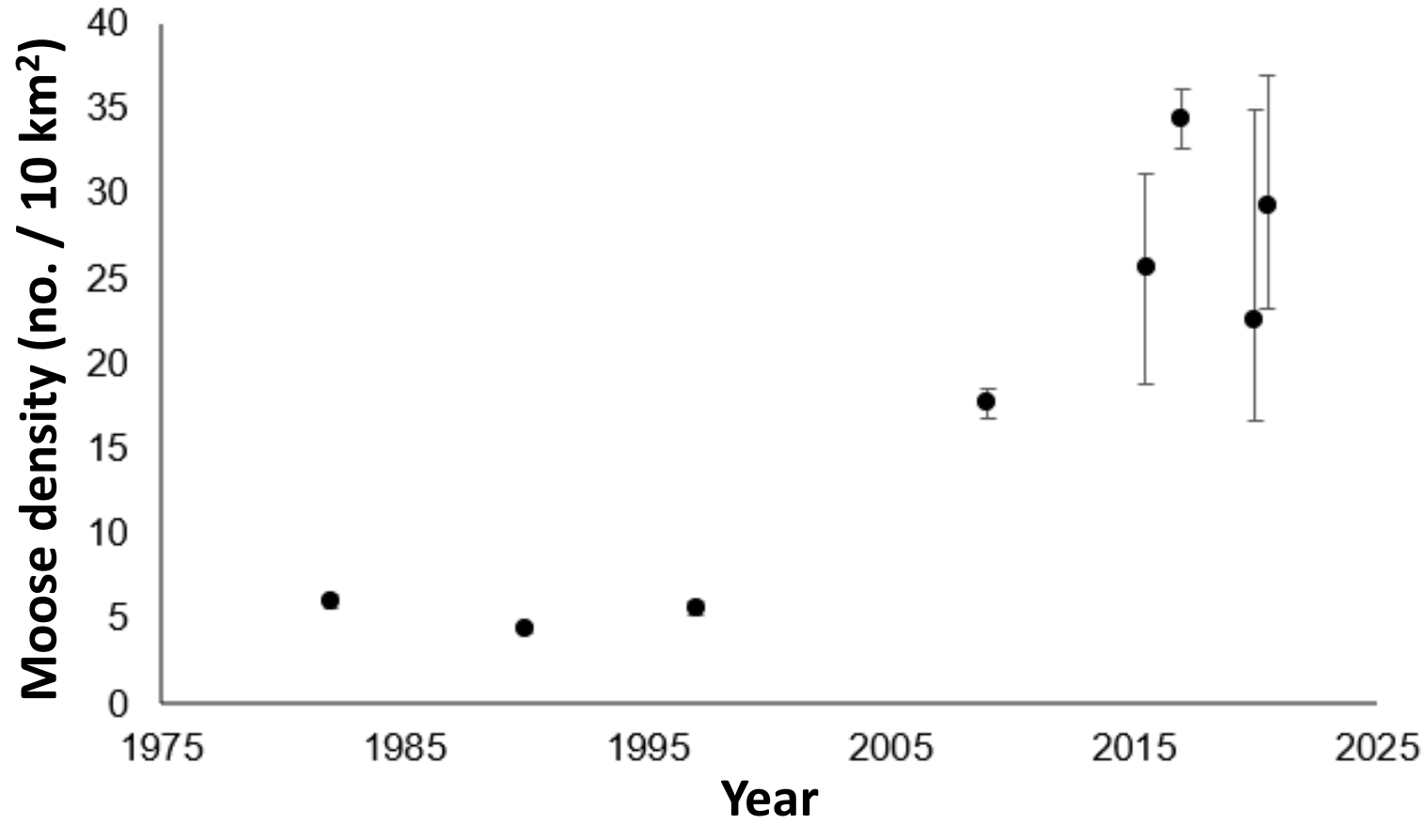


Sub-objective 2 : develop a predictive model to help managing overabundant populations

METHODS







Modeling period

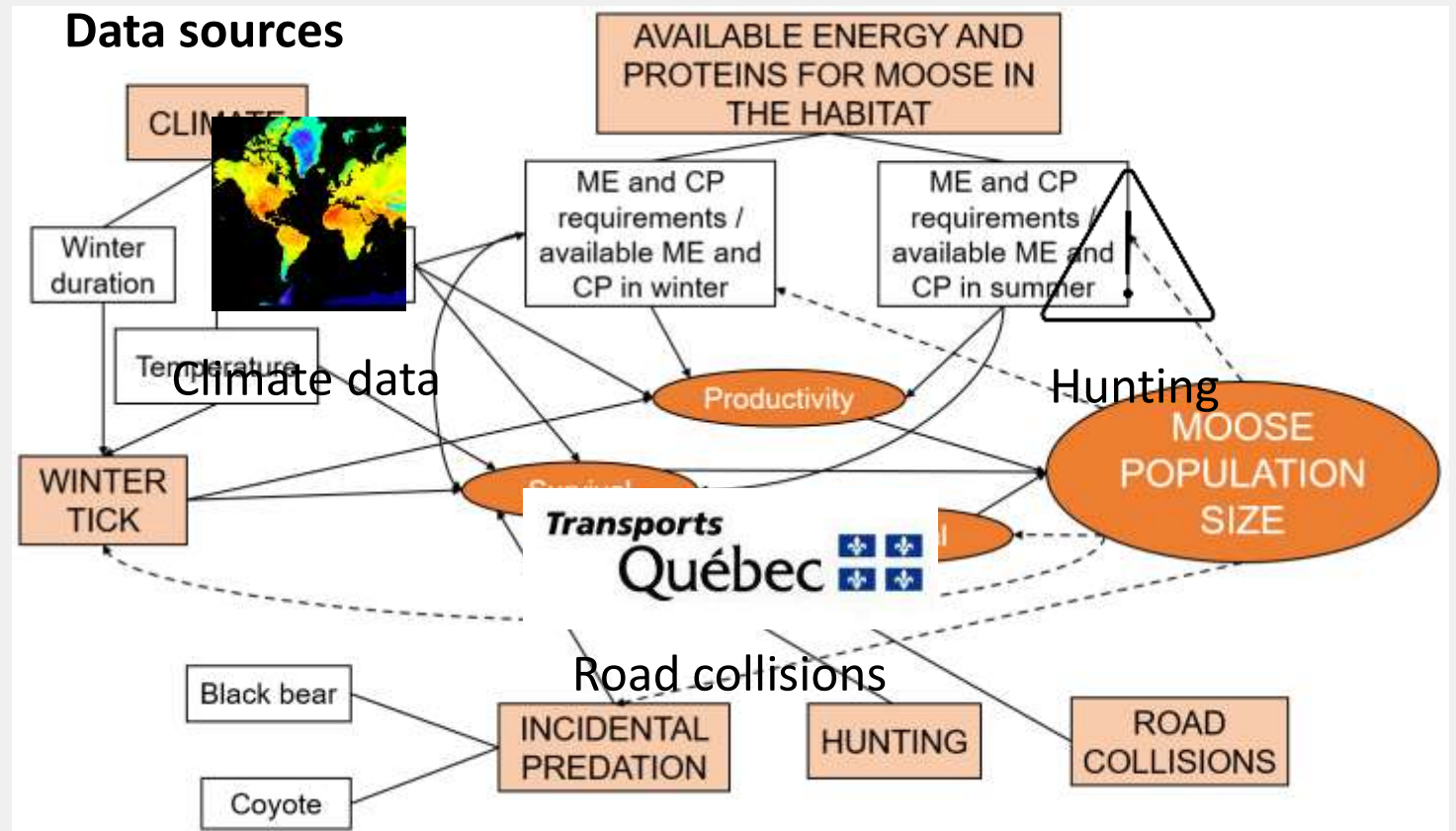
- 1982 to 2020

Time step

- Yearly (starting the 1st of March)

Age-structured model

- Juveniles (females and males < 1 y)
- Yearling females (1 to 2 y)
- Yearling males
- Adult females (> 2 y)
- Adult males

6 environmental factors

Forêts, Faune
et Parcs
Québec



Energy and proteins

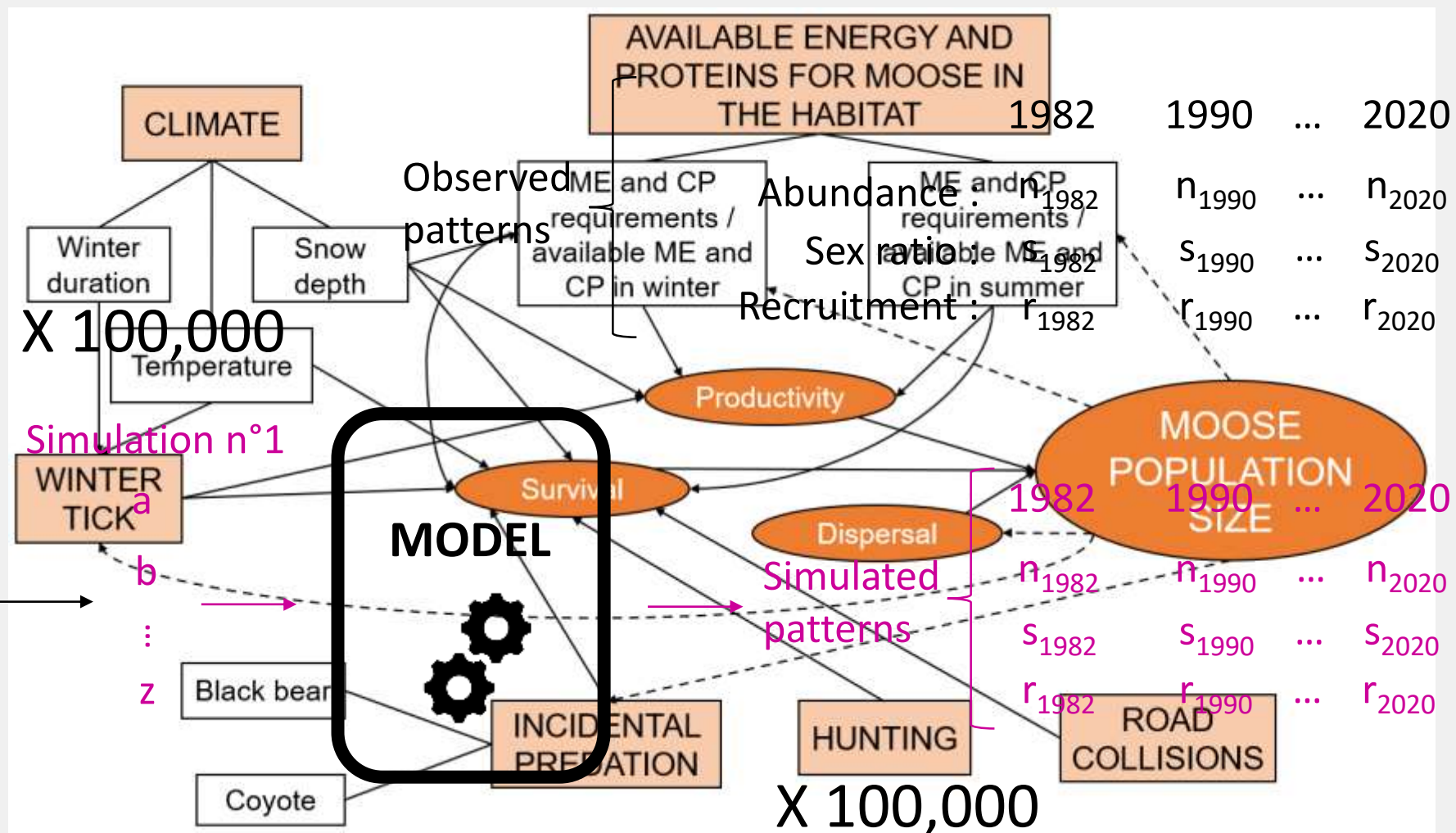


Predation and winter tick

Pattern-oriented modeling

x parameters
to calibrate

a [a₁;a₂]
b [b₁;b₂]
⋮ ⋮
z [z₁;z₂]



Ex. : Black bear kill rate $\sim a * (\text{moose density} / \text{bear density}) + b$

[a₁;a₂]

[b₁;b₂]

Pattern 1 Pattern 2 Pattern 3

Simulation n°1

dev₁

dev₂

dev₃

Simulation n°2

dev₁

dev₂

dev₃

⋮

Simulation
n°77 888

dev₁

dev₂

dev₃

⋮

Simulation
n°100 000

dev₁

dev₂

dev₃

Simulation n°1

Simulation n°77 888

a

a

b

b

⋮

⋮

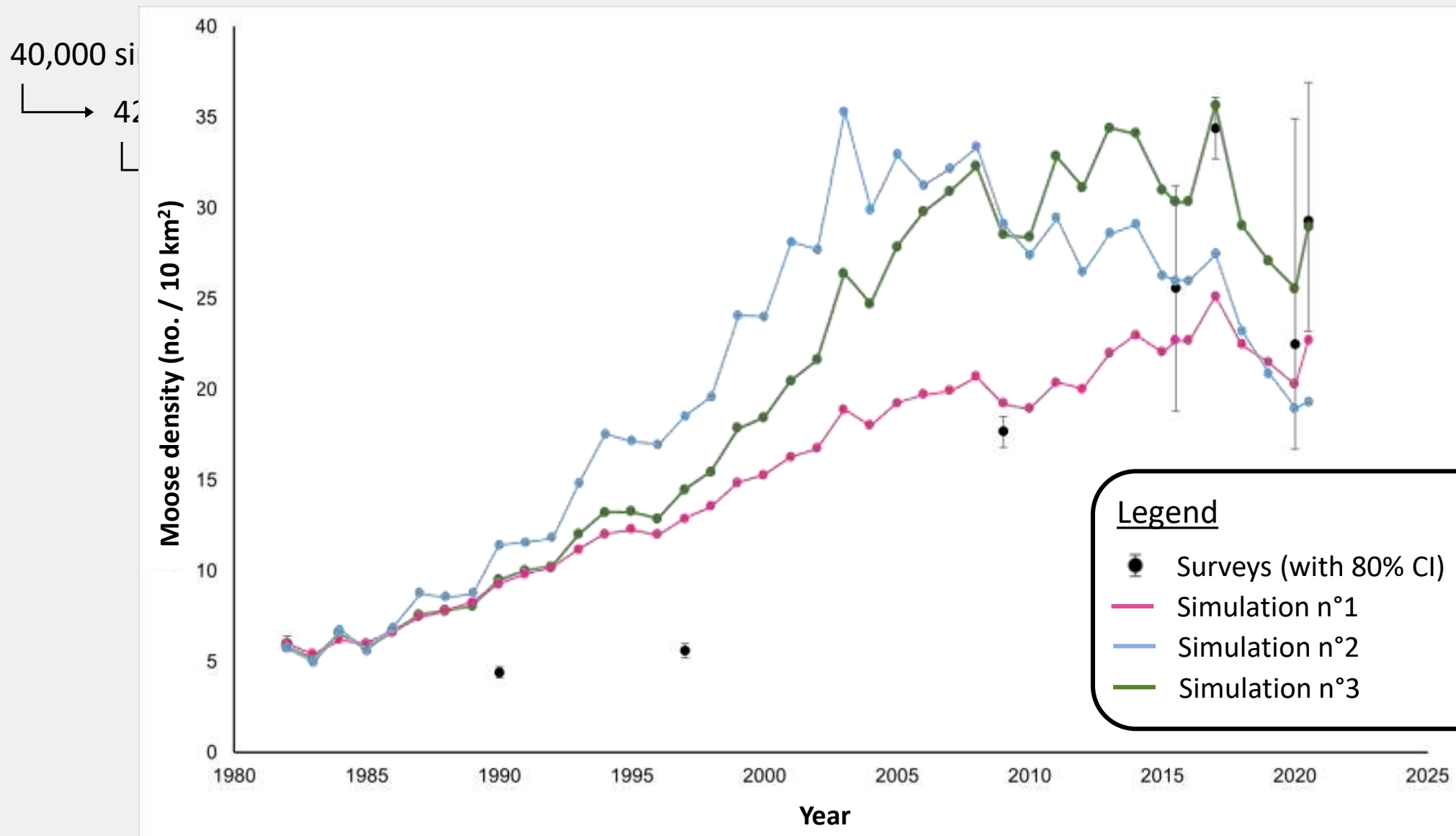
z

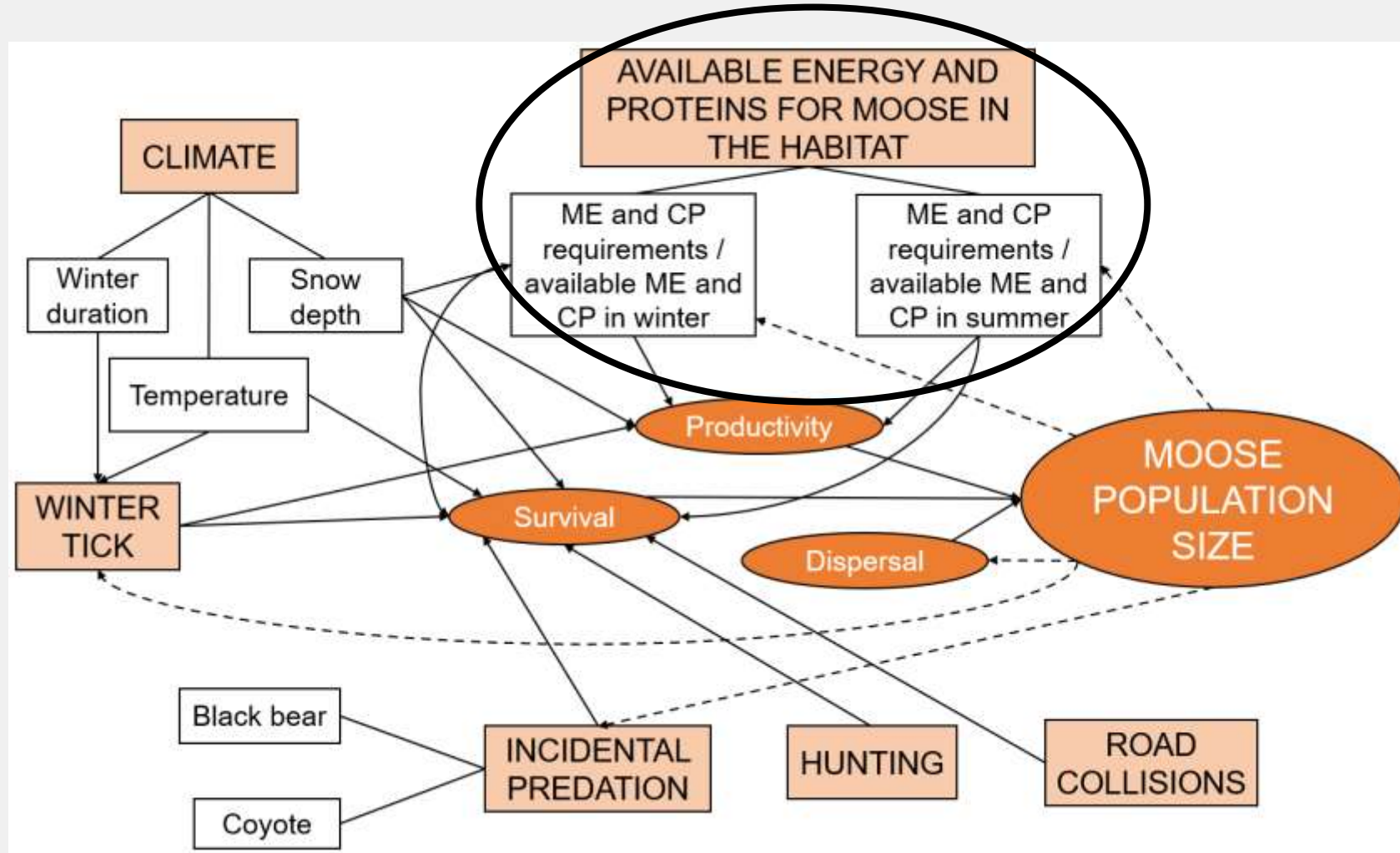
z

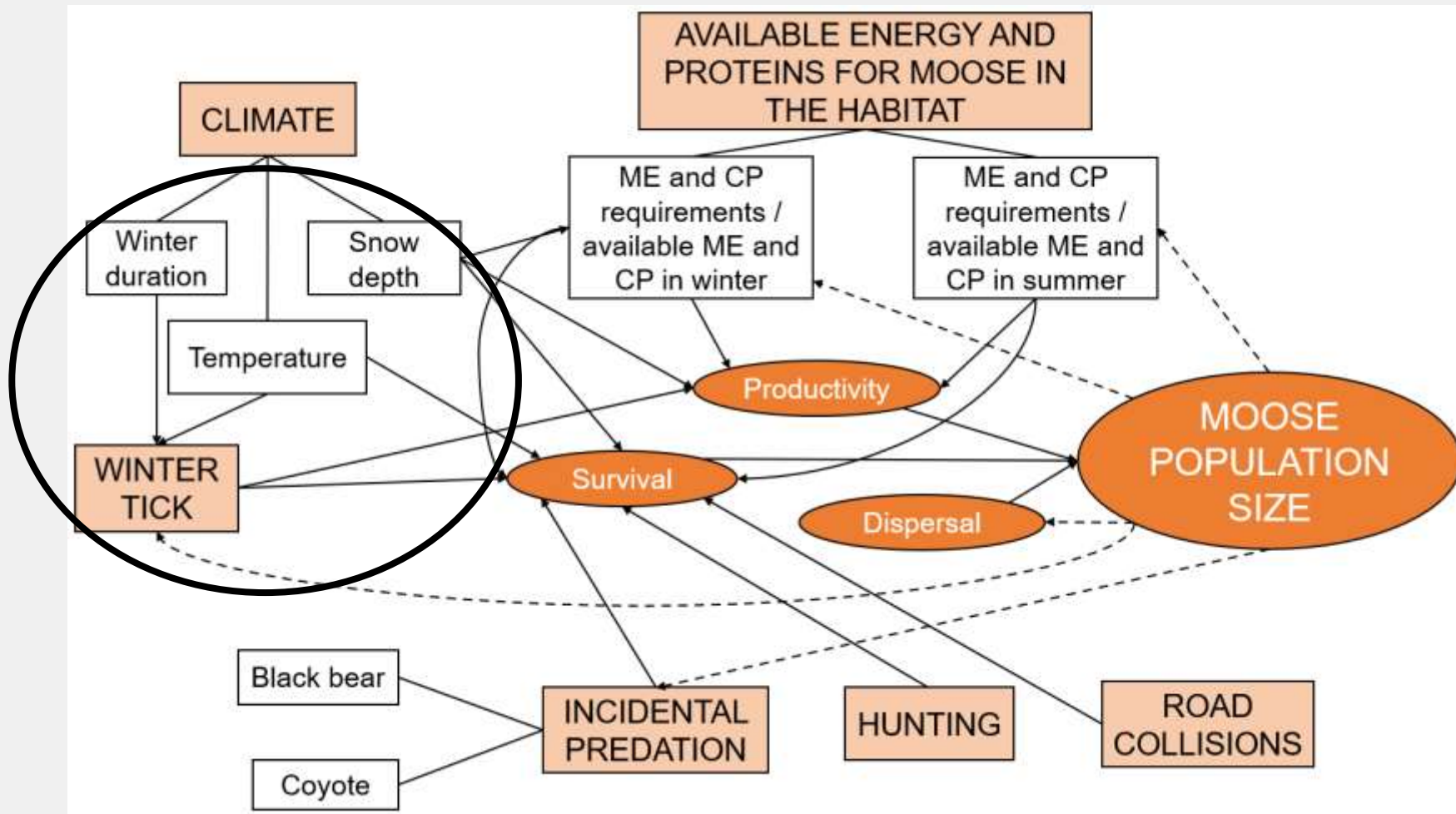





RESULTS & DISCUSSION




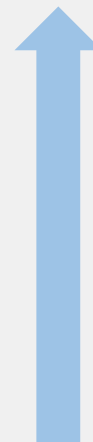




**WINTER
TICK**

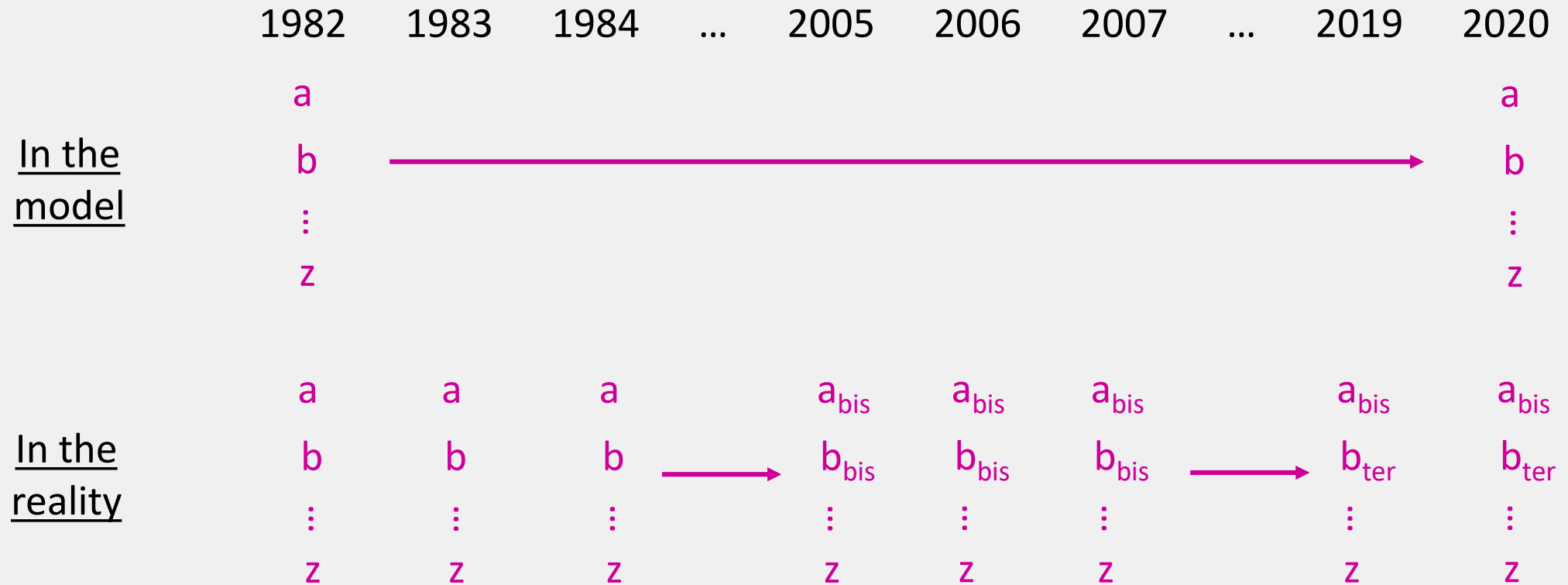
 Prevalence varying between the simulations,
but infestation level < 35,000 ticks/moose

 Probably underestimating the infestation level
of the past 10 years



+ Effect of host density
(Dunfey-Ball, 2017)

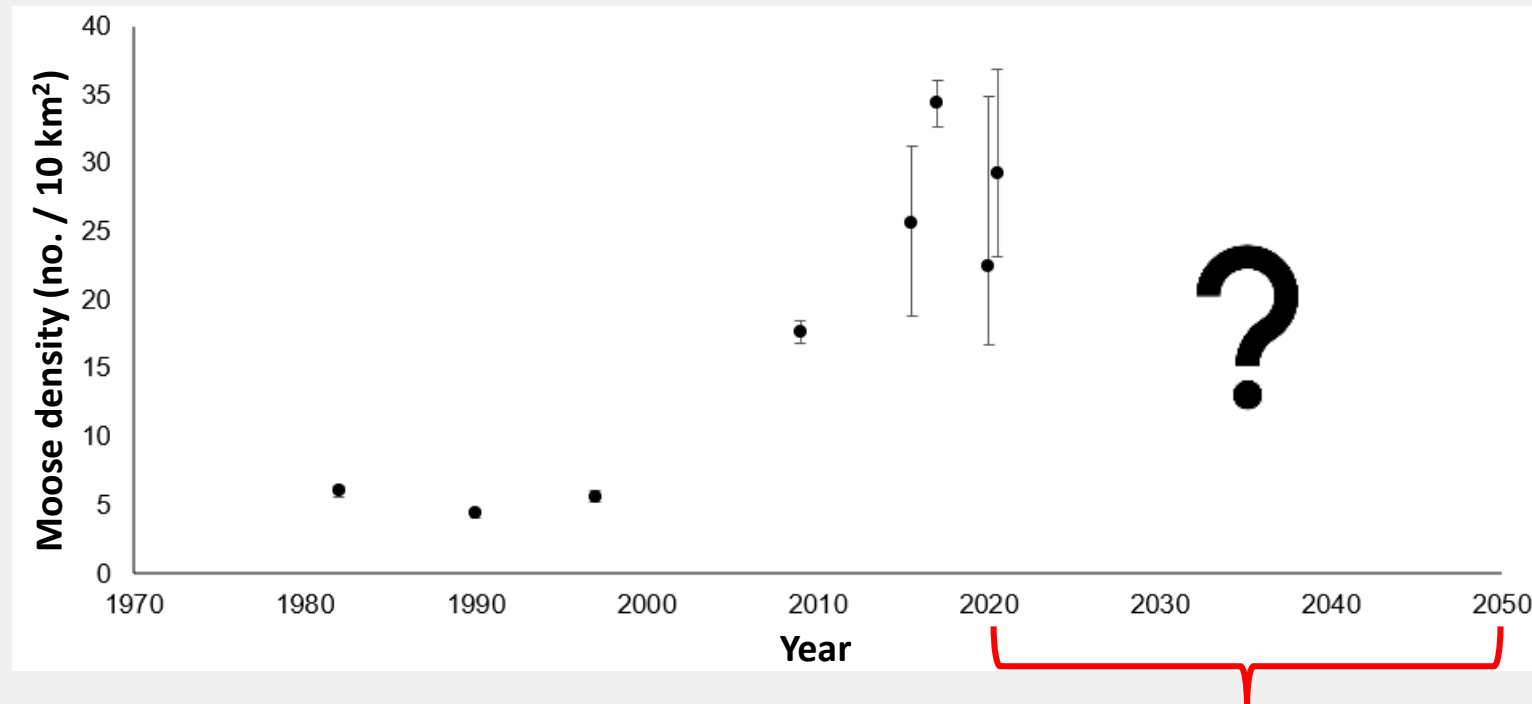
Limit





WHAT IS NEXT?

- More simulations to improve the precision of the parameter values
- Sensitivity analysis
- Use of the model to project the dynamics of the population until 2050 under several scenarios of intervention by the park managers (still to define)



ACKNOWLEDGEMENTS

I thank the funding organizations !

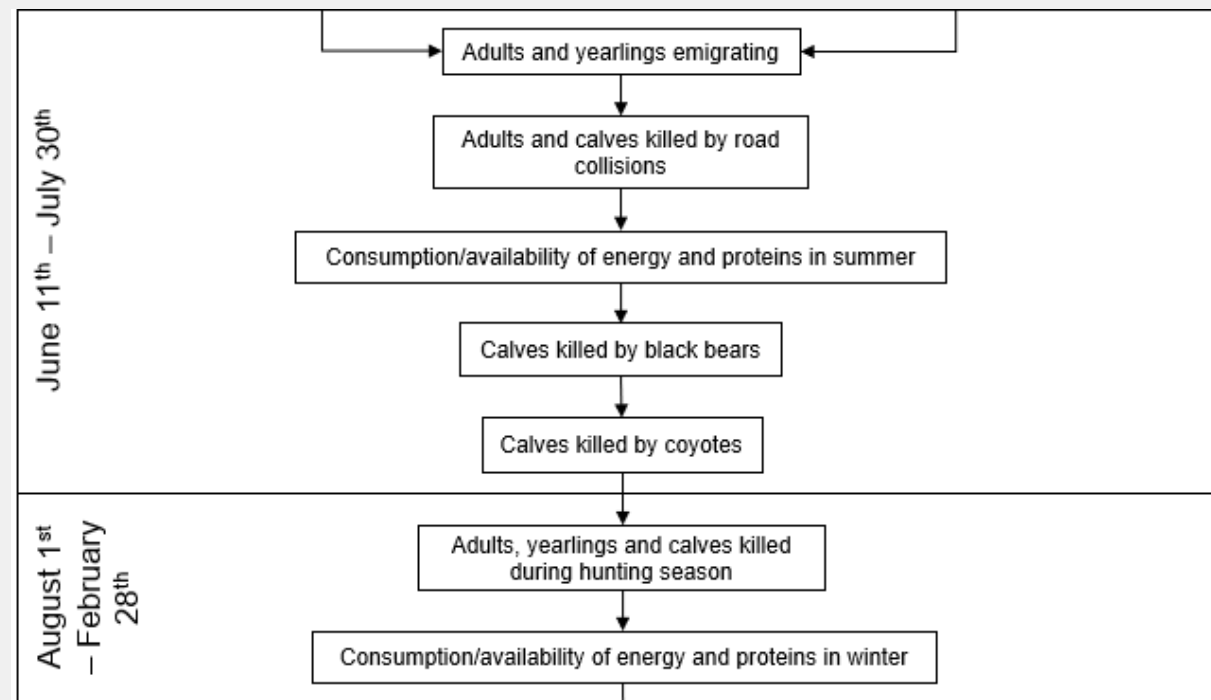
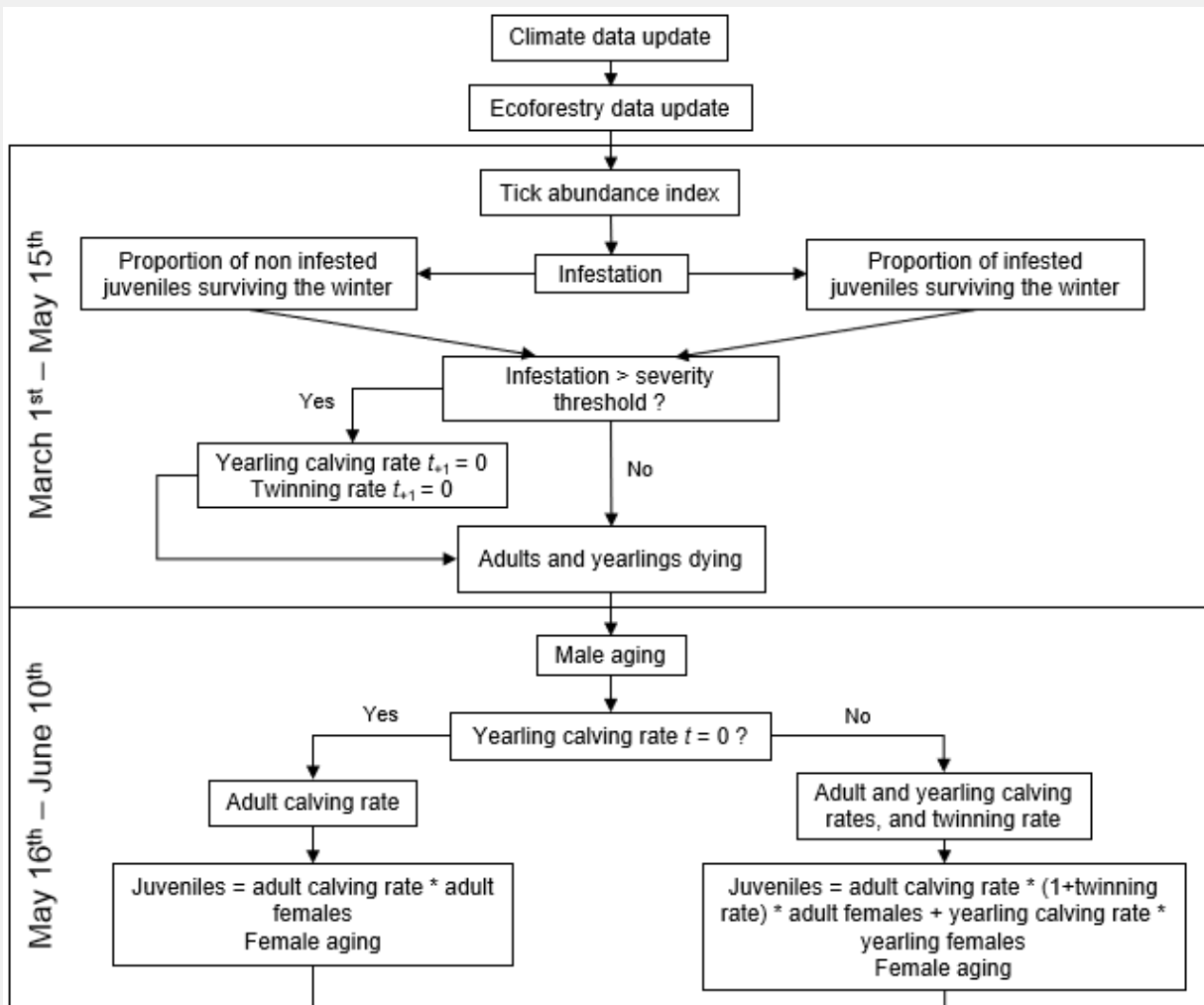
... Martin-Hugues St-Laurent (UQAR) and Pierre Etcheverry (Parks Canada)!

... Sarah Bauduin (Office Français de la Biodiversité)!

... Daniel Sigouin (Parks Canada), Jean-Pierre Tremblay (ULaval), Martin Dorais (MFFP), Jean-François Desgagnés (Pourvoirie Seigneurie Nicolas Riou), Alain Caron (UQAR) and Jean-David Dupuis (Parks Canada) !

And the members of the Laboratoire de gestion de la faune terrestre !





CLIMATE

Survival rate of adult males = **snowm1** * index of winter duration + **nccs1** * carrying capacity of the last summer + **n**

Survival rate of adult females = **snowm2** * index of winter duration + **nccs2** * carrying capacity of the last summer + **o**

Survival rate of yearling males = **snowm3** * index of winter duration + **nccs3** * carrying capacity of the last summer + **p**

Survival rate of yearling females = **snowm4** * index of winter duration + **nccs4** * carrying capacity of the last summer + **q**

Survival rate of juveniles non infested by winter tick = **nijs** * number of snow-days + **d**

Calving rate of adult females = **a_repro** * number of snow-days + **i**

Calving rate of yearling females = **y_repro** * number of snow-days + **j**

Twinning rate (adult females) = **tw_rt** * number of snow-days + **k**

Threshold value of the number of snow-days [9,000 ; 12,000]

WINTER TICK

Percentage of juveniles infested [10 ; 70] (Pouchet et al., in press)

Infestation = **c_infes** * index of tick abundance + **a**

w, x, y et **z** (multipliers for the 4 components of the index of tick abundance) 1 or 2

Survival rate of the infested juveniles above the snow-days threshold = **sijsup** * infestation + **b**

Survival rate of the infested juveniles under the snow-days threshold = **sijinf** * infestation + **c**

Threshold value of the infestation [50,000 ; 90,000]

**INCIDENTAL
PREDATION**

Kill rate of bears = \mathbf{krb} * (moose density / bear density) + \mathbf{l}

Kill rate of coyotes = \mathbf{krc} * (moose density / coyote density) + \mathbf{m}

Dispersal

Emigration rate of adult males = \mathbf{eam} * moose density + \mathbf{e}

Emigration rate of adult females = \mathbf{eaf} * moose density + \mathbf{f}

Emigration rate of yearling males = \mathbf{eym} * moose density + \mathbf{g}

Emigration rate of yearling females = \mathbf{eyf} * moose density + \mathbf{h}