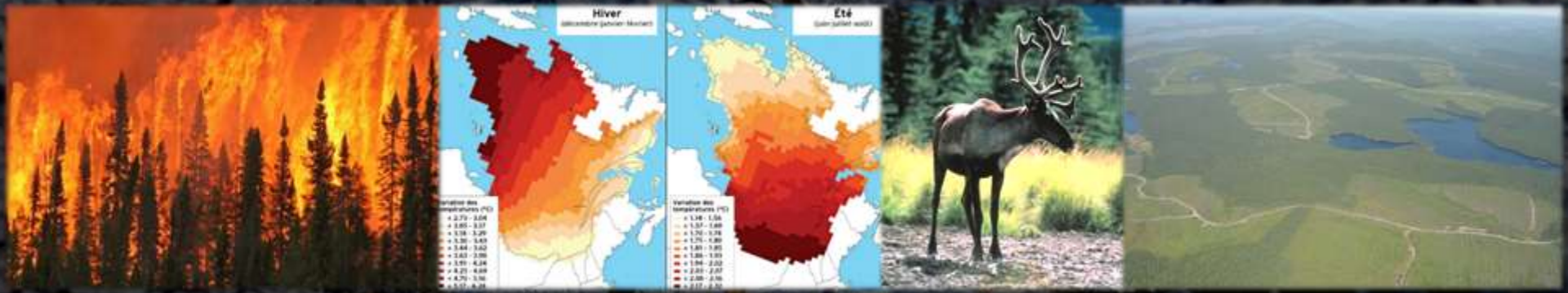
Lowering the rate of timber harvesting to mitigate impacts of climate change on boreal caribou habitat quality



M.-H. St-Laurent, Y. Boulanger, D. Cyr, F. Manka, P. Drapeau & S. Gauthier

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Professor - UQAM

Sylvie Gauthier

Senior Research Scientist - NRCan

Threats to biodiversity

Climate change and human-caused habitat disturbances are leading threats to biodiversity

Both are known to influence different facets of animal biology, from behaviour to vital rates

Global Change Biology

Global Change Biology (2009) 15, 2626–2633, doi: 10.1111/j.1365-2486.2009.01974.x

Global declines of caribou and reindeer

LIV SOLVEIG VORS and MARK STEPHEN BOYCE
Department of Biological Sciences, University of Alberta, Edmonton, Alberta, T6G 2E9, Canada

Different subspecies, different limiting factors, different combinations of drivers explaining the decline of local populations

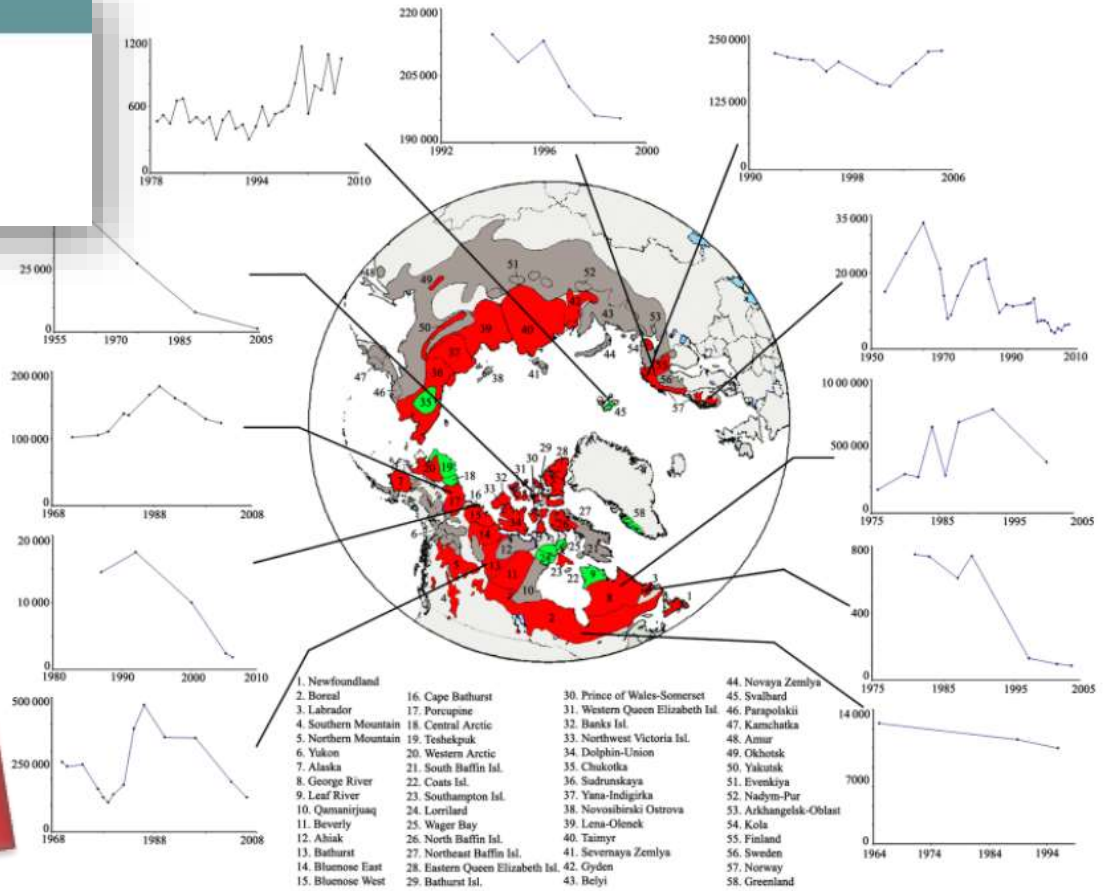


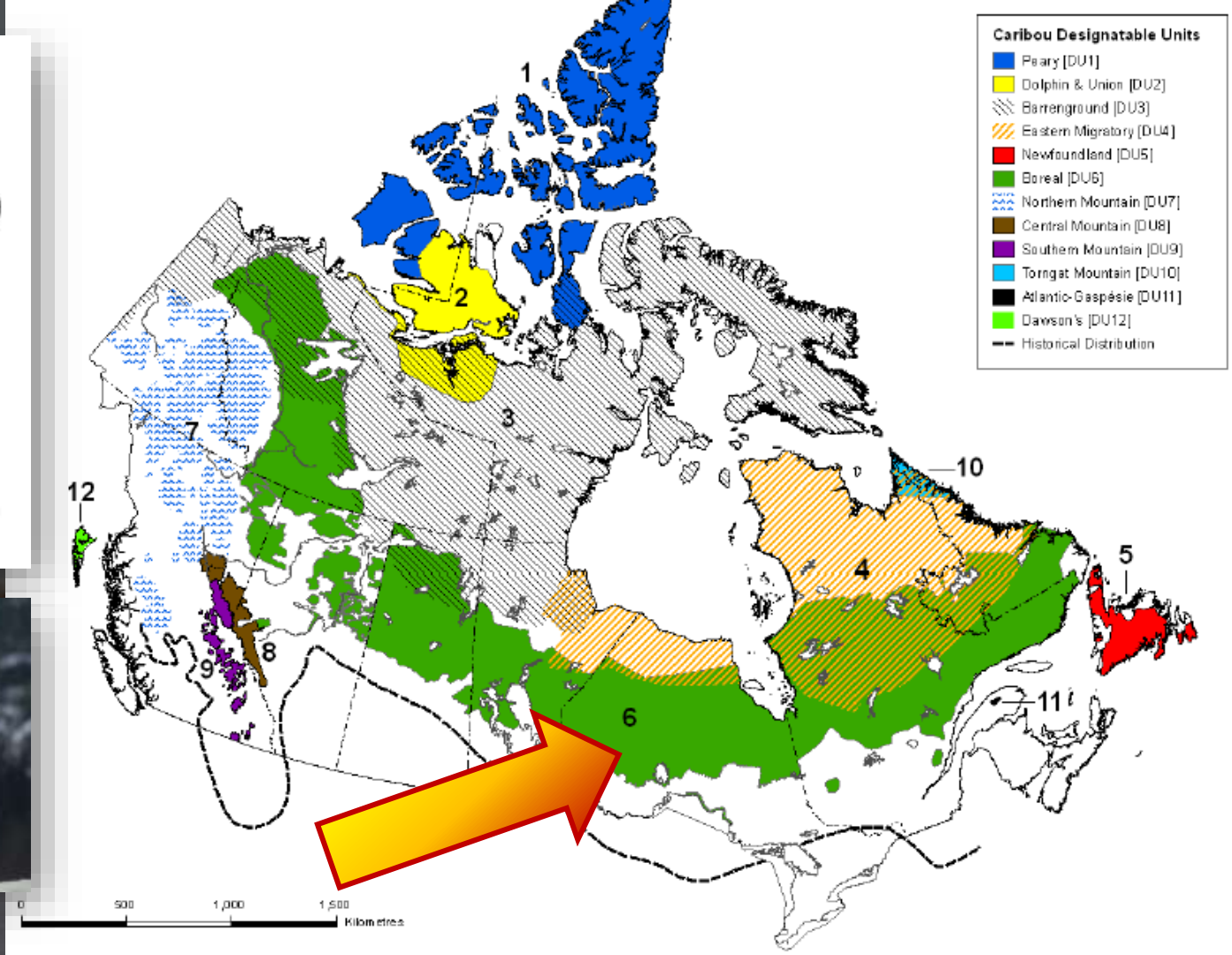
Fig. 2 Population trajectories of 58 major caribou and reindeer herds worldwide. Herd ranges depicted in red are in population decline and ranges depicted in green are experiencing population growth. Population data are unavailable for herd ranges illustrated in grey. Time series of population estimates for 11 caribou and reindeer populations are included to illustrate historical fluctuations in population size. The *x*-axis represents year of population estimate and the y-axis represents estimate of population size.

COSEWIC Report

Designatable Units for Caribou (*Rangifer tarandus*) in Canada

COSEWIC
Committee on the Status of Endangered Wildlife in Canada

COSEPAC
Comité sur la situation des espèces en péril au Canada



Boreal populations of woodland caribou

Its conservation is subject of a national recovery strategy

Designated as Threatened in 2000 under SARA, most populations are declining

Designation & recovery plans supported by a strong scientific consensus (>30 yrs of empirical evidence,~450 peer-reviewed articles)

Disinformation and knowledge gap

« Malheureusement, les informations et les faits ne sont pas suffisamment précis donc on manque d'information. Il faudrait qu'on trouve le moyen de documenter encore mieux. »

— Steeve St-Gelais, président de Boisaco

« On part, au Québec, avec la prémisse que le caribou est menacé, qu'il est en déclin. Or, il n'existe aucun rapport qui démontre cet état de fait, ni aucun inventaire. »

— Extrait du mémoire déposé par Boisaco pour la Commission indépendante sur les caribous forestiers et montagnards

Alliance
FORÊT BORÉALE

caribou forestier pour 2023.

Mythe # 3

L'état des connaissances sur le caribou permet de prendre des décisions de gestion bien éclairées

Réalité

En 2019, encore plusieurs éléments ne sont pas bien documentés : les impacts des changements climatiques, les populations de prédateurs, l'état de situation de certaines populations de caribou, le comportement de l'espèce, les habitudes d'alimentation du caribou, la fermeture des chemins forestiers, etc. Plusieurs projets de recherches sont actuellement en cours et apporteront de nouvelles connaissances afin de prendre les meilleures décisions.

Mythe # 4

Les changements climatiques n'ont pas d'incidence sur les populations de caribou

Réalité

L'impact des changements climatiques poussera les populations fauniques à migrer vers le nord et ce, plus rapidement que les végétaux. À chaque décennie, une espèce peut migrer, selon les chercheurs, de 45 km vers le nord. De plus, l'arrivée de certaines populations d'espèces est accompagnée de certaines maladies, comme le ver des méninges, ce qui peut avoir des conséquences catastrophiques sur l'espèce en place. Tout l'habitat de l'espèce en place sera alors convoité par la nouvelle espèce où la Loi du plus fort s'appliquera. Le caribou ne fait pas exception à cette règle.

Research efforts mostly focused on the role of human-induced disturbances in the decline of boreal caribou

Importance of mature, undisturbed forests

Vegetation regrowth in cutblocks suitable to bears, moose and deer

Roads facilitate predator movement and ↑ hunting success

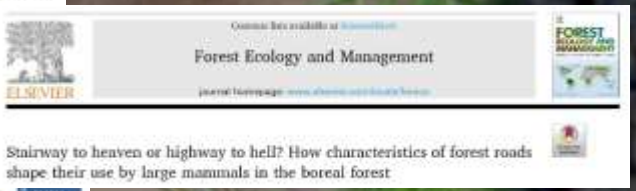
Caribou are spacing away from predators and alternative prey


RESEARCH ARTICLE

WILEY

Trophic niche partitioning between two prey and their incidental predators revealed various threats for an endangered species

Ève Rioux[1] | Fanie Pelletier[2] | Martin-Hugues St-Laurent[1]


Forest Ecology and Management

Stairway to heaven or highway to hell? How characteristics of forest roads shape their use by large mammals in the boreal forest

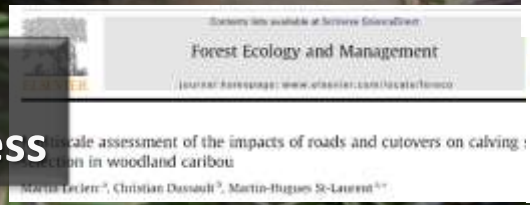

Biological Conservation


Global Ecology and Conservation

Original Research Article

Linking habitat, predators and alternative prey to explain recruitment variations of an endangered caribou population

Jonathan Frenette, Fanie Pelletier, Martin-Hugues St-Laurent


Forest Ecology and Management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ECOSPHERE

Exposure to historical burn rates shapes the response of boreal caribou to timber harvesting


Forest Ecology and Management

Wolf habitat selection is shaped by human activities in a highly managed boreal forest


PLOS

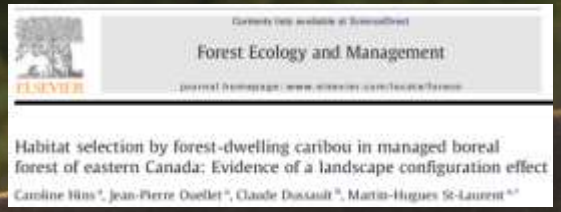
Disentangling Woodland Caribou Movements in Response to Clearcuts and Roads across Temporal Scales

Boreal caribou is known to be negatively impacted by disturbances due to maladaptive behaviours

Selecting for cutblocks under certain circumstances

Trying to avoid different predators found at increased densities

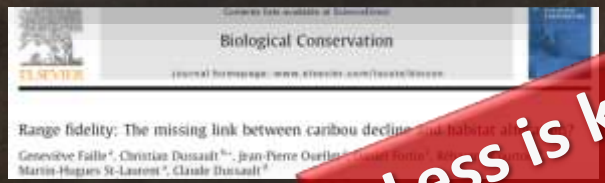
Influencing range fidelity behaviour and thus impacting survival


Forest Ecology and Management

Habitat selection by forest-dwelling caribou in managed boreal forest of eastern Canada: Evidence of a landscape configuration effect


Biological Conservation

Thresholds in the capacity of boreal caribou to cope with cumulative disturbances: Evidence from spatial pattern

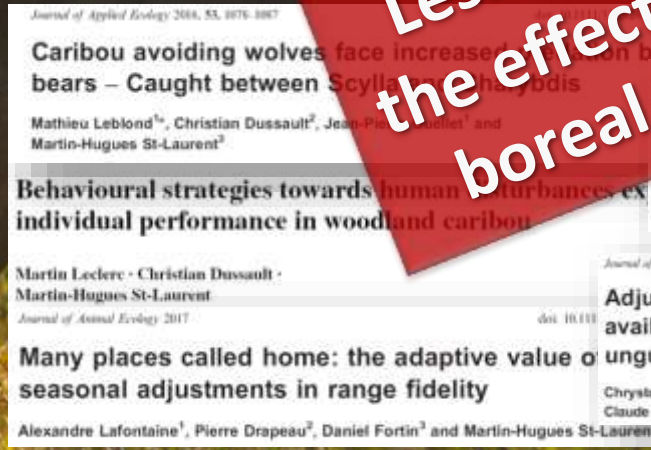

Biological Conservation

Range fidelity: The missing link between caribou decline and habitat alteration?


PROCEEDINGS B

Spatial theory for characterizing predator–multiprey interactions in landscapes

Less is known on the effects of CC on boreal caribou…


Journal of Applied Ecology 2016, 53, 1076–1085

Caribou avoiding wolves face increased predation by bears – Caught between Scylla and Charybdis

Mathieu Leblond[1]*, Christian Dussault[2], Jean-Pierre Ouellet[1] and Martin-Hugues St-Laurent[3]

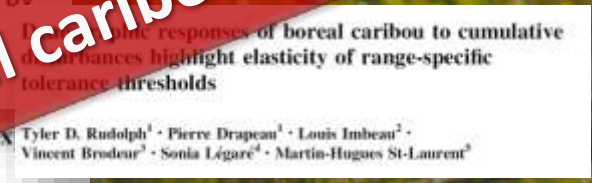
Behavioural strategies towards human disturbances explain individual performance in woodland caribou

Martin Leclerc · Christian Dussault · Martin-Hugues St-Laurent

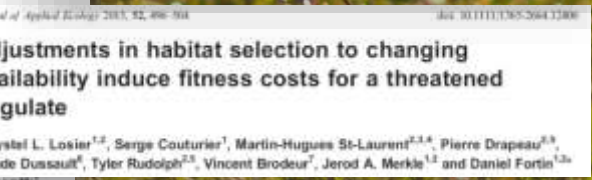
Journal of Animal Ecology 2017

Many places called home: the adaptive value of seasonal adjustments in range fidelity

Alexandre Lafontaine[1], Pierre Drapeau[2], Daniel Fortin[3] and Martin-Hugues St-Laurent[4]*


Demographic responses of boreal caribou to cumulative disturbances highlight elasticity of range-specific tolerance thresholds

Tyler D. Rudolph[1] · Pierre Drapeau[1] · Louis Imbeau[2] · Vincent Brodeur[3] · Sonia Légaré[4] · Martin-Hugues St-Laurent[5]


Journal of Applied Ecology 2015, 52, 486–504

Adjustments in habitat selection to changing availability induce fitness costs for a threatened ungulate

Chrystel L. Losier[1,2], Serge Couturier[1], Martin-Hugues St-Laurent[2,3,4], Pierre Drapeau[2,3], Claude Dussault[5], Tyler Rudolph[2,3], Vincent Brodeur[7], Jerod A. Merkle[1,8] and Daniel Fortin[1,2]*

…but a few studies already looked into that direction!

Contents lists available at ScienceDirect

Climate Change Ecology

journal homepage: www.elsevier.com/locate/ecoevo

The direct and habitat-mediated influence of climate on the biogeography of boreal caribou in Canada

E.W. Neilson[a,*], C. Castillo-Ayala[a], J.F. Beckers[a], C.A. Johnson[b], M.H. St-Laurent[c], N. Mahony[a], D. Price[a], A. Kelly[d], M.A. Parisien[a]

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ECOSPHERE

Potential impacts of climate change on the habitat of boreal woodland caribou

Marc-Andre Parisien,[1] Ellen Whitman,[1,2] Diana Stralberg,[2] Chris J. Johnson,[3] Martin-Hugues St-Laurent,[4] Evan R. DeLancey,[5] David T. Price,[1] Dominique Arseneault,[4] Xianli Wang,[6] and Mike D. Flannigan[2]

Yes, more to learn about the effects of CC, especially in Quebec

The distribution ranges are less sensitive to climate than to human-induced disturbances

In Alberta, simulations suggest that grassland vegetation would covered ~50% of the study area by 2080s, contributing to a significant contraction of coniferous forests

But as the climate changes, future ranges may be relegated to refuge habitats, particularly in western boreal forest

This would increase the risk of predation and disease, as habitat becomes more suitable for deer and wolves

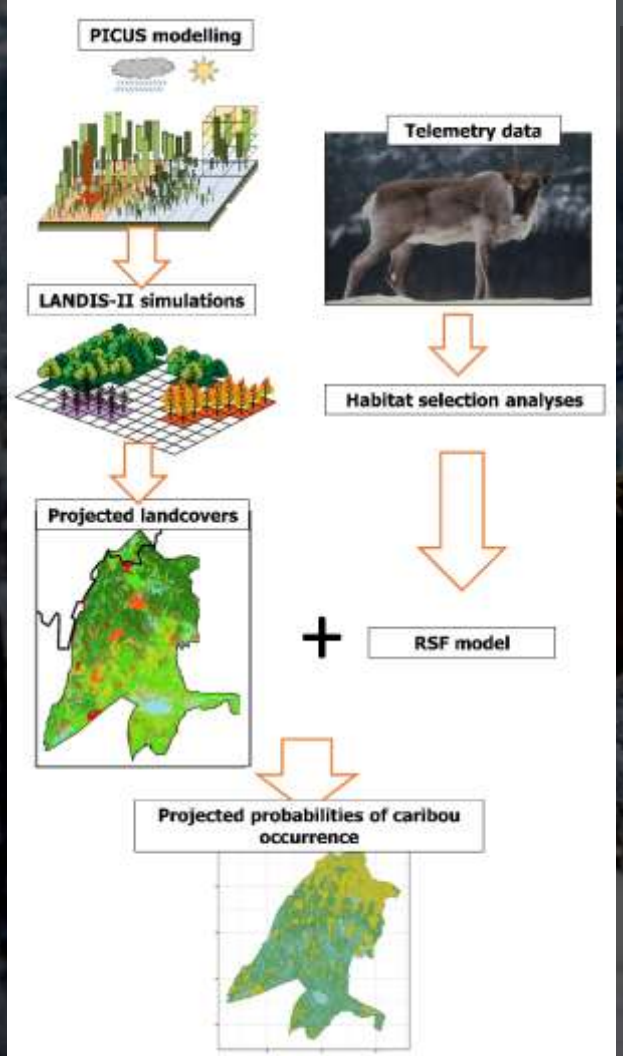
Projecting how CC will interact with harvest to alter caribou habitat is critical for conservation planning and adaptive management strategies

Objectives

Provide projections of future habitat of boreal populations of woodland caribou over a spatiotemporal horizon relevant to both forest management planning and caribou conservation

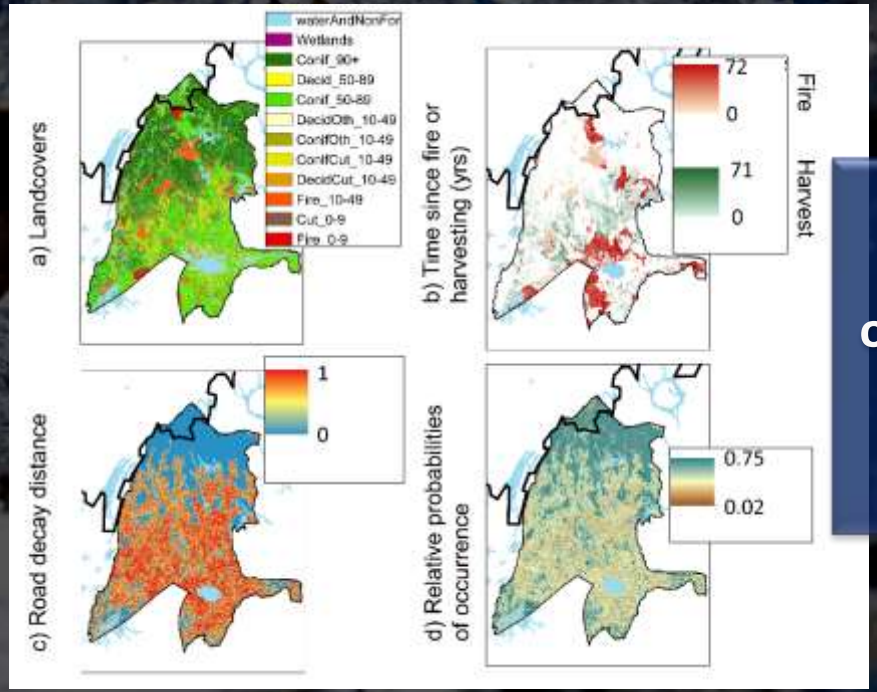
1. Evaluate the impacts of CC through alteration of stand-level tree species interactions and expected modification of fire regime as well as of various levels of timber harvesting on habitat quality

2. Compare the relative importance of each agent of change

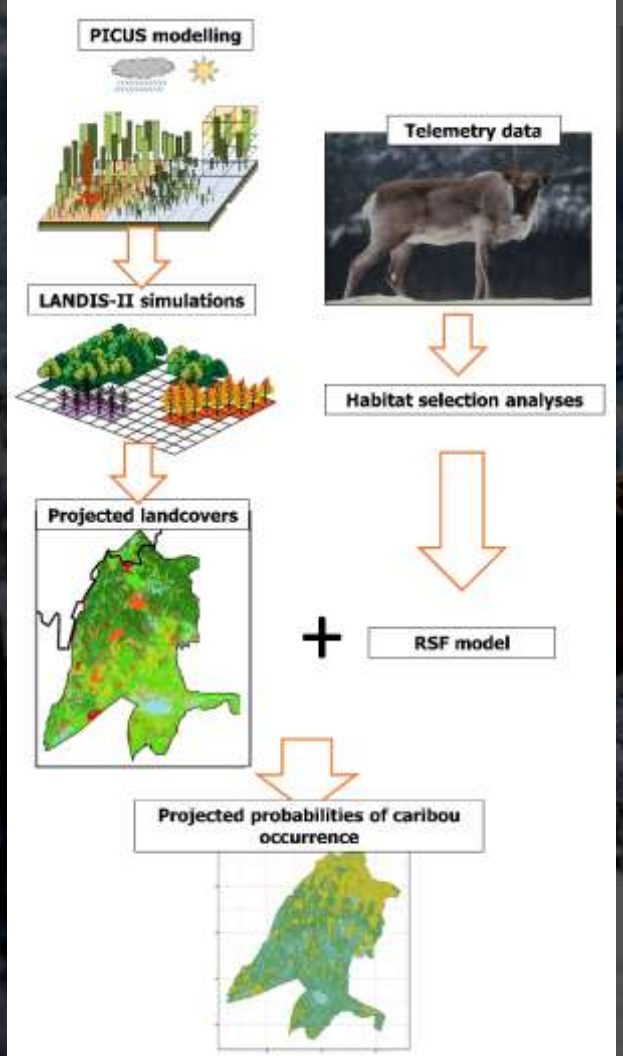


Overview of Methods

Caribou GPS telemetry data: 121 individuals in 7 populations from 2004 to 2011 (735 000 relocations!)



Relative probability of occurrence used as a proxy of habitat quality



Overview of Methods

Forest landscape simulations were used to assess the impacts of…

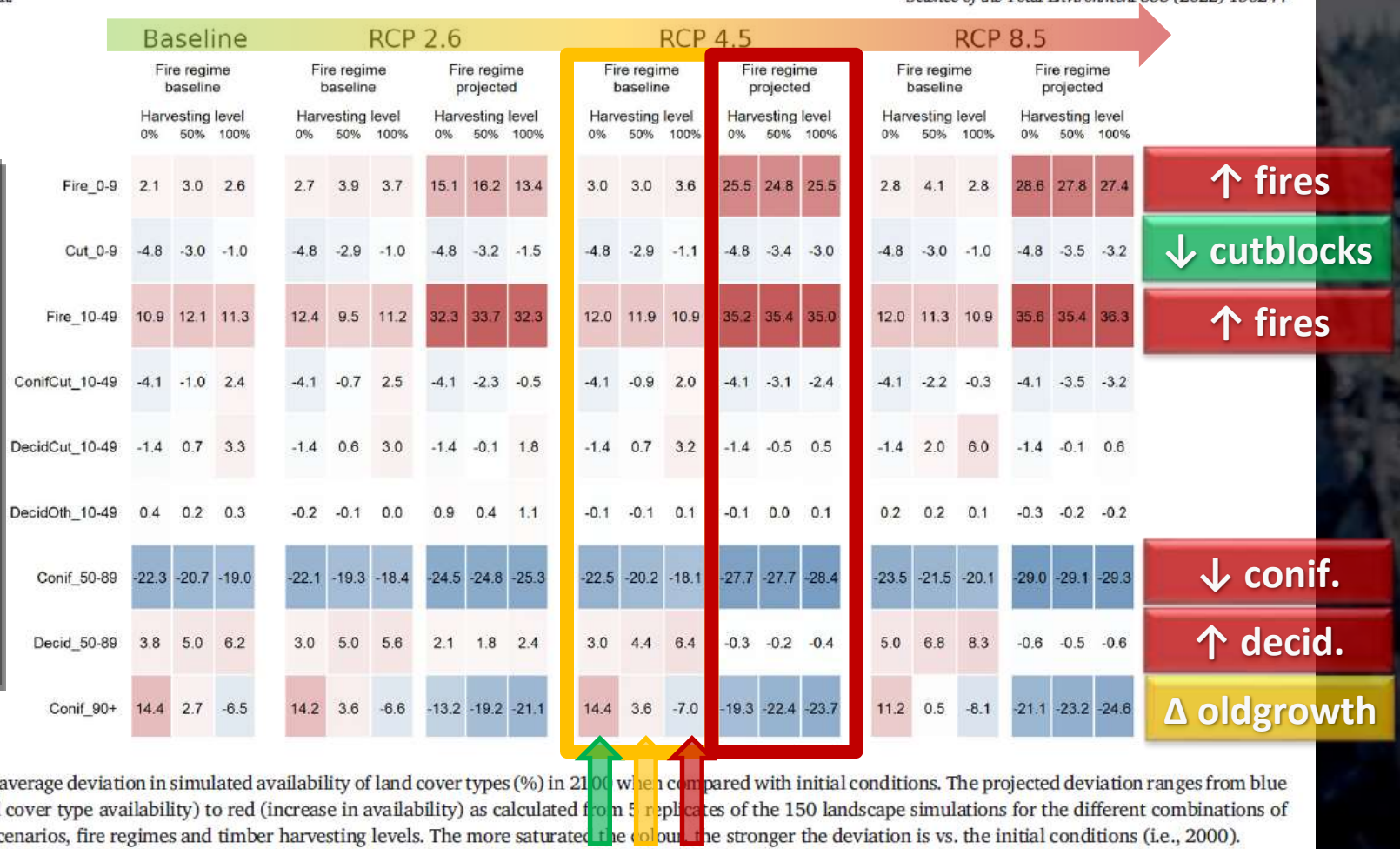
4 climate scenarios: Baseline, RCP 2.6, 4.5 and 8.5

3 harvesting scenarios: Historical, 50% historical, no harvest

…on 2 variables describing caribou habitat

Average habitat quality, % of high-quality habitats (i.e. >75% of relative probability of occurrence)

Changes in landcovers



	Baseline			RCP 2.6						RCP 4.5						RCP 8.5					
	Fire regime baseline			Fire regime baseline			Fire regime projected			Fire regime baseline			Fire regime projected			Fire regime baseline			Fire regime projected		
	Harvesting level			Harvesting level			Harvesting level			Harvesting level			Harvesting level			Harvesting level			Harvesting level		
	0%	50%	100%	0%	50%	100%	0%	50%	100%	0%	50%	100%	0%	50%	100%	0%	50%	100%	0%	50%	100%
Fire_0-9	2.1	3.0	2.6	2.7	3.9	3.7	15.1	16.2	13.4	3.0	3.0	3.6	25.5	24.8	25.5	2.8	4.1	2.8	28.6	27.8	27.4
Cut_0-9	-4.8	-3.0	-1.0	-4.8	-2.9	-1.0	-4.8	-3.2	-1.5	-4.8	-2.9	-1.1	-4.8	-3.4	-3.0	-4.8	-3.0	-1.0	-4.8	-3.5	-3.2
Fire_10-49	10.9	12.1	11.3	12.4	9.5	11.2	32.3	33.7	32.3	12.0	11.9	10.9	35.2	35.4	35.0	12.0	11.3	10.9	35.6	35.4	36.3
ConifCut_10-49	-4.1	-1.0	2.4	-4.1	-0.7	2.5	-4.1	-2.3	-0.5	-4.1	-0.9	2.0	-4.1	-3.1	-2.4	-4.1	-2.2	-0.3	-4.1	-3.5	-3.2
DecidCut_10-49	-1.4	0.7	3.3	-1.4	0.6	3.0	-1.4	-0.1	1.8	-1.4	0.7	3.2	-1.4	-0.5	0.5	-1.4	2.0	6.0	-1.4	-0.1	0.6
DecidOth_10-49	0.4	0.2	0.3	-0.2	-0.1	0.0	0.9	0.4	1.1	-0.1	-0.1	0.1	-0.1	0.0	0.1	0.2	0.2	0.1	-0.3	-0.2	-0.2
Conif_50-89	-22.3	-20.7	-19.0	-22.1	-19.3	-18.4	-24.5	-24.8	-25.3	-22.5	-20.2	-18.1	-27.7	-27.7	-28.4	-23.5	-21.5	-20.1	-29.0	-29.1	-29.3
Decid_50-89	3.8	5.0	6.2	3.0	5.0	5.6	2.1	1.8	2.4	3.0	4.4	6.4	-0.3	-0.2	-0.4	5.0	6.8	8.3	-0.6	-0.5	-0.6
Conif_90+	14.4	2.7	-6.5	14.2	3.6	-6.6	-13.2	-19.2	-21.1	14.4	3.6	-7.0	-19.3	-22.4	-23.7	11.2	0.5	-8.1	-21.1	-23.2	-24.6

Fig. 3. Projected average deviation in simulated availability of land cover types (%) in 2100 when compared with initial conditions. The projected deviation ranges from blue (decrease in land cover type availability) to red (increase in availability) as calculated from 5 replicates of the 150 landscape simulations for the different combinations of climate change scenarios, fire regimes and timber harvesting levels. The more saturated the colour, the stronger the deviation is vs. the initial conditions (i.e., 2000).

Impacts on caribou habitat quality

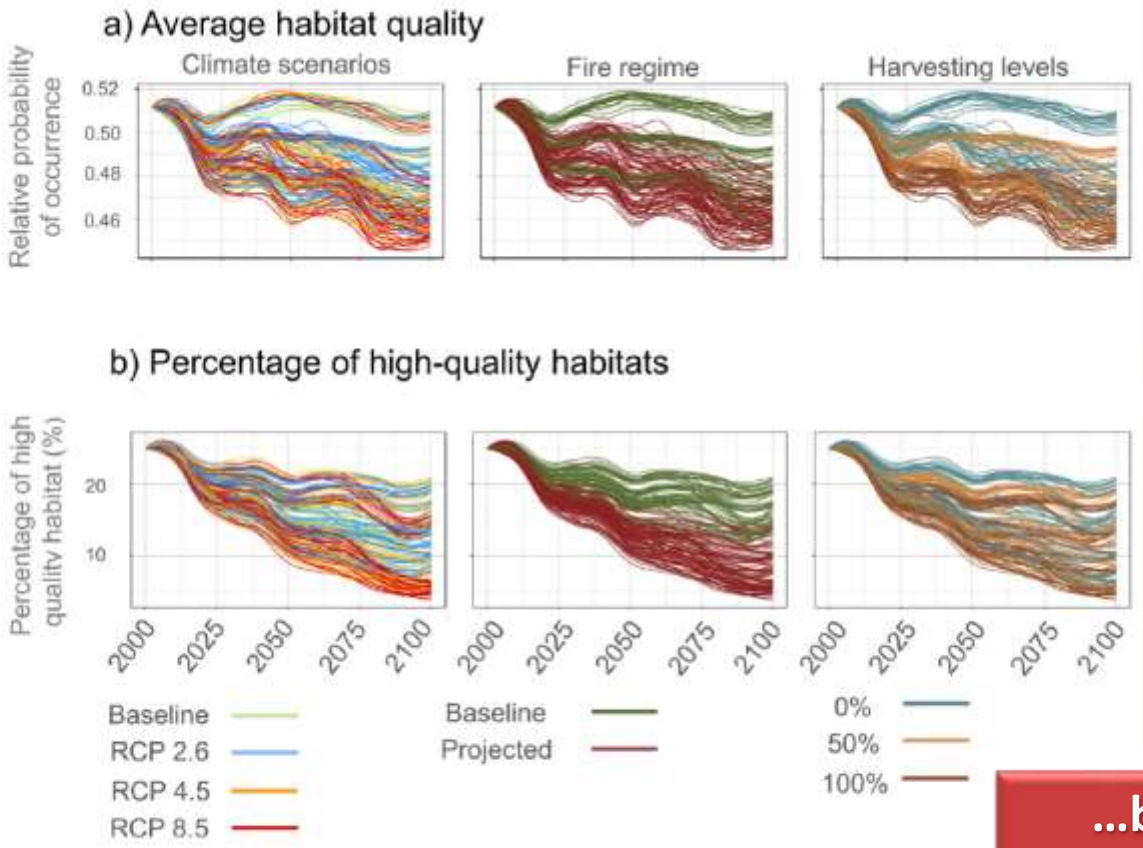


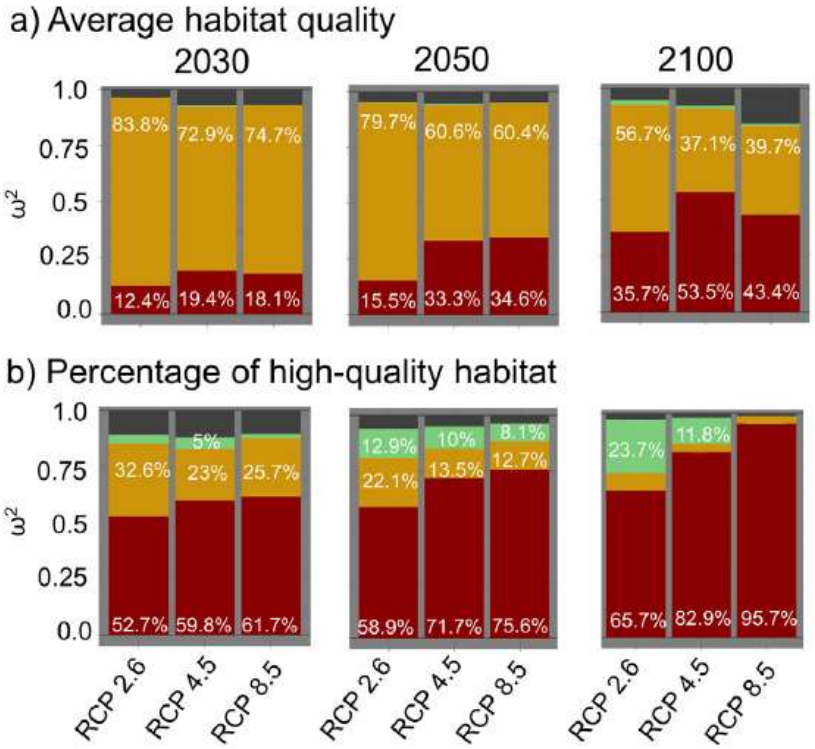
Fig. 4. Sensitivity analysis of the (a) caribou relative probability of occurrence average as a proxy of habitat quality, and (b) percentage of [illegible] panels present the exact same 150 simulations (30 treatments each replicated 5 times) with colour schemes that identify them according to a specific factor, namely climate change scenario (left), fire regime (middle), and harvesting level (right). Curves show the marginal effects of the given factor, i.e., they [illegible] of the remaining simulation factors.

More severe are the CC scenarios, worst is the caribou habitat

Future fire regimes will strongly decrease habitat quality

…but adjusting harvest levels could provide flexibility

Partitioning the effects of the 3 drivers



Very little impact on Δ in caribou habitat quality

The most important driver after 2050 for the average habitat quality and after 2030 for the high-quality habitat

Fig. 6. Variation partitioning of simulated caribou habitat quality in 2030, 2050 and 2100. In each bar, the relative importance of climate-induced changes in fire regime, climate-induced changes in stand dynamics and harvesting are shown for both the average habitat quality (a) and the percentage of high-quality habitat (b). Importance was assessed by calculating ω^2-values after a three-way factorial ANOVA. The dark gray area represents residuals.

Projected changes in habitat quality (2100)

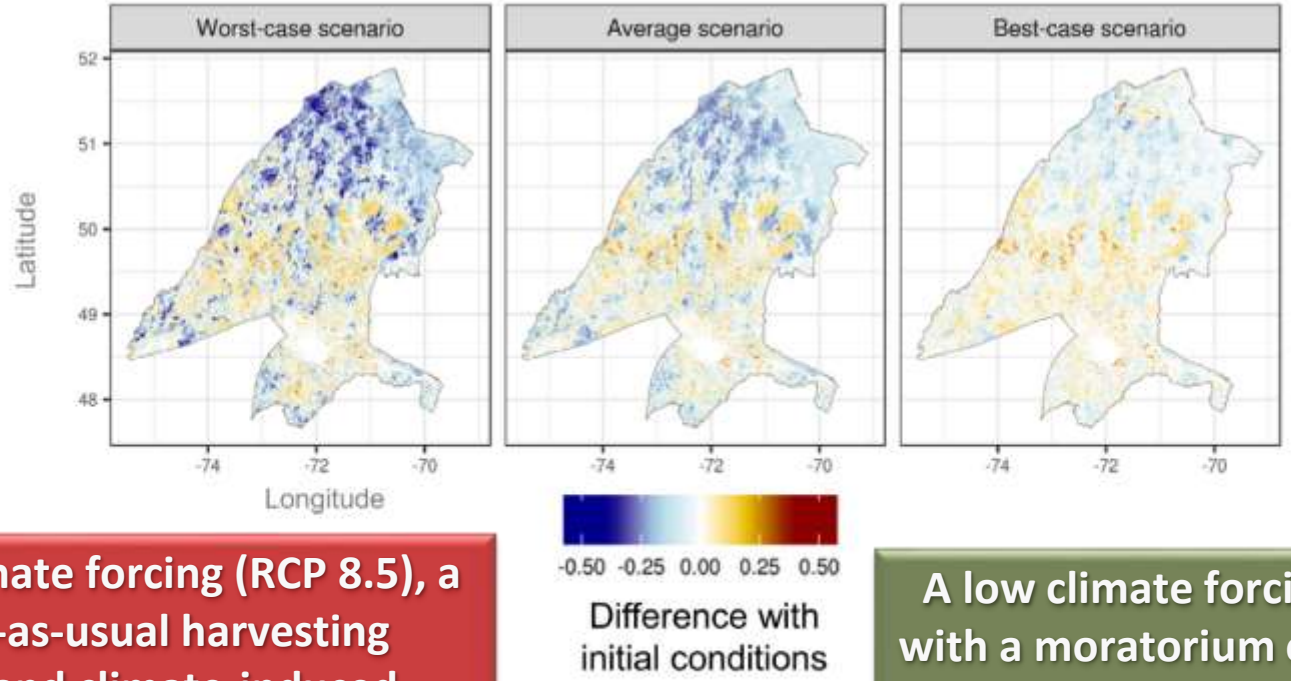
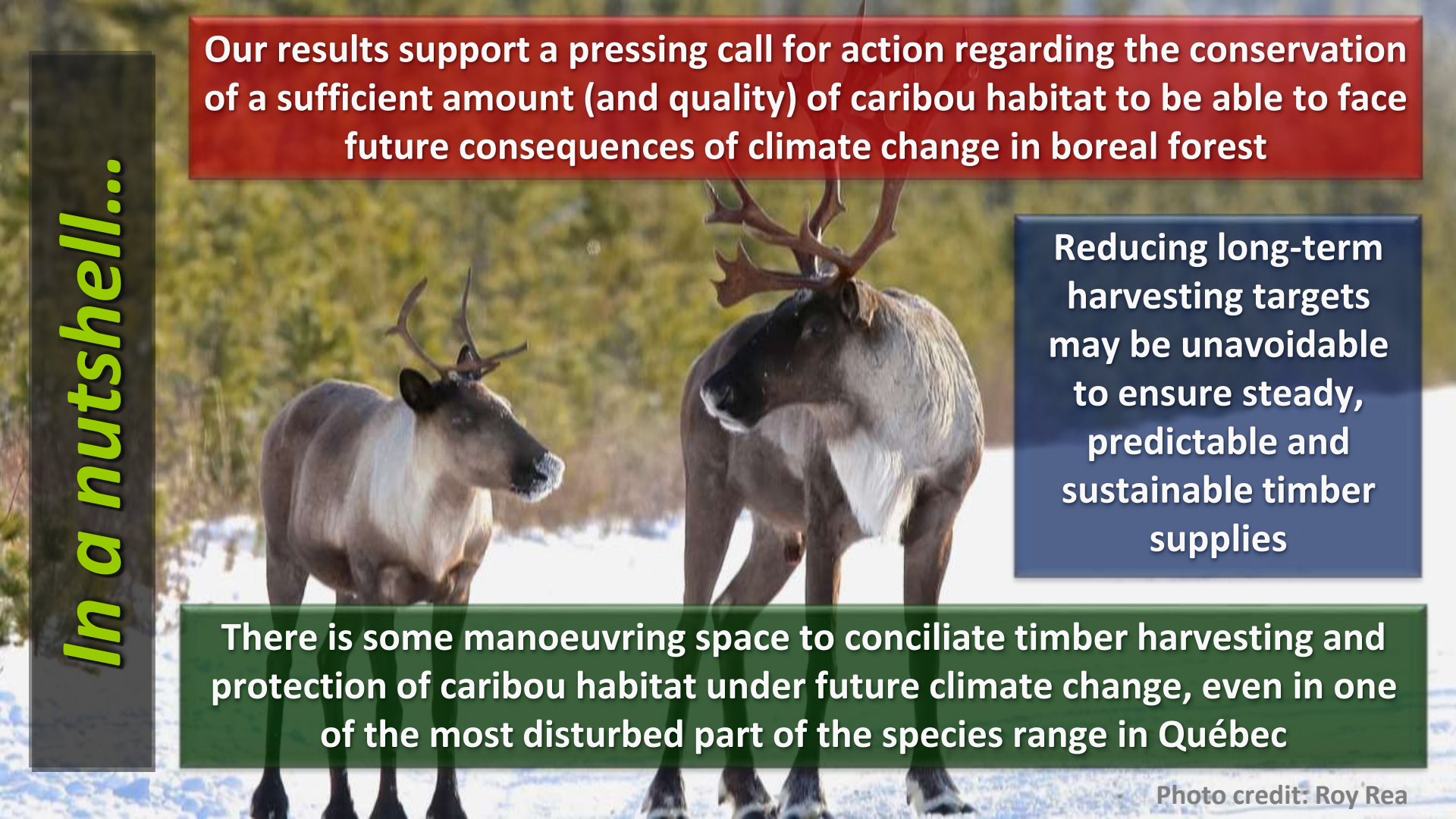


Fig. 5. Projected deviation from initial conditions regarding relative probabilities of occurrence (as a proxy of habitat quality) for boreal caribou in 2100. Only projected (i.e. simulations under RCP 8.5 and 100% harvesting) and best-case scenario (RCP 2.6 without harvesting) scenarios and to compute the average scenario.

A strong climate forcing (RCP 8.5), a business-as-usual harvesting scenario and climate-induced changes in fire regime resulted in a landscape of low-quality habitat

A low climate forcing (RCP 2.6) with a moratorium on harvesting resulted in a subtle increase in average habitat quality



In a nutshell…

Our results support a pressing call for action regarding the conservation of a sufficient amount (and quality) of caribou habitat to be able to face future consequences of climate change in boreal forest

Reducing long-term harvesting targets may be unavoidable to ensure steady, predictable and sustainable timber supplies

There is some manoeuvring space to conciliate timber harvesting and protection of caribou habitat under future climate change, even in one of the most disturbed part of the species range in Québec

Photo credit: Roy Rea

Many thanks to…

C. Dussault, J.-P. Ouellet and S. Légaré (MFFP) for the access to the different GPS telemetry caribou datasets, A.R. Taylor (NRCan) for the calibration and validation of the PICUS gap model, and D.T. Price (NRCan) for tus access to the climate data. Thanks to A. Caron, F. Lesmerises and M. Leclerc (UQAR) for geomatics and statistical support, and K. Malcolm (UQAR).

Natural Resources Canada / Ressources naturelles Canada

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NSERC CRSNG

Environment and Climate Change Canada

Environnement et Changement climatique Canada

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Fondation de la faune du Québec

POUR NOS PÈRES ET NOS ENFANTS

For more details…!

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Global Ecology and Conservation

There is still time to reconcile forest management with climate-driven declines in habitat suitability for boreal caribou

--Manuscript Draft--

Accepted on Sept. 26th !

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Article Type:	
Keywords:	harvesting; Woodland caribou
Corresponding Author:	Mathieu Leblond Environment and Climate Change Canada National Wildlife Research Centre Ottawa, CANADA
First Author:	Mathieu Leblond
Order of Authors:	Mathieu Leblond Yan Boulanger Jesus Pascual Puigdevall Martin-Hugues St-Laurent

Lowering the rate of timber harvesting to mitigate impacts of climate change on boreal caribou habitat quality in eastern Canada

Martin-Hugues St-Laurent [a,*], Yan Boulanger [b], Dominic Cyr [c], Francis Manka [b], Pierre Drapeau [d], Sylvie Gauthier [b]

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[b] *Natural Resources Canada, Canadian Forest Service, Laurentian Forestry Centre, 1055 rue du P.E.P.S., P.O. Box 10380, Stn. Sainte-Foy, Québec, Québec G1V 4C7, Canada*

[c] *Environment and Climate Change Canada, Science and Technology Branch, 351 Boulevard Saint-Joseph, Gatineau, Quebec J8Y 3Z5, Canada*

[d] *Département des sciences biologiques, Centre for Forest Research, UQAT-UQAM Research Chair in Sustainable Forest Management, Université du Québec à Montréal, 141 Avenue du Président-Kennedy, Montréal, Québec H2X 1Y4, Canada*


UQAR
Laboratoire de gestion de la faune terrestre
Photo credit: Nicolas Bradette
Questions…?
martin-hugues_st-laurent@uqar.ca

Limitations

Roads were considered as a fixed landscape feature, so future cutblocks were simulated without creating new roads that would connect these patches to the existing road network

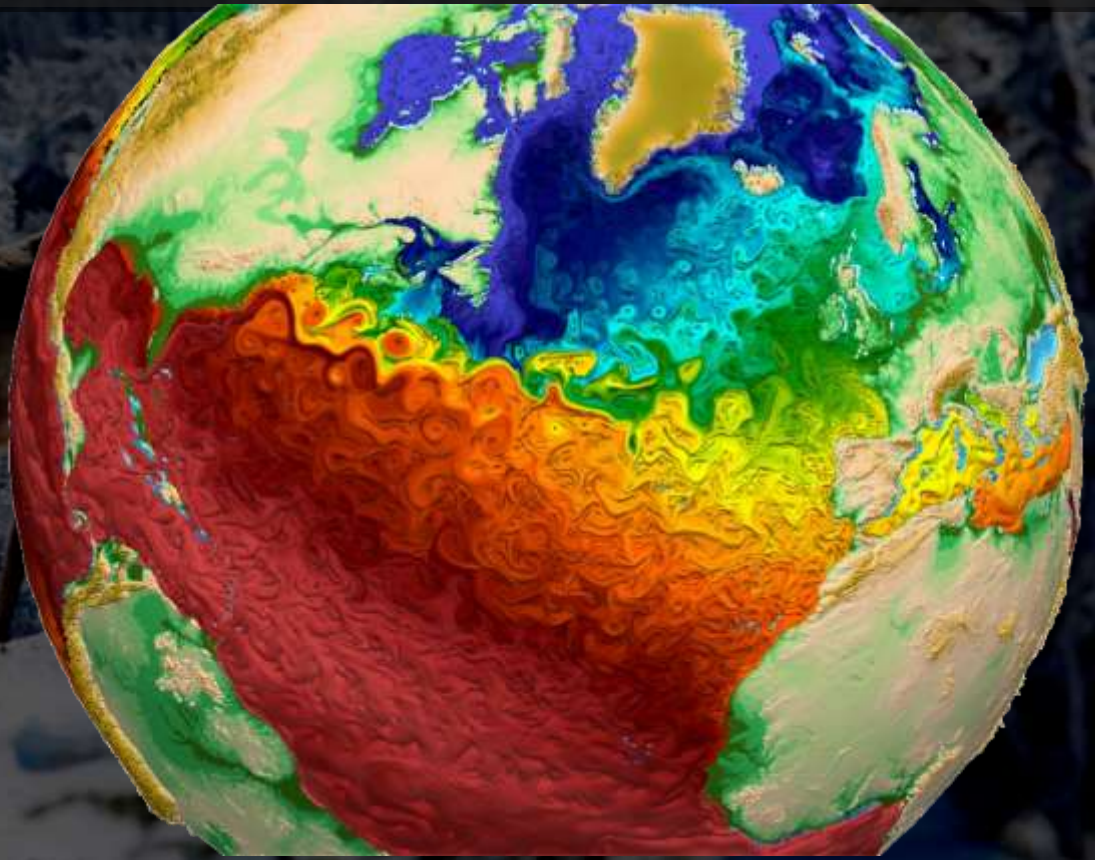
We did not correct for potential feedbacks between land cover change and fire activity, so we potentially underestimated the relative importance of timber harvesting on the long-term (2050-2100)

We fixed the average clearcut rate at 0.45%/yr, which might be considered low compared to what should be expected under sustainable forest management (~0.8%/yr), again underestimating the importance of harvest

We assumed that caribou behaviour will remain constant until 2100, so we excluded any potential for local adaptation among caribou populations, forcing our model to be conservative

Coping with climate change…

One can assume that the mobility of an individual will partly define its capacity to adjust its movements to changing environmental conditions



Climate Change vs. ANTHRO disturbances

Studying these effects simultaneously could help us understand if these drivers shape animal movement additively or synergistically

Synergistic effect may exacerbate negative impacts under future CC…

…or compensate some of the negative impacts depending on the direction of interactions between weather and disturbance-related factors