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Biodiversity offsets and caribou conservation in Alberta: opportunities and challenges

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Abstract: The federal recovery strategy for boreal woodland caribou (*Rangifer tarandus caribou*) sets a goal of self-sustaining populations for all caribou ranges across Canada. All caribou herds in Alberta are currently designated as not self-sustaining and the recovery strategy requires an action plan to achieve self-sustaining status. At the same time, continued natural resource extraction in caribou ranges may be worth hundreds of billions of dollars. Some regulatory bodies have recognized an opportunity for biodiversity offsets to help meet the caribou recovery strategy's goals while still permitting economic benefits of development. In this review, we evaluate offset opportunities for caribou in Alberta and practical impediments for implementation. We conclude that a number of actions to offset impacts of development and achieve no net loss or net positive impact for caribou are theoretically feasible (i.e., if implemented they should work), including habitat restoration and manipulations of the large mammal predator-prey system. However, implementation challenges are substantial and include a lack of mechanisms for setting aside some resources for long periods of time, public opposition to predator control, and uncertainty associated with loss-gain calculations. A framework and related policy for offsets are currently lacking in Alberta and their development is urgently needed to guide successful design and implementation of offsets for caribou.

Key words: Alberta; biodiversity offsets; conservation; habitat restoration; no net loss; woodland caribou.

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Introduction

In an effort to halt escalating global biodiversity loss caused by human development activities, new development projects are increasingly required to achieve no net loss (NNL) or net positive impact (NPI) for biodiversity. Such requirements come from a variety of sources, including governments, lending institutions, and even the corporate sector. Examples of government-driven NNL or NPI requirements are numerous and include the United States wetland policy (Environmental Law Institute, 2002), Canada's fish habitat compensation policy (Pearson *et al.,* 2005), and France's no net loss policy for biodiversity (Quétier *et al.,*

2014). The International Finance Corporation's Performance Standard 6 requires that developers demonstrate an approach to achieve NNL for biodiversity in natural habitats and NPI in critical habitat prior to obtaining a loan from the World Bank (IFC, 2012a), and many other large lending institutions have similar requirements. Several resource extraction and manufacturing companies, including large mining companies such as Teck and Rio Tinto, have adopted voluntary corporate NNL or NPI policies with respect to the impacts of their operations on the environment; by 2013 at least 32 companies had made public commitments to NNL or NPI (Rainey *et al.,* 2014).

Biodiversity offsets are a key mechanism for achieving NNL or NPI and addressing some of the world's most pressing conservation problems. Biodiversity offsets are defined by the Business and Biodiversity Offsets Programme (BBOP) as *"measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken"* (BBOP, 2012a). Offsets can be applied to biodiversity as a whole, but are frequently applied to individual biodiversity elements, such as a habitat type or even individual species, depending on what biodiversity elements are significantly impacted (IFC, 2012a; Bull *et al.,* 2013b). Actions to achieve offsets occur along a continuum of compensation for adverse impacts, but compensation must reach a minimum of NNL before a true offset is achieved (BBOP, 2012a).

Offsets should be employed only as the final step of the standard mitigation hierarchy for development projects, which includes avoiding adverse effects where possible, minimizing adverse effects to the extent feasible, restoring biodiversity to the extent practicable through restoration, and finally compensating for any residual effects that could not be otherwise mitigated (Kiesecker *et al.,* 2010; Saenz *et al.,* 2013). Offsets should achieve long-term conservation outcomes (IFC, 2012b), lasting at least as long as the impacts from the project (Bull *et al.,* 2013a). Offsets are typically achieved through three primary types of actions: financial mechanisms, protecting existing biodiversity that might otherwise be lost, and enhancing existing biodiversity through management actions (Poulton, 2014).

Biodiversity offsets have received much attention over the last decade and are increasingly advocated as a conservation tool (Bull *et al.,* 2013a). However, with the exception of compensation for fish habitat, offsets have not been widely applied in Canada. This is now changing with increasing pressure for application of offsets in Alberta (Dyer *et al.,* 2008; ABCOG, 2009), and regulatory requirements to maintain critical habitat as defined under Canada's *Species at Risk Act*.

Conservation of boreal woodland caribou ([*Rangifer tarandus caribou*], hereafter caribou), which are a species listed federally as 'Threatened' on Schedule 1 of the *Species at Risk Act* (Species at Risk Public Registry, 2014) and provincially as "At Risk" (AESRD, 2010), is among the most pressing issues for which offsets are being considered in Alberta (Habib *et al.,* 2013). Most of Alberta's caribou populations are declining rapidly (Hervieux *et al.,* 2013), generating international attention and numerous appeals to limit development in Alberta's caribou ranges (e.g., ALT, 2009; Boutin, 2010; Ethical Consumer, 2010). On the other hand, development in Alberta's caribou ranges contributes significantly to the Canadian economy and opportunity costs associated with protecting all of Alberta's caribou ranges (i.e., avoiding all future impacts) have been estimated to be in excess of 100 billion dollars (Schneider *et al.,* 2010).

In theory, offsets designed to achieve NNL or NPI for caribou could simultaneously support both development and caribou conserva-

tion; however, such offsets may prove difficult to achieve in practice. Demonstrations of NNL or NPI for biodiversity as a consequence of large development projects are few, and offset implementation rarely meets the conceptual principles applied during planning (Fox & Nino-Murcia, 2005; Bull *et al.,* 2013a). In Canada, for example, 67% of fish habitat compensation failed to meet objectives and resulted in net losses of habitat area (Quigley & Harper, 2006a). Moreover, government NNL or NPI policies may not be successful because organizations to govern such policy or institutional frameworks to evaluate and enforce them have not been created, and/or because the appropriate legal framework permitting implementation of offset requirements is not in place (Quétier *et al.,* 2014).

The purpose of this review is to better understand the opportunities and challenges associated with developing a caribou offset strategy in Alberta and improve the potential for successful offset applications. We have organized our review into sections presenting: 1) the causes of caribou decline in Alberta, 2) a review of recent regulatory mechanisms and decisions recommending or requiring caribou offsets, 3) a theoretical discussion of offset opportunities for caribou, 4) an investigation of the practical challenges associated with implementing caribou offsets, and finally 5) our conclusions and recommendations for a successful offset application.

Causes of caribou decline in Alberta

In order to identify opportunities to efficiently and effectively offset adverse effects of a development project to a particular biodiversity value, one must first understand the proximate and ultimate drivers of change for that value, even when they may not be immediately linked to activities of a project. In the case of caribou in Alberta, substantial research over the last 3 decades has clearly identified causes of rapid decline (Hervieux *et al.,* 2013). To achieve measurable conservation outcomes of NNL or better for a development project in a cost effective way, offsets must focus efforts on addressing the most important of these causes.

Available evidence overwhelmingly indicates that predation is the primary proximate factor limiting caribou populations (Bergerud, 1988; Stuart-Smith *et al.,* 1997; James & Stuart-Smith, 2000; Boutin *et al.,* 2012; Hervieux *et al.,* 2013; Latham *et al.,* 2013). Increased predation can largely be attributed to a phenomenon known as apparent competition (Holt, 1977) where growing number of predators, such as wolves (*Canis lupus*), increase in tandem with the number of primary ungulate prey, such as white-tailed deer (*Odocoileus virginianus*), to the detriment of secondary prey species, such as caribou. White-tailed deer have increased substantially in northeast Alberta in recent decades (Dawe, 2011; Latham *et al.,* 2011a), resulting in a near doubling of the wolf population in the west side of the Athabasca River caribou range from approximately 6 wolves/1000 km^2 in the mid 1990's to more than 11 wolves/1000 km^2 in 2005-2009 (Latham *et al.,* 2011a), and probably in most other caribou ranges (Hervieux *et al.,* 2013). Other predators such as cougars (*Puma concolor*) and black bears (*Ursus americanus*) may also contribute to caribou declines in some places, and white-tailed deer increases have been linked to cougar population increase and expansion in Alberta, including into caribou range (Knopff *et al.,* 2014).

Although predation is the proximate cause of decline, changing predator-prey dynamics in Alberta's caribou ranges are ultimately driven by broader landscape-level habitat changes caused by agriculture, forestry, oil and gas, and climate change, which are creating increasingly favorable conditions for species like white-tailed deer (Dawe, 2011; Boutin *et al.,* 2012). Specifically, anthropogenic development is creating more early successional or other habitats with higher

forage potential for non-caribou ungulates. In addition to increasing the number of predators on the landscape, anthropogenic development in caribou range may facilitate increased wolf movements into caribou habitats along linear features such as roads, pipelines and seismic lines, which can increase encounter rates between wolves and caribou, thereby increasing predation (Latham *et al.,* 2011b; DeCesare, 2012; McKenzie *et al.,* 2012). Wolf use of linear features to make forays into caribou habitat may be especially high during summer when wolves focus hunting efforts on prey such as beavers (*Castor canadensis*) that tend to be found in the same habitats as caribou (Latham *et al.,* 2013).

Less well understood are possible changes in caribou carrying capacity as a result of anthropogenic development. Forage availability is, of course, fundamental to the persistence of caribou populations (Darby *et al.,* 1989). Some studies have found that caribou avoid anthropogenic disturbances such as seismic lines, roads, or forestry cutblocks (Dyer *et al.,* 2001), and cutblocks in particular may reduce available forage over long periods of time (Herbert & Weladji, 2013). Other developments such as oil sands mines completely remove caribou foraging opportunities over large areas. However, forage quantity and quality probably does not limit non-migratory caribou populations (McLellan *et al.,* 2012). Indeed, because caribou may avoid areas of high forage quality that also have high predation risk (Briand *et al.,* 2009), addressing the predation problem could both improve survival and recruitment and provide recovering caribou populations with additional access to high quality forage resources.

Consequently, to achieve measureable conservation benefits for caribou, caribou offsets focused on managing large mammal predator-prey dynamics in caribou range may prove to be most effective. Until the predation problem has been addressed, actions focused on creating new habitats, more forage, or otherwise increasing landscape-level carrying capacity may fail to improve caribou conservation prospects in the short term. Over the long term, creating new habitats through restoration activities will be essential to address the ultimate cause of caribou decline (Hervieux *et al.,* 2013).

Regulatory requirements for caribou offsets

In 2012, the Government of Canada released a federal recovery strategy that aims to achieve "self-sustaining local populations in all caribou ranges throughout their current distribution in Canada, to the extent possible" (Environment Canada, 2012a, p. 19). The status of 51 identified local caribou populations include 26 that are "not self-sustaining", 10 that are "as likely as not self-sustaining", 14 that are "self-sustaining", and 1 is "unknown". Where populations are not self-sustaining, the federal strategy dictates that recovery actions be implemented. All of the populations in Alberta (n=12) are considered "not self-sustaining" (Environment Canada, 2012a).

To achieve acceptable probability of a self-sustaining caribou population (i.e., 60%), the recovery strategy sets a target of at least 65% undisturbed habitat within each caribou range. The proportion of undisturbed habitat within Alberta's 12 caribou ranges varies between 5% and 43% (Environment Canada, 2012a). Because critical habitat for caribou has been identified and a disturbance threshold within critical habitat has been set, developments can theoretically be stopped under Canada's *Species at Risk Act* should the development compromise the ability of a range to maintain or be restored to 65% undisturbed habitat.

The recovery strategy is based on a habitat disturbance threshold because the probability of a population being self-sustaining is linked to the proportion of disturbed habitat contained within its range (Environment Canada,

2012a). Environment Canada (2011) concluded that the percentage of range disturbed, defined as all anthropogenic disturbances plus a 500 m buffer and all areas burned in the last 40 years, best explained the variation in calf recruitment across 24 ranges, which probably also reflects the extent to which the predator-prey system has changed. The 500 m buffer around anthropogenic disturbances not only captured the effects of habitat loss but also those related to fragmentation and spatial configuration of disturbances (Environment Canada, 2011). Hervieux et al.'s (2013) evaluation of caribou demographics in Alberta supported Environment Canada's habitat-based approach linking range condition and population viability. Habitat creation through caribou offsets for each newly approved project is one way to work towards achieving recovery strategy habitat intactness goals (i.e., if NPI is achieved), or at least to prevent further reductions of undisturbed habitat within critical habitat ranges already below 65% undisturbed habitat (i.e., if offsets achieve NNL).

Some regulatory bodies within Canada have begun to request or require caribou offsets as part of review panel recommendations or approval conditions for new development projects in caribou ranges. Recently issued project approvals recommending or requiring offsets for caribou are summarized in Table 1. Guidance from the National Energy Board on offset plan design has evolved with each project decision as more detailed requirements have been included in project decisions over time. Projects reviewed by joint federal and provincial panels have offset considerations limited to recommendations, as opposed to conditions.

Offset opportunities

In theory, actions to achieve a caribou offset can take a variety of forms. Based on our review of the causes of caribou decline, we investigated four types of actions that might achieve a caribou offset: 1) protecting existing caribou habitat that might otherwise be lost, 2) restoring disturbed caribou habitat, 3) manipulating the predator-prey system to reduce predation rates, and 4) in lieu fees.

Regardless of which type of action or combination of actions is used, at least NNL must be demonstrated to achieve an offset. Demonstrating NNL or NPI entails some method of measuring losses as a result of development and gains as a result of conservation actions (Quétier & Lavorel, 2011; BBOP, 2012b). The ideal measure, or currency, to use for offsets focused on a single species, such as caribou, is the number of individuals in the population (Doherty *et al.,* 2010), or a surrogate that accurately reflects this. Gains measured using the selected currency must demonstrate additionality relative to a counterfactual in an amount equal to or greater than the losses incurred from the project. Additionality means that the conservation actions undertaken as part of a development project must be over and above actions planned without the project (BBOP, 2013). A counterfactual is a measurement of what might have occurred without implementation of the conservation action (Bull *et al.,* 2014).

Protecting existing caribou habitat that would otherwise be impacted achieves what is known as an averted loss offset. Averted loss offsets can be problematic because they would still result in a net decline in caribou populations relative to existing conditions (Maron *et al.,* 2012). However, averted loss offsets still produce an advantage compared to a case where all development were to proceed, and such offsets can be acceptable where background rate of habitat loss is high and protective legislation and mandatory compensation policies are not in place (Gibbons & Lindenmayer, 2007; Maron *et al.,* 2012).

The most common method of achieving an averted loss offset is to apply some mechanism of permanent protection to land that is other-

Table 1. Project approvals during 2011-2013 recommending or requiring the implementation of caribou offsets in Alberta.

Project	Project Description	Regulator	Location	Offset Requirements	Source
NOVA Gas Transmission Ltd. Horned River Project	Construction of a new natural gas pipeline consisting of approximately 72 km of 914 mm outside diameter pipe, 2.2 km of 610 mm outside diameter pipe, and related facilities.	National Energy Board	NW Alberta / NE British Columbia	NGTL shall file with the Board, prior to requesting leave to open, a plan which describes measures to offset unavoidable and residual impacts to boreal woodland caribou habitat identified by NGTL within the Footprint. For the purposes of this Project, offset measures for boreal woodland caribou do not include actions that require land acquisition, replacement or substitution of habitat, habitat compensation, terrestrial no-net-loss measures or the regional application of mitigation strategies.	NEB, 2011
NOVA Gas Transmission Ltd. Northwest Mainline Project	Construction of three new natural gas pipeline loops totaling 111.2 km, of which 103.8 km is alongside existing disturbances. Project requires a minimum 32 m wide right of way for its entire length.	National Energy Board	NW Alberta / NE British Columbia	NGTL shall file with the Board for approval a plan to offset all unavoidable and residual Project-related effects to caribou habitat within the Chinchaga caribou range. The plan shall describe measures that would offset all effects identified in the quantitative and qualitative assessment to be conducted as part of Condition 7(b)(vi)[1]. NGTL shall file with the Board for approval […] a plan for monitoring the caribou habitat restoration and offset measures implemented […].	NEB, 2012a
NOVA Gas Transmission Ltd. Leizmer to Kettle River Crossover Project	Construction of 77 km of new natural gas pipeline and associated facilities. Approximately 55 km parallels existing linear disturbances.	National Energy Board	NE Alberta	NGTL shall file with the Board for approval […] a preliminary and final versions of a plan to offset all residual Project-related effects resulting from directly and indirectly disturbed caribou habitat, after taking into account the implementation of the EPP [environmental protection plan] and CHRP [caribou habitat restoration plan] measures. NGTL shall file with the Board for approval […] a program for monitoring and verifying the effectiveness of the caribou habitat restoration and offset measures implemented as part of the CHRP and Offset Measures Plan.	NEB, 2012b

Table 1 continued.

Project	Project Description	Regulator	Location	Offset Requirements	Source
Shell Canada Energy Jackpine Mine Expansion Project	Amendment to expand an existing open pit oil sands extraction mine. Addition to include additional mining areas, and associated processing facilities, utilities and infrastructure. Increase production capacity by 15,900 m^3/day dry bitumen.	Alberta Energy Regulator and Canadian Environmental Assessment Agency (joint review panel)	NE Alberta	The Panel recommends that […] the Governments of Canada and Alberta consider the need for conservation offsets to further mitigate project effects. The potential use of conservation offsets should include a consideration of the need to compensate for project effects to wetland-reliant species at risk and migratory birds that are wetland-reliant or species at risk. […] The Panel further recommends that during development of the biodiversity management framework, consideration be given to principles such as no net loss of caribou habitat, limiting linear disturbances in critical caribou habitat, and restoration of historical and present caribou ranges.	AER & CEAA, 2013
Northern Gateway Pipelines Inc. Northern Gateway Pipeline Project	Construction of a new oil product pipeline spanning 1,178 km and associated facilities. Project application identified a 1 km wide right of way along the entire route.	National Energy Board	Alberta / British Columbia	Northern Gateway must file with the NEB for approval […] an Offset Measures Plan for each affected caribou range to offset all residual Project-related effects resulting from directly- and indirectly-disturbed caribou habitat […] Northern Gateway must file with the NEB for approval […] a program for monitoring and verifying the effectiveness of the caribou habitat restoration and offset measures implemented as part of the CHRP and Offset Measures Plan.	NEB, 2013

Notes: NGTL = NOVA Gas Transmission Ltd.; NEB = National Energy Board; CHRP = caribou habitat restoration plan; NE = north-east; NW = north-west.

[1] Condition 7(b)(vi) refers to a quantitative and qualitative assessment of the area of caribou habitat within the Chinchaga caribou range that was directly and indirectly disturbed as a result of construction of the Project. The assessment shall identify and assess the caribou habitat to be mitigated for as a result of the implementation of the Caribou Protection Plan and Caribou Habitat Restoration Plan, as well as identify the remaining residual effects.

wise under legitimate threat of disturbance. For caribou in Alberta this type of offset could be achieved by protecting land that occurs in caribou range and would otherwise be developed. A theoretical example of an averted loss offset would be an oil sands development identifying and protecting an area of caribou habitat that otherwise would be disturbed by an approved forestry operation and that supports an equal or greater number of caribou than the land disturbed by the oil sands development.

Active management interventions are required to achieve caribou offsets that provide NNL or NPI relative to baseline conditions. Caribou populations are linked to their habitat (Environment Canada, 2012a), much of which has been previously disturbed and has not been reclaimed. Restoration efforts to offset the impacts of a new development project on caribou populations can target historic disturbances. This includes reclaiming historic disturbance on public lands, but may be especially effective in areas that were previously disturbed but now reside in newly created conservation areas protected under provincial land-use plans, such as the Lower Athabasca Regional Plan (Government of Alberta, 2012).

Given that anthropogenic disturbances and areas deforested by wildfires within the last 40 years cover 57 to 95% of caribou ranges in Alberta (Environment Canada, 2012a), we can confidently assume that there exist many opportunities to reclaim forested habitat preferred by caribou in each of Alberta's 12 caribou ranges. Habitat restoration can be implemented using different techniques depending on disturbance type and local site conditions. Treatments such as mounding, tree planting, tree/shrub transplanting and spreading of coarse woody debris can accelerate natural reforestation or encourage reforestation on sites that otherwise might remain a shrubland or grassland (Coupal & Bentham, 2014).

Reclaiming historic linear features such as trails, seismic lines, and abandoned roads is a logical first step given their prominence on Alberta's landscape and potential importance for caribou predator-prey relationships (Latham *et al.,* 2011b), but reclaiming any disturbance in caribou range would likely count towards an offset. To meet the requirement of additionality, restoration activities must target disturbances outside the proponent's approved project footprint that have not recovered either due to environmental conditions (e.g., cold, wet soils) and/or historical clearing and restoration practices, such as mulched seismic lines, admixing of soils during facilities construction, low-blading during access clearing, and seeding of grasses on reclaimed areas.

Offsets achieved by active restoration of previously disturbed areas away from the project can be implemented directly by project proponents, or provided through a conservation bank managed by a third party. A conservation bank is an offset generated by a third party that develops and controls the offset and subsequently sells it, in whole or in part, to developers. Conservation banks provide an opportunity to combine habitat protection (i.e., averted loss), restoration (e.g., reforestation), and enhancement (e.g., reduced white-tailed deer density), and most importantly, would ensure the creation of offset credits before development occurs. Third party offset banking is the preferred offset approach under the US federal wetland compensatory mitigation system (Gardner *et al.,* 2009), and could be applied to caribou.

Most offsets focus on conservation actions that benefit habitat, and habitat restoration is likely the only way to address the ultimate causes of caribou population decline and achieve the federal recovery strategy goal of self-sustaining caribou herds (Hervieux *et al.,* 2013). However, because predation is the central proximate cause of caribou decline, predator management may be required to stop caribou declines in the short term (Boutin *et al.,* 2012; Hervieux *et al.,*

2013; Hervieux *et al.,* 2014), and offsets focusing on actions to reduce predation may have some of the strongest immediate benefits for caribou.

Although not a traditional habitat-based offset, actively managing interactions between caribou and their predators addresses the most immediate threat to caribou. Similar non-traditional offset actions have been proposed elsewhere. For example, impacts of unintentional bycatch of seabirds from the fishing industry may not be best addressed by focusing on the industry itself; instead knowing that a much greater source of seabird mortality results from nest predation from invasive predators provides opportunities to deliver offsets using predator control (Pascoe *et al.,* 2011). Another proposed application of non-traditional offset is to fund anti-poaching efforts to improve conservation prospects for saiga antelope (*Saiga tatarica*) in Uzbekistan and Kazakhstan, where traditional protected area offsets cannot achieve NNL because saiga migrate over large areas and the primary cause of decline is poaching, not habitat loss (Bull *et al.,* 2013b).

Managing interactions between caribou and their predators can take a variety of forms. One option is to take action to directly reduce wolf populations. Wolf control measures, including aerial gunning and poisoning, have been implemented by the Government of Alberta in the Little Smoky Caribou Range since winter 2005-2006 (ASRD and ACA, 2010; Hervieux *et al.,* 2014). These measures appear to have been effective; the Little Smoky caribou population growth rate increased and the population has stabilized (Hervieux *et al.,* 2013; Hervieux *et al.,* 2014).

Environment Canada (2012a) and the Government of Alberta (2011) highlight that maintenance and recovery of caribou is unlikely to succeed without the implementation short-term predator management. By contributing to such efforts, developers can partially offset some of the adverse impacts they have on caribou. This type of management action would need to be implemented by the appropriate government body (i.e., Fish and Wildlife Division) as project proponent and third parties do not have jurisdiction over wildlife management.

Increasing wolf populations in northern Alberta appear to be driven by invading white-tailed deer (Latham *et al.,* 2011a). Consequently, direct control measures also could be applied to white-tailed deer, which should elicit a numerical response in the wolf population and presumably reduce the predation pressure on caribou (Serrouya, 2013; Wittmer *et al.,* 2013; Serrouya *et al.,* 2015). However, we caution against the use of primary prey reductions as an offset mechanism in isolation of other management actions such as wolf control. Without simultaneously controlling wolves, reducing non-caribou ungulate populations could cause wolves to switch to killing more caribou before their numbers fall, exacerbating instead of relieving predation pressure on caribou (Wittmer *et al.,* 2013; Serrouya *et al.,* 2015). Similar to wolf control, reductions in white-tailed deer would require implementation by government; however, hunters could play a key role if the approach involves liberalizing harvest quotas.

Another method of changing predation rates on caribou is the use of predator fencing. Caribou calf survival is typically low, with the highest rate of mortality occurring in the first month after birth (e.g., Stuart-Smith *et al.,* 1997; Mahoney & Virgl, 2003; Gustine *et al.,* 2006). Juvenile recruitment rates are important determinants of population dynamics (Gaillard *et al.,* 1998); in Alberta caribou recruitment is very low due to high predation, ranging from 0.100 to 0.206 calves/cow (Hervieux *et al.,* 2013). Improving calf survival could therefore constitute an offset action. By corralling female caribou into maternity pens, equipped with predator-proof fencing, while they give birth and for the first few months of the newborn

calf's life, recruitment may improve. Maternity pens have been previously implemented in Alberta (Smith & Pittaway, 2011), the Yukon (CCRT, 2010), and in British Columbia, where pens have been developed through partnership among industry, First Nations, and the provincial government (Hume, 2014). Industry contribution to such a project may contribute to or meet offset requirements for a new development, depending on the magnitude of the development and of the benefit from the maternity pen. Although not without risk, predator fencing also might be extended beyond maternity pens to encompass larger areas that could support the entire caribou lifecycle, similar to conservation fencing implemented in other parts of the world (Hayward & Kerley, 2009).

The recovery goal for caribou targets self-sustaining populations in each caribou range. Active management of predator-prey interactions by controlling predators and non-caribou ungulates and constructing fences may sustain a caribou population artificially, but when active management ceases, caribou decline towards extirpation may begin anew. In such cases, caribou populations would not meet the self-sustaining requirement of the federal recovery strategy. Predator control can be part of an offset strategy, but is an interim solution to a problem that requires substantial change in habitat such that the carrying capacity for non-caribou ungulates and the predators they feed is significantly reduced. Reclaiming disturbed habitats to mature forests that support caribou but contain minimal forage for other ungulates would be required with predator control.

Lastly, in lieu fees represent payments set by a regulator and made by a developer according to a predetermined fee schedule to finance actions that lead to an offset. Such payments are convenient for developers because costs of the offset are clearly defined up front and the developer is not responsible for designing or implementing the offset. In lieu fees can work to achieve a caribou offset, as defined by BBOP (2012a), only if they fund actions that achieve a NNL or better conservation outcome. Consequently, these financial mechanisms require the regulator, or a third party, to implement actions already described. Although in lieu fees have not been formally identified as an option for caribou in Alberta, the Government of British Columbia has proposed payment of a predetermined fee per hectare of caribou habitat disturbed as an offset mechanism for future development projects (MFLNRO, 2012). The proposed amount paid increases from $1250/ha to $10 000/ha as one moves from 'low value' caribou habitat to 'very high value' caribou habitat (MFLNRO, 2012).

Implementation challenges

Achieving NNL or NPI for caribou through careful application of the mitigation hierarchy, including offsets, represents an ambitious and laudable environmental goal and, in theory, there are several actions that might be implemented to achieve this for caribou. However, as good as offset theory may be, implementing offsets in practice has proven challenging. Measurable conservation outcomes that achieve NNL and NPI have rarely been demonstrated (Quigley & Harper, 2005 and 2006b; Burgin, 2010). Indeed, the concept of biodiversity offsets has recently been criticized by academics and non-government organizations (NGOs) for achieving the opposite of what it intends; instead of biodiversity conservation, offsets sometimes create a "license to trash" because developers receive approvals for their developments based on a promise to offset that cannot be realized or for which actions are not appropriately implemented (e.g., ten Kate *et al.,* 2004; Matthews & Endress, 2008; Walker *et al.,* 2009; Burgin, 2010).

Failure to implement appropriate action to achieve an offset can have a variety of causes,

and effective implementation of caribou offsets in Alberta requires that these are overcome. Potential problems include inconsistent interpretations of NNL (Gardner *et al.,* 2013); lack of information required to clearly assess and quantify project impacts (Brownlie *et al.,* 2013); failure to identify impacts that cannot be offset under any circumstance (Norton, 2009; Bull *et al.,* 2013a); inappropriate use of metrics or currencies (Quigley & Harper, 2006b; Walker *et al.,* 2009; Doherty *et al.,* 2010; Bull *et al.,* 2013a; Gardner *et al.,* 2013); non-compliance with regulations and lack of enforcement (Quigley & Harper, 2006a; Matthews & Endress, 2008; Norton, 2009); failure to use appropriate offset ratios (Quigley & Harper, 2006b; Moilanen *et al.,* 2009); implementation without prior evidence of technical feasibility or effectiveness (Gibbons & Lindenmayer, 2007); inadequate regulatory framework and government oversight (Quétier *et al.,* 2014); and lack of monitoring and maintenance (Brown & Lant, 1999; Quigley & Harper, 2006b).

Perhaps the most important challenge that applies to all offset opportunities summarized in this paper is that there currently is no clear guidance or framework for offset requirements in Alberta. Provision of key design elements for offsets provided through a comprehensive offset framework and policy would greatly improve the effectiveness of offset implementation (e.g., Quétier *et al.,* 2014). Proponents requiring offsets in Alberta currently have little guidance on basic standards and performance criteria such as (i) offset currency, (ii) loss-gain calculations, (iii) equivalency and 'trading up' (e.g., Bull *et al.,* 2013a; Habib *et al.,* 2013), (iv) uncertainty and time lags, (v) duration, and (vi) monitoring requirements and appropriate indicators.

An offset policy is required to identify what actions constitute permissible offsets and to ensure that offsets are consistently applied across development projects. Recent applications of caribou offsets in Alberta have been either voluntary or individual offset plans required by regulators (Poulton, 2014). Although these one-off project-specific offsets can effectively compensate for impacts to caribou at the local project scale, they are unlikely to contribute to broader landscape conservation strategies and outcomes if they are not coordinated with regional plans or initiatives (Kiesecker *et al.,* 2010). On the other hand, if offset requirements are regulated and standardized, land managers can more readily incorporate offset actions into broader initiatives (Poulton, 2014). Previous consideration of offsets in Canada (DFO, 1986; Government of Canada, 1991; Lynch-Stewart, 1996; Environment Canada, 2012b; DFO, 2013; Poulton, 2014), could serve as useful building blocks for policy makers and environmental practitioners tasked with developing effective and efficient offset plans for caribou.

Even if a regulatory framework were established, implementation of theoretical options for caribou offsets is not straightforward. Financial mechanisms, for example, typically include fees paid to support caribou and wolf monitoring programs, maternal pens, as well as other research and outreach programs (MFLNRO, 2012). Although worthwhile endeavours, monitoring, research, and outreach do not typically deliver measurable conservation outcomes and therefore do not provide offsets. Although the simplest option for developers, the risk associated with financial offsets is that the funds do not deliver the direct conservation outcomes required to achieve NNL or NPI. Adequate means of defining on-the-ground benefits of actions implemented using funds generated from financial offset requirements are needed to demonstrate success of this approach, but guidance for achieving this for caribou is not currently available. The US regulations governing compensatory mitigation for wetlands and other aquatic resources can provide useful guid-

ance for a payment program (Gardner *et al.,* 2009). Achieving specific milestones and performance standards prior to the release of offset credits is a central consideration of the regulation and emphasizes the importance of timely compensatory actions (Gardner *et al.,* 2009).

Averted loss offsets established by protecting caribou habitat that otherwise would be disturbed are even less straightforward, to the point of being nearly impossible under current provincial legislation. Caribou range in Alberta is almost entirely restricted to public lands which cannot be purchased. The exception is a small tract of private land located in the Chinchaga caribou range in northwest Alberta (http://thecarbonfarmer.ca). There is no established conservation banking system in the province, and even if one existed, private lands that could be purchased and protected or improved primarily occur outside of caribou range and would not benefit caribou.

Extinguishing development rights on public land in Alberta also is prohibited and averted loss offsets cannot be achieved by one industry paying for another not to develop (e.g., an oil and gas company cannot purchase development rights from a Forestry Management Agreement holder). The petroleum and natural gas mineral rights leasing system, guided by the *Mines and Minerals Act*, requires all lease holders to 'prove the mineral resource' by drilling, production or technical mapping. Failure to do so can result in loss of the lease. Some oil and gas producers in the province have indicated that provincial regulators do not always consider technical mapping an acceptable means of delineating the resource, which encourages more drilling and therefore more habitat loss (CAPP, 2013). Hence, setting aside or otherwise not developing an oil and gas lease in caribou range as an averted loss offset for impacts elsewhere does not appear to be an option.

Inability to implement averted loss offsets may not be a substantial constraint for caribou conservation because such offsets do not typically provide NNL or NPI relative to existing conditions; hence, they cannot contribute to the net restoration of habitat required to achieve the caribou recovery strategy objective of achieving self-sustaining caribou herds.

Habitat restoration is the best approach to address ultimate causes of caribou decline and is currently being implemented in Alberta (Coupal & Bentham, 2014). Key problems with habitat restoration are the long time-lag before caribou benefit from the action and uncertainty about loss-gain calculations, restoration success, and the potential for future development programs where habitats have been reclaimed. Boreal forests grow slowly and even with extensive restoration, readjustments to predator-prey systems that are driven by landscape change at broad spatial extents (i.e., north-eastern Alberta) probably will take decades. Despite Environment Canada's (2012a) support for habitat restoration, they fail to provide a formal definition of restored caribou habitat, pointing to a need to develop targets and measureable criteria for restoration. Such targets and criteria are required to determine when an offset is realized.

Some guidance for offset currency is provided by the federal recovery strategy, which uses 65% undisturbed habitat within a caribou range as a surrogate for achieving a self-sustaining population (Environment Canada, 2012a). Surrogate currencies can be useful, but may have risks associated with them if they are not closely linked to the desired outcome (e.g., self-sustaining caribou populations). For example, reclaiming linear features may provide the greatest value for a developer's investment in terms of demonstrating an offset using loss-gain calculations derived from the federal caribou recovery strategy habitat models, but this may not translate into an equal benefit to caribou. Consider a 5 m wide seismic line that extends over 1000 m with no other disturbances near-

by. Because caribou range disturbance metrics in the federal recovery strategy were calculated by applying a 500 m buffer on either side of that seismic line, successful restoration returns 5000 m^2 (i.e., 5 m x 1000 m) of forest, but 1 010 000 m^2 of caribou habitat (i.e., ([500 m x 1000 m] + [5 m x 1000 m]) x 2). Reclaiming 1000 m of seismic line will likely benefit caribou populations, but perhaps not by a factor of over 200 for every habitat unit reclaimed.

Uncertainty around loss-gain calculations and restoration success, along with any time-lags prior to achieving functional habitat also may require offset multipliers that are unachievable, depending on how loss-gain calculations are implemented. Curran *et al.,* (2014) suggest ratios required to achieve a true NNL offset through habitat restoration may be as high as 100:1, which is much higher than typically applied ratios less than 10:1 and probably cost-prohibitive for most development projects in Alberta. A better option to address time lags is to have an offset policy requiring demonstrated conservation outcomes ahead of development, which would reduce the required ratio (Gardner *et al.,* 2009; Maron *et al.,* 2012).

There is also the matter of where to implement restoration (or any other offset action). In the context of oil and gas development, a developer may choose to implement offsets by conducting on-lease or off-lease habitat restoration. On-lease restoration provides more certainty that restoration efforts will not be disturbed by future development because the developer exerts more control over the land base, albeit not full control owing to overlapping oil and gas tenures issued in stratigraphic layers and forestry management areas. On the other hand, on-lease restoration is likely to have limited benefits for caribou during the project's operational phase because the restored areas will presumably be located in proximity to existing and/or future disturbances. Off-lease restoration provides the opportunity to target areas of core habitat to maximize the benefit to caribou. The Alberta *Public Lands Act* does not include mechanisms for permanent protection of such restoration efforts; therefore, they are at risk of being destroyed or compromised by other land-users. This deficiency must be addressed to ensure that offsets are in place for the duration of project impacts, and preferably for much longer (Gibbons & Lindenmayer, 2007; McKenney & Kiesecker, 2010; Bull *et al.,* 2013a). Protection of restored sites could be achieved by creating a new disposition type for offsets under the *Public Lands Act* and would require the development of a regulatory review process to approve offset site selection.

To be most effective, caribou habitat restoration activities should consider future development footprint and industrial access requirements, relative quality of adjacent caribou habitat, recreational use by the public, Aboriginal use, caribou occurrence, and provincial habitat restoration priorities for caribou. Weighing competing land-use demands is a challenging process and may require complex and lengthy consultation, but ignoring it may result in failure. For example, recreational all-terrain vehicles use can significantly hinder revegetation efforts implemented at high cost (Coupal & Bentham, 2014).

Resolving issues pertaining to habitat based caribou offsets will be challenging, and even if achieved, probably cannot be implemented without simultaneously addressing predation because habitat values for caribou herds in Alberta are already considered below those required to achieve caribou conservation (Environment Canada, 2012a), because caribou habitat takes a long time to reclaim, and because caribou are in such steep decline that any substantial time-lag may result in conservation failure (Hervieux *et al.,* 2013).

Addressing predation in the short-medium term is necessary, but applying them as offsets is extremely challenging. Management actions

such as predator and/or prey control through aerial gunning or poison directly address the proximate causes of caribou decline and are much more likely to facilitate caribou population persistence, but still present numerous challenges (Hervieux *et al.,* 2014). Wolf control and prey control generally generate negative public perceptions (NRC, 1997; Martínez-Espiñeira, 2006; Van Ballenberghe, 2006), and developers could contribute only through a program implemented by the province, which has the responsibility for directly managing wildlife. Fencing options, especially large-scale predator exclusion fences may work, but also will probably be viewed negatively (Pickard, 2007; Scofield *et al.,* 2011) and may have unintended consequences (Pople *et al.,* 2000; Norrdahl *et al.,* 2002; Long & Robley, 2004; Hayward & Kerley, 2009).

Changes in hunting regulation to encourage greater harvest rates of moose and deer may be more palatable and have been applied previously (Serrouya *et al.,* 2015), but this is also not an offset that can be actioned by a developer. Developers might contribute to these efforts by creating financial incentives for hunters and trappers to reach prescribed quotas for moose, deer and wolves. Implementation of such incentives would likely necessitate lengthy negotiations with government in order to reach an agreement, they may be viewed negatively as "bounties", and their effectiveness relative to aerial control or poisoning is questionable (Webb *et al.,* 2011).

A final challenge to offset implementation is achieving clarity about where offsets, either habitat-based or focused on addressing predation, might be appropriately undertaken. Standard like-for-like approaches indicate that offset sites should be as close as possible to impact sites to ensure that benefits are realized in the same area (McKenney & Kiesecker, 2010); however, the selection of offset locations that best balance proximity to the impact sites with effectively achieving conservation outcomes is often unclear (Kiesecker *et al.,* 2009). For caribou offsets, our interpretation of the federal recovery strategy's goal to maintain or recover all populations within caribou range in Canada (Environment Canada, 2012a) is that any negative impacts to caribou or caribou habitat should be offset within that same range. This added restriction poses an additional challenge by spatially limiting acceptable offset locations. The requirement to offset within a given caribou range precludes the application of the triage-based approach recommended by Schneider *et al.,* (2010). Given that there are limited resources to implement recovery efforts and that population viability varies among herds, Schneider *et al.,* (2010) argue that caribou conservation efforts should focus on probability of success and cost as opposed to risk of extirpation. Considering the Alberta context where resources have been over-allocated in some caribou ranges, we think it prudent that policy makers consider prioritizing caribou offsets where there is a greater probability of success. This approach would consider caribou offsets at the provincial scale with the trade-off of potentially losing herds in highly impacted areas while increasing the odds of successful conservation of other herds.

Conclusions and recommendations

We have discussed offset opportunities for caribou and identified practical challenges associated with them. The prevalence of implementation challenges is not surprising given that the science of offsets is still in its early development stage and government policy has not yet developed to accommodate it. A common challenge for all caribou offset opportunities in Alberta is the lack of framework and policy to guide consistent and appropriate application of offsets. Successful implementation of caribou offsets will depend in part on the development of comprehensive offset framework and policy to

guide project proponents and environmental practitioners. Such framework and policy are urgently needed.

Regulations and policy need to emphasize that offsets are not a panacea. Offsets are the last resort in the mitigation hierarchy and are not a solution to failing to do a good job of avoidance, minimization and rehabilitation/ restoration. The mitigation hierarchy has not always been systematically applied in Alberta's environmental assessment process (Clare *et al.,* 2011; Clare & Krogman, 2013). Project developers and environmental practitioners could benefit from evaluation criteria to help determine when one can defensibly move down the mitigation hierarchy (e.g., move from avoidance to minimization). Clear guidance from government agencies would provide much needed consistency across projects and could prevent bureaucratic slippage (Clare & Krogman, 2013), that is the propensity for broad policies to be changed through successive reinterpretation, such that the ultimate implementation may bear little resemblance to the broad statements of policy intent (Freudenburg & Gramling, 1994).

Habitat restoration is likely the most promising caribou offset strategy for industry given the extensive opportunities for habitat restoration, its technical feasibility, and the fact that maintenance of critical habitat is mandated under the federal recovery strategy. Although habitat restoration has been criticized as an inappropriate offset tool in some cases (e.g., Curran *et al.,* 2014), we argue that this approach is applicable to achieve offsets specifically for caribou because habitats can be restored to a form that is less likely to support alternate prey. Under the current public lands tenure system, no mechanism is in place to secure restoration efforts on caribou ranges and this deficiency must be addressed before restoration can serve as a viable offset strategy.

Time-lags between restoration actions and the provision of measurable offsets means that restoration cannot be the sole solution to caribou recovery. Current levels of population decline dictate that restoration should be used in conjunction with immediate management actions (i.e., manipulations of the large mammal predator-prey system) addressing proximate causes of caribou declines to ensure their persistence over the short and medium-term. These kinds of programs are more difficult for industry to contribute to and may be less commonly used as a caribou offset. Where industry cannot contribute, such programs must remain the responsibility of government (Environment Canada, 2012a; Hervieux *et al.,* 2014).

Given the many challenges of implementing caribou offsets, we think there is much value in considering Schneider et al.'s (2010) triage perspective further. Using a provincial scale for caribou offset site selection would facilitate this approach. Although a triage approach where offsets focus on the least affected herds may mean accepting the loss of some of Alberta's caribou herds, it may also mean that some can be saved while simultaneously developing some of the province's most valuable resources (Schneider *et al.,* 2010). The current policy of exploration and development everywhere all the time and conservation everywhere all the time may result in both conservation failure and higher costs and increased uncertainty for developers.

We recommend that future research focus on evaluating the efficacy of proposed offset strategies for caribou. Further empirical evidence is required to reduce uncertainty and to help policy makers, regulators, project proponents, and environmental practitioners make informed decision on offset design and implementation. Specifically, a caribou offset framework would benefit greatly from understanding the time interval until restored habitat benefits caribou by adjusting predator-prey dynamics, or the scale at which restoration of historic dis-

turbance must occur to achieve a measurable benefit to caribou populations given the scale at which large mammal predator prey systems operate. Similarly, changes in predation rates or caribou populations due to a project are rarely quantified in environmental assessments, making it difficult to estimate what kind of changes to the predator-prey system may be required to offset impacts of a project (e.g., using wolf control, large scale predator fencing, or maternity penning). A better understanding of how to apply multiple offset currencies, including both habitat and predation rates (*sensu* Bull *et al.,* 2013a), would be helpful for loss-gain calculations.

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