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Discussion

Potential pitfalls of private initiatives in conservation planning: A case study from Canada's boreal forest

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ABSTRACT

Large-scale conservation planning entails the establishment of protected area networks that retain substantive natural habitat, biodiversity, and functional connectivity, but developing such networks at the spatial extent needed for meeting global targets involves considerable logistical, political, and social challenges. Normally, governments oversee development of protected area networks, but in the absence of political leadership private initiatives may offer a reasonable alternative approach in conservation planning. We review the Canadian Boreal Forest Agreement (CBFA), a private conservation planning initiative established by forestry companies and environmental organizations that suspends permitted logging activities on roughly 29 million hectares of boreal forest in Canada. The CBFA is touted as a milestone in conservation planning, multi-stakeholder cooperation, and woodland caribou conservation. Yet, the CBFA: 1) involves public land but excludes federal, provincial and aboriginal governments; 2) is not legally binding or necessarily transferrable upon sale of forest tenures; and 3) exempts industrial activities other than logging. Covering 4.6% of the boreal region of Canada, CBFA land tenures do not include most boreal ecozones and do not conform to standard guidelines for designing effective protected area networks. Further, the CBFA does not anticipate effects of climate change, which by 2080 likely will render land tenures unsuitable for caribou, the flagship species of the agreement. We conclude that private initiatives like the CBFA may constitute positive, initial steps toward large-scale conservation planning, but their successful integration into protected area networks will require scientifically robust and transparent efforts that are more fully coordinated with public initiatives.

1. Introduction

There is mounting global interest in establishing protected area networks that span biomes, ecosystems, and political boundaries, to help ensure persistence of representative portions of natural areas and their biodiversity (Chape et al., 2003; Rodrigues et al., 2004). Currently, 12.7% of terrestrial areas worldwide are protected through parks or reserves that restrict human use and exploitation; the target for the year 2020 is protection of 17% of terrestrial areas (Convention on Biological Diversity, 2010). Normally, protected areas are established through government action, and when designed using established standards in conservation planning and accompanied by appropriate governance and management, such areas can contribute substantially to conservation objectives (Bertzky et al., 2012). However, there are daunting challenges associated with establishing truly functional large-scale (i.e., spanning multiple political jurisdictions, biomes, or topographies) protected area networks; these challenges can include a lack of political will or support for such initiatives (Knorn et al., 2012; Brandt et al., 2015). Yet, the absence of political impetus and associated resources may be overcome, at least in part, by initiatives that are spearheaded by industry, land trusts, or other non-governmental entities that either own the land or else oversee its conservation and management.

Increasingly, private protected areas (PPA) are contributing to global conservation efforts; such areas occur on all continents and across a large variety of geographical regions and landscapes (Stolton et al., 2014). In principle, PPAs should adhere to established standards in conservation planning, including protecting natural landscapes with appropriate species composition, and having large size, low edge-to-area ratio, and high functional connectivity (Gaston et al., 2008; Watson et al., 2011). All PPAs should receive some form of legal protection and

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management oversight. As more PPAs are established each year, they may importantly complement traditional protected areas if their design and management conform to established standards and they are integrated into existing or planned networks (Holmes, 2013). However, because PPAs are characterized by a wide range of physical and ecological features and levels of protection, their individual contribution to conservation goals is inconsistent (Stolton et al., 2014). Accordingly, given challenges in meeting global protection targets via traditional parks and reserves alone, it is crucial to assess the potential importance of private initiatives in contributing to conservation targets and large-scale protected area networks.

1.1. The boreal forest of Canada

The present paper reviews the design and importance of a major private initiative, the Canadian Boreal Forest Agreement (CBFA), for protecting large portions of the boreal forest of Canada. The boreal forest is among the largest biomes in the world, and in Canada it spans from the Pacific and Atlantic oceans and encompasses most of the country's landmass, extending into Alaska and northern portions of the contiguous United States (Brandt, 2009). The Canadian boreal forest is unique in possessing large tracts of inaccessible forested land that remain undeveloped (Andrew et al., 2012). The boreal region also includes the largest concentration of freshwater lakes and wetlands in the world, and provides important ecosystem services through capture and storage of carbon and moisture (Brandt, 2009; Kurz et al., 2013). Thus, the boreal forest holds substantive natural value and should receive robust protection to ensure long-term environmental benefits.

The boreal forest region of Canada is becoming increasingly industrialized, with exploitation of wood, hydroelectric, mineral, and oil and gas resources being primarily located across the region. In Canada, most forested lands are 'crown lands', with public ownership and industrial activity being authorized through government approval under a land tenure system. Overall, 56% (234.5 million hectares) of Canada's forests are classified as commercial, with 28% being actively managed for timber extraction and roughly 0.5% being logged annually, mostly in the boreal region (Schindler and Lee, 2010). Increased industrial development may threaten the integrity of the boreal forest and species residing therein (Venier et al., 2014), especially given that the boreal forest is home to unique ecosystems and endemic plants and animals. For example, woodland caribou (*Rangifer tarandus*) are uniquely adapted to the boreal environment and require large tracts of undisturbed forest to meet their ecological needs; this makes caribou iconic of the boreal forest and indicators of a healthy ecosystem (Festa-Bianchet et al., 2011). Yet, woodland caribou have undergone extensive decline and range recession in the boreal region, largely due to direct and indirect effects of industrial activity, including logging (Schaefer, 2003). Currently, woodland caribou are of significant conservation concern in Canada (Festa-Bianchet et al., 2011; COSEWIC, 2014).

There is mounting interest in establishing sustainable industrial practices that will promote persistence of biodiversity and maintain essential ecosystem services in the boreal forest, while also allowing continued economic and social benefits to be derived. To date, this has been initiated through sustainable forest management and third-party wood certification, which allows certified products to be beneficially marketed; currently, many of Canada's forests are managed according to these guidelines (Natural Resources Canada, 2014). Yet, notwithstanding the broader importance of the forest industry to Canada's economy, the value of ecosystem services provided by the boreal forest outweighs those of its wood products (Schindler and Lee, 2010). Beyond industrial activity, there are additional threats facing the boreal forest, including climate change, which is predicted to impact the boreal region disproportionately relative to most terrestrial biomes (Meehl et al., 2007; Andrew et al., 2014). Climate change could transform the boreal forest at the regional or continental scale via increased temperatures and altered hydrological and geochemical cycles (Schindler and Lee, 2010; Price et al., 2013), and thereby surpass the impact from industrial development, which can be more localized. Therefore, sustainable industrial practices alone will not ensure persistence of the boreal forest, and related socioeconomic prosperity will depend on the effective forecasting of environmental changes in the region and corresponding adjustment and mitigation of human activity.

These concerns highlight the need for effective conservation planning in the boreal forest of Canada, including the development of a robust network of protected areas. However, the boreal forest is underrepresented in protected area coverage compared to other biomes (Sala et al., 2000; Andrew et al., 2014), and currently only 8.1% of Canada's boreal region is protected via traditional parks and reserves (see Supplemental Information). This is below both national (e.g., 12% Environment Canada, 2006; 20% Canadian Boreal Initiative, 2003; 50% Canadian Boreal Initiative, 2005) and global (Brooks et al., 2004; Pouzols et al., 2014) conservation targets. Further, protected area planning for the boreal forest should follow established standards by retaining biodiversity and ecosystem functionality (Moffett and Sarkar, 2006; Gaston et al., 2008; Andrew et al., 2014), which could be a challenge given the spatial extent of the biome and the diversity of species and ecosystems therein.

2. Canadian Boreal Forest Agreement

The CBFA was established in 2010 by 21 member companies of the Forest Products Association of Canada (FPAC) and 9 environmental non-governmental organizations (ENGOs) (full list of signatories available at http://cbfa-efbc.ca/team/; accessed June 1, 2015). The agreement recognizes that the ecological, economic and social values of Canada's boreal forest are best managed through sustainable development and cooperation between stakeholder groups. The CBFA suspends logging activity on roughly 29 million hectares of forest in exchange for cessation of ENGO-driven negative publicity and boycotts targeted at FPAC member companies. FPAC member companies also practice sustainable forest harvest on an additional 42 million hectares of forest. Specifically, the CBFA's strategic goals are to: 1) achieve sustainable forest management through ecosystem management, adaptive management, and third party certification; 2) implement a network of protected areas representing the diversity of ecosystems in the boreal region; 3) recover species at risk in the region, including woodland caribou; 4) reduce greenhouse gas emissions accrued through forestry practices; 5) improve prosperity for the Canadian forestry sector; and 6) provide recognition benefiting forest companies and their products (CBFA, 2010). Since establishment, some of these goals were accomplished (but see Pala, 2011; Gunn, 2013), and the CBFA has become recognized as perhaps the most extensive forest conservation agreement in the world and a model for stakeholder cooperation and sustainable forest management (see Pala, 2010; Dellasala et al., 2012; Reid, 2014).

Despite these laudable accomplishments, aspects of the CBFA beg closer attention. First, the agreement excludes federal, provincial and aboriginal governments even though most of the tenured area is publicly-owned. Governments having jurisdiction over CBFA lands ultimately are expected to turn CBFA land tenures into parks or reserves, but mechanisms for this transfer are not defined in the agreement and to date none have done so (Gunn, 2013). In fact, there remains disagreement among CBFA signatories on the extent of forest protection from the CBFA and allowable activity on some land parcels, leading some signatories to withdraw from the agreement (Pala, 2011). The exclusion of Aboriginal groups is especially problematic because many CBFA tenures overlap with their lands and some have requested that CBFA provisions be removed (Pala, 2011). In light of these problems, the absence of active involvement and oversight from governments is perplexing. Indeed, it is generally understood that government engagement in conservation planning can be crucial by establishing appropriate oversight and anticipating governance and legislative needs (Pressey and Bottrill, 2009).

Second, restrictions on activities on CBFA lands are not necessarily transferred upon sale of forest tenures, meaning that a company can purchase rights to CBFA tenures without having to retain associated restrictions (CBFA, 2010). Indeed, the CBFA is entirely voluntary and non-binding, weakening the assurance that subject lands will be protected in perpetuity. Further, FPAC members (or ENGOs) can unilaterally withdraw from the CBFA pending economic or other circumstances, again, eroding the assurance that the land parcels will receive sustained protection. This weakness highlights that the CBFA concerns lands that are not actually owned by the signatories and that the public owners are not directly involved in the agreement.

Third, while the CBFA covers logging on tenured lands, the agreement excludes other industrial activity on the same lands (CBFA, 2010). Yet, the boreal forest is subject to several types of development and there is no assurance that CBFA protection will preclude other activities. For instance, of the total 29 million hectares of protected lands under the CBFA, >25% are also committed to other industrial activities (coal (0.1%); mining (9.8%); oil (10.9%); natural gas (11.4%) see Supporting Information). In eastern Canada CBFA land tenures have relatively few additional industrial interests, but in western Canada there are often several overlapping industries (Fig. 1).

The International Union for the Conservation of Nature (IUCN) defines a protected area as a recognized geographical space receiving protection and management through legal or other means (Stolton et al., 2014). Based upon the biodiversity attributes and protection status of a given land parcel, the IUCN classifies protected areas into 6 categories, ranging from Strict Nature Reserve (Ia) to Protected Area with Sustainable Use of Natural Resources (VI). Although one of the primary goals of the CBFA is to establish protected areas for the boreal region (CBFA, 2010), at this stage the uncertain governance and inventory of individual land parcels precludes their IUCN classification (see Stolton et al., 2014).

3. Protected area network

In principle, CBFA land tenures could contribute to a protected area network in the boreal forest of Canada. We examined the extent of boreal forest that is either currently contained within established parks and reserves or else occurs in the CBFA land tenures (see Supplemental Information). Currently, 8.1% of Canada's boreal forest is protected within existing parks and reserves; the 29 million hectares in CBFA land tenures encompass 4.6% of the total land mass for the boreal region, as delineated by Brandt (2009). Some CBFA lands are already considered protected, and thus overlap with existing, recognized protected areas. The sum of protected lands in Canada's boreal region, with inclusion of CBFA lands, is 12.6% of the total land mass. Thus, when combined with existing protected areas, CBFA land tenures allow proposed minimum thresholds for global protected area coverage to be met (see Brooks et al., 2004), although this level falls short of the more recent 17% target (Convention on Biological Diversity, 2010). Independently of the CBFA, territorial and provincial governments have proposed through the Boreal Forest Conservation Framework (see www.borealcanada.ca; accessed January 1, 2015) or other entities to protect up to half of their northern forests, which could substantially bolster the total area of protected land in the boreal forest of central Canada.

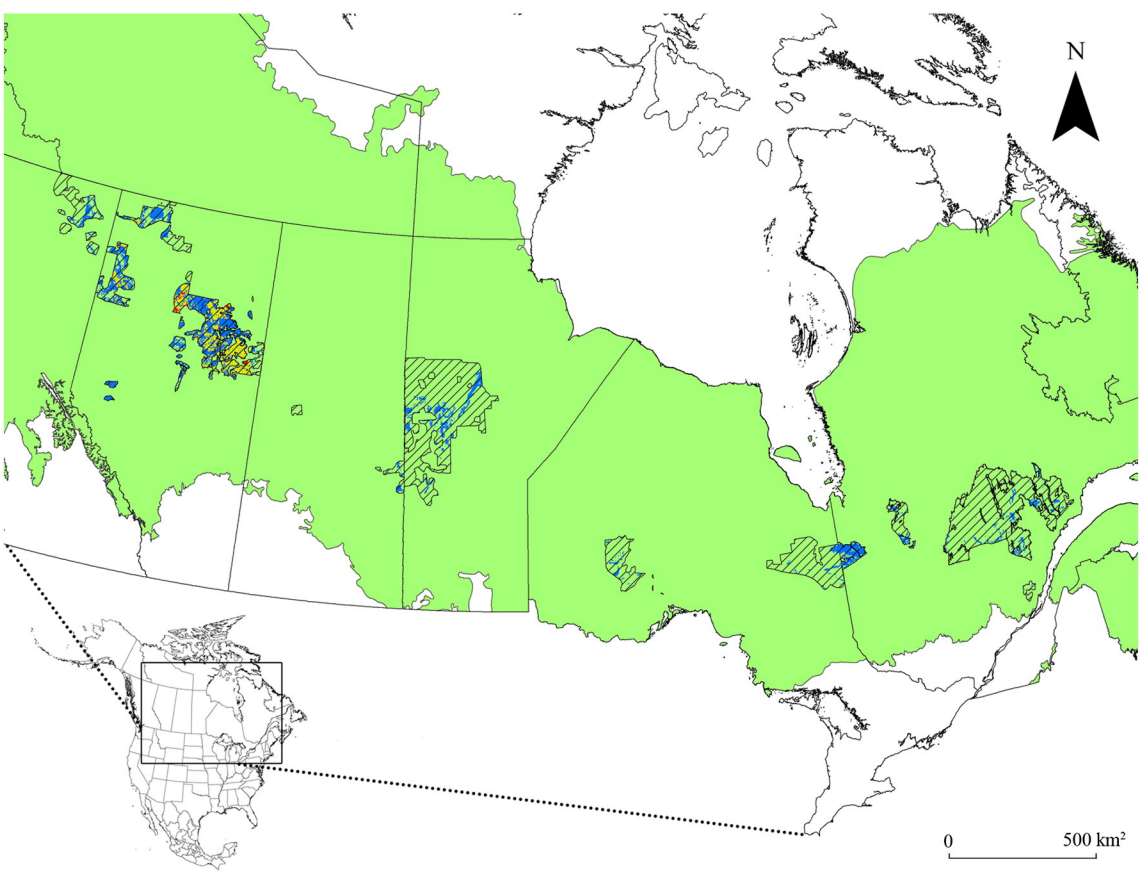

Fig. 1. Extent of Canadian Boreal Forest Agreement (CBFA) land tenures and multiple industrial development permits in Canada. Hatched areas represent CBFA land tenures, blue, yellow and red represent one, two and three overlapping approved industrial development permits for the same area, respectively. Industrial development areas were determined using the Global Forest Watch dataset (www.globalforestwatch.ca). Green indicates the boreal forest region as determined by Brandt (2009). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Strategic location of the protected area network is critical to its success (Andrew et al., 2014), including representation of all ecosystems within a given region or biome. Consistent with that theme, the CBFA seeks to establish a network that represents the diversity of ecosystems in the boreal region of Canada (CBFA, 2010). However, the 29 million hectares are concentrated in the central boreal region (Fig. 1) and include only 4 of 13 ecozones found in the boreal forest in Canada (CBFA coverage: Taiga Plain (8.9%); Boreal Plain (29.9%); Boreal Shield (60.7%); Hudson Plain (0.5%); see Supporting Information). Ecozones in the southern and northern portions of the boreal region are almost entirely excluded, even though some FPAC member land tenures are present in those areas. (see http://canadianborealforestagreement.com/publications/CBFAAgreement_Map_NewLook-EN-oct-2013.pdf; accessed January 1, 2015). Therefore, CBFA land tenures include only a minority of ecozones, reflecting limited representation of the diversity of boreal ecosystems.

A successful protected area network should include land tenures with large size and low nearest neighbor distance (Possingham et al., 2000; Cabeza and Moilanen, 2001). Our GIS analysis detected 54 distinct CBFA land tenures covering the 29 million hectares, ranging in size from approximately 100 ha to 8,500,000 ha (mean ± SD: 541,748.1 ± 1,584,280.7 ha; median: 29,000 ha; see Supporting Information for details regarding these calculations). Therefore, many CBFA land tenures are suitably large although there is substantial variability in parcel size. Indeed, we found that although roughly 69% of CBFA land tenures measure >1000 ha (i.e., >10 km^2), 28% are <501 ha (<5.0 km^2), and 22% are <101 ha (<1.0 km^2). Therefore, there will be high variability in the level of biodiversity supported within individual land parcels, with the smaller parcels being less suitable for species with large spatial requirements (Andrew et al., 2014).

To an extent, concerns related to small parcel can be alleviated by close proximity and high functional connectivity of parcels. However, on average nearest neighbor distance between parcels ranges from approximately 2.0 km to 155.6 km (mean ± SD: 14.4 ± 27.2 km; median: 5.0 km). Even if CBFA land tenures are considered part of a larger network of protected areas including existing parks and reserves (see Supplemental Information), nearest neighbor distance remains relatively high (mean ± SD: 5.74 ± 10.92 km; median: 3.2 km). Accordingly, functional connectivity in the network will be limited unless additional corridors and linkages are established. This is especially relevant for the success of smaller and more isolated CBFA land tenures, which otherwise may have little conservation value (see Gaston et al., 2008). Yet, this concern represents an opportunity to implement creative conservation planning on some of the 42 million hectares of FPAC member land tenures that are subject to sustainable harvest practices. To maximize the conservation value of the CBFA land parcels, select parcels under sustainable harvest could be strategically managed as corridors and buffers for protected lands.

4. CBFA and woodland caribou

Woodland caribou population decline and range recession in the boreal forest are mainly due to direct and indirect effects of industry (Schaefer, 2003; Festa-Bianchet et al., 2011), and in theory caribou persistence could be enhanced by forest retention on CBFA land tenures. In fact, the 29 million hectares of protected land span virtually the entire range of woodland caribou habitat within lands tenured by FPAC member companies (CBFA, 2010). Therefore, it is notable that caribou conservation played a critical role in the selection of CBFA lands. However, our estimates of parcel size and parcel connectivity suggest that some CBFA lands will not contribute to woodland caribou conservation because of their small size and isolation (see Andrew et al., 2012). Additional holdings currently occupied by woodland caribou are tenured by non-FPAC member companies and remain available for logging and other developments.Such is a common problem in Canada, as protected areas tend not to adequately reflect occurrence of species-at-risk (Deguise and Kerr, 2006).

In addition to industrial development, caribou are vulnerable to climate change because of altered timing of freeze-thaw processes affecting their mobility and access to food (Festa-Bianchet et al., 2011). Although forest retention on the 29 million hectares of CBFA lands should benefit caribou over the long term, robust conservation planning should explicitly consider the effect of climate change on the potential distribution and abundance of species (Andrew et al., 2014). Environmental suitability models projecting caribou distribution to 2080 predict that caribou range in North America will decline by 19.1% and 33.9% under conservative (scenario B1) or more liberal (scenario A2) global carbon emission projections, respectively (Fig. 2; see Supporting Information). These projected declines are underestimates because they include areas beyond current and projected northern treeline as potentially suitable, even though it is unclear whether woodland caribou will be present in treeless landscapes. When the shift in caribou climate suitability is restricted to the current extent of the boreal forest (Brandt, 2009), overall woodland caribou suitable space declines by 28.7% and 51.5% using B1 and A2 scenarios, respectively. Therefore, it is evident that caribou in the boreal forest will be strongly affected by climate change. Currently, 97.4% of CBFA land tenures have suitable environmental niches for caribou, but by 2080 virtually none of the CBFA parcels will retain caribou climate suitability (Fig. 2; Table 1).

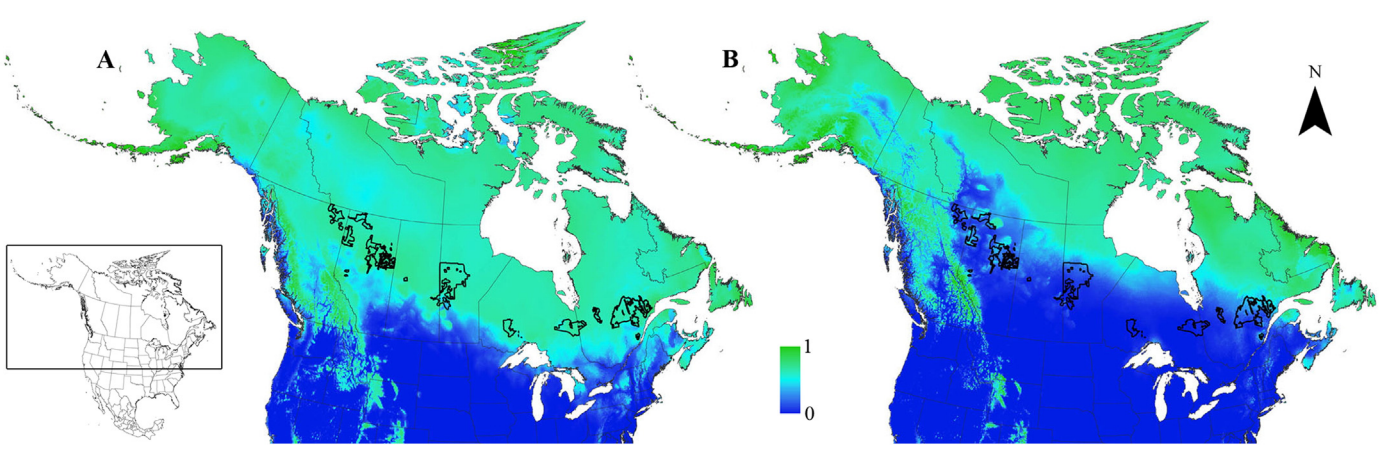

Fig. 2. Change in climate habitat suitability for woodland caribou from current (A) to 2080 (B) under the A2 global carbon emissions scenario. Blue represents unsuitable, green represents suitable climate. CBFA land tenures are outlined in black. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 1
Percent change in climate suitability for boreal forest species under current and projected future climate scenarios (scenarios B1 and A2), and current and projected future coverage on Canadian Boreal Forest Agreement land tenures. Changes were calculated for the full current range of each species and current extent of the boreal forest (Brandt, 2009). Percentages for the CBFA represent actual extent of suitable area, not change.

Species	Full Range		Boreal Forest			CBFA	
	B1	A2	B1	A2	Current	B1	A2
Mammals							
Caribou (*Rangifer tarandus*)	−19.2	−33.9	−28.8	−51.5	97.4	10.4	0
Moose (*Alces alces*)	−15.4	−49.9	−10.6	−45.1	100	86.8	40.8
Northern Flying Squirrel (*Glaucomys sabrinus*)	2.2	−0.1	7.5	8.4	100	100	100
Snowshoe hare (*Lepus americanus*)	−7.9	−14.0	−1.3	−4.4	100	100	100
Marten (*Martes americana*)	−0.3	−12.4	7.3	−5.2	100	100	81.5
Birds							
Spruce grouse (*Dendragapus canadensis*)	−14.4	−33.1	−10.0	−29.5	100	91.4	44.5
Gray jay (*Perisoreus canadensis*)	−10.2	−21.5	−5.8	−17.6	100	100	81.8
Boreal chickadee (*Poecile hudsonicus*)	−17.2	−49.6	−15.1	−46.8	100	75.3	14.4
Trees							
White birch (*Betula papyrifera*)	−0.3	−4.3	14.8	15.9	100	100	100
White spruce (*Picea glauca*)	−11.6	−23.3	−5.8	−17.1	100	100	91.5
Black spruce (*Picea mariana*)	−10.7	−30.7	−3.6	−24.2	100	98.9	73.7
Jack pine (*Pinus banksiana*)	7.7	11.4	16.4	24.2	100	100	100

The loss of caribou climate suitability within CBFA land tenures reflects that assigned land parcels are concentrated in the southern extent of the caribou range. These areas will be at the trailing edge of further northward range recession, meaning that even without industrial development, the designated land tenures will not remain viable for caribou. This point is reinforced by random placement of hypothetical land parcels similar in configuration to those in the CBFA (see Supporting Information); hypothetical land parcels would retain greater caribou climate suitability compared to that from CBFA land tenures (Fig. 3). Therefore, even if left unharvested, CBFA lands likely will not remain viable for woodland caribou, meaning that climate forecasts were probably not prominent when selecting CBFA lands for caribou protection. It follows that caribou conservation should not be highlighted as a main priority in the CBFA (see CBFA, 2010).

Other boreal-obligate species may receive long-term benefits from the absence of logging on CBFA lands. Climate forecasts for 11 additional plant and animal species reveal that currently all are fully represented from a climate suitability standpoint within the CBFA protected area, but by 2080 most will experience an overall decline in their probability of occurrence across the boreal region (Table 1). However, although moose (*Alces alces*), boreal chickadee (*Poecile hudsonicus*), and spruce grouse (*Dendragapus canadensis*) will lose climate suitability within the protected CBFA parcels, most species will retain full climate suitability in CBFA areas. Remarkably, none of the 11 species will undergo the extent of decline in climate suitability predicted for woodland caribou, implying that other boreal species would be more suitable as flagships for the CBFA.

5. Discussion

Our results point to several concerns regarding the CBFA and its contribution to protection of Canada's boreal forest, including that: 1) there is no formal government (including aboriginal) involvement or assured legal protection for CBFA land tenures; 2) CBFA lands overlap with additional industrial claims that are not subject to similar restrictions; 3) the protected area network does not adhere to established conservation planning principles (e.g., representativeness, proximity to other protected areas, high connectivity); and 4) CBFA lands are not suitably located to remain viable for woodland caribou, despite the use of caribou as the flagship species. However, because the CBFA is among the largest land conservation efforts of its kind in the world and its successful implementation could serve as a template for other private initiatives seeking to establish protected area networks, it is important to review where the effort went wrong and how to avoid similar pitfalls in the future.

5.1. The need for consultation and transparency

Successful conservation planning usually requires sustained government oversight and involvement to ensure robust governance and policy basis (Pressey and Bottrill, 2009; Watson et al., 2011). Government involvement also facilitates consultation with a range of stakeholders and experts, while ensuring that the broader public interest is represented. During its development, the CBFA should have received broad consultation and input, while the completed agreement should have been subject to government support and arms-length peer-review and analysis. A Google Scholar search for "Canadian Boreal Forest Agreement" (accessed January 2, 2015) yields few hits, none assessing quantitative metrics associated with the agreement. Perhaps relevant analyses are forthcoming, but such a major agreement involving extensive public lands and a marked planning shift should have received close scrutiny in the 5 years since it was signed. This concern is further highlighted by the fact that visual review of the CBFA area is possible through an online map (see http://canadianborealforestagreement.com/publications/CBFAAgreement_Map_NewLook-EN-oct-2013.pdf; accessed January 1, 2015), but shapefiles of CBFA land tenures are not available from FPAC (unanswered written requests: May 9, 2014; January 2, 2015). Notwithstanding industry confidentiality matters, government oversight could

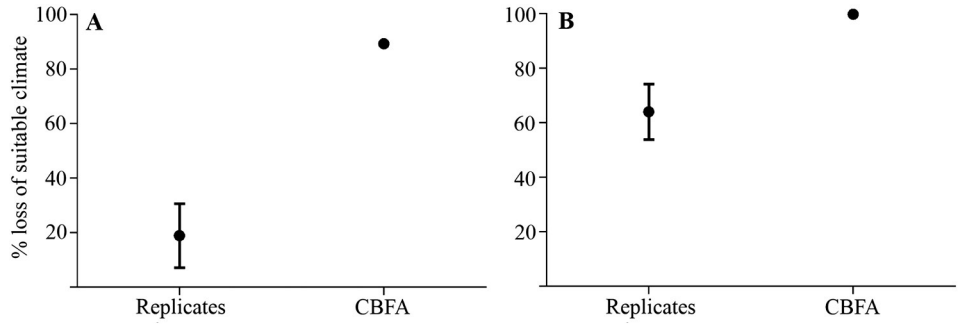

Fig. 3. Percent of caribou climate habitat suitability loss occurring in 2080 under B1 (A) and A2 (B) global emission scenarios for the actual CBFA land tenures and random parcels. Placement of the random parcels was restricted to the extent of the boreal forest (Brandt, 2009) and locations were replicated 10 times. Mean (± 95% CI) overlap is shown.

have helped overcome these problems. Further, that the CBFA was signed without aboriginal involvement or support remains especially troublesome. Because the public (through governments) is the ultimate arbiter of the fate of public land, but that CBFA provisions involving public lands have not been approved beyond the group of forest companies and ENGO signatories, provides a weak foundation for the agreement's long-term success.

Since its inception, the CBFA benefitted from a marketing strategy that included media reports, a web page, and public presentations in communities across Canada (see http://canadianborealforestagreement.com/index.php/en/on-the-move; accessed January 1, 2015). However, of the 6 stated CBFA goals, we consider that the two involving conservation planning (i.e., #2— Complete a network of protected areas representing the diversity of ecosystems in the boreal region; #3— Recover species at risk in the region, including woodland caribou, see CBFA, 2010), are unattainable as the CBFA currently stands. Indeed, protected area networks are most successful when directly tied to legislative mandates, political will, and a funding basis (Gleason et al., 2010), none of which presently underlies the CBFA. Further, based on our climate suitability projections, woodland caribou protection will not be increased via the CBFA. More broadly, it is notable that >25% of CBFA lands remain authorized for other industrial activity, despite being protected from logging according to the agreement. Therefore, it is presumptuous to refer to CBFA lands as 'protected areas' (see CBFA, 2010), because no protection is assured. Likewise, because the network functionality of CBFA lands remains suspect given the spatial configuration of parcels, these areas are better referred to as a 'portfolio' of land parcels (sensu Gaston et al., 2008) rather than a 'protected area network' (see CBFA, 2010). Accordingly, nomenclature related to the CBFA appears to be imprecise and misleading. Ultimately, we feel that many of these concerns could have been overcome through increased consultation, oversight and transparency.

5.2. The need for robust conservation planning

In theory, protected areas should promote persistence of species and ecosystems but often this goal is unrealistic given rapid and profound environmental change (Lemieux et al., 2011). In fact, protected areas often are established in areas disproportionately affected by climate change (Wiens et al., 2011), and for woodland caribou forest protection in CBFA land tenures will not favor long-term persistence because designated parcels are mistakenly concentrated at the trailing edge of caribou range. Presumably, selection of woodland caribou as the flagship species for the CBFA is based on the umbrella species concept (see Fleishman et al., 2000), but we showed that other species actually have long-term habitat requirements that are better aligned with designated CBFA parcels. Moreover, the umbrella species concept is losing favor in conservation planning as single-species approaches rarely reflect the needs of the broader ecological community (Caro, 2003; Roberge and Angelstam, 2004). Our analysis including 12 species (Table 1) provides preliminary insight into the range of climate suitability responses to be expected in the boreal forest, highlighting the need for a more comprehensive ecosystem-based approach in future boreal forest conservation planning.

Considerable further work is needed to fully reveal the conservation value of CBFA lands and their potential contribution to a broader matrix of protected areas for the boreal forest of Canada. Systematic conservation planning (SCP, Margules and Pressey, 2000, Margules and Sarkar, 2007) is a structured framework for designing protected area networks that best serve persistence of biodiversity and other natural features. By collating expert opinion and existing data, SCP better addresses the current state of conservation in the region of interest. Through the application of optimization algorithms, SCP can identify new areas for protection in light of user-defined criteria concerning the physical and ecological attributes of land parcels, their proximity and connectivity to existing protected areas, and constraints related to land ownership and conflicting uses (Watson et al., 2011). Because successful SCP requires involvement from an extended group of experts and stakeholders, the outcome tends to be broadly-informed and scientifically robust (Pressey and Bottrill, 2009; Watson et al., 2011).

It is unclear to what extent SCP methodology was used in development of the CBFA, but regardless it is evident that a different approach would have led to a more defensible product. Nevertheless, there is an opportunity for further efforts to complement the contribution of the CBFA toward a conservation solution for the boreal forest of Canada. For instance, additional FPAC member company land tenures may offer protection either for ecozones that are omitted from the initial agreement, or for woodland caribou populations that in the future will occur to the north of designated CBFA land parcels. Functional linkages between existing CBFA lands and other protected areas can be established through landscape corridors (Rouget et al., 2006), whereas spatial needs of smaller parcels can be met via buffers (Wittemeyer et al., 2008). The conservation benefits of corridors and buffers may be received even without the full extent of protection typically afforded to parks and reserves, implying that there are opportunities for creative solutions involving FPAC member company lands subject to sustainable management practices or having multiple uses. Ultimately, these steps can bolster the conservation value of CBFA lands, while contributing importantly to much-needed planning and development for the boreal forest of Canada (see Andrew et al., 2012, 2014).

6. Conclusion

It is increasingly evident that recent changes in economic, political and social climates will require that future large-scale conservation planning efforts extend beyond traditional approaches. In principle, PPAs may serve as an important complement to existing parks and reserves, and thereby contribute meaningfully to reaching global conservation targets. However, to fully capitalize on private initiatives, they must be successfully aligned with existing and proposed planning efforts, including being subject to the level of consultation, oversight, analysis, and independent review that is expected from public efforts. In the absence of broader integration, private initiatives may be

misguided and contribute only modestly to large-scale conservation efforts. Therefore, we conclude that the CBFA should be viewed as an initial step in boreal forest conservation planning, with additional efforts being necessary to provide the broad support, high professional standard, and maximum benefit needed to meet global conservation targets. It follows that future private initiatives aiming to establish protected area networks would be well advised to integrate these standards and expectations at the outset of their activities.

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Appendix A. Supplementary data

Supporting information provides further explanation of the CBFA mapping process and summary of land parcel attributes, protected area analysis, as well as the data and approach used in climate niche modeling. The authors are solely responsible for the content of these materials. Queries should be directed to the corresponding author. Supplementary data associated with this article can be found in the online version, at http://dx.doi.org/10.1016/j.biocon.2015.09.017.

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