Gap analysis of parks and protected areas in the boreal region of Alberta

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INTRODUCTION

The creation of a parks and protected area (PPA) network is a key tool in conserving local and regional biodiversity: to sustain species' populations, it is critical to protect their natural habitats. Ideally, PPAs are selected using a systematic conservation planning process based on comprehensive species distribution data. This ensures that the final PPA network accommodates the ecological requirements of all native biota. However, due to limited knowledge of individual species' abundance and habitat requirements, most planning resorts to coarse-filter approaches that focus on selecting natural ecosystems or landcsape types as proxies that roughly represent the biological diversity of a particular region [1].

In Alberta, as part of the province's vision of sustainable resource development, a PPA network has been established to ensure the longevity of the province's rich natural heritage [2]. These PPAs were selected based on a "coarse filter" habitat approach that included the diversity of natural landscape types, such as bedrock, colluvial deposits, eolian deposits, moraine, organic wetland, and mineral wetlands within Alberta's Natural Regions and Subregions [3]. In addition, various "fine filters"—for example, unique geologic features, localized species/communities, and species with legislated protection requirements—were used to fill potential gaps in the "coarse filter" approach. One key way to evaluate the success of a PPA network is to assess the extent to which it captures the range of vegetation types and biodiversity found in a region. How well do existing Alberta PPAs represent regional vegetation types and biota? Information collected by the Alberta Biodiversity Monitoring Institute (ABMI) provides a unique opportunity to address this question. With this in mind, this *ABMI Science Letter* will:

- Assess the degree to which the current PPA network contains representative amounts of each vegetation type and species found in the Boreal and Canadian Shield Natural Regions (hereafter Boreal Region) of Alberta, which covers 391,803 km^2 of the province.
- Apply a systematic approach to identify additional areas that would complement existing PPAs and result in a proportional representation of the major vegetation types in this region.
- Evaluate the degree to which conservation planning based on vegetation types effectively includes proportional representation of the distribution of individual species and identify areas that would be needed to ensure proportional representation of species that remain under-represented using a vegetation types-based conservation planning approach.

1 R.F. Noss (1990) Indicators for monitoring biodiversity: a hierarchial approach. Conservation Biology 4, 355–364.
2 Sustaining Alberta's Biodiversity. http://environment.gov.ab.ca/info/library/5852.pdf
3 Alberta's Parks, 2015. Natural Regions & Subregions of Alberta: A Framework for Alberta's Parks. Alberta Tourism, Parks and Recreation. Edmonton, Alberta. 72 pp.

METHODS

Our analyses focused on the PPA network in the Boreal region of Alberta, including the recently proposed Lower Athabasca Regional Park (Fig 1).

1. We compared the current amounts of several vegetation types in Boreal PPAs with the total regional extents of these types expected under reference conditions [4]. The current and expected extents of vegetation were determined using GIS layers created by, and freely available from, the ABMI. We examined the following vegetation types: Upland spruce, pine, deciduous, mixedwood, black spruce and larch-fen, as well as shrub, grass, marsh/swamp and non-treed bog and fen.

2. We also quantified the proportional representation of 408 species in the current PPA network. Relative abundance data for each species were obtained from the ABMI's models, which relate the relative abundance of individual species to a set of vegetation, human footprint, climate, and spatial variables [5]. We assessed the proportional representation of each species by comparing its predicted current abundance in the PPA network against its predicted total regional abundance under reference conditions. Comparison with a reference condition ensures that the analysis recognizes the regional status and historical decline of vegetation types and species. Accordingly, we set a proportionally higher target for vegetation types that have declined due to human impact. Four biological groups were included in the analysis: lichens (95 species), mosses (94 species), vascular plants (146 species) and birds (73 species).
3. To select a network of areas that efficiently fills gaps in the current PPA network—and includes at least 10% of the regional extent of the vegetation types expected under reference conditions—we used Marxan software, which selects sites based on complementarity [6]. Next, we examined if the current PPA network, when combined with this gap-filling, could support at least 10% of the regional abundance for each of the 408 species.
4. Finally, we extended the complementarity analysis to species that remained under-represented even after gap-filling, by selecting additional areas such that at least 10% of their regional abundance was included in the enhanced network.

FIGURE 1
Map of the Boreal region of Alberta showing current parks and protected areas (dark green), candidate gap-filling areas selected by our analyses to attain at least 10% representation of each vegetation type (brick red), and additional gap-filling areas required to attain at least 10% representation for species that remained under-represented even after gap-filling (orange).

4 Alberta Biodiversity Monitoring Institute. 2014. Alberta Backfilled Wall-to-Wall Vegetation Layer (Version 4) Metadata. Alberta Biodiversity Monitoring Institute, Alberta, Canada. Report available at: abmi.ca.
5 http://species.abmi.ca/
6 Ball, I.R., H.P. Possingham & M. Watts. 2009. Marxan and relatives: Software for spatial conservation prioritisation. Chapter 14: Pages 185-195 in Spatial conservation prioritisation: Quantitative methods and computational tools. Eds Moilanen, A., K.A. Wilson, and H.P. Possingham. Oxford University Press, Oxford, UK.

RESULTS AND DISCUSSION

1. *Representation of vegetation features and biodiversity in the current PPA network*

✔ The existing PPA network covers 17.3% of the Boreal region, which meets the 17% target set in the Canadian Biodiversity 2020 Target [7]. The PPAs are largely covered by vegetation (> 88%), with the remaining area comprising water, bare ground, and human footprint (Fig 2a).

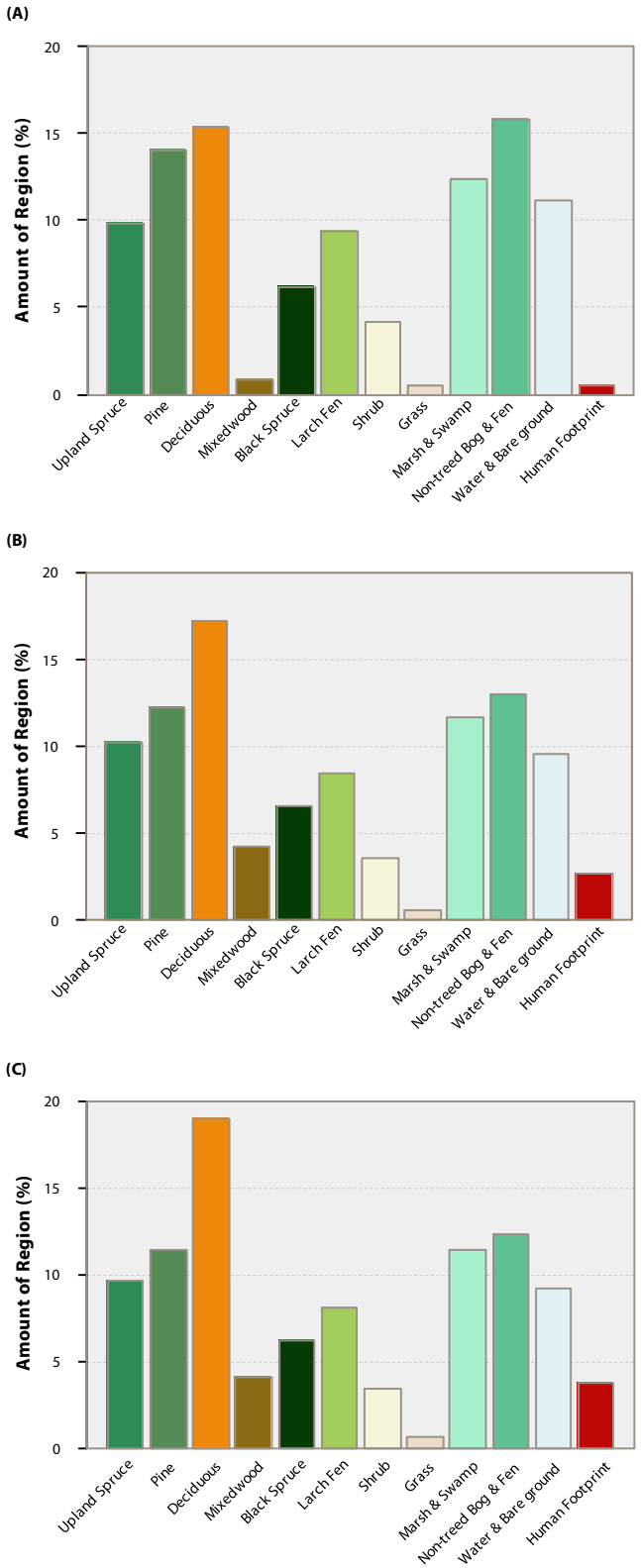
✔ Many of the vegetation types had at least 15% of their area contained in the current PPA network (Fig. 3a; e.g., upland spruce and pine). However, mixedwood forest was obviously under-represented (< 5% of reference; Fig. 3a). This forest type has been disproportionately affected by forest harvesting and agriculture [8]. Other vegetation types with relatively low representation in the current PPA network included deciduous forest, black spruce forest, and grassland (Fig. 3a).

✔ Species representation in the PPA network ranged from 1% to 62% of the respective regional abundances expected under reference conditions. 34.2% of vascular plant and 38.4% of bird species had under 10% of their populations in existing PPAs (Fig 4). A lower proportion of lichen and moss species (13.8%) had under 10% of their populations in existing PPAs (Fig 4). Of the vascular plant and bird species with under 10% of their populations in current PPAs, most were found in the Dry Mixedwood and Central Mixedwood Subregions and were associated with mixedwood and deciduous forest types. In addition, some of these species were most abundant in the southern part of the Dry Mixedwood, and were associated with grasses and shrubs.

2. *How much area is required to fill gaps in vegetation features?*

✔ Based on systematic selection, an additional 16,002 sq. km (i.e. 4.1 % of the region) had to be added to the PPA network to ensure that at least 10% of every vegetation type was included (Fig 1). Most of the selected gap-filling areas were located within the Central Mixedwood (44.4%), Dry Mixedwood (14.9%) and Lower Boreal Highland (30.3%) subregions, which contain abundant mixedwood forests (Fig. 1).

FIGURE 2
Summary of habitats: percentage of each vegetation type in (A) the current PPA network (B) the current PPA network and gap-filling areas to achieve 10% representation of all vegetation types and (C) the current PPA and gap-filling areas to ensure 10% representation of both vegetation types and species distributions.



7 http://biodivcanada.ca 2020 Biodiversity Goals and Targets for Canada
8 Shieck, J., Huggard, D. & Sólymos, P., 2014. Human footprint in Alberta. ABMI Science Letters, September 5, 2014

3. *Representation of species in PPAs and gap-filling areas: Can vegetation features act as a rough proxy for species?*

✔ As expected, gap-filling to ensure a 10% representation of each vegetation type increased the number of species with at least 10% of their populations represented in the enhanced network (Fig 4). However, gap-filling based on vegetation was less effective at increasing representation of bird and vascular plant species than for moss and lichen species; nearly 13.7% of birds and vascular plants failed to reach 10% population representation (Fig. 4). The proportion not reaching 10% was relatively small for mosses and lichens: 4.3% and 3.2%, respectively (Fig. 4).

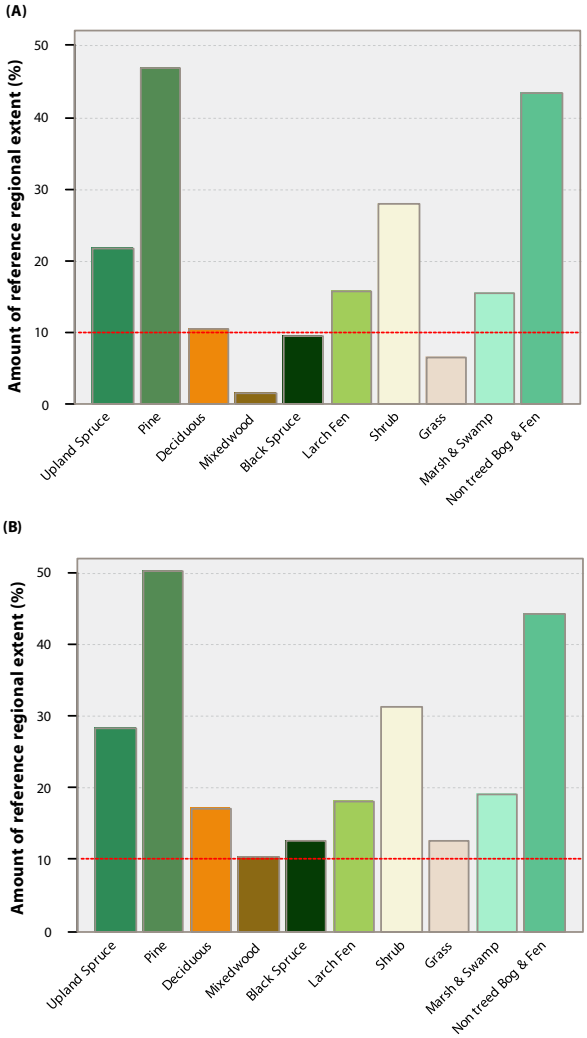


FIGURE 3
Percentage of vegetation types relative to their regional extents under reference conditions in (A) the current PPA network and (B) with additional gap-filling to reach 10% representation of vegetation types and species in the Boreal region of Alberta. The broken horizontal line represents 10% of the vegetation types regionally under reference conditions.

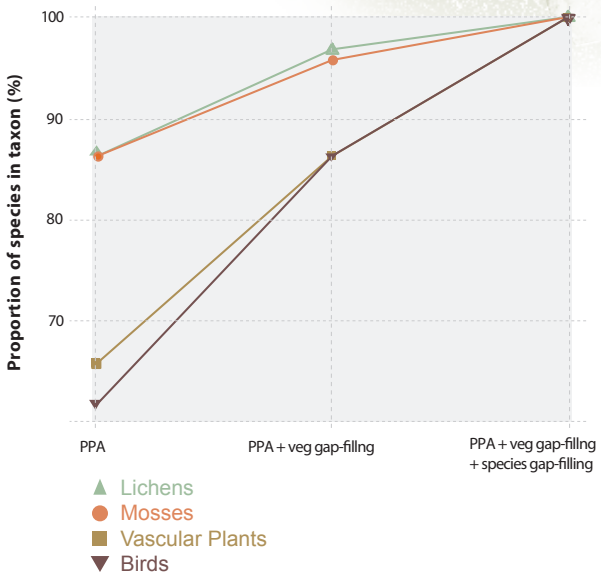


FIGURE 4
Proportions of species in each taxon with at least 10% of their regional abundance in the current PPA network, in combined PPAs than include gap-filling areas selected to attain at least 10% representation of vegetation types, and in gap-filling areas selected to attain at least 10% of vegetation types and species distributions under reference conditions.

4. *Representation of species that fall through the coarse filter approaches*

✔ To achieve 10% representation of all species, an additional 5462 sq. km (1.4 % of the region) had to be added to the "enhanced" network with gap-filling areas for vegetation types (Fig 1), bringing the total additional area required to ensure the proportional representation of vegetation types and species to 5.5% of the region. A significant part of the additional area was located in the southern part of the Boreal region, where many of the under-represented bird and vascular plant species are most abundant. Moreover, with the additional areas, the relative proportion of grassland habitat represented increased (Figure 3b), underscoring the importance of grassland habitat for these species.

MANAGEMENT IMPLICATIONS

- Some vegetation types and species within the boreal region have < 10% representation in the existing PPA network.
- A systematic selection of areas to obtain 10% representation of all vegetation types requires additional protected areas in the Central Mixedwood, Dry Mixedwood, and Lower Boreal Highlands.
- Gap-filling based on vegetation types resulted in better representation for many of the species, but some birds and vascular plants were still under-represented.
- To achieve 10% representation for all species in the PPA network, further additional areas in the southern portion of the Boreal Region (particularly in grassy habitats) were needed on top of those used to fill gaps in vegetation types.
- We were unable to include rare species that are infrequently detected by the ABMI's monitoring when doing our gap analyses. Managers may wish to consider these species when filling PPA gaps.
- The ABMI's predictive species maps can help in evaluating how well existing PPA networks represent regional biodiversity, and be used to identify candidate areas to expand the network to achieve regional representation of species.

INTERPRETATION CAVEATS

- The methodologies discussed in this Science Letter are sensitive to changes in the conservation features included for analysis. Managers should ensure that input parameters are appropriate to the questions they seek to answer, and take care when generalizing results.

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