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Does expected future landscape condition support proposed population objectives for boreal birds?

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ABSTRACT

Assessing the feasibility of proposed Bird Conservation Region (BCR) population objectives requires comparing expected future population size estimates to proposed population objectives. Linking statistical bird habitat models with landscape simulation models can provide a direct method for assessing the ecological and economic implications of alternative land and resource scenarios within a BCR or BCR subregion. We demonstrate our approach for analyses of future habitat supply and population size for a suite of priority landbird species using the ALCES® landscape simulation model and empirical bird habitat models within a multi-use landscape located in northeast Alberta, Canada and BCR 6-Boreal Taiga Plains. We used ALCES® to simulate future landscape condition over a 100 year time period under three scenarios: business as usual, protected areas, and climate change. Shortfalls between simulated population size estimates at year 30 and proposed population objectives existed for each of the four priority bird species examined suggesting that expected future landscape condition will not support proposed population objectives for these species. Boreal species strongly associated with mature and old forest habitats exhibited population declines over the 100 year simulation period. One habitat generalist, a species associated with both early and late seral stages, appeared to benefit from the range of land use scenarios examined. Our approach improves upon current static approaches used to step down BCR scale population objectives to sub-regional scale habitat objectives by utilizing statistical bird population response models to estimate density and a dynamic landscape simulation model to estimate expected future habitat condition.

1. Introduction

The North American Bird Conservation Initiative (NABCI) was formed in 1999 with the mission to deliver bird conservation through regionally based, biologically driven, landscape oriented partnerships across Canada, the United States, and Mexico. To facilitate integration and cooperation among various avian conservation partners NABCI (1) defined ecologically distinct regions with similar bird communities, habitats, and resource management issues known as Bird Conservation Regions (BCRs), and (2) set continental objectives for population size for most North American birds that were based largely on reversing population declines over the next 30 years (Rich et al., 2004). Conservation partners are now stepping down continental population objectives to the BCR scale to direct on-the-ground conservation. This includes the development and application of regional scale habitat objectives that, if achieved across BCRs, will help reach continental population objectives. Fundamental steps in the process to create habitat objectives are (1) conducting habitat assessments across the BCR, (2) estimating bird density and population size by habitat, and (3) applying population estimates to habitat assessments to determine the quantity and quality of breeding habitats needed to meet population objectives at the BCR scale (Will et al., 2005). This process assumes that amount of breeding habitat is the main factor limiting avian populations and that reversing long-term population declines at BCR or landscape scales will be achieved by increasing the availability of suitable breeding habitat.

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A number of approaches have been proposed to link bird population size estimates with habitat assessments at BCR and landscape scales in order to develop habitat objectives (Jones-Farrand et al., 2011; Rosenberg and Blancher, 2005; Thogmartin et al., 2004; Thogmartin and Knutson, 2007; Tirpak et al., 2009) (for a review see Fitzgerald et al., 2009). A major limitation of these approaches is the static nature of the habitat assessments. Existing regional and sub-regional land use and resource development plans are documents that could be used to (1) anticipate future landscape change and subsequent influences on habitat supply, bird population sizes, and conservation design, and (2) assess whether regional population objectives are feasible. A variety of advanced landscape simulation models such as ALCES (A Landscape Cumulative Effects Simulator; Schneider et al., 2003), LANDIS (Forest Landscape Disturbance and Succession; Mladenoff and He, 1999), LMS (Landscape Management System; McCarter et al., 1998), and SELES (Spatially Explicit Landscape Event Simulator; Fall et al., 2001) can be used by land managers to project future habitat conditions (i.e., age, species composition of vegetation types) across complex, multi-use landscapes. In forested systems, these models allow users to specify rates of forest growth and succession, natural disturbance, resource development, urban expansion, and habitat reclamation or recovery, and then project future changes in habitat supply given alternative management scenarios. Many studies have used the output from these landscape simulation models in tandem with wildlife habitat suitability indices (HSI) to evaluate the effects of alternative scenarios of forest management on the quality and quantity of wildlife habitat (Larson et al., 2004; Marzluff et al., 2002; Shifley et al., 2006).

One limitation of the HSI–landscape modeling approach is that HSI models do not estimate bird density which is required to generate population size estimates. Habitat models that estimate avian densities relative to forest type and forest age can be applied to dynamic landscape models so that the effects of simulated changes in future habitat supply (e.g., the amount, type, and age of forests) can be evaluated in terms of their impacts on avian population sizes. Ideally avian densities should be empirically estimated from avian survey data and adjusted for incomplete detection probabilities and how these vary among habitats, temporal sampling frames, and differences in survey protocols (i.e., count duration and count radius) (Matsuoka et al., 2012; Sólymos et al., 2013).

In this study our objective was to demonstrate a new approach for stepping down BCR population objectives for four priority landbirds within the 6.86 million ha Forest Management Agreement area of Alberta-Pacific Forest Industries Incorporated in Bird Conservation Region 6-Boreal Taiga Plains (hereafter BCR 6). Although this landscape is largely intact, resource development is diverse, intensive at local scales, extensive in spatial extent, and occurring at a rapid rate. This landscape provides a unique opportunity to assess whether proposed aspirational BCR population objectives can be achieved. Our approach uses a comprehensive modeling procedure that combines a landscape simulation model with statistical bird habitat models that estimate species density. We used a land use accounting model, A Landscape Cumulative Effects Simulator III (hereafter ALCES®; Schneider et al., 2003), to simulate changes in habitat supply for three land use scenarios over a 100 year time period within a rapidly changing, multi-use landscape in northeast Alberta, Canada. We used an extensive database of point counts in northern Alberta, forest attribute data, and a new density estimator (Sólymos et al., 2013) to model bird-habitat relationships and derive habitat-specific density estimates. We then evaluated each scenario and the associated impacts on the population size of our four priority landbird species by applying habitat-specific estimates of avian density to simulated ALCES® output. Finally, we assessed the feasibility of the proposed BCR 6 population objectives, by comparing these population objectives against our simulations of future population sizes from each land use scenario.

2. Methods

2.1. Study site

Our study area comprised the Forest Management Agreement (hereafter FMA) area of Alberta-Pacific Forest Industries Incorporated (hereafter Al-Pac) located in northeast Alberta, Canada and BCR 6. The Al-Pac FMA encompasses 6.86 million ha in northeastern Alberta, Canada (Fig. 1) and is found within the Boreal Forest natural region and the Central Mixedwood, Dry Mixedwood, and Boreal Highlands natural subregions (Beckingham and Archibald, 1996). The Boreal Mixedwood ecological area dominates the subregions found within the Al-Pac FMA. Summer (May, June, July, August) mean temperature ranges from 7.2 to 20.2 °C and mean total precipitation is 2.4 cm. Within the Boreal Mixedwood, mesic sites in upland areas are dominated by pure and mixed stands of trembling aspen (*Populus tremuloides*) and white spruce (*Picea glauca*) mixed with balsam poplar (*Populus balsamifera*), white birch (*Betula papyrifera*), and balsam fir (*Abies balsamea*), while drier upland sites are dominated by jack pine (*Pinus banksiana*). Lowland areas are composed of wetlands in the form of marshes, swamps, and black spruce (*Picea mariana*) and tamarack (*Larix laricina*) dominated bogs and fens (Beckingham and Archibald, 1996).

Stand boundaries (polygons), forest type (composition), and forest age were derived from Alberta Vegetation Inventory, a forest resource inventory database provided by Al-Pac that is used for resource industry and land-use planning applications. The inventory is created by interpreting medium-scale (1:60,000 or 1:40,000) aerial photographs to map vegetation cover types and determine the origin year (age) in forested stands and other vegetated and non-vegetated cover types. Vegetation plots, air calls (low elevation over-flights of area to be mapped), and past plots and surveys (temporary or permanent sample plots, regeneration surveys) are also used as information sources to map current vegetation conditions (Alberta Sustainable Resource Development, 2005). Classification error is unknown but potential map classification errors likely exist for the two spruce-dominated forest types: white spruce and hygric softwood/black spruce. Within the Al-Pac FMA, 4.77 million ha is not commercially productive, while 2.10 million ha is managed for timber harvest. The study area is managed using sustainable forest management, which considers ecological or biodiversity objectives (e.g., habitat), economic objectives (e.g., wood supply), and social objectives (e.g., heritage resources) when managing human activities within forest ecosystems (Alberta-Pacific Forest Industries, 2007). The operational harvesting currently being conducted within the Al-Pac FMA is within its first forest rotation (rotation age is the number of years required to establish and grow timber to maturity) although planning to identify harvest levels (annual allowable cut) is being conducted for a period equivalent to two forest rotations (200 years). In addition to forest harvesting, large-scale oil sands development that involves bitumen exploration, extraction (mines, in-situ sites), and infrastructure construction is co-occurring within the Al-Pac FMA.

2.2. Landscape simulation approach

We used the dynamic land use accounting model ALCES® to (1) specify the current landscape condition within the Al-Pac FMA, and (2) simulate future changes in forest habitat supply for existing and alternative land use scenarios (www.alces.ca). ALCES® is a non-spatially explicit simulation model designed to track the cumulative effects of ecological processes and human activities under alternative management scenarios (Carlson et al., 2011;