Global Ecology and Conservation 8 (2016) 1–17

Contents lists available at ScienceDirect

Global Ecology and Conservation

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

Original research article

Examining climate-biome ("cliome") shifts for Yukon and its protected areas

Erika L. Rowland [a,*], Nancy Fresco [b], Donald Reid [c], Hilary A. Cooke [c]

[a] Wildlife Conservation Society, North America Program, 332 Del Chadbourne Road, Bridgton, ME 04009, United States

[b] Scenarios Network for Alaska & Arctic Planning (SNAP), International Arctic Research Center (IARC) 415A#1, University of Alaska Fairbanks, Fairbanks, AK 99709, United States

[c] Wildlife Conservation Society Canada, 169 Titanium Way, Whitehorse, YT, Canada Y1A 0E9

ARTICLE INFO

Article history:
Received 29 April 2016
Received in revised form 30 June 2016
Accepted 26 July 2016

Keywords:
Yukon
Climate change
Protected areas
Cliome
Climate change adaptation

ABSTRACT

Protected area networks are the foundation of conservation, even in northern Canada where anthropogenic impact on the landscape is currently limited. However, the value of protected areas may be undermined by climate change in this region where the rate and magnitude is high, and shifts in vegetation communities and associated wildlife species are already underway. Key to developing responses to these changing conditions is anticipating potential impacts and the risks they pose. Capitalizing on an existing modeled dataset for Yukon from Scenarios Network for Alaska and Arctic Planning (SNAP), we examine projected shifts in the distribution of 18 clusters of climate parameters, and the vegetation communities currently associated with them (collectively termed "cliomes") across three 30-year time steps, from the present through the 2090s. By the 2090s, Yukon may lose seven cliomes and gain one. Three regional changes, if accompanied by vegetation redistribution, represent biome shifts: complete loss of climate conditions for arctic tundra in northern Yukon; emergence of climate conditions supporting grasslands in southern Yukon valleys; reduction in climates supporting alpine tundra in favor of boreal forests types across the mountains of central and northern Yukon. Projections suggest that, by the end of the 21st century, higher elevations in southern Yukon change least when compared to the turnover in cliomes exhibited by the high latitude, arctic parks to the north. This analysis can assist with: planning connectivity between protected areas; identifying novel conservation zones to maximize representation of habitats during the emerging changes; designing plans, management and monitoring for individual protected areas.

1. Introduction

The challenge of conserving the world's ecological systems and biodiversity is amplified by the numerous and significant biophysical changes occurring, and expected to occur, under changing climate conditions. In many countries conservation strategies are anchored on protected area (PA) networks that will be affected as individual species and ecosystems track climate changes into the future (Araújo et al., 2004; Chen et al., 2011; Lemieux and Scott, 2005; Hole et al., 2009). As species distributions shift in and out of PAs with the potential for creating novel communities, the ecological representation on which protected designations were based may be altered and potentially undermine their conservation values

* Corresponding author.
E-mail address: erowland@wcs.org (E.L. Rowland).

http://dx.doi.org/10.1016/j.gecco.2016.07.006

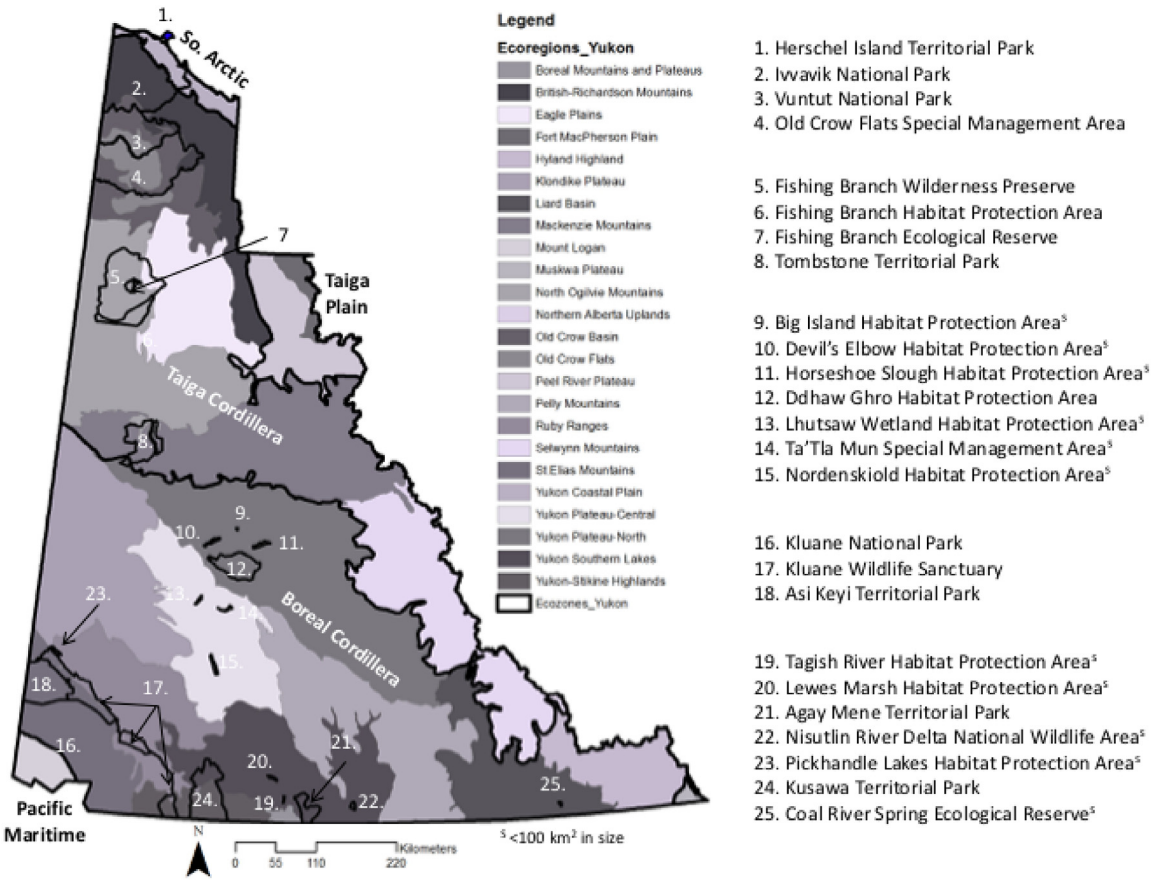

Fig. 1. The protected areas of Yukon, Canada, including National Parks, Territorial Parks, Habitat Protection Areas, Special Management Areas, Wildlife Sanctuaries, Wilderness Preserves, Ecological Reserves, and National Wildlife Areas. The backdrop includes the 23 ecoregions and 5 ecozones occurring in the territory.

(Scott and Lemieux, 2005; Hannah et al., 2007; Beale et al., 2013). Conservation planners and PA managers need to understand the potential responses of ecological systems both inside and outside reserves to develop proactive approaches to achieve conservation goals and strengthen the effectiveness of entire networks (Hannah et al., 2007; Lawler et al., 2008; Hole et al., 2011; Lemieux et al., 2011; Garcia et al., 2014).

Canada's boreal and arctic regions have already experienced warming and associated ecological change. In northwest Canada, Yukon's mean annual surface temperature has risen by between 1.0 and 2.5 °C from 1901 to 2012 (Stocker et al., 2013). Documented changes in Yukon's environment and PAs include decreases in glacier volume with increasing melt (Flowers et al., 2014), increasing permafrost melt (Lyon and Destouni, 2010), alpine tree line advance (Danby and Hik, 2007), shrub expansion on the arctic tundra (Myers-Smith et al., 2011), range expansion of some butterflies (Leung and Reid, 2013), and earlier egg-laying in arctic passerines and shorebirds in response to earlier snow melt (Grabowski et al., 2013).

Yukon's system of PAs is comprised of 26 management units representing a variety of land designations, including National Parks (NP), Territorial Parks (TP), Wilderness Preserves (WP), Ecological Reserves (ER), National Wildlife Areas (NWA), Habitat Protection Areas (HPA), Special Management Areas (SMA), and Wildlife Sanctuaries (WS) (Fig. 1; see Lemieux et al., 2010, p. 55 for descriptions). Ranging in area from ∼5 to 22,000 km^2, Yukon's PAs cover ∼65,000 km^2 or 13.4% of the total Yukon area. The PA network is currently incomplete in terms of representation of Yukon ecoregions (12 of 23 in the network), which is the basis for conservation planning in Canada's PA network (Lemieux and Scott, 2005). However, Yukon's boreal and arctic landscapes are relatively intact with a minimal human footprint, and thus retain significant ecological and conservation value (Sanderson et al., 2002; Schmiegelow et al., 2006; Schindler and Lee, 2010). Understanding potential changes in Yukon's ecological systems under climate change will facilitate management of the existing PA network and planning for conservation across the broader region.

There are multiple approaches for assessing the potential impacts of future climate conditions to ecosystems, their components, and associated conservation values (Araújo and Luoto, 2007; Morin and Thuiller, 2009; Lawler et al., 2009; Dobrowski et al., 2013). Many are species-based efforts, relying on climate envelope or distribution modeling, sometimes integrated with other modeling approaches. Such efforts describe species distributions based on climate and other habitat variables, and project these distributions into the future using the outputs of climate models (e.g., Global Circulation Models or GCMs) (e.g. Hannah et al., 2007; Beale et al., 2013). Process-based models that project vegetation types associated with