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Can natural disturbance-based forestry rescue a declining population of grizzly bears?

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ABSTRACT

Forest managers are increasingly considering historic patterns of natural forest disturbance as a model for forest harvesting and as a coarse-filter ecosystem management tool. We evaluated the long-term (100-year) persistence of a grizzly bear population in Alberta, Canada using forest simulations and habitat modelling. Even with harvesting the same volume of timber, natural disturbance-based forestry resulted in a larger human footprint than traditional two-pass forestry with road densities reaching 1.39 km/km^2 or more than three times baseline conditions and suggested maximum levels of security for grizzly bears. Because bears favour young forests and edges where food resources are plentiful, a future shift to young forests and more edge habitat resulted in a 20% projected increase in habitat quality and a 10% projected increase in potential carrying capacity. Human-caused mortality risk, however, offset any projected gains in habitat and carrying capacity resulting in the loss of all secure, unprotected territories, regardless of forest harvest method, within the first 20–30 years of simulation. We suggest that natural disturbance-based forestry is an ill-suited management tool for sustaining declining populations of grizzly bears. A management model that explicitly considers road access is more likely to improve grizzly bear population persistence than changing the size of clear-cuts. In fact, large clear cuts might be counter productive for bears since a diversity of habitats within each bear's home range is more likely to buffer against future uncertainties.

1. Introduction

Emulating natural forest disturbances or the historic range of natural variation in forest disturbance is increasingly suggested as a model for sustainable forest management and biodiversity conservation (Swanson and Franklin, 1992; Hunter, 1993; Bergeron et al., 1999; Palik et al., 2002). This coarse-filter approach to ecosystem management assumes that replicating the area and/or spatial pattern of past forest disturbances, such as stand-replacing wildfires, results in the maintenance of forest composition and structure, thereby conserving forest biodiversity. Although much has been done to measure natural ranges and patterns of historic forest disturbances (Frelich and Lorimer, 1991; Gauthier et al., 1993; Veblen et al., 1994; Bergeron and Harvey, 1997), much less is known about how emulating natural disturbances through

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forest harvesting affects biodiversity conservation. Simon et al. (2002) found small mammal populations to be similar among natural disturbance-based forestry and wildfire stands, but others have suggested that such coarse-filter approaches are ill-suited without consideration of mechanisms and/or trade-offs among species (Granström, 2001; Armstrong et al., 2003; Work et al., 2004). Assessing where natural disturbance-based forestry would be most beneficial to the maintenance of biodiversity or a species of conservation concern is therefore needed.

One species of conservation concern that is potentially well-served by altering conventional forestry practices to natural disturbance-based forestry is grizzly bears (*Ursus arctos*). Grizzly bear habitat use is relatively well-studied and understood, with known responses to alteration and configuration of habitat from forest harvesting (Zager et al., 1983; McLellan and Hovey, 2001; Wielgus and Vernier, 2003; Nielsen et al., 2004a,b; Munro et al., 2006), as well as changes in access from associated road development (McLellan and Shackleton, 1988; Mace et al., 1996; Benn and Herrero, 2002; Nielsen et al., 2006). In Alberta, Canada, current forest management centres on a two-pass harvest design with small clear-cuts (*c.* <40 ha) placed in a checkerboard pattern within a larger management block. Adjacent stands are subsequently harvested only after a minimum of 15 years (reforestation green-up period) has passed (Smith et al., 2003). Such forest harvest designs result in a staggered and fragmented pattern of disturbed and undisturbed forests, as well as prolonged human activity within any particular management block. In contrast, the natural disturbance-based model emphasizes large, isolated clear-cuts, sometimes with retention islands, to emulate historic patterns of wildfire (Andison, 1998; Smith et al., 2003). As a consequence, natural disturbance-based approaches should result in lower road densities, shorter periods of human access and activity, and less overall human disturbance; all characteristics that presumably would benefit species that are sensitive to human activity, including grizzly bears. For grizzly bears, reductions in road density and human access in general are seen as the cornerstone of management and conservation of declining or sensitive populations (Mattson, 1992; Stenhouse et al., 2003; Nielsen et al., 2006). Natural disturbance-based forestry therefore has the potential to be a valuable resource management model benefiting grizzly bear populations. Reducing human footprints (Sanderson et al., 2002), while still providing access to socio-economically important resources, such as timber, is particularly relevant in Alberta where undeveloped forest and non-renewable energy resources are expected to be developed fully in the next few decades (Schneider et al., 2003).

There are only 177 (160–248) grizzly bears on nearly 25 000 km^2 of range in the foothills and mountains of southwest Alberta (Boulanger et al., 2005a,b, 2007), a low density compared with other North American populations (Mowat et al., 2005) possibly as a result of high numbers of human-caused mortality (Benn and Herrero, 2002; Nielsen et al., 2004c). Furthermore, population estimates indicate the population is in decline (Stenhouse et al., 2003). Most agree that continual alteration of habitat and more importantly, high rates of human-caused mortality (Benn, 1998; Benn and Herrero, 2002; Nielsen et al., 2004c, 2006) threaten the long-term persistence of grizzly bears in Alberta. Given possible benefits to forest biodiversity and the simplicity of the coarse-filter approach to ecosystem management, Alberta has considered natural disturbance-based forestry as an alternate strategy (Smith et al., 2003).

To determine the efficacy of natural disturbance-based forestry, we simulate future landscape condition using a forest harvest model and predict grizzly bear habitat conditions from resulting landscape patterns for a 100-year period. We compare two forest harvest scenarios by monitoring amount of habitat states and number of potential and effective (free from excessive levels of human-caused mortality risk) adult female territory units as a measure of potential carrying capacity and population persistence, respectively. We hypothesize that natural disturbance-based forestry will be more effective than two-pass forestry in minimizing the human footprint and maintaining grizzly bear populations.

2. Study area

We studied grizzly bear habitats and populations in a 9800-km^2 multi-use landscape in west-central Alberta, Canada (53°15′N, 118°30′W, Fig. 1). The western area consists of protected mountainous terrain in Jasper National Park, while the east is characterized by rolling foothills widely altered by anthropogenic activities (forestry and non-renewable energy exploration and extraction). Land cover types include montane forests of lodgepole pine (*Pinus contorta*) and to a lesser extent trembling aspen (*Populus tremuloides*) or balsam poplar (*P. balsamifera*), conifer forests of lodgepole pine and white spruce (*Picea glauca*), sub-alpine forests of lodgepole pine and Engelmann spruce (*P. engelmannii*), alpine meadows in the mountains and small herbaceous or shrubland meadows in the foothills, areas of open and treed bogs with black spruce (*P. mariana*) and eastern tamarack (*Larix laricina*), and high elevation areas of rock and ice (Achuff, 1994; Franklin et al., 2001; Huettmann et al., 2005; Beckingham et al., 1996). Numerous roads and seismic lines typify the eastern part of the study resulting in fragmented forest patterns (Popplewell et al., 2003; Linke et al., 2005). Periodic, stand-replacing fires historically burned on average 20% of the landscape per 20-year period, yielding a 100-year fire cycle (Andison, 1998). With a short growing season, lack of salmon and other high-protein foods (Jacoby et al., 1999), this interior population of grizzly bears occurs at low densities compared to other populations (Mowat et al., 2005).

3. Materials and methods

3.1. *Future scenario modelling*

We used the programme PATCHWORKS (Spatial Planning Systems, Deep River, Ontario, Canada) to simulate two potential future landscapes under two possible forest harvest scenarios for decadal intervals over a 100-year period. PATCHWORKS is a spatially explicit optimization model that maximizes the objective within a framework of constraints. PATCHWORKS uses information on forest yield within individual forest stands (polygons) to harvest timber, transport raw materials to a defined mill (node) along existing roads, or build roads