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Successional development of silviculturally treated and untreated high-latitude *Populus tremuloides* clearcuts in northern Alberta, Canada

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Abstract

Seventy 1–28-year-old clearcuts were sampled to characterize post-harvest vegetation development and to determine the effect of mechanical site treatment and *Picea glauca* (Moench) Voss (white spruce) crop-seedling planting on regenerating boreal forest stands in the John D'Or—Wood Buffalo National Park area of northern Alberta in western Canada (58°35′N, 114°37′W). Natural *Populus tremuloides/Rosa–Viburnum* stands of wildfire origin ($n = 25$), widespread occurrence, and 52–91-year-old were sampled as a benchmark for comparison. Clearcut *Populus-Picea* and *Picea* stands reverted to early successional *Populus tremuloides* Michx. (trembling aspen)—dominated vegetation, with maximum sucker densities (mean 18 716, S.D. 13 239) within 4 years after stand initiation. Stem exclusion occurred most intensively 5–20 years after initiation, but was expected to continue until stands were >40–50-year-old. In untreated clearcuts, tree and understory shrub cover peaked near natural stand levels 18–20 years after harvesting, and graminoid cover remained constant (∼3%) but elevated compared to natural levels (<1%); whereas forb cover decreased linearly to natural stand levels by Year 28. The early composition of clearcuts was primarily composed of species that were common to the natural stands and also vegetatively reproduced. Mechanical site treatment and crop-seedling planting delayed attainment of maximum tree cover by 7 years, with total cover similar to natural stands. Site treatment reduced total shrub cover and prolonged the occurrence of elevated forb and graminoid cover values, probably in response to disruption of the pre-treatment ground vegetation. *Calamagrostis canadensis* L., a common crop-seedling competitor, was typically of minor importance on the sampled clearcuts compared to levels associated with more southerly boreal clearcuts. Detrended correspondence analysis ordinations based on species cover suggested untreated and treated clearcuts >13–16-year-old approximated the composition of natural stands. The data also suggested that silvicultural planting of *P. glauca* will accelerate stand development toward late-successional conifer-dominated vegetation relative to unplanted and natural stands.

Keywords: Boreal forest; *Picea glauca*; Silviculture; Understory vegetation; White spruce

1. Introduction

Forest clearcutting is a relatively common and sometimes controversial practice in the boreal forest of North America (Keenan and Kimmins, 1993). Those opposing the practice often identify the general extent of harvesting, aesthetics, changes in hydrologic regime and nutrient supply, and the loss of wildlife habitat as their concerns. In addition, a harvest rotation period shorter than the natural fire-return-interval is also a potential consideration with respect to maintaining the range of natural variation in forest structure and biotic composition (Stelfox, 1995). Such concerns are primarily linked to severe disturbance of the natural vegetation due to tree removal and perturbation of the understory. How quickly, if ever, harvested stands return to the original vegetation has yet to be adequately determined due to the limited study of the large variety of plant community-types that form the boreal forest.

Most post-harvest studies in the boreal forest of western Canada have focused on crop-tree regeneration and the influence of different harvesting and silvicultural practices on future timber supplies (e.g., Steneker, 1976; Bella, 1986; Navratil et al., 1994, 1996). Some studies have examined the effects of harvesting on vegetation adjacent to clearcuts (Harper and Macdonald, 2002), differences in forest floor chemistry and soil quality (e.g., Maynard and MacIsaac, 1998; Krzic et al., 2003; Hannam et al., 2005), and the short-term effects (≤5 years) of site treatment on reinitiated vegetation (Fenniak, 2001; Bock and Van Rees, 2002; Frey et al., 2003); but few have evaluated in detail longer term temporal changes in deciduous

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forest composition (e.g., Ehnes and Shay, 1995; Crites, 1999; Haeussler et al., 1999, 2004; Reich et al., 2001; Strong, 2004).

In the boreal mixedwood forest zone of western Canada (B18—Rowe, 1972), it is known that *Populus tremuloides* Michx. (trembling aspen), shrubs, and herbs rapidly initiate stand development on upland sites following harvesting through vegetative propagation. Initial *Populus* densities have been reported as great as 225 000 stems ha^{-1}, but decrease to 40 000–50 000 after 5 years, and to <5000 stems ha^{-1} in older seral stands (Peterson et al., 1989; Hays-Byl and Linnell Nemec, 2001; Krzic et al., 2004). Current literature suggests herbaceous cover in regenerating stands either remains constant (Strong, 2004) or decreases (Haeussler et al., 2004) during the first 20 years after disturbance, whereas shrub cover (Strong, 2004) and moss richness (Haeussler et al., 2004), and presumably, cover increase. Studies concerned with coniferous seedling regeneration have also reported that forbs and shade-intolerant native grasses, such as *Calamagrostis canadensis*, proliferate during the first decade after harvesting (Lieffers and Stadt, 1994; Landhäusser et al., 1996; Frey et al., 2003; Krzic et al., 2004). Haeussler et al. (2004) also noted a large proportion of nonnative species in mechanically treated compared to untreated clearcuts, with richness increasing with treatment severity. Mechanical site treatment or site preparation following clearcutting has also been shown to affect plant community development, often altering the pattern of succession (Peltzer et al., 2000; Frey et al., 2003; Haeussler et al., 2004). Such treatments commonly involve machinery such as plows and trenchers to create surface disturbance that result in more and better planting microsites, and improved site conditions (e.g., improved moisture conditions, greater exposed mineral soil, and reduced competitive vegetation by disrupting the root systems of plants that often asexually reproduce—von der Gönna, 1992). In comparison, untreated clearcuts may only experience minor ground disturbance as a result of the harvesting process. Clearcuts are sometimes left untreated to promote natural regeneration based on intact root systems and *in situ* seed banks. Most information on post-harvest vegetation development has been derived from the southern portion of the boreal forest, and, by default, this knowledge is generally applied to regenerating stands throughout the boreal mixedwood forest zone.

The purpose of this research was to determine the potential long-term effects of clearcutting and mechanical site treatment on plant community development, and species composition and cover relative to mature (>50-year-old) deciduous forest stands in northern Alberta. Without a more comprehensive understanding of stand succession and development patterns within clearcuts, it will be difficult to minimize long-term environmental impacts to vegetation resources and maximize crop-tree production.

2. Materials and methods

2.1. Study area

The study area is located in western Canada about 125 km east of High Level, Alberta, between John D'Or Prairie Reserve and the west boundary of Wood Buffalo National Park (Fig. 1). It is bounded by the lower slopes of the Caribou Mountains on the north and the Peace River on the south (centre 58°35′N, 114°37′W). This area occurs in the Mid Boreal Mixedwood ecoregion, the largest ecoclimatic zone in Alberta (Strong, 1992). The climatic regime is boreal, with long cool winters that have mean temperatures of −13.2 °C, and short warm summers with mean temperatures of 13.5 °C (Strong, 1992). On average, the area annually receives 394 mm of precipitation, with approximately half falling during the growing season (Environment Canada, 2004). Physiographically, the area is

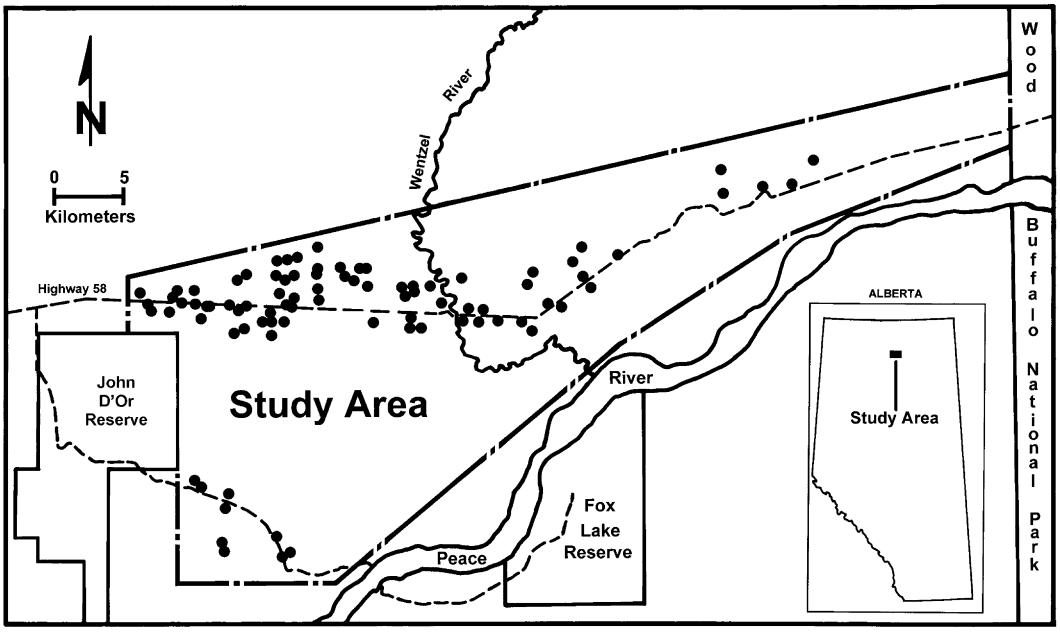

Fig. 1. Location of the study area and sampled clearcut and natural stands (●) from the John D'Or—Wood Buffalo National Park area of northern Alberta.