12. Influence of Fire on Long-Term Patterns of Forest Succession in Alaskan Boreal Forests

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Introduction

The cold climate and resulting low decomposition rates in the ground layers of boreal forests (such as those found in interior Alaska) result in the development of deep organic soils. In turn, these soils have an important role in many physical, chemical, and biological processes (Van Cleve et al. 1986). In combination with the slope, aspect, elevation, and composition of the underlying mineral soil profile of a specific site (Swanson 1996), organic soils are particularly influential in regulating ground temperature and moisture. As a general rule, the presence of a deep organic soil layer serves to insulate the forest floor during the growing season, causing colder temperatures than would otherwise occur. In many forested sites, autogenic cooling resulting from deepening organic soil layers eventually leads to the formation of permafrost, which, in turn, impedes drainage and substantially increases soil moisture (Van Cleve and Viereck 1981; Van Cleve et al. 1983a, b).

It has been shown that the distribution of different boreal forest ecosystems in Alaska is strongly correlated with a gradient of soil moisture and temperature (Fig. 12.1, modified from Van Cleve and Viereck 1981). In general, black spruce (Picea mariana [Mill.], BSP) forests inhabit sites with cooler, wetter conditions, such as north-facing hill slopes, all slopes at higher elevations, and low-relief areas with poorly drained soils. White spruce (Picea glauca [Moench] Voss) forests (which include successional stages dominated by deciduous trees [Populus...
balsamifera L., Populus tremuloides Michx., and Betula papyrifera Marsh.) inhabit warmer, drier sites including south-facing slopes, river floodplains, and low-relief areas with well-drained soils. Furthermore, it has been hypothesized that the autogenic cooling of the forest floor during primary succession is partially responsible for the mosaic of white and black spruce forests found on river floodplains in interior Alaska (Drury 1956; Van Cleve and Viereck 1981; Viereck et al. 1983, 1986, 1993).

Fire also plays an important role in the regulation in ground temperature and moisture. The paradigm presented in Figure 12.2 was developed to explain variations in ground temperatures and moisture following fires in black spruce forests of interior Alaska (Van Cleve et al. 1983a; Viereck 1983). Studies have shown that for the first several years immediately after a fire there is a significant increase in soil temperature from increased solar insolation, decreased shading, and decreased surface albedo. In addition, there is a decrease in soil moisture during the growing season (due to a recession of the permafrost layer resulting in improved soil drainage) (Dyrness and Norum 1983; Dyrness et al. 1986; Viereck et al. 1983). Although this paradigm can be used to explain patterns of soil temperature and moisture over the short term, the longer-term effects of fire on these