

Postfire response of North American boreal forest net primary productivity analyzed with satellite observations

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Abstract

Fire is a major disturbance in the boreal forest, and has been shown to release significant amounts of carbon (C) to the atmosphere through combustion. However, less is known about the effects on ecosystems following fire, which include reduced productivity and changes in decomposition in the decade immediately following the disturbance. In this study, we assessed the impact of fire on net primary productivity (NPP) in the North American boreal forest using a 17-year record of satellite NDVI observations at 8-km spatial resolution together with a light-use efficiency model. We identified 61 fire scars in the satellite observations using digitized fire burn perimeters from a database of large fires. We studied the postfire response of NPP by analyzing the most impacted pixel within each burned area. NPP decreased in the year following the fire by 60–260 g C m⁻² yr⁻¹ (30–80%). By comparing pre- and postfire observations, we estimated a mean NPP recovery period for boreal forests of about 9 years, with substantial variability among fires. We incorporated this behavior into a carbon cycle model simulation to demonstrate these effects on net ecosystem production. The disturbance resulted in a release of C to the atmosphere during the first 8 years, followed by a small, but long-lived, sink lasting 150 years. Postfire net emissions were three times as large as from a model run without changing NPP. However, only small differences in the C cycle occurred between runs after 8 years due to the rapid recovery of NPP. We conclude by discussing the effects of fire on the long-term continental trends in satellite NDVI observed across boreal North America during the 1980s and 1990s.

Keywords: boreal forest, carbon cycle, emissions, fire, NDVI, net primary productivity

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Introduction

Fires are an integral component of the global carbon (C) cycle, releasing ~4 Pg C yr⁻¹ through combustion to the atmosphere globally (Andreae & Merlet, 2001). Global net primary productivity (NPP), the net amount of C fixed by vegetation, is about 55 Pg C yr⁻¹ (Cramer *et al.*, 1999), implying that about 7% of NPP is returned to the atmosphere via combustion. These carbon

emissions occur in addition to the effects of reduced productivity and changes in decomposing carbon pools caused by fire-induced mortality. Modeled estimates have found that these decomposition losses following fire often exceed the combustion loss (Auclair & Carter, 1993; Kurz & Apps, 1999). Auclair & Carter (1993) estimated that gross carbon fluxes from decomposition in temperate and boreal forests are greater than combustion losses by a factor of seven, and can last for 100 years. Net fluxes, including carbon accumulation through regrowth, reduce these estimated large losses. Field studies of net losses from biomass

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