

Modeling the effects of changing climate and fire regimes on productivity, carbon storage and nitrogen fluxes in lodgepole pine forest stands

E.A.H. SMITHWICK¹, M.RYAN², D.M. KASHIAN³,

W.H. ROMME³, D.B.TINKER⁴, M.G. TURNER¹

¹ Department of Zoology, University of Wisconsin, Madison WI 53706

² USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO 80526

³ Department of Forest, Rangeland, and Watershed Stewardship, Colorado State University, Fort Collins, CO 80523

⁴ Department of Botany, University of Wyoming, Laramie, WY 82071

Abstract

Altered climates and fire regimes affect ecosystem productivity, carbon (C) storage, and nutrient cycling. Yet, in heterogeneous landscapes, forest stands are likely to have variable responses to climate and fire. We used a process-based model (CENTURY v. 4.5) to predict how climate change and fire regimes may affect C and nitrogen (N) stocks and fluxes in lodgepole pine (*Pinus contorta*) forest stands in Yellowstone National Park (Wyoming U.S.A.), which had variable patterns in sapling density recovery (ranging 5 orders of magnitude) following a severe fire in 1988. The model was parameterized to account for two different pathways in stand recovery, i.e., slow (low density) versus fast (high density), to determine the sensitivity of C and N cycling to disturbance legacies and future climate change (projected by the Hadley and Canadian Climate Center climate models). In the absence of fire, future climate change caused forest stands to be net C sink (+19 % to +31 %, depending on the climate model selected). Severe fire caused forest stands to be a net source of C to the atmosphere but ultimately, C sink strength varied between the modeled stands. By 2100, fast regeneration stands were a net C sink (+3 % to +14 %) whereas slow regeneration stands remained a net C source (-2 % to -16 %). Stands that regenerated slowly had lower gross mineralization and more variable net mineralization for 80 years following fire. Simulations resulted in two important conclusions for understanding lodgepole pine responses to climate change and fire: (1) large, infrequent disturbances may overwhelm responses to altered climate for at least a century, and (2) estimates of future landscape C balance must integrate the complexity in forest stand responses to disturbance.