Introduction

Wildfire and forest harvesting are the two major disturbances in the Russian boreal zone. Currently, several million hectares per year burn annually in Russia with Siberia accounting for the major area burned (Fig. 1). Wildfires are projected to increase in both intensity and severity as climate changes (Fangkan et al. 2009). Both legal and illegal logging are also increasing rapidly in many forest areas of Siberia (Vandergeist and Newell 2003). Non-recovered logged sites total about a million hectares in Siberia (Valderrama et al. 2011). These logged areas appear very susceptible to fire due to a combination of high fuel loads and accessibility for human-caused ignition. Changing patterns of timber harvesting increase landscape complexity and can be expected to increase the emissions and ecosystem damages from wildfires, inhibit recovery of natural ecosystems, and exacerbate impacts of wildfires on changing climate and on air quality. The Angaran region is the largest forest harvesting zone in the Krasnoyarsk Region of Siberia and most fires here occur on logging sites. Every year about 200 thousand hectares are logged in the Angaran region (Fig. 2). Large amounts of coarse fuel branches, tops, and fallen deadwood tree parts are left on logged forest sites. This logging slash in combination with burned grass contributes greatly to site fire load. Scots pine and larch logging sites become readily ignitable under earlier forest canopies. Fire spreading from logging sites to surrounding forest is a common situation in this region. This study focuses on estimating fire impact on fuel consumption and carbon emissions in Scots pine (Pinus sylvestris) forests of the Angaran region in central Siberia.

Materials and Methods

Logging/fire interactions in the region are represented in Fig. 4. Fire is present on the overstory trees, subcanopy woody layers, and ground vegetation biomass were estimated on 37 logged and unlogged units of Scots Pine (Pinus sylvestris) and larch (Larix sibirica) in the Lower Angara Region of Siberia at 10 sites in 2009-2011 as part of the NASA-funded NEESPi project 'The Influence of Changing Forestry Practices on the Effects of Wildfires and on Interactions Between Fire and Changing Climate in Central Siberia'. At each unit, we established 5 m triangular sampling plots. In each plot we estimated percent cover of the surface vegetation (Fig. 6) and percent projected ground cover for each different type of ground fuel (moss, lichen, grass, and litter). We measured dead and down woody fuels using a line intercept method adapted from Van Wagner (1969). Ground fuels (e.g., lichen, moss, shrubs and litter, forest floor) were sampled in three 20 x 25 cm subplots within a 50 cm diameter circle centered at the plot center. Understory shrubs and sprout stumps taller than 1.3 m were measured within the triangle area and biomass regressions were developed. Tree density and size were measured at 0.5 m diameter (204.5 m rebar cylinder plots at the center of the triangle). Diameter was measured at breast height for each tree was measured. If the area had been harvested, stump diameter at 20-cm above ground level were measured. Carbon emission from fires on both logged and unlogged burned sites were estimated based on calculated fuel consumption. We measured soil respiration at each site using a 1 liter PVC chamber placed on to surface of the ground cover. Transient CO2 was measured with a model Li-8200 CO2 analyzer.

Results

Investigations were carried out at four types of units: 1. logged/unburned; 2. logged/burned; 3. unlogged/unburned; and 4. unlogged/burned (Fig 7-12). Logged blocks accounted up to 90% of the total logging site area, 8-10% of the area was shrublands, and up to 2% was logged area. Fuel loading varied from 55 to 80 t/ha across the logging sites, except for leading areas. Although the zones near skid trails did not cover much area, fuel accumulation exceeded 100 t/ha in some of them. The presence of these zones of heavy fuel loads complicate forest fire suppression and containment. Cooking slash contributed 2/3 of the total fuel loading. Logging slash amounts this highly complex wildfire control and increase its cost. Dead load appeared to be 50% lower than the skid trail in logging blocks. This might be attributable to partial fuel removal due to skidding operations. However, the loading of needles and small tree branches (up to 7 cm in diameter) and on along skid trails was almost 5 times that in logging blocks. High fire fuel loads are responsible for generally high fire hazard of this area.

Species composition of grasses and herbs did not change after cutting, but productive cover increased up to 75% due to Calluna vulgaris epigeoic and C. Arnicaeae (Fig. 5). Mosses decreased in vigor on logged sites but their biomass did not change significantly. Post-fire projected cover and biomass of the grass and herb layer decreased both on logged and unlogged sites. Moisture and dead completely on logged/burned sites. Logged sites have higher fire hazard than forest sites because unlogged logging slash dries out much more rapidly than undergrowth fuels. This results in 3-5 times higher fuel consumption on logged sites compared to unlogged sites. Dead down woody fuels up to 1 cm in diameter are consumed almost completely on both logged and unlogged areas, while the percent of branches 1-7.5 cm in diameter tends to increase (Fig. 15,14). Fuel consumption was typically less in spring fires than during summer fires (Fig. 15). Summer stable fires were found to consume more fuels (30-40%). Total fuel consumption was higher at repeatedly burned areas. Here often dead was burned till the mineral layer and ground surface fuel loading accounted for no more than 10% of its pre-fire value.

Fig. 7. Unlogged / unburned unit
Fig. 8. Surface fire in Scots pine forest
Fig. 9. Logged / unburned unit
Fig. 10. Logged / unburned unit
Fig. 11. Surface fire at logged area
Fig. 12. Logged / burned unit

Fig. 13. Ground fuel consumption due to fire on unlogged (a) and logged (b) units
Fig. 14. Down woody fuel consumption due to fire at unlogged (a) and logged (b) units
Fig. 15. Fuel consumption depending on time of the fire

Conclusions

Fire occurrence on logged areas were typically of higher severity than those in unlogged forests, but the specific effects of fire and logging varied widely among forest types and as a result of weather patterns during and prior to the fire. Consumption at spring fires was 2-4 times less than at summer fires. Carbon emissions due to fire were 2-5 times higher on logged areas compared to unlogged sites. Post-fire soil respiration decreased for both sites types partially offset carbon losses. Carbon emissions from fire and post-fire ecosystem damage on logged sites are expected to increase under changing climate conditions and as a result of anticipated increases in future forest harvesting in Siberia.

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Affiliations:

1. Russian Academy of Sciences, Siberian Branch, VN. Sukachev Institute of Forest, Krasnoyarsk, 660036; E-mail: geovivier@ikal.ru
2. U.S. Forest Service, Rocky Mountain Research Station, Missoula, MT 59802, USA

Citations


