The Russian FIRE BEAR Project

Estimating and Monitoring Effects of Area Burned and Fire Severity on Carbon Cycling, Emissions, and Forest Health and Sustainability in Central Siberia

Introduction:

Boreal forests are important globally as major carbon reservoirs, as relatively undisturbed natural ecosystems, and as sources of wood fiber and other forest products. Changes in land use, cover, and disturbance patterns in boreal forests can impact fire regimes and forest health, global carbon budgets, atmospheric chemistry, wood supply, and sustainability of local subsistence economies. Wildfire is a key disturbance process in these systems, and fire affects about 12-15 million ha of closed boreal forest annually, most of it in Eurasia. This exceeds the annual area harvested or disturbed by any other natural agents, such as insects.

The Russian boreal forest contains about twenty-five percent of the global terrestrial biomass, yet data on the extent and impacts of fire in these forests are scarce and often contradictory. Several recent studies indicate that the impacts on terrestrial carbon storage of fires in boreal forest regions have been vastly underestimated. Furthermore, changes in land management and land-use practices, regional climate, and fire suppression capability will affect fire risk and ecosystem damage from fires in ways that are poorly understood. In changing environments, fire can be a key agent to accelerate changes toward new ecosystem conditions. Improved understanding of the landscape extent and severity of fires and of factors affecting fire behavior, effects of fire on carbon storage, air chemistry, vegetation dynamics and structure, and forest health and productivity is needed before such considerations can be adequately addressed in regional planning. To monitor effects on a landscape scale, and to provide inputs into global and regional models of carbon cycling and atmospheric chemistry, requires development of validated remote-sensing-based approaches to measurement of fire areas and fire severities.

The Russian FIRE BEAR (Fire Effects in the Boreal Eurasia Region) Project is a research study in central Siberia developed to provide answers to these basic questions on the management of fuels, fire, and fire regimes to enhance carbon storage, and forest sustainability in ways that minimize negative impacts of fire on global environment, wood production, and ecosystem health.

Research objectives:

(1) To use experimental fires of varied intensity to measure fire behavior, and effects of fire severity on combustion, emissions, and ecosystem impacts for estimating effects of fire regimes on carbon balance, greenhouse gas releases, and forest health and productivity.
(2) To refine and test methods for remote-sensing-based estimates of fire areas and fire severity for forests of central Siberia, by combining ground sampling of burned areas with medium-resolution (15-120 m.) and 1-km resolution satellite data.
(3) To combine process data and models developed through experimental fires with remote-sensing to produce validated regional estimates of fire areas, fire severity, and the impact of fire on carbon balance, emissions, and forest health.
(4) To provide information and tools useful for fire management decision making and for evaluating possible future use of prescribed fire.

Study area

During 1998 and 1999, two research sites were located for the study in the Krasnoyarsk Region of central Siberia. The Yartsevo site west of the Yenisey River represents a scots pine/lichen/feather moss forest type, while the Boguchany site east of the Yenisey River represents a scots pine/feather moss forest type with a shrub-rich understory. Replicated experimental plots of about 4 ha were installed on both sites, and baseline data were collected on vegetation, fuels, soils, and other ecosystem characteristics. The experimental plots will be burned over several years to ensure a range in fire behavior and burning conditions. Onsite environmental data, construction of protective fire lines, and collaboration between fire crews of the Federal Forest Service of Russia and prescribed fire experts from North America, help ensure that the fires are safely maintained inside the plots. The experimental plots are burned using line ignition along the windward side to quickly create equilibrium fire behavior that mimics wildfires under similar burning conditions. The first two plots were burned at the Yartsevo site in July 2000.


Sample Line 1 - Preburn

A preburn shot of Plot 14 at the Yartsevo site shows a typical dry scots pine forest with lichen and feather moss covering the forest floor. The lack of ladder fuels on such sites prevents crown fires except under extreme conditions.


Sample Line 1 - Postburn

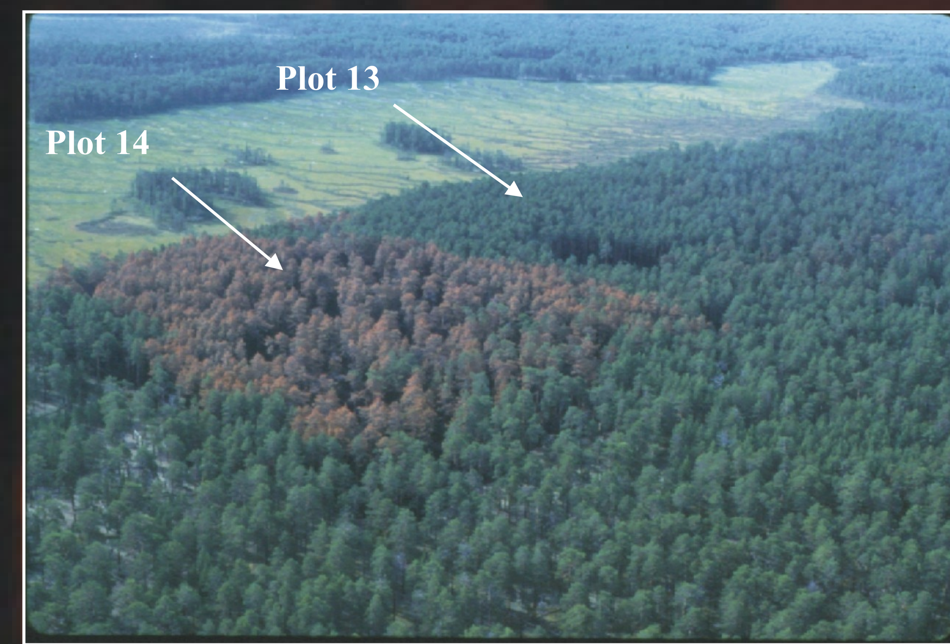
A postburn picture of Plot 14 viewed from the same point as in the preburn picture. This is an example of the effects from a high-intensity surface fire. Most of the fuel consumption on the site occurs when the forest floor burns.


Plot 13

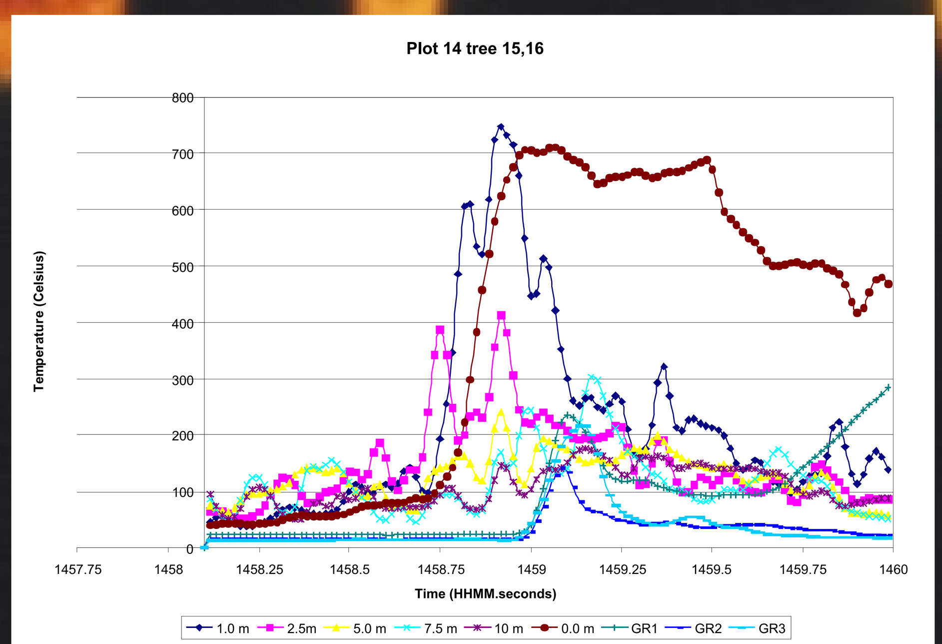
In this low-intensity headfire observed under low fire hazard conditions, even logs lying on the ground were effective in preventing fire spread. The low fire intensity results in dense smoke at ground level because the upward convection of a fire column is poorly developed.


Plot 14

This large fire whirlwind visually indicates the high-intensity fire that develops under more severe burning conditions. Even at these high fire danger conditions, only a surface fire was able to develop. However, the fire intensity was sufficient to cause complete mortality to all the overstory trees.

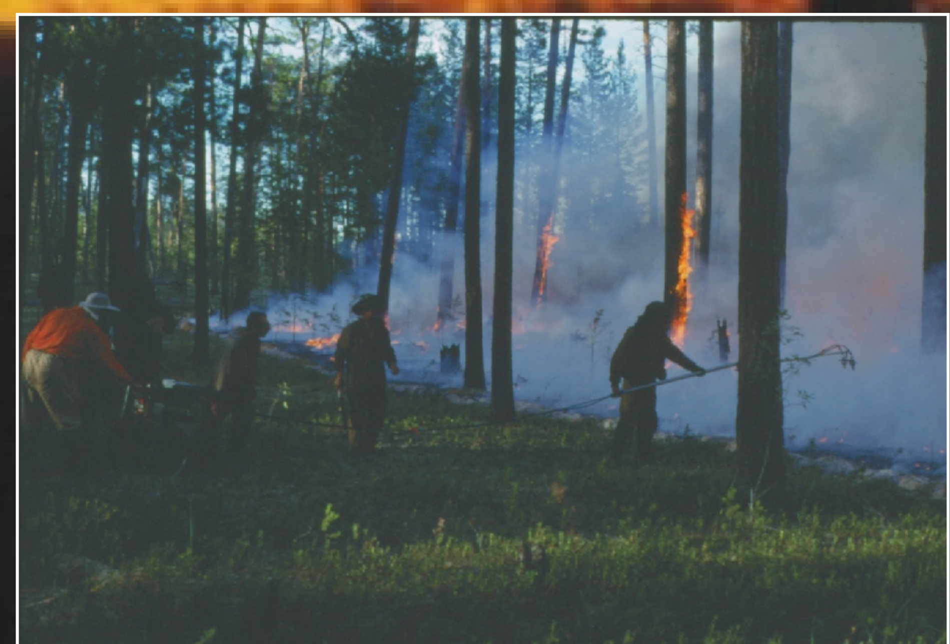


A postburn aerial view shows the extensive crown damage to scots pine on Plot 14 (200x200 m). No crown damage is visible from the adjacent low-intensity fire on Plot 13. Studying such diverse fire behavior helps researchers understand the many factors that affect fire behavior, ecological effects, and emissions.

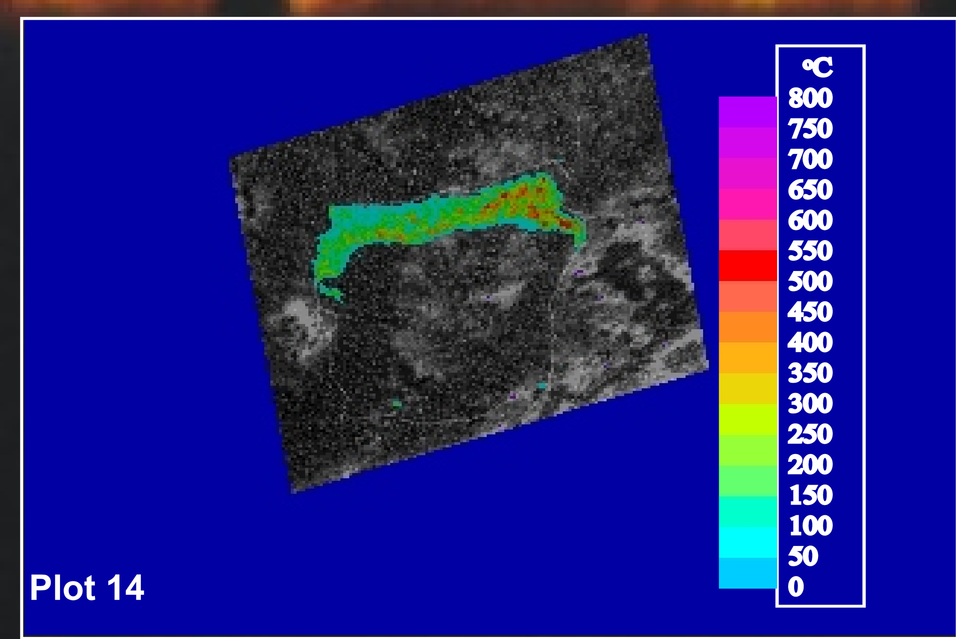


Equipment installed in the burn area provides valuable information, since personnel can not safely remain on the site during the fire. This graph shows temperature changes with time at various distances above and below the ground surface.

Extensive sampling must be completed before, during and after each fire. Here surface woody fuels are being measured as part of the methodology to document all fuels on the site and to determine the amount of fuel burned in the fire.



On-ground emission measurements, coupled with aerial sampling, are important in monitoring the type and amounts of chemicals found in the smoke and determining effects of fire on air quality and climate change.



Plot 14

Aerial infrared technology is being used to monitor and document fire behavior through dense smoke. Similar measurements on wildfires provide valuable verification for interpretations of satellite images.

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