# Predicted and observed climate- induced fire in the Altai-Sayan Mts, Central Asia, in the past, present and future

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**Fig. 1.** *Study area is within the window 42-56$^0$N and 82-106$^0$E in central Siberia*

## Introduction and Goals

Wildfire is a catalyst for maintaining stability and diversity in boreal forests in synchronization with the climate. Wildfire is a mechanism by which forests move more rapidly towards equilibrium with a new climate in the future. Satellite and ground data show an increase in extreme fire seasons in Siberia, which coincides with the warmer and longer fire seasons of the contemporary climate. Nine of the last eleven years 1997-2000 have resulted in extreme fire seasons, which would change the definition of a normal fire season (Fig.2). Under future climate change, fire frequency, fire severity, area burned and fire season length are predicted to increase in boreal regions.

Our goal was to predict high fire danger periods from weather and climate in the past, present and future over a vast mountain country, Altai-Sayan Mts, Central Asia (Fig. 1), using different climate change scenarios from 10000 years before the present (BP) through nowadays to the year 2080 AD.

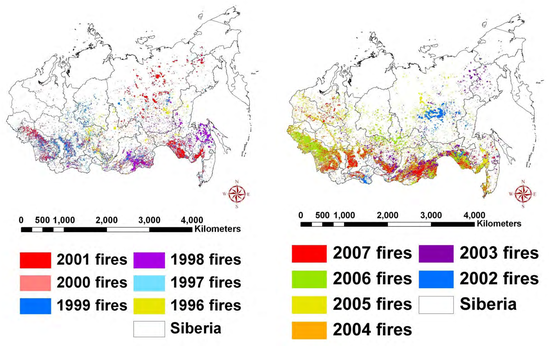



**Fig.2. Satellite-derived area burned in Siberia. Extreme fire seasons have been increasing in Siberia, and these changes are directly related to weather and climate.**

## Methods.

To estimate potential fire danger for past and future climates, a linear regression model ($R^2$ = *0.52, Fig. 3*) of fire weather was developed that relates an annual number of days with high fire danger (Nesterov index is greater than 4000) to annual moisture index, a ratio between growing degree-days above 5$^o$C, to annual precipitation, characterising dryness/wetness of the climate.

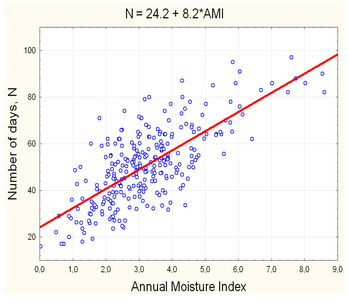



**Fig.3.** ***The relationship between*** *an annual number of days with high fire danger and annual moisture index*

**Methods.** Our fire weather model was coupled with climate change scenarios to predict fire potential distribution during the Holocene. In the past, climate change scenarios were derived from pollen-based reconstructions of paleo vegetation and climates for 10000 BP, 8000 BP, 5300 BP, 3200 BP. To define contemporary fire-weather relationships, satellite-based weather data were overlain with fire data for the period 1997-2007 demonstrating the coincidence in fire activity and severe fire weather and the converse, low fire weather and low fire activity.

In the future, two International Panel of Climate Change (IPCC, 2007) climate change scenarios of the Hadley Centre HadCM3 that reflect largest (A2) and lowest (B1) temperature increases by the year 2080 were used.

**Results.** In current climate, Canadian Fire Weather Indices (FWI) derived using 1-degree weather reanalysis data overlain with fire data. Severe fire weather (cumulative temperature, precipitation, wind speed and relative humidity) is directly related to the ability of large fires to be sustained.

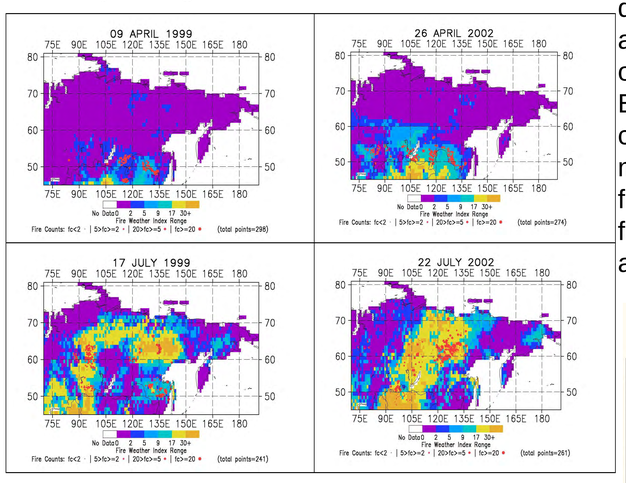



**Fig.4.** *These maps are examples used to demonstrate the coincidence in fire activity and severe fire weather and the converse, low fire weather and low fire activity.*

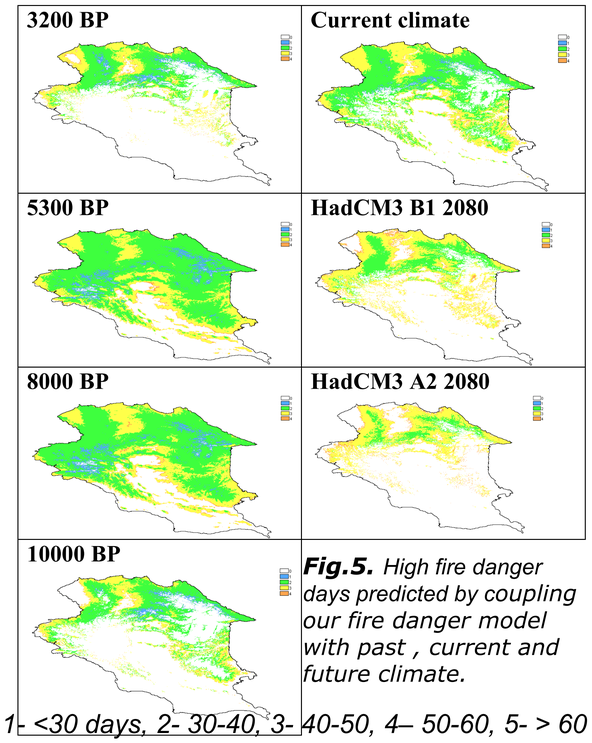
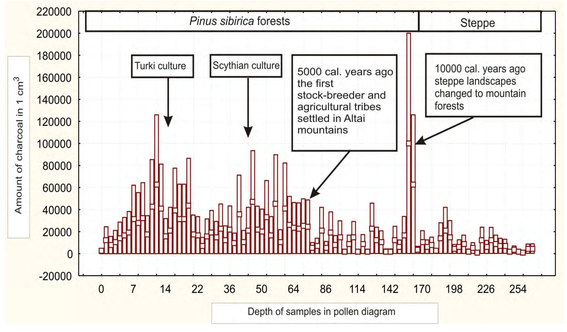



***Fig.5.*** *High fire danger days predicted by coupling our fire danger model with past , current and future climate.*

*1- <30 days, 2- 30-40, 3- 40-50, 4– 50-60, 5- > 60*

**Results.** In the past, at 10000 BP and 3200 BP, under cold and dryer climates, forests covered only 30% of the area and 30-40 high fire danger days occurred on about 55% of the forest area and 40-50 high fire danger days occurred on 35% of the forest area. Between 8000-5300 BP, under warm and moist climates, forests covered about three quarters of the Altai-Sayan mountains, mainly in the north. About 30-40 high fire danger days occurred on 60% of the entire forest area and 40-50 days occurred 30% of the area those times (fig.5, left).




*Yergaki, a range in the Sayan Mts*

**Results.** In the future warmer and dryer climates, the proportion between numbers of high fire danger days would be opposite: the number of high danger days 40-50 would prevail on 60% (the B1 scenario) and on 70% (the A1 scenario) of the forest area (fig. 5, right).

A dryer climate would result in increased tree mortality in the transition between forest and steppe, thus increasing fire fuel accumulation.

When superimposed, both factors, fuel load and fire weather create high risks of large fires escalation.

## Conclusions.

Fires are predicted to be more severe and extended in comparison with the past, because future climates are predicted warmer and dryer compared to the past warmer and wetter climates. Frequent fires would change forest structure: eliminate dark conifers (Siberian stone pine and fir). Slow growing dark conifers are not adapted to frequent fires and typically die. Dark conifers would be replaced by pine and larch in the lowlands and move upslope to the highlands, replacing montane tundra.

Following forest fire, forest regeneration may not be possible due to increased temperature and evapotranspiration and decreased precipitation. As reported, the Tuvan relic pine forest in the Sayan Mts is currently being converted to steppe at the lower tree line.

**Fig.6.** *From palynology data in the south of Siberia, large amounts of charcole are found in deposits associated with large fires during forest-steppe transitions induced by climate warming and peoples' (Turks, Scithians) migration in the past.*

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