Predicting Forest Fire Numbers Using Deterministic–Probabilistic Approach

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ABSTRACT

The annual task of forecasting forest fire danger is becoming increasingly relevant, especially in the context of global warming. The forecast of surface fires is most important, as more than 80% of all vegetation fires are surface fires. Practically all crown fires develop from surface fires. This chapter discusses the deterministic-probabilistic method for predicting the number of forest fires in a controlled forest area. This methodology is based on the assumption that the number of registered and projected forest fires is related to the probability of their occurrence. The influence of forest fire retrospective data on the predicted number of forest fires for some sites of the Timiryazevskiy forestry of the Tomsk region was studied. This chapter presents the results of a comparative analysis of forecast data and statistics.

INTRODUCTION

The task of forecasting forest fire danger with each passing year is becoming increasingly relevant, especially in the context of global warming (Budyko, 1980). Forecast of surface fires are of the greatest importance, since more than 80% of all vegetation fires are surface fires, almost all crown fires develop from surface fires (Valendik, 1979). A deterministic-probabilistic method for determining the probability of forest fires (Baranovskiy, 2004) was proposed earlier, which takes into account the influence of meteorological conditions, thunderstorm activity, and anthropogenic load and is based on simple mathematical models of drying a layer of forest fuels (Grishin and Baranovskiy, 2003; Baranovskiy and Grishin, 2002). As a result of calculations, the numerical value of the probability of occurrence of forest fires in a controlled area with spatial detail at the level of the minimum forest taxation unit (site) is...
determined. Despite the fact that such an assessment is both qualitative and to some extent quantitative, it does not give an answer to the question - how many forest fires should be expected at a given level of forest fire danger at a certain time interval in a controlled forest area?

The purpose of this work is to develop a deterministic-probabilistic method for predicting the number of forest fires in a controlled forest area and to carry out a parametric study of the effect of weather conditions, anthropogenic load, thunderstorm activity and fire retrospective data on the predicted number of forest fires, as well as comparative analysis with statistical data on real forest fires forestry.

BACKGROUND

Note that information on methods for predicting forest fire danger existing in Russia and abroad can be found in (Nesterov, 1949; Reyfsnyder, 1978; Kurbatskiy and Kostyrina, 1977). All techniques are based, as a rule, on the analysis of weather data.

Attempts were made in (Kataeva, 2000) to relate the moisture content of the forest fuel layer and the number of forest fires, but this is incorrect, since not always a high degree of fire danger due to weather conditions or forest vegetation conditions will lead to a high fire danger in the area. For example, the Bogorodskoye local forestry of the Timiryazevskiy forestry of the Tomsk region, in contrast to other forestry, even during dry periods is characterized by a small number of forest fires (Matsenko et al., 1999). The main reason is a weak anthropogenic load on this territory. In turn, work (Garcia Diez et al., 1993) presents a method for predicting the number of forest fires, which is based on taking into account the effect of instability in the atmospheric column on a controlled forest area on the forest fire danger. The authors of (Garcia Diez et al., 1993) note that their approach can be used simultaneously with other indices and, moreover, that their methodology can be built on the basis of other meteorological parameters. However, it does not take into account the real processes that affect forest fire danger, namely, drying of the forest fuel layer under the influence of external conditions, thunderstorm activity and the level of anthropogenic load.

In this work, as well as in (Baranovskiy et al., 2003), when developing a quantitative forecast method for the occurrence of forest fires, it is proposed to focus on the prospects for interactive interaction with computer programs that implement global or regional atmospheric models (for example, the semi-lagrangian model (Tolstykh, 2001).

Thus, at the moment in Russia and abroad there is virtually no physically meaningful method for predicting the number of forest fires and the relevance of developing such a technique is not in doubt.

PROBABILISTIC CRITERION

The formula was obtained to predict forest fire probability for time interval $j$ of a forest fire season using the basic principles of the probability theory (Baranovskiy, 2017; Baranovskiy & Zharikova, 2014):

$$P_j = [P(A)P(A_j / A)P(FF / A / A_j) + P(L)P(L_j / L)P(FF / L / L_j)]P_j(D)$$

(1)