Chapter 3
Mathematical Simulation of Anthropogenic Load on Forested Territories for Point Source

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ABSTRACT

An anthropogenic load is the main cause of forest fires in the vicinity of settlements and various objects of transport or industrial infrastructure. It is proposed to mark out linear and point sources of anthropogenic load. For the numerical simulation, the similarity in the processes of propagation of anthropogenic load and diffusive heat transfer was used. The quantitative characteristic of the anthropogenic load is the virtual (possible) number of forest fires in the controlled forest area. A mathematical model to predict the distribution of anthropogenic load from a point source is presented. Distributions of the virtual number of forest fires for model data from a point source are obtained. Conclusions about the patterns of the distribution of anthropogenic load from a point source are formulated. The prospects for the further development of these results are described.

INTRODUCTION

Forest fires occur as a result of the weather, thunderstorm activity and anthropogenic load (Baranovskiy & Kuznetsov, 2017a; Read et al., 2018; Ye et al., 2017; Benavent-Corai et al., 2007; Gorev, 2004; Perminov et al., 2014; Jiménez-Ruano et al., 2017). The processes of forest fires occurrence as a result of the thunderstorm activity have been studied quite well (Canadian Wildland Fire Information System; van Wagner, 1987; WFAS Wildland Fire Assessment System) by now compared with fires caused by the anthropogenic load (Lee et al., 2002; Ruffault & Mouillot 2017; Poulos et al., 2013; Amatulli et al., 2003). For example, a group of mathematical models was developed to determine the conditions for

DOI: 10.4018/978-1-7998-1867-0.ch003
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the ignition of trees by the cloud-to-ground lightning discharge, taking into account various discharge parameters and the structure of coniferous and deciduous trees (Baranovskiy et al., 2017; Baranovskiy & Kuznetsov, 2017b; Baranovskiy & Kuznetsov, 2017c). For the mathematical description of heat and mass transfer, nonstationary partial differential equations are used (Samarskii & Vabishchevich, 1995a, 1995b). An analysis of forest fire distributions in the vicinity of settlements allowed the idea that, in the first approximation, the distribution of anthropogenic load can be described using the equations of the general theory of heat and mass transfer (Baranovskiy, 2018). That is, it is proposed to use the similarity of the processes of heat transfer and the spread of anthropogenic load in the forested area. Deterministic approach is used instead of soft and statistical computing methods (Al Janabi et al., 2017; Rawlings et al., 2015).

The aim of the research is to develop a mathematical model of the spatial-temporal dynamics of anthropogenic load from a point source based on the similarity of heat transfer processes and the spread of anthropogenic load.

BACKGROUND

Forest fires destroy the forest stands and pollute the atmosphere with the products of pyrolysis and combustion of forest fuels (Baranovskiy & Kuznetsov, 2017a). An important part of strategic measures to prevent the negative impact of forest fires on plant communities and settlements is the forecast of their occurrence.

In Canada, the forest fire risk prediction is carried out as part of the Canadian Wildland Fire Information System (CWFIS) multicomponent system (Canadian Wildland Fire Information System; Wotton, 2009; Gould et al., 2013). The Canadian Forest Fire Danger Rating System (CFFDRS) (van Wagner, 1987; Martell, 2000) is used to predict the risk of the forest fires. It produces a qualitative and quantitative prediction of the fire potential index, which is used in a wide range of management activities. The input data includes weather conditions, characteristics of forest fuel, topographic parameters that are necessary to predict forest fire maturation, the occurrence of a forest fire and a prediction of the behavior of a forest fire. CFFDRS includes the following subsystems (van Wagner, 1987):

- Canadian Forest Fire Weather Index (FWI) System; The components of the subsystem are calculated using daily data on temperature, relative humidity, wind speed and daily precipitation.
- Canadian Forest Fire Behavior Prediction (FBP) System; This subsystem provides quantitative estimates of the possible speed of fire line propagation, the consumption of forest fuel, the intensity of the fire and its description.
- Canadian Forest Fire Occurrence Prediction (FOP) System (in fact, still under development, there are several regional schemes); this system is used to predict the probability of a forest fire.
- Accessory Fuel Moisture System (under development).
- Fire Monitoring, Mapping and Modeling System (Fire M3) (Lee et al., 2002); The system was launched in 1998 as a initiative of the Canada Center for Remote Sensing and the Canadian Forest Service. System is included in Natural Resources Canada. Fire M3 goals include the use of low-resolution satellite data to identify and localize active forest fires on a daily basis, estimate the daily and annual area of burnt areas and simulate fire behavior, and biomass consumption by fire.