Chapter 11
Classification of Territory on Forest Fire Danger Level Using GIS and Remote Sensing

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ABSTRACT
The vegetation cover is the most important factor in forest fires, because it reflects the presence of forest fuels. The study of the variability of the vegetation cover, as well as observation of its condition, allows estimating the level of fire danger of the forest quarter. The work presents a geo-information system containing a set of tools to determine the level of fire danger of the forest quarter. The system is able to predict (determine the probability) and classify forest quarters according to the level of fire danger. The assessment of forest fire danger of Tomsk forestry of Tomsk region has been carried out. Fire probability maps of forest quarters were created based on remote sensing data and ArcGIS software.

INTRODUCTION
The assessment of the forest fire danger probability is of great importance in creating an effective forest fire management system. Identifying forest areas that are highly likely to cause burning of forest fuel is an important component of fire management planning. The development of geo-information technologies greatly facilitates this process, allowing you to create maps and analyze the factors causing the occurrence of fires in forested areas.

In this work, geographic information systems (GIS) technologies are used in combination with remote sensing data to solve problems of forest fire management. The use of satellite imagery materials is more applicable to remote monitoring of forests, as well as updating land-based forest inventory data.

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Medium resolution remote sensing data remain essential for many tasks. The obvious advantage of medium spatial resolution surveys is their spectral characteristics - the ability to obtain data not only in the visible and near, but also in the middle and far infrared parts of the spectrum. An important circumstance is also the fact that accumulated long-term archival materials of remote sensing.

Free-access materials from multispectral space surveys of the Landsat 7 ETM + system were used in the work. In this work, various geo-information tools were used to combine the parameters necessary for calculating the level of forest fire danger and creating maps of fire danger of forest quarters. Processing input data, calculation of intermediate and final results is carried out in the ArcGIS environment. Forest fire danger assessment was carried out for Tomsk forestry of Tomsk region.

BACKGROUND

The ability to determine the place where a fire is probably to occur is a prerequisite for planning fire management. The vegetation cover is the most important factor in forest fires, because it reflects the presence of forest fuels (Roy, 2003). The use of remote sensing data in the classification and mapping of vegetation becomes the main method of fuel assessment. Existing methodologies for determining the type of vegetation include the traditional classification with and without training (Hansen et al., 2000; Churches et al., 2014), the method based on phenology (Yan et al., 2015), and the object classification (Mitchell et al., 2016).

Vegetation type maps are necessary for the spatial calculation of fire danger and for estimation of fire risks by using them in models that simulate the growth and intensity of a fire in a landscape. Forest fuel maps are used in various widespread systems for the forest fire danger forecasting. For example, such models are used in the North American models National Fire Danger Rating System (NFDRS), Fire behavior (BEHAVE), Fire Area Simulator (FARSITE), National Fire Management Analysis System (NFMAS) (Deeming et al., 1978; Finney, 1998; Lundgren et al., 1995; Arroyo et al., 2008). The McArthur Forest Fire Danger Rating System and the McArthur Grassland Fire Danger Rating System (McArthur, 1967) are widely used in Australia. The Canadian Forest Fire Danger Rating System is used in Canada, which consists of two main subsystems: the Fire Weather Index (FWI) and Fire Behavior Prediction System (Arroyo et al., 2008; van Wagner, 1987). The Forest Fire Satellite Monitoring Information System of Russian Federal Forestry Agency (SMIS-Rosleshoz) is used in the Russian Federation and is based on the Nesterov index. The ground-based observations, aerial photography, modeling and remote sensing data (Arroyo et al., 2008; Lasaponara and Lanorte, 2007; Keane et al., 2001; Wang et al., 2004; Ustin et al., 2004) are used for mapping. In general, data on the greenness of vegetation, meteorological data, data on wetting the surface and moisture content of forest fuel are necessary to forecast and to monitor forest fires (Kononov and Ka, 2008).

In addition, numerous studies showed the feasibility of geographic information system and remote sensing data (Chowdhury and Hassan, 2015; Hernandez-Leal et al., 2008). The GIS is a widely used tool for processing spatial data and displaying results. A model of a potential forest fire using satellite data and the GIS was developed in China to identify areas with a high probability of forest fire (Butt et al., 2015). In (Sheriza et al., 2010) five fire danger classifications were identified in developed forest fuel maps and the degree of fire danger in peat-bog forests was assessed. Vegetation types in the study area were analyzed using digital classification systems, namely, two vegetation indices: an extended vegetation index (AVI) and a Tasseled Cap (TC) conversion.