



WARSZAWA 2004 Vol. 11

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THE REMOTE SENSING METHOD OF FOREST FIRE DANGER RATING CATEGORIZATION*

Abstract: The article presents the use of satellite images in the determination of forest fire danger rating categories. The assessment was carried out based on images from the LANDSAT TM, IKONOS and NOAA satellites, with the finding that the LANDSAT TM images are the most useful. A new solution proposed is to make forest fire danger rating categories refer to forest ranger sub-districts, what gives the forest service greater control over forest fire prevention activities. Forest fire danger assessment was done taking into account remote sensing indices such as the NDVI, TNDVI, and IHT, as well by the analysis of the spatial distribution and the number of fires in the previous six years. In accordance with the Polish State Forest Classification System, three classes were specified: 1 – high fire danger, 2 – moderate fire danger, 3 – low fire danger.

Key words: forest fire danger rating classification, remote sensing as used in research.

By being a manifestation of spectral reflection, satellite images express the character of the geographic environment. The spatial relationship between natural and anthropogenic features provides a complex picture of the terrain, which can be classified into photomorphic units [1]. Most often, a photomorphic unit can be distinguished by its specific land cover, which is a product of the conditions present within the unit. Due to the composite nature of wooded areas, their satellite images are composites of photometric units. The remote sensing analysis of these images has made it possible to distinguish between areas which differ with regard to susceptibility to fire, and to assign them to categories based on their fire danger rating.

With regard to classifying fire danger in forest areas, in Poland the criteria which have been formulated and are in effect [4], are given in the Forest Fire Prevention Guidelines [2].

The classification specifies the potential fire danger in the given area. In Poland, fire danger ratings are specified for areas at the level of forest ranger districts and Regional State Forest Directorates. The factors taken into

* This article was written by the author with contributions from Evgeny Ponomarev and Olga Slinkina – fellows at the Institute of Forestry in Krasnoyarsk; and thanks to the research conducted by interns at the Laboratory of Forest Fire Prevention at the Forest Research Institute in Warsaw.

account in this classification system are: factors of the forest environment (the distribution of various habitat types in the given area and of classes of standing growth based on age), the frequency of forest fires in the given area over the period of at least the previous five years, climatic conditions as specified by the Selyaninov hydrothermal coefficient, as well as by indices describing the air pollution from industrial emissions. The classification process is carried out every 10 years. Three fire danger rating categories are set for Polish forest ranger districts and national parks. Since they are not required to have a fire danger rating, forests under other ownership, including privately owned forests, most often do not have it.

- Category I – high forest fire danger
- Category II – moderate forest fire danger
- Category III – low forest fire danger

The categories pertain to individual forest ranger districts, and yet it is often the case that areas of standing growth included within a district are highly diverse, among other things with regard to their fire danger rating, which is why the remote sensing method for specifying fire danger ratings described here is done with respect to sub-districts. This more highly subdivided system makes possible the diversification of fire prevention activities within the administration of the Polish State Forests. Most important, it facilitates the organizational and technical aspects of fire preparedness, as well as the carrying out of firefighting operations in the case of a fire.

Furthermore, the system takes into consideration all forest growth areas regardless of ownership (state-owned forests take up about 78% of the area of all forests in Poland, privately-owned forests constitute about 16% and national parks about 2%). It has to be pointed out, that due to the negligence of landowners, privately-owned forests are the most highly susceptible to fire, what is confirmed by statistics on forest fires collected by the Polish State Forest Service [5].

The test area chosen for the satellite image study was the Dobieszyn Ranger District, which lies at the junction of the rivers Pilica, Radomka and Wisłuta, to the north of Radom.

For a project of this scale (concentrated at the sub-district level), it was decided that images from the satellites LANDSAT TM, IKONOS and NOAA-AVHRR, would be used.

The spectral analysis of the individual tree species determined the choice of satellite images to be used. The images chosen were recorded in the autumn. The IKONOS satellite image was recorded on October 24, 2000; the LANDSAT TM image on August 18, 1993; and the NOAA-AVHRR image on August 21, 2002 and on September 9, 2002.

Due to the high diversity of the standing growth, as far as the mixture of the types of species, and their age, the unsupervised classification procedure was chosen [6]. Six classes were created for each of the images, representing stands of pine, spruce, oak and other broad-leaved trees, also divided into classes with regards to age.

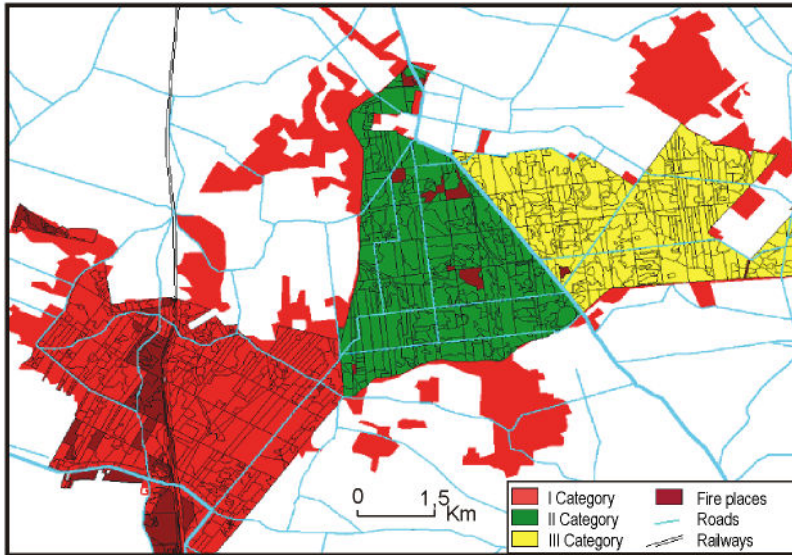


Fig. 1. The Remote Sensing Map of Forest Fire Danger Rating Categories.

The boundaries of the classes outlined very clearly corresponded to the boundaries of particular species areas, as illustrated on a map of the standing growth done previously for this district. The classification, which involved isolating units homogeneous with regard to species type and age, was the basis of further analysis.

One of the important factors influencing the image of a photomorphic unit is the moisture content, which affects the biomass and is expressed by the Normalized Difference Vegetation Index (NDVI) [3].

In the next stage, the Transformed Normalized Difference Vegetation Index (TNDVI) was also obtained for all of the images. These maps give a picture which is clearer and creating six classes made it possible to characterize the standing growth with regards to its type and age, and also its moisture content.

Subsequently, a map of the hydrothermal properties of the area studied was created for the LANDSAT TM image only. This index includes the medium and thermal infrared bands. The map illustrating this coefficient is highly similar to the NDVI classification map. Conversely, for the NOAA images, the values of the radiational terrain surface temperatures were specified.

Superimposing all of the maps – the map of homogeneous units, and then the NDVI and TNDVI, hydrothermal coefficient and radiational temperature value distribution maps – upon each other, resulted in the compilation of a composite map, illustrating the region's susceptibility to fire.

Only then was it decided to classify all the areas of forest growth within the district into three classes, corresponding to the fire danger rating categories.

After analyzing the previous ten years' worth of data regarding the fire situation, a final map of the Dobieszyn Ranger District was drawn up; illustrating the spatial distribution of fires, by their size and the year they took place. This map was used as the basis for the classification of individual sub-districts according to the forest fire danger classification system. All of the forest growth areas within one district were given the same forest fire danger rating.

The results of the analysis carried out here are illustrated by the Remote Sensing Map of Forest Fire Danger Rating Categories (Fig. 1).

Due to the fact that forests are a slow, but ever-changing, element of the geographic environment, the procedure should be repeated periodically, conceivably every 10 years, in accordance with the Forest Organization Plan, in order to verify the satellite-image-based categorization system for forest fire danger ratings.

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English translation: Joanna M. Kwiatowska