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Editors
Radoje V. Pantovic
Zoran S. Marković

Vrnjacka Banja, Serbia
12-15 June 2017

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XXV International Conference

"ECOLOGICAL TRUTH"

Eco-Ist'17

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THE NORTH ATLANTIC OSCILLATION (NAO), THE ARCTIC OSCILLATION (AO) AND FOREST FIRES IN LITHUANIA

Milan Milenkovic[1*], V. Babic[2], M. Krstic[2], T. Jojic Glavonjic[1], S. Denda[1]

[1]Geographical Institute "Jovan Cvijic", Serbian Academy of Sciences and Arts, Belgrade, SERBIA
[2]University of Belgrade, Faculty of Forestry, Belgrade, SERBIA

[*]*mmilenkovic@gi.sanu.ac.rs*

ABSTRACT

In Lithuania in the period 1992–2015, decreasing trends were recorded for the annual number of forest fires (significant at $p \leq 0.05$) and the annual burned area (not significant). In the research of the connection between forest fires and the North Atlantic Oscillation (NAO) index, the highest values of Pearson correlation coefficient (significant at $p \leq 0.01$) were recorded for the annual number of fires and NAO index for June (0.589) and summer (0.538). With the Arctic Oscillation (AO) index, the highest value was recorded for the annual number of fires and AO index for June (0.486).

Key words: forest fires, Lithuania, NAO, AO.

INTRODUCTION

Forests cover 2,173,000 ha (33.3%) of the territory of Lithuania. Conifer stands constitute 56.1% of forest area. The most widespread species is Scots pine (38% of forest area), followed by spruce (24%) [1]. Despite significant presence of coniferous species very endangered by fires, Lithuania could be considered less affected by fires. Smaller fires are typical for this country and in 2015 only 8 fires bigger than 1 ha were recorded [2]. Factors which determine fire frequency and size could be climate influences of the North Atlantic Oscillation (NAO) and the Arctic Oscillation (AO).

NAO index is calculated on the basis of the difference in sea surface air pressure between Iceland (low) and the Azores (high). It is characterized by both a positive and a negative phase. Strong positive phase is connected with above-normal temperatures across northern Europe. On the other side, it is also associated with above-normal precipitation over northern Europe and Scandinavia. Opposite patterns of temperature and precipitation anomalies are typically observed during strong negative phases of the NAO [3].

AO index is calculated on the basis of the difference in air pressure between 45° N (high) and above Arctic (low). It is also characterized by both a positive and a negative phase. When the AO is in the positive phase, strong winds circulate around the North Pole. This belt of winds becomes weaker and more distorted in the negative phase of the AO, which allows an easier southward penetration of colder, arctic air masses that cause increased storminess in the mid-latitudes [4].

The main aim of this research is the analysis of the connection between these teleconnections and forest fires in Lithuania. The analysis of forest fire trends on the basis of available data was also conducted.

DATA AND METHODS

The main source of the data on forest fires was the European Commission report [2]. The data on forest fires in Lithuania (period 1992–2015) cover:

- the annual number of forest fires – N;
- the annual burned area – P;
- the average burned area per fire – A.

For these datasets linear trends were determined. In addition, statistical significance of linear trend was determined for (n-2) and on the basis of the coefficient of determination (R^2). For the testing of the significance t test was used:

$$t = R\sqrt{\frac{n-2}{1-R^2}}$$

where n – the length of the series.

Monthly and seasonal values of NAO index and AO index were used in the research. The data were downloaded from the Earth System Research Laboratory, National Oceanic & Atmospheric Administration, U.S. Department of Commerce [5, 6].

For the calculation of correlation Pearson correlation coefficient (R) on the basis of linear trend was used. Statistical significance was tested on $p \leq 0.05$ and $p \leq 0.01$. Calculation did not use the data for the period October to December, since fire season in Lithuania is in the period April–September [2].

RESULTS AND DISCUSSION

In Lithuania in the period 1992–2015, a decreasing trend of the annual number of forest fires was recorded (Figure 1). It was determined that the trend is statistically significant at $p \leq 0.05$.

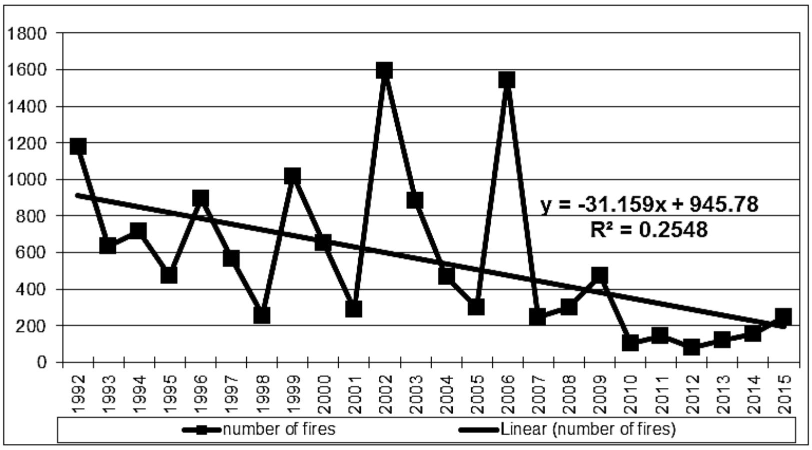

Figure 1. The annual number of forest fires in Lithuania (1992–2015) [2] with the trend line

A decreasing trend of the annual burned area was also noted (Figure 2). The trend is not statistically significant at $p \leq 0.05$.

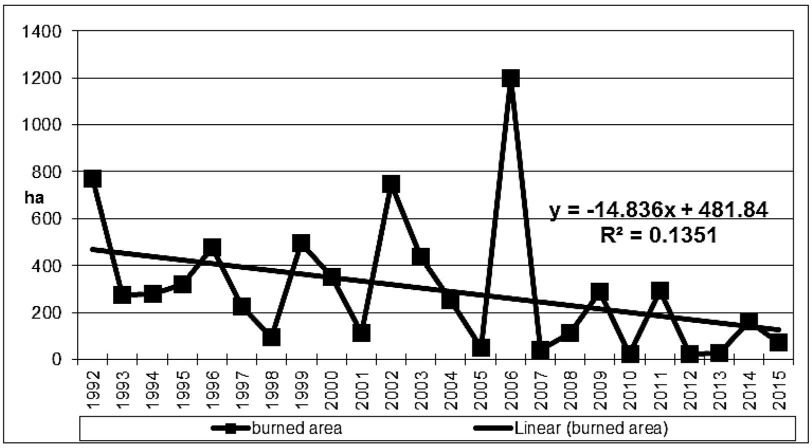

Figure 2. The annual burned area in Lithuania (1992–2015) [2] with the trend line

An increasing trend of the average burned area per fire was recorded (Figure 3). The trend is not statistically significant at $p \leq 0.05$.

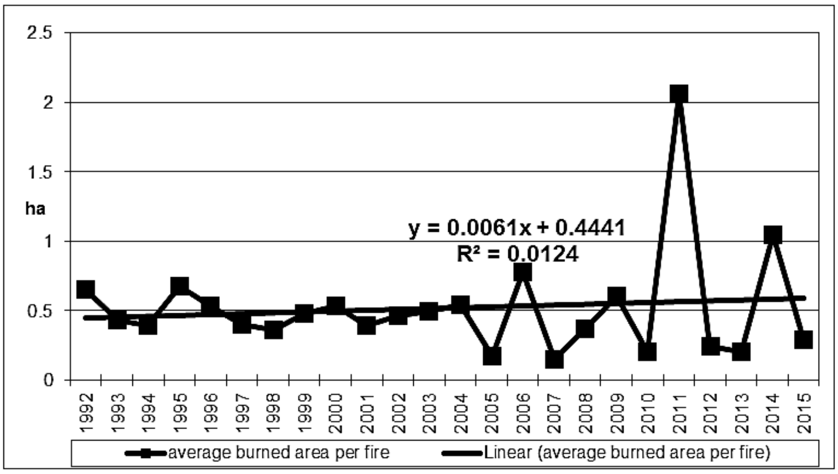

Figure 3. The average burned area per fire in Lithuania (1992–2015) [2] with the trend line

Lithuania is not much endangered by forest fires. In the period 1992–2015, the annual number of forest fires varied between 81 in 2012 and 1596 in 2002. The annual burned area varied between 20 ha in 2012 and 1199 ha in 2006. The average burned area per fire was below 1 ha in all years of the period, except in 2011 (2.06 ha) and 2014 (1.05 ha).

The results of the research of the correlation between forest fires in Lithuania and NAO index are shown in Table 1.

Table 1. Pearson correlation coefficient (R): Forest fires in Lithuania (1992–2015) – NAO index

	NAO index											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Winter	Spring	Summer
N	0.121	0.165	-0.023	0.232	0.221	0.589**	0.358	0.250	-0.343	0.024	0.208	0.538**
P	0.043	0.124	-0.075	0.365	0.204	0.515**	0.341	0.026	-0.308	-0.042	0.237	0.400
A	-0.351	0.269	0.132	0.506*	0.072	-0.041	-0.039	-0.368	0.218	-0.173	0.344	-0.196

* significant at $p \leq 0.05$;** significant at $p \leq 0.01$; N – annual number of fires; P – annual burned area; A – average burned area per fire.

The highest value of R was recorded for the annual number of fires and NAO index for June (0.589) (Figure 4). On the seasonal level, the highest value is for summer (0.538). These two values are significant at $p \leq 0.01$.

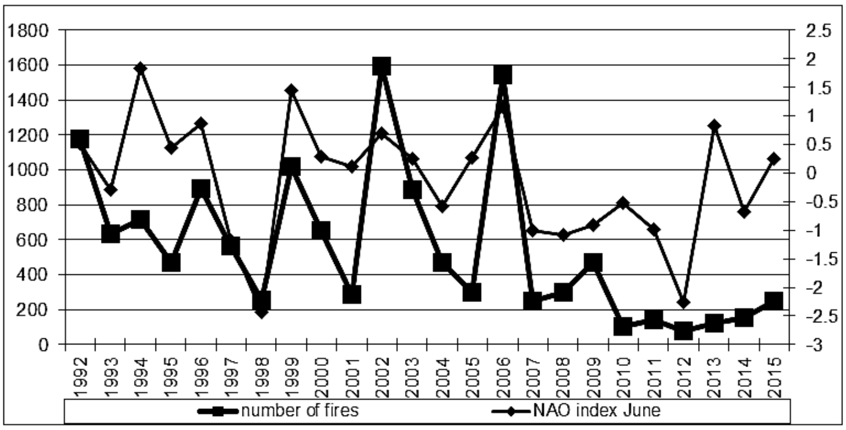

Figure 4. The annual number of fires in Lithuania (1992–2015) – NAO index for June: R=0.589 (significant at p≤0.01)

For the annual burned area the highest value of R was recorded in June (0.515) (Figure 5). The value is also significant at p≤0.01.

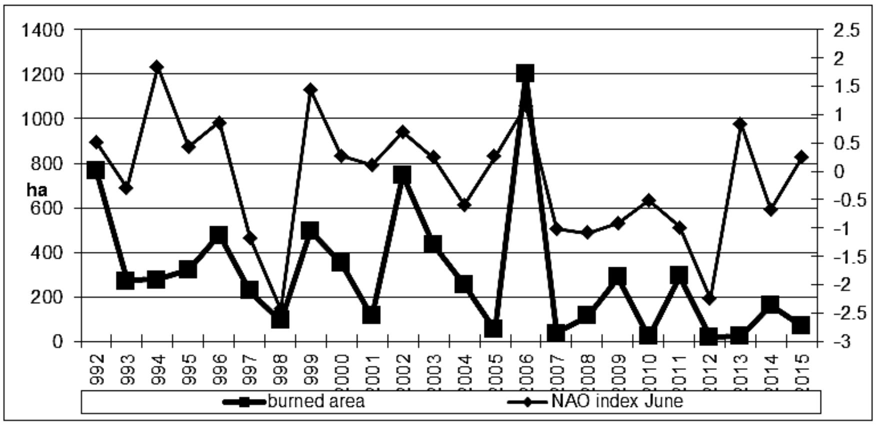

Figure 5. The annual burned area in Lithuania (1992–2015) – NAO index for June: R=0.515 (significant at p≤0.01)

For the average burned area per fire the highest R value was recorded in April (0.506). It is significant at p≤0.05.

The results of the research of the correlation between forest fires in Lithuania and AO index are shown in Table 2.

Table 2. Pearson correlation coefficient (R): Forest fires in Lithuania (1992–2015) – AO index

	AO index											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Winter	Spring	Summer
N	0.274	0.328	-0.066	-0.230	0.173	0.486*	0.359	0.017	0.021	0.183	-0.065	0.425*
P	0.135	0.343	-0.090	-0.135	0.205	0.400	0.285	-0.070	0.095	0.100	-0.030	0.313
A	-0.250	0.404*	0.236	0.468*	0.069	-0.198	-0.169	-0.433*	0.245	-0.056	0.369	-0.347

* significant at p≤0.05;** significant at p≤0.01; N – annual number of fires; P – annual burned area; A – average burned area per fire.

The highest value of R was recorded for the annual number of fires and AO index for June (0.486). For the average burned area per fire the highest R value was recorded in April (0.468). These two values are significant at p≤0.05.

In similar research, the Atlantic Multidecadal Oscillation (AMO) was brought into connection with forest fires in France [7] and Portugal [8]. Outside Europe, AO was brought into connection with the annual burned area and the average burned area per fire in Manitoba (Canada) [9]. The NAO positive phase is linked with increased wildfire activity in the central Gulf Coast (United States) [10]. El Niño-Southern Oscillation (ENSO), NAO, Pacific Decadal Oscillation (PDO), and Pacific-North American (PNA) showed significant correlations with wildfire data in the state of Mississippi. The combination of these teleconnection indices might form the basis for the creation of predictive fire-risk models [11].

Results of the research of the connection between the NAO index and the AO index on one side and forest fires in Lithuania on the other side could be the basis for future fire danger forecast. Similar research could be done in other European countries, but the research using other teleconnection indices is necessary. The use of forest fires datasets for longer periods (for example 40–50 years) presents a precondition for satisfactory results of the research.

Also, it should be kept in mind that a new theory on the causes of forest fires exists. According to this theory, forest fires are caused by highly energetic particles of solar wind, which penetrate through geomagnetic field and reach the vegetation on the Earth's surface [12–15].

CONCLUSION

In Lithuania in the period 1992–2015, the decrease of the annual number of forest fires was statistically significant at p≤0.05, while the decrease of the annual burned area was not. The increase of the average burned area per fire was not statistically significant at p≤0.05. Lithuania is not much endangered by forest fires. The average burned area per fire was below 1 ha in all years, except in 2011 and 2014. The highest values of Pearson correlation coefficient (significant at p≤0.01) were recorded for the annual number of fires and NAO index for June (0.589) and summer (0.538). Statistically significant values were also recorded for the annual burned area and NAO index for June and the average burned area per fire and NAO index for April. In the research with AO index, the highest value of R was recorded for the annual number of fires and AO index for June (0.486). Results of the research could be used in future fire danger forecast.

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REFERENCES

1. http://www.gmu.lt/forest_resources/
2. 2] San-Miguel-Ayanz, J., Durrant, T., Boca, R., Libertà, G., Boccacci, F., Di Leo, M., López Pérez, J., & Schulte, E. (2016). Forest Fires in Europe, Middle East and North Africa 2015; EUR 28158 EN; http://dx.doi.org/10.2788/914; http://forest.jrc.ec.europa.eu/effis/reports/annual-fire-reports/
3. https://www.ncdc.noaa.gov/teleconnections/nao/
4. https://www.ncdc.noaa.gov/teleconnections/ao/
5. https://www.esrl.noaa.gov/psd/data/correlation/nao.data
6. https://www.esrl.noaa.gov/psd/data/correlation/ao.data
7. Milenković, M., Ducić, V., Burić, D., Lazić, B. (2016). The Atlantic Multidecadal Oscillation (AMO) and the forest fires in France in the period 1980–2014. *Journal of the Geographical Institute "Jovan Cvijić" SASA, 66*(1), 35–44. doi: 10.2298/IJGI1601035M
8. Milenković, M., Yamashkin, A. A., Ducić, V., Babić, V., Govedar, Z. (2017). Forest fires in Portugal – the connection with the Atlantic Multidecadal Oscillation (AMO). *Journal of the Geographical Institute "Jovan Cvijić", 67*(1), 27–35. doi: 10.2298/IJGI1701027M
9. Milenkovic, M., Ducic, V., Babic, V., Krstic, M., Lazic, B. (2016). The connection between Arctic Oscillation (AO) and the forest fires in Manitoba province (Canada). In R. V. Pantovic & Z. S. Markovic (Eds.), *Proceedings / XXIV International Conference "Ecological Truth", Eco-Ist '16* (pp. 740–746). Bor: University of Belgrade, Technical Faculty.
10. Labosier, C. F., Frauenfeld, O. W., Quiring, S. M., Lafon, C. W. (2015). Weather type classification of wildfire ignitions in the central Gulf Coast, United States. *International Journal of Climatology, 35*(9), 2620–2634. doi: 10.1002/joc.4160
11. Dixon, P. G., Goodrich, G. B., Cooke, W. H. (2008). Using teleconnections to predict wildfires in Mississippi. *Monthly Weather Review, 136*(7), 2804–2811. doi: 10.1175/2007MWR2297.1

12. Gomes, J. F. P., Radovanovic, M. (2008). Solar activity as a possible cause of large forest fires —a case study: Analysis of the Portuguese forest fires. *Science of the Total Environment, 394*(1), 197–205. doi: 10.1016/j.scitotenv.2008.01.040, ISSN 0048–9697
13. Radovanović, M. (2010). Forest fires in Europe from July 22–25, 2009. *Archives of Biological Sciences, 62*(2), 419–424. doi: 10.2298/ABS1002419R
14. Radovanović, M., Vyklyuk, Y., Jovanović, A., Vuković, D., Milenković, M., Stevančević, M., Matsiuk, N. (2013). Examination of the correlations between forest fires and solar activity using Hurst index. *Journal of the Geographical Institute "Jovan Cvijić"SASA, 63*(3), 23–32. doi: 10.2298/IJGI1601035M
15. Radovanović, M. M., Vyklyuk, Y., Milenković, M., Vuković, D. B., Matsiuk, N. (2015). Application of adaptive neuro-fuzzy interference system models for prediction of forest fires in the USA on the basis of solar activity. *Thermal Science, 19*(5), 1649–1661. doi: 10.2298/TSCI150210093R