Monitoring of forest biodiversity and climatic impact on forest environment with the use of high-resolution satellite images

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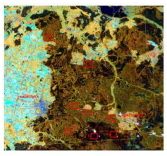
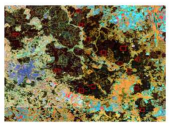
STUDY AREAS AND DATA

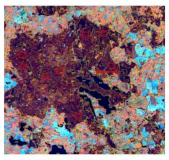
Three study areas located in northeastern Poland, characterized by various forest parameters – Bialowieska, Knyszynska and Borecka Forest, have been selected. Two types of satellite images were applied: Landsat TM / OLI and SPOT images. They were collected within three vegetation seasons – 2006, 2014 and 2015, which differed in meteorological conditions. Meteorological data – air temperature and precipitation were gathered for all study areas. Moreover, reference data were collected for the regions of interest: digital forest maps, the results of ground spectral measurements and the results of pigment content measurements.



BIALOWIESKA FOREST

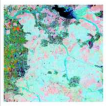


KNYSZYNSKA FOREST



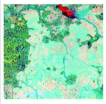
BORECKA FOREST

VEGETATION INDICES DERIVED FROM SATELLITE DATA AND GROUND MEASUREMENTS

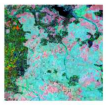


NDVI RGB
APR09, JUL03, AUG27

NDII RGB
APR09, JUL03, AUG27



EVI RGB
APR09, JUN12, AUG31



DSWI RGB
APR09, JUL03, AUG27

Four vegetation indices have been derived from SPOT 5 and Landsat 7/8 images.
They characterize different aspects of vegetation development:

Normalized Difference Vegetation Index – NDVI
NDVI = (NIR – RED) / (NIR + RED)
characterizing general vegetation condition

Normalized Difference Infrared Index – NDII
NDII = (NIR – SWIR1) / (NIR + SWIR1)
sensitive to water content in plants

Enhanced Vegetation Index – EVI
EVI = 2.5x (NIR – RED) / (NIR + 6xRED – 7.5xBLUE + 1)
sensitive to canopy structure

Disease Water Stress Index – DSWI
DSWI = (NIR – GREEN) / (SWIR1 + RED)
sensitive to stress due to water shortage and plant damage

Numerous vegetation indices have been derived from ground spectral measurements.
The most significant for vegetation discrimination were:

Normalized Difference Infrared Index - NDII
NDII = (NIR – SWIR1) / (NIR + SWIR1)

Simple Ratio Index - SR
SR = NIR / RED

Normalized Difference Vegetation Index 705 - NDVI705
NDVI705 = (R750 – R705) / (R750 + R705)

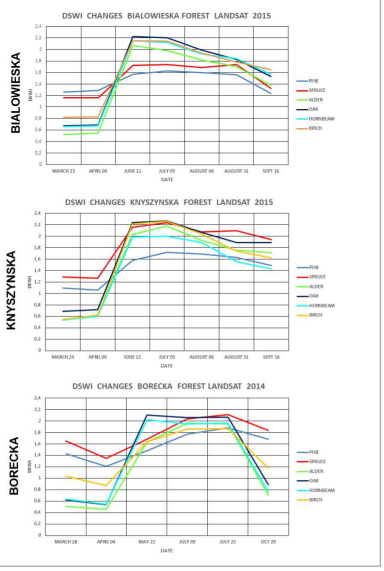
Green Normalized Diff. Vegetation Index – Green NDVI
Green NDVI = (R801 – R550) / (R801 + R550)

Enhanced Vegetation Index - EVI
EVI = 2.5x (NIR – RED) / (NIR + 6xRED – 7.5xBLUE + 1)

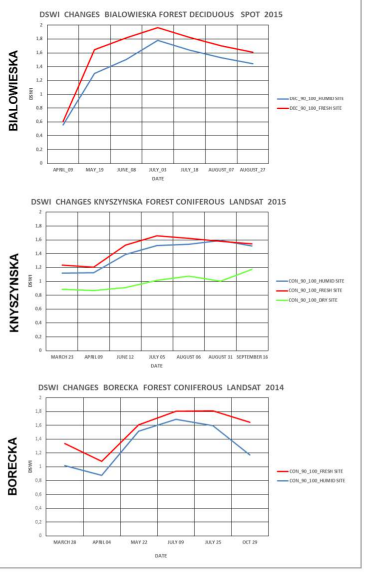
Simple Ratio Pigment Index - SRPI
SRPI = R430 / R680

STUDY OF VARIOUS ENVIRONMENTAL FEATURES OF FOREST AREAS – BASED ON DSWI INDEX

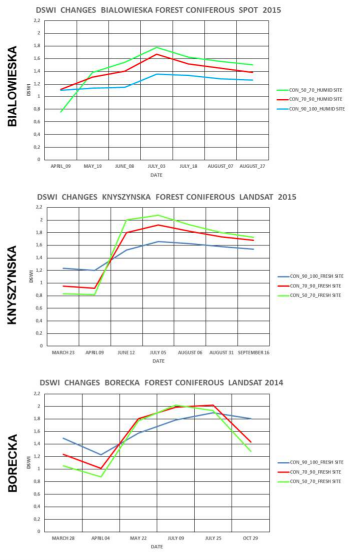
TREE SPECIES



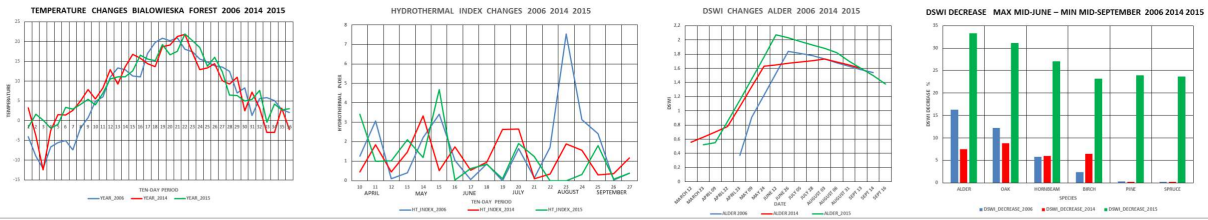
FOREST SITE TYPE



STAND MIXTURE



STUDY OF CLIMATIC IMPACT ON FOREST EXPRESSED BY CHANGES OF VEGETATION INDEX



CONCLUSIONS

- Comparative analysis of various vegetation indices – NDVI, NDII, EVI and DSWI demonstrated that Disease Water Stress Index – DSWI is most correlated with changeable features of forest areas: tree species, type of forest site and stand mixture
- DSWI index enables to make discrimination between two types of conifers – pine and spruce – and between some deciduous species at the early stage of growing season
- DSWI value is influenced by type of forest site - coniferous forests located on dry forest sites tend to have lower DSWI values than those situated on fresh and humid sites
- Deciduous forests located on fresh forest sites have higher DSWI values than those situated on humid sites throughout the whole growing season
- Stand mixture has impact of DSWI value - mixing of conifers with hardwoods increases DSWI index while deciduous stands mixed with conifers reveal DSWI decrease
- Drought period characterized by meteorological based index has impact on decrease of values of vegetation indices; especially DSWI index proved to be useful for detecting drought in 2015
- Coniferous forest stands situated on dry forest sites are more resistant to drought impact than those located on humid and fresh sites

ACKNOWLEDGMENTS

The research work has been conducted within the Polish-Norwegian Research Programme, Norway Grants, financed by the National Centre for Research and Development, as a part of the WICLAP project " Ecosystem stress from the combined effects of winter climate change and air pollution – how do the impacts differ between biomes?"