# Application of high-resolution satellite data for monitoring forest areas in changeable climatic conditions

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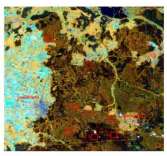
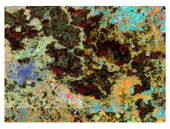
## STUDY AREAS AND DATA

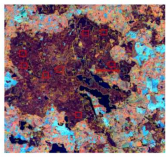
Three study areas located in northeastern Poland, characterized by various environmental features – Bialowieska, Knyszynska and Borecka Forest, have been selected. Three types of satellite images were applied: Landsat TM / OLI, SPOT and Sentinel 2 images. They were collected within four vegetation seasons – 2006, 2014, 2015 and 2016, which differed in meteorological conditions. Meteorological data – air temperature and precipitation were collected for all study areas. Moreover, reference data were obtained for the regions of interest: digital forest maps, the results of ground spectral measurements and the results of pigment content measurements.



BIALOWIESKA FOREST

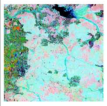


KNYSZYNSKA FOREST

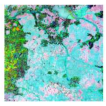


BORECKA FOREST

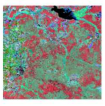
## VEGETATION INDICES DERIVED FROM SATELLITE DATA AND GROUND MEASUREMENTS



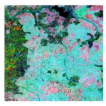
NDVI RGB
APR09, JUL03, AUG27



NDII RGB
APR09, JUL03, AUG27



TVI RGB
MAR28, JUN29, AUG28



DSWI RGB
APR09, JUL03, AUG27

Four vegetation indices have been derived from SPOT 5, Landsat 5/8 and Sentinel 2 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

**Triangular Vegetation Index – TVI**
TVI = 0.5*[(120*(R750 – R550) – 200*(R670 – R550)]
sensitive to chlorophyll content

**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 proved to be:

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

**Modified Red Edge Simple Ratio Index - MRESR**
MRESR = (R750 – R445) / (R705 – R445)

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

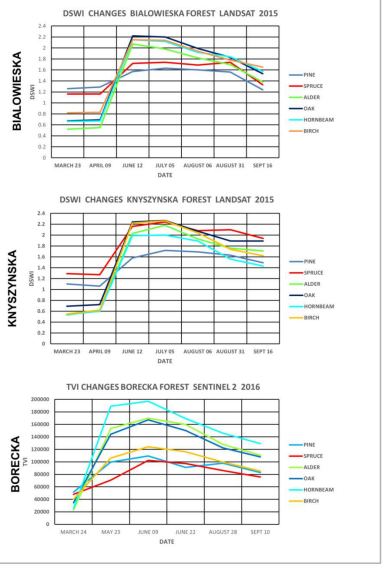
**Triangular Vegetation Index - TVI**
TVI = 0.5*[(120*(R750 – R550) – 200*(R670 – R550)]

**Transformed Chlorophyll Absorption Ratio Index - TCARI**
TCARI = 3*[(R700 – R670) – 0.2*(R700 – R550)*(R700/R670)]

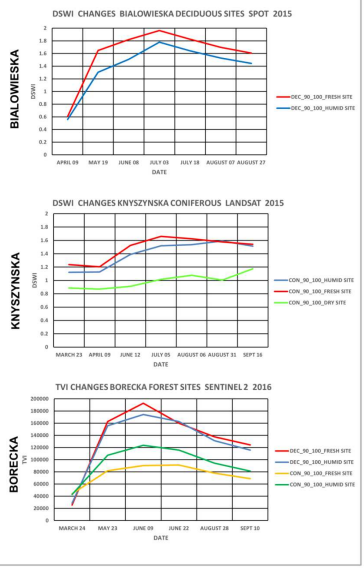
**Plant Senescence Index - PSRI**
PSRI = (R680 – R500) / R750

## STUDY OF VARIOUS ENVIRONMENTAL FEATURES OF FOREST AREAS – BASED ON VEGETATION INDICES

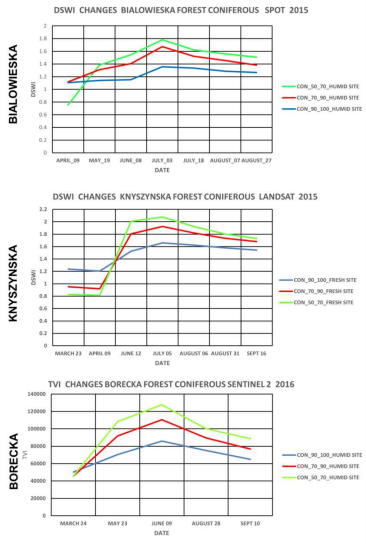
### TREE SPECIES



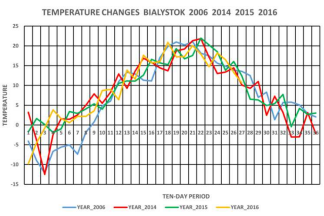

### FOREST SITE TYPE

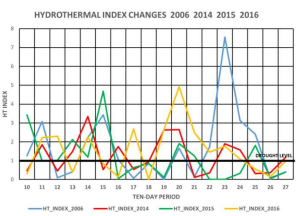


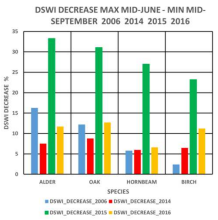

### STAND MIXTURE

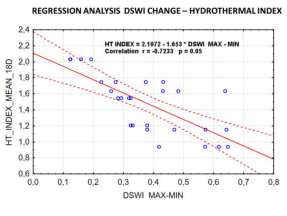



## STUDY OF CLIMATIC IMPACT ON FOREST EXPRESSED BY CHANGES OF VEGETATION INDEX




## CONCLUSIONS

- Comparative analysis of various vegetation indices – NDVI, NDII, TVI and DSWI demonstrated that Disease Water Stress Index – DSWI and Triangular Vegetation Index - TVI are most correlated with changeable features of forest areas: tree species, type of forest site and stand mixture
- Both indices enable to make discrimination between two types of conifers – pine and spruce – and between some deciduous species at the early stage of growing season
- DSWI and TVI values are 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, while TVI index enables to differentiate fresh and humid sites for conifers
- 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 and TVI values - mixing of conifers with hardwoods increases DSWI and TVI indices, while deciduous stands mixed with conifers reveal reverse tendency
- Drought period characterized by hydrothermal index has impact on decrease of values of vegetation indices; high correlation was found between this index and DSWI index
- Coniferous forest stands situated on dry forest sites are more resistant to drought impact

## ACKNOWLEDGMENTS

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