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Effects of winter snow cover on summer vegetation: a spectral analysis in the "Parco delle Foreste Casentinesi" con Sentinel_2

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Goal

This study aims to verify the possible influence of snow cover in the winter months, quantified by the NDSI index, on the vigor of summer vegetation, represented by the NDVI index, within the Parco delle Foreste Casentinesi in the period 2018–2024.

Dataset

The images used are from the Sentinel-2 mission of the Copernicus programme. Main features:

- Two identical satellites in synchronized orbit
- High-resolution multispectral sensor
- 13 spectral bands (from visible to infrared)
- Revisit time: 5 days

Importing images

The study area corresponding to the Casentinesi Forests National Park was selected from the Copernicus Browser portal. The following Sentinel-2 images were downloaded for the years 2018 and 2024:
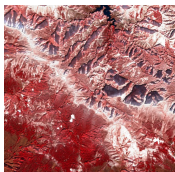
- Winter months: December, January, February
- Summer months: June, July, August
- Image types:
    - True Color (B4, B3, B2 bands)
    - False Color (B8, B4, B3 bands)
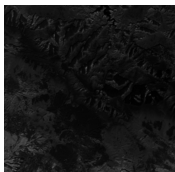   - Band 11 (SWIR), useful for calculating the NDSI

Image Types

True Color
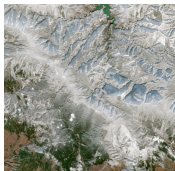
False Color

B11 (SWIR)

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NDSI

The NDSI is an index used to identify the presence of snow on the ground. It is based on the difference between the reflectance of green (Green) and shortwave infrared (SWIR):

$$NDSI = \frac{Green - SWIR}{Green + SWIR}$$

Snow reflects a lot in the visible but absorbs in the SWIR: this contrast makes the NDSI effective for distinguishing snow from other bright surfaces such as clouds.

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NDVI

NDVI is an index used to evaluate the presence and health of vegetation on the Earth's surface, using the difference in reflectance between the red (Red) and near infrared (NIR) bands. High NDVI values indicate lush vegetation, while low values may indicate areas with little or no vegetation.

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

NDVI classification

Based on the NDVI values, it is possible to evaluate the health status of vegetation. The following classification parameters were adopted in this study:

- Absent vegetation: $NDVI < 0.2$
- Stressed vegetation: NDVI between 0.2 and 0.5
- Healthy vegetation: $NDVI > 0.5$

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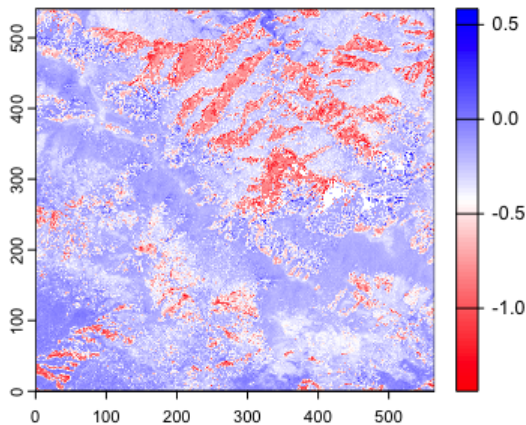
ΔNDSI

To visualize the variation of the NDSI (Normalized Difference Snow Index) between the years 2018 and 2024, the NDSI was calculated, that is the difference between the NDSI values of the two years. As you can see below, the image highlights areas with loss of snow cover in red, while areas with increase in snow cover in blue.

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Delta NDSI 2024-2018

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ΔNDVI

To visualize the variation of the NDVI (Normalized Difference Vegetation Index) between the years 2018 and 2024, the NDVI was calculated, that is the difference between the NDVI values of the two years. As you can see below, The image highlights areas with worsening vegetation health in red, and those with improvement in blue

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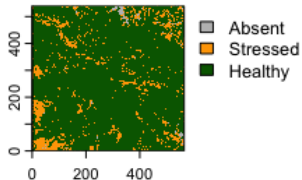
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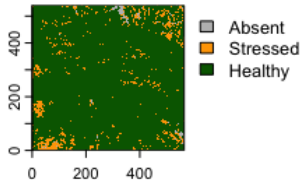Results
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Delta NDVI 2024-2018
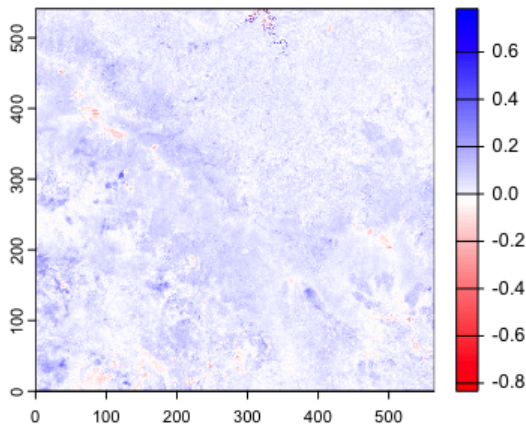
NDVI classification

By applying the classification criteria to the NDVI values of 2018 and 2024, the following images were obtained:
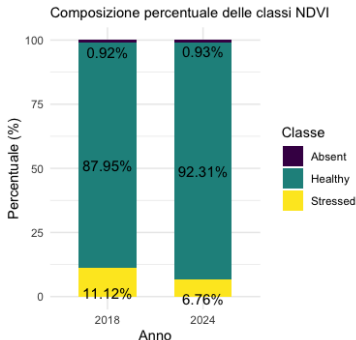
NDVI classes 2018

NDVI classes 2024

NDVI class frequencies

The classes in question have the following frequencies over the years. A slight improvement in vegetation conditions can be observed.

Composizione percentuale delle classi NDVI

NDSI-NDVI correlation

To verify the existence of a correlation between snow cover and vegetation status, the Pearson correlation between NDVI and NDSI values in the years considered was calculated. For both the years 2018 and 2024, a very weak negative correlation was observed ($r << 0$), which however was statistically significant in both cases ($p << 0$)

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- Between 2018 and 2024, snow cover shows local variations, with areas of increase and decrease.
- Vegetation shows a slight improvement, with more healthy and less stressed areas.
- The correlation between snow cover and vegetation health is negative, very weak but significant.
- The impact of snow cover on vegetation is therefore limited in the period analyzed.

Thank you!