

Dynamic Vegetation Changes in the Arctic: Circumpolar Trends based on Earth Observation

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Rapid warming rates impact the vegetation in the Arctic Region

The accelerated warming rates of roughly four times the global average since 1979 [1] and subsequent climatic shifts impact the ecosystem of the Arctic drastically, e.g. through changes of the energy and carbon balance [2,3]. Satellite remote sensing applications are capable to observe and derive several central plant properties of the Arctic ecosystem.

The developments of dynamic vegetation trends in the Arctic and sub-Arctic regions were identified based on a literature review of 162 SCI articles published between 2000 and 2024. The articles were selected based on key words relating to tundra vegetation, satellite platforms and exclusion criteria.

Circumpolar trends and ecological drivers

Consistent circumpolar trends are difficult to define, partly due to methodological differences in deriving these trends but also due to the variety of ecological drivers in the circumpolar tundra. The absence of trends also does not imply ecological stability, as e.g. circa 12 % of the reviewed studies found ecological changes while radiometric indices showed no significant trends.

Greening trends

Increasing vegetation index trends occur in all ecozones (low to high Arctic, Oro Arctic) and often in shrub and herbaceous land cover types. Changes in surface water and temperature were identified as drivers on circumpolar scale.

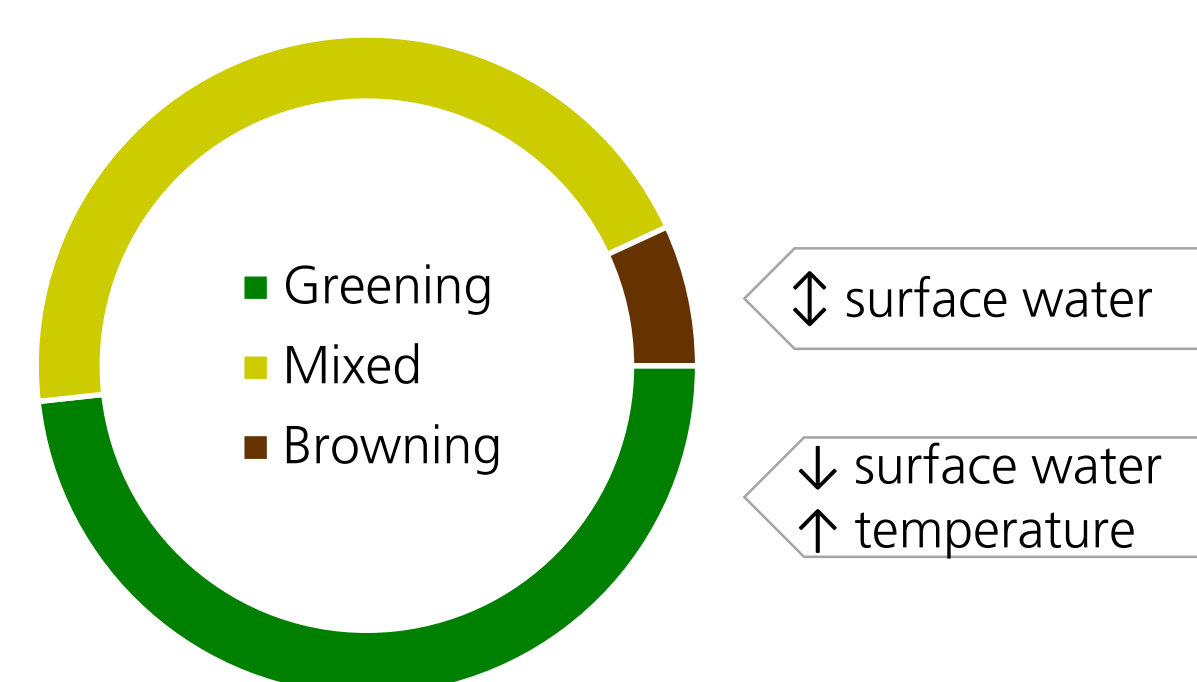


Fig. 1: Distribution of significant VI trends and key circumpolar drivers (box). The arrows indicate the direction of influence.

Shrubification

The species composition changed in various ways, however a general increase of shrubs and a decline of lichen was found on a circumpolar scale. Tree lines both advanced and declined in the circumpolar Tundra-Taiga Ecotone zone. Drivers of species composition changes varied greatly and were related to e.g. climatic changes and animal grazing.

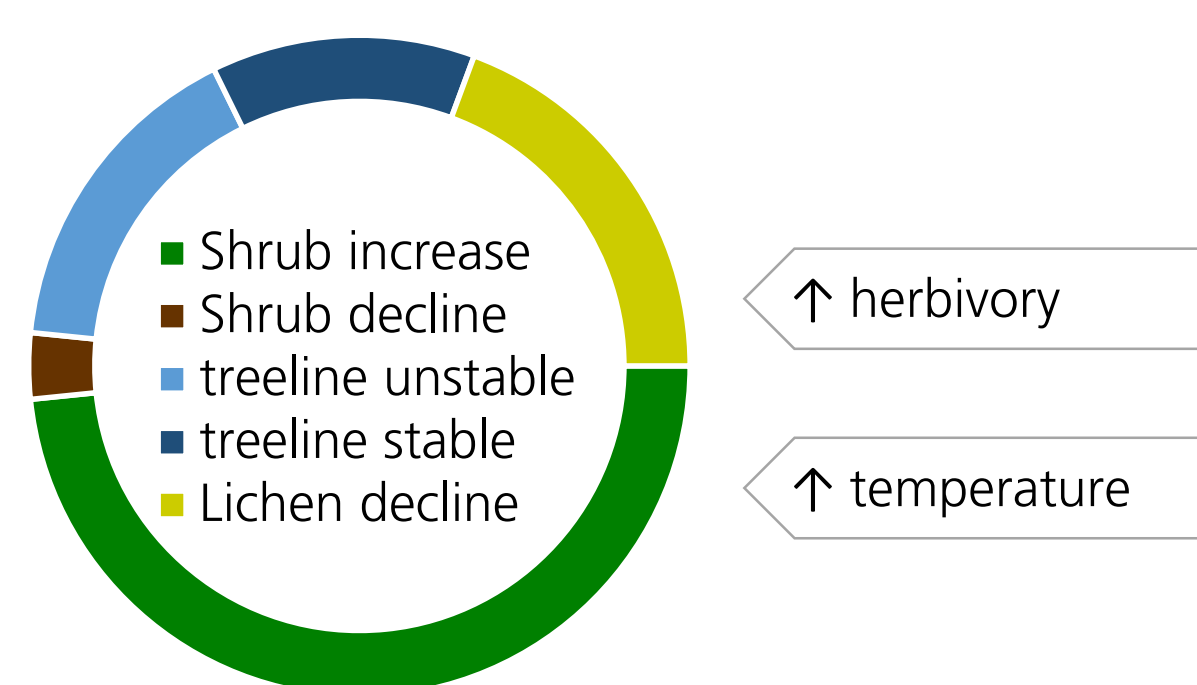


Fig. 2: Distribution of changes in species composition and key circumpolar drivers (box). The arrows indicate the direction of influence, e.g. increasing temperature drives shrub increase.

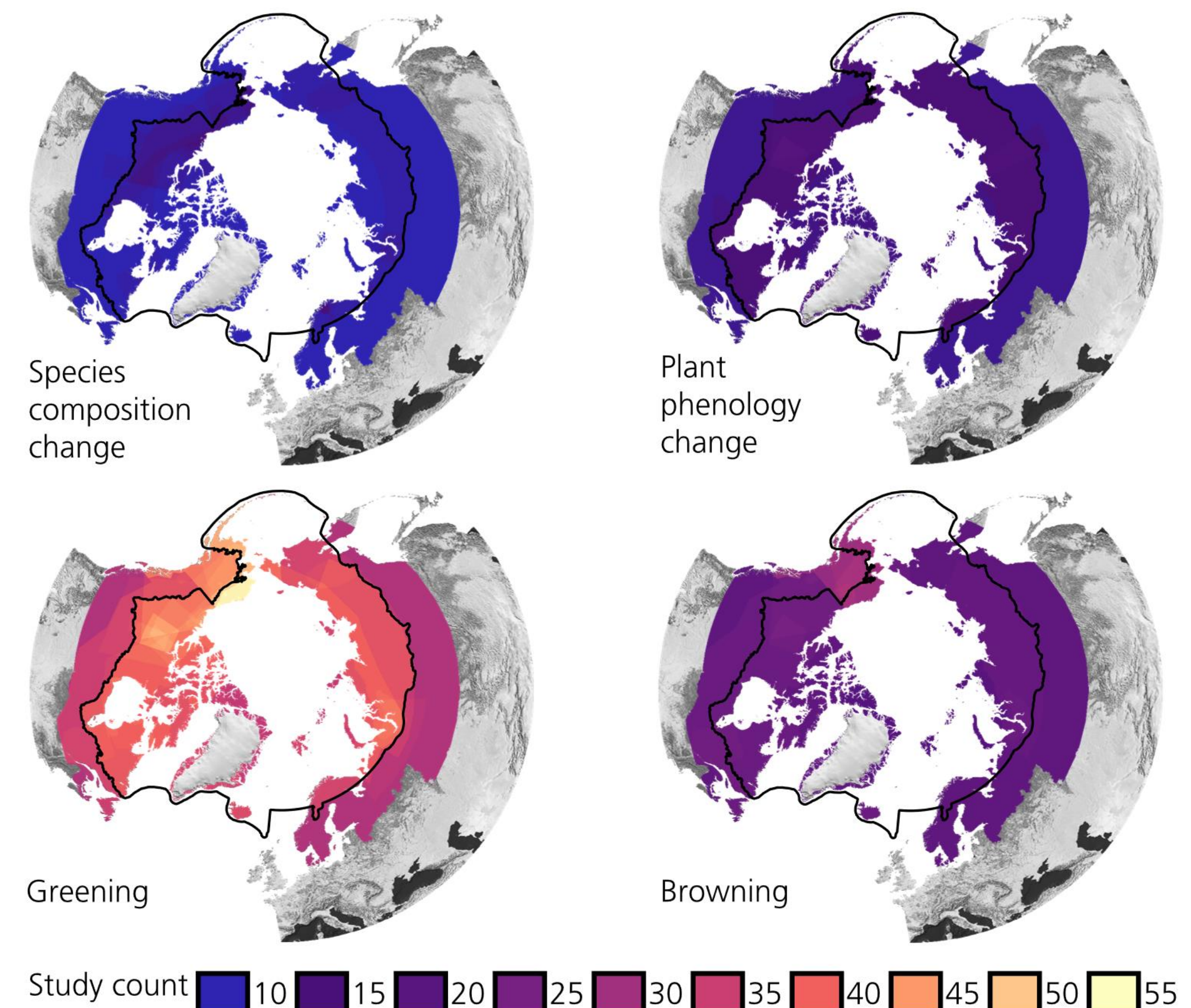


Fig. 3: Circumpolar distribution of study regions for selected study foci [5]. The black line depicts the boundary for the circumpolar Arctic and sub-Arctic regions and is based on the CAFF boundary [4]. The colour represents the number of studies with significant trends.

Primary data source: Medium-resolution multispectral data

Medium to low resolution satellite data (Landsat, AVHRR, Aqua-Terra) was the primary data source for all research foci. Thermal data was also utilized to investigate vegetation disturbance, while other sensor types were negligible.

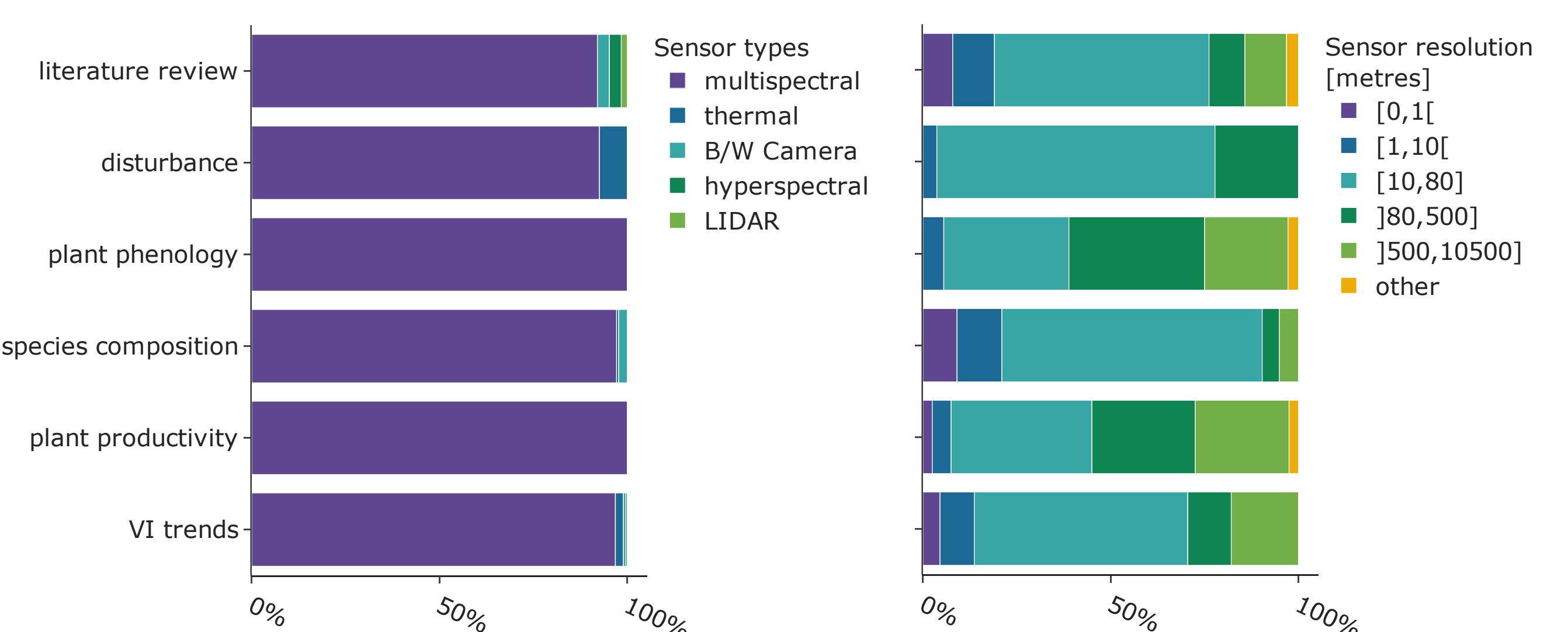


Fig. 4: Distribution of sensor resolution and sensor types grouped according to the primary research focus areas identified across all reviewed studies [5].

Key environmental parameters used to investigate the research foci included land cover, temperature, and precipitation. The temporal resolution of the satellite data varied both between and within the research foci.

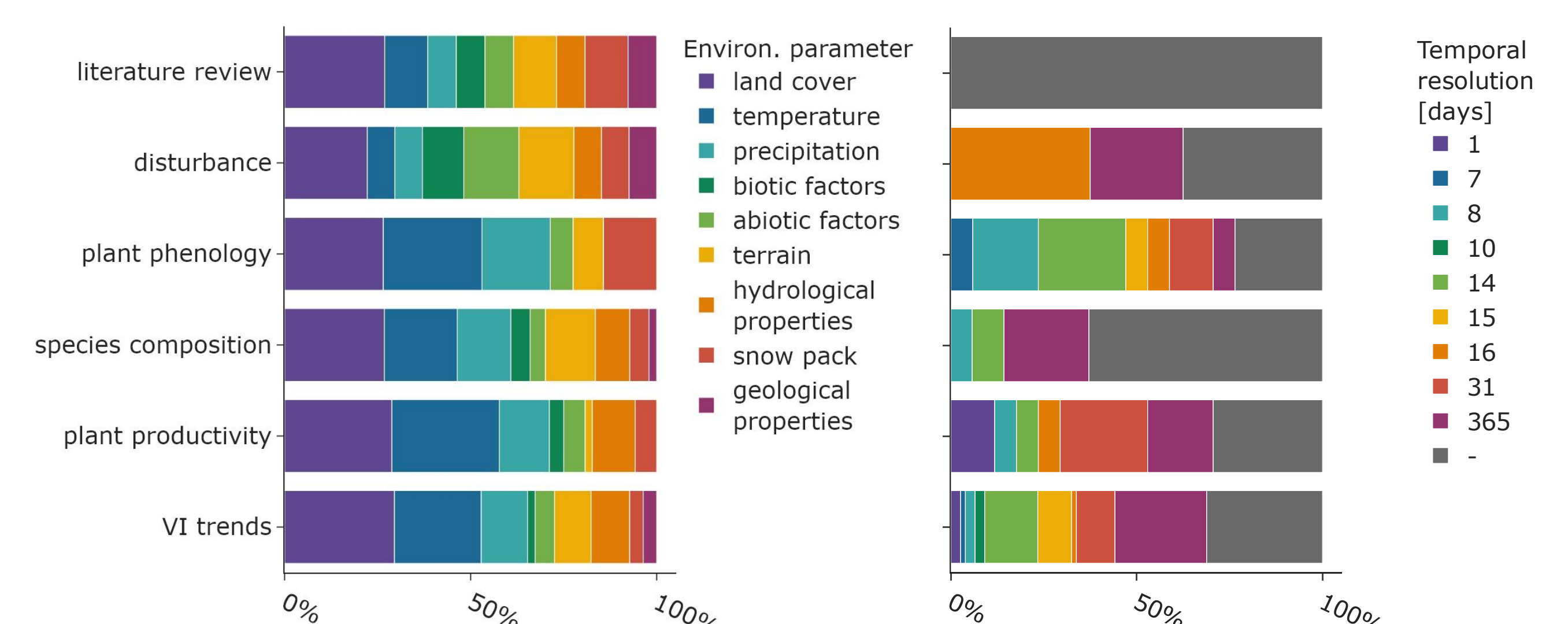


Fig. 5: Distribution of environmental parameters and temporal resolution of satellite data grouped according to the primary research focus [5].

References

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