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Arctic Browning: vegetation damage and implications for carbon balance.

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'Arctic browning' is the loss of biomass and canopy in Arctic ecosystems. This process is often driven by climatic and biological extreme events - notably extreme winter warm periods, winter frost-drought and severe outbreaks of defoliating insects. Evidence suggests that browning is becoming increasingly frequent and severe at the pan-arctic scale, a view supported by observations from more intensely observed regions, with major and unprecedented vegetation damage reported at landscape (>1000km2) and regional (Nordic Arctic Region) scales in recent years.

Critically, the damage caused by these extreme events is in direct opposition to 'Arctic greening', the well-established increase in productivity and shrub abundance observed at high latitudes in response to long-term warming. This opposition creates uncertainty as to future anticipated vegetation change in the Arctic, with implications for Arctic carbon balance. As high latitude ecosystems store around twice as much carbon as the atmosphere, and vegetation impacts are key to determining rates of loss or gain of ecosystem carbon stocks, Arctic browning has the potential to influence the role of these ecosystems in global climate. There is therefore a clear need for a quantitative understanding of the impacts of browning events on key ecosystem carbon fluxes.

To address this, field sites were chosen in central and northern Norway and in Svalbard, in areas known to have been affected by either climatic extremes or insect outbreak and subsequent browning in the past four years. Sites were chosen along a latitudinal gradient to capture both conditions already causing vegetation browning throughout the Norwegian Arctic, and conditions currently common at lower latitudes which are likely to become more damaging further North as climate change progresses. At each site the response of Net Ecosystem CO_2 Exchange to light was measured using a LiCor LI6400 Portable Photosynthesis system and a custom vegetation chamber with artificial shading. These data allowed the impact of browning on plot-level Gross Primary Productivity (GPP), Net Ecosystem Exchange and ecosystem respiration to be calculated. Substantial site-level impacts were identified, with heavily damaged vegetation converted from a net CO_2 sink to a net source. Plot-level spectral data were then used to establish a relationship between Leaf Area Index (LAI), as predicted from Normalised Differenced Vegetation Index (NDVI), and GPP. This builds on work demonstrating that NDVI-derived LAI can explain up to 80% of variation in GPP in healthy vegetation. Confirmation that this relationship holds true in browned vegetation validates its use for estimating browning impacts on Arctic carbon balance using remotely sensed data.