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Microfossils in Greenland ice cores reveal high-latitude ecosystem responses to past climate and human impact

Content

Modern observations show rapid transformations of high-latitude environments in response to a warming climate. These include plant compositional changes, increasing biological productivity, and unprecedented boreal and tundra wildfires. However, placing recent changes in the context of centennial to millennial-scale ecosystem change remains a challenge. Available paleoecological records from sedimentary archives are scattered through the vast northern biomes and have limited chronological constraint. Recent methodological advances permit extraction of pollen and spores from remote polar ice cores in sufficient numbers to achieve contiguous environmental records. Such palynological analyses provide new insights into the long-term and large-scale relationship of high latitude vegetation with human activities, fire, and climate in the Arctic region with precise chronologies.

We present palynological results from southern (ACT11d), central (Summit Eurocore'89), and eastern Greenland (RECAP) ice cores. Atmospheric transport and deposition modelling (FLEXPART) indicates that each of the ice cores tracks environmental change in different airsheds allowing us to investigate large-scale vegetation change in space and time. Our results indicate that, in addition to abundant tundra herb and shrub taxa, all three pollen records contain considerable contributions from boreal forests and scattered occurrences of warmth-loving temperate species indicating long-distance transport. Pollen of the subarctic tree birch (Betula alba-type) and several important herbaceous tundra taxa decreased at the beginning of the Little Ice Age (LIA) around 1400 in response to a cooling climate. At the end of the LIA, our records suggest expansion of regional tundra vegetation or increases in tundra pollen productivity that was possibly favored by the warming temperatures, consistent with tree-ring inferred shrubland expansions. The spread of subarctic tree birch abruptly ended after 1850 CE when birch pollen decreased again to scattered finds in the southern ACT11d record. The Summit Eurocore'89 record indicates a similar decrease of tree birch after 1900 CE coinciding with the beginning of coal mining in the Arctic. Considering the latitudinal difference of the two ice core sites and the FLEXPART sensitivity estimates for the different regions, we hypothesize that ACT11d reflects the initial phase of land use activities related to European settlers affecting regional birch populations in eastern Canada around 1850 CE, followed by wider arctic shrubland impacts reflected in the Summit Eurocore'89 record in relation to 20th century coal mining in the Arctic. Moreover, all three ice cores indicate that ecosystems have changed through the spread of adventive weeds in the past centuries and show the sensitivity of arctic ecosystems to limited human impacts at a regional scale.

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Track Classification: Progress in proxy development and interpretation