

Ecological Responses to Late-glacial Climate Changes in Northern and Western Norway

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Fact There were rapid climate changes in the late-glacial (Allerød and Younger Dryas) and in the early Holocene in western Norway

- How do species and vegetation respond? Ecological processes

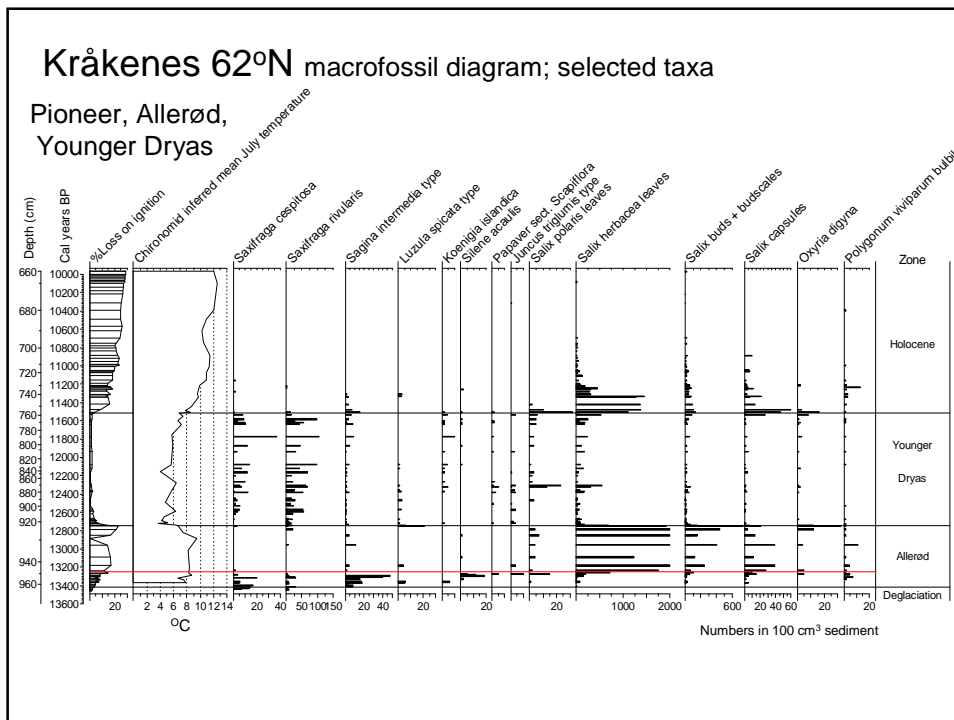
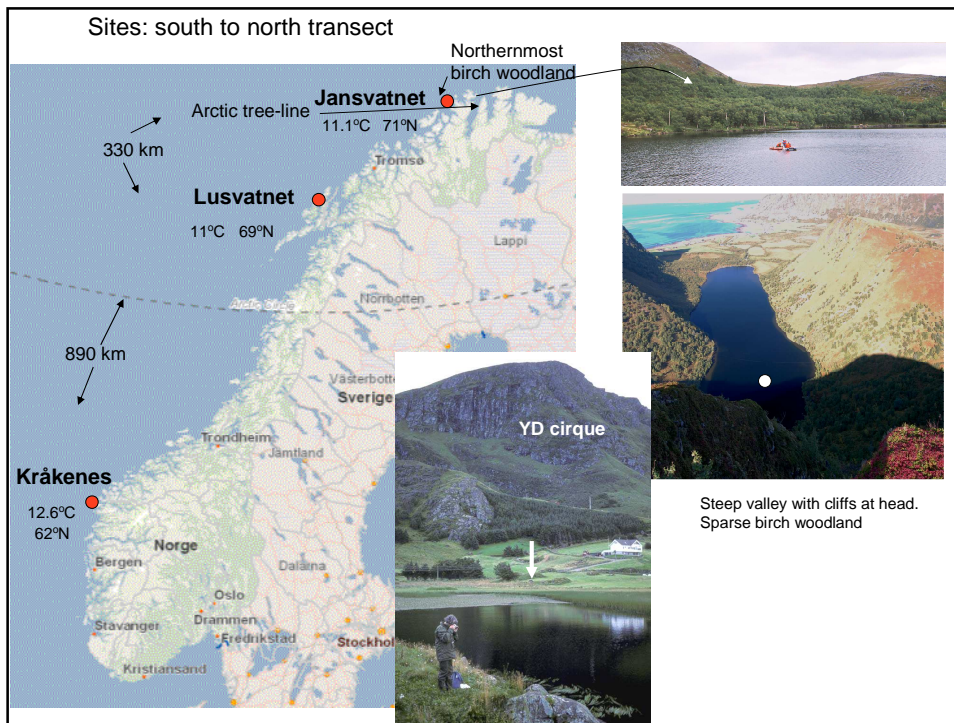
Fact There is a small South-North climate gradient in Norway today; ameliorated by Gulf Stream

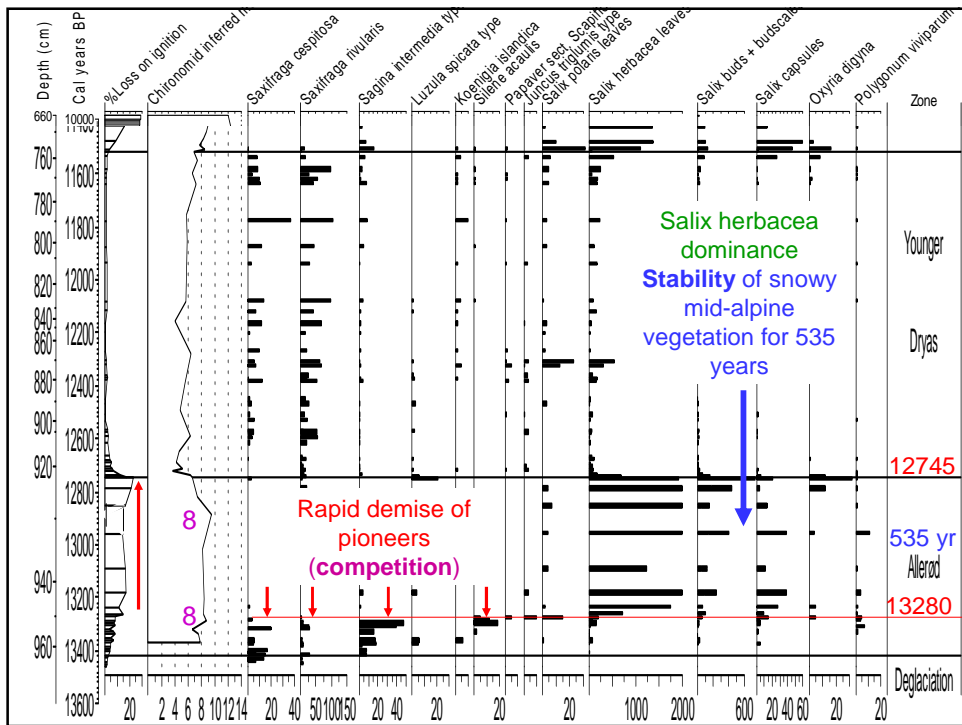
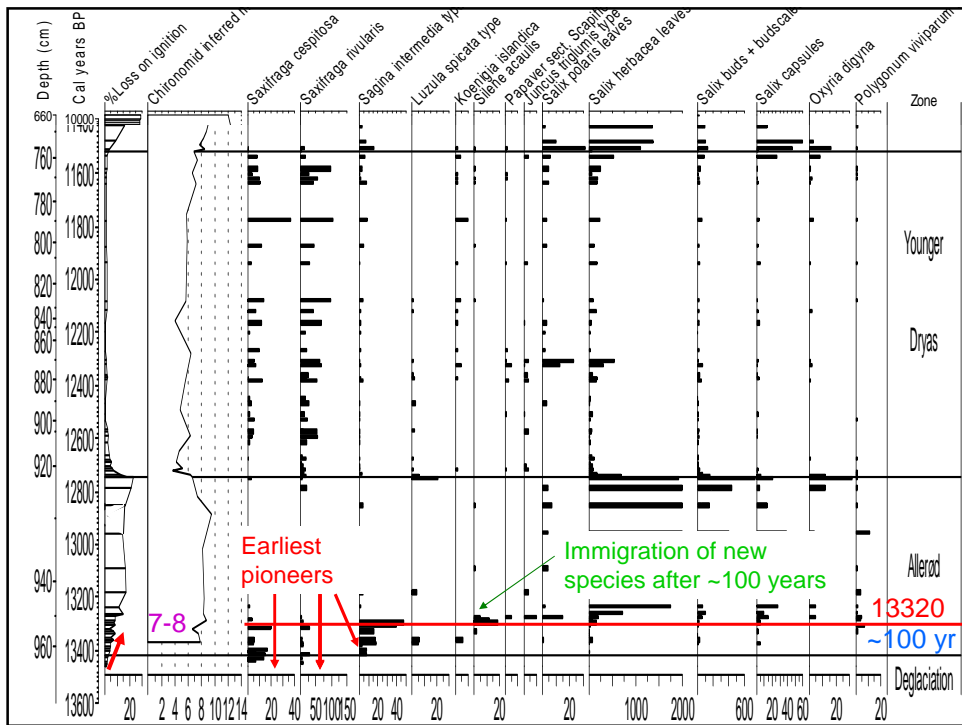
- Did the gradient operate during the late-glacial and early Holocene?
- Was the gradient different from that of today?
- How did these differences affect vegetation development?

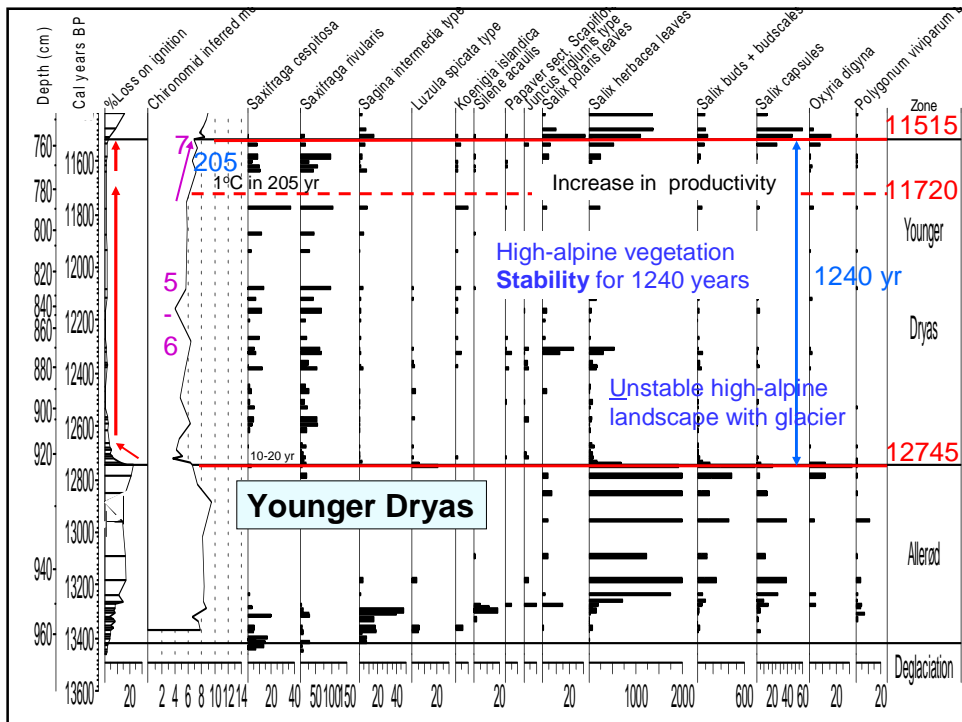
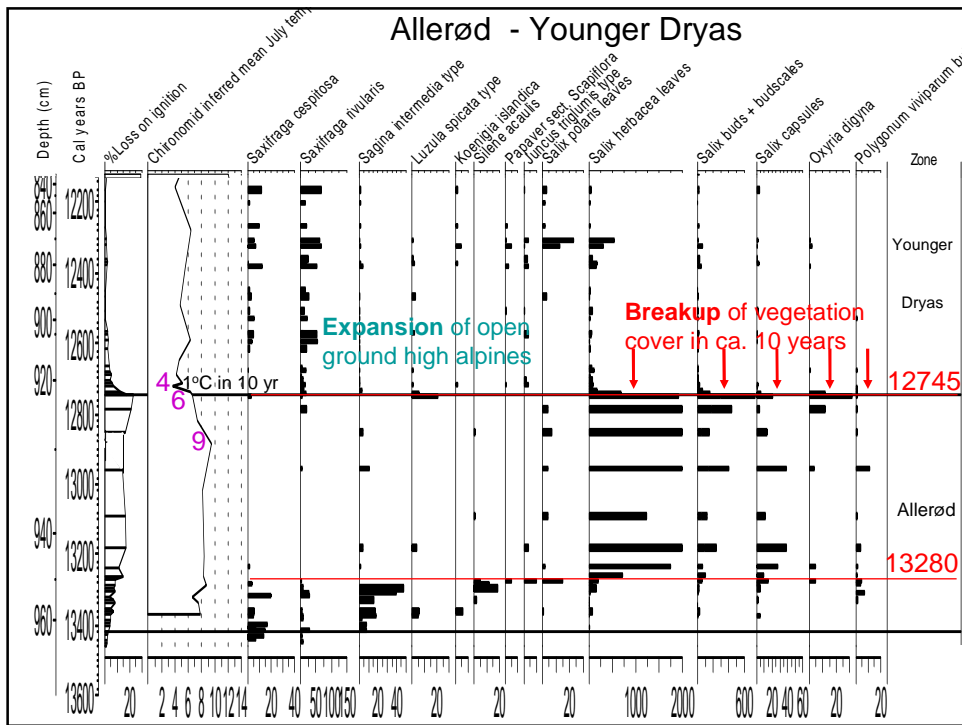
Method Temperature was reconstructed from fossil Chironomid data from same cores as the plant data. Independent climate record.

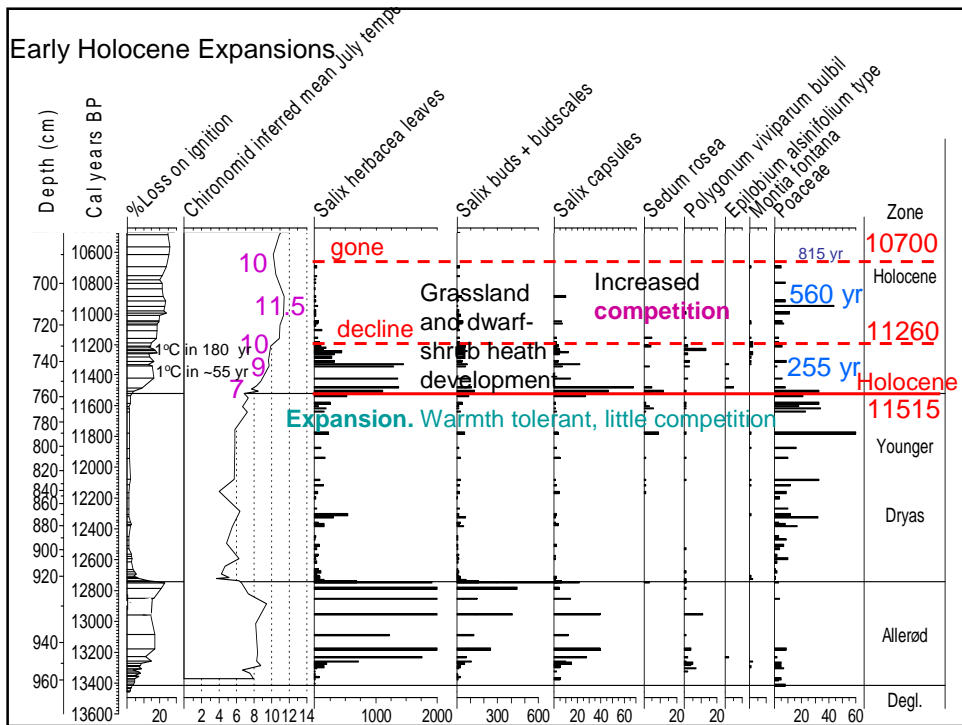
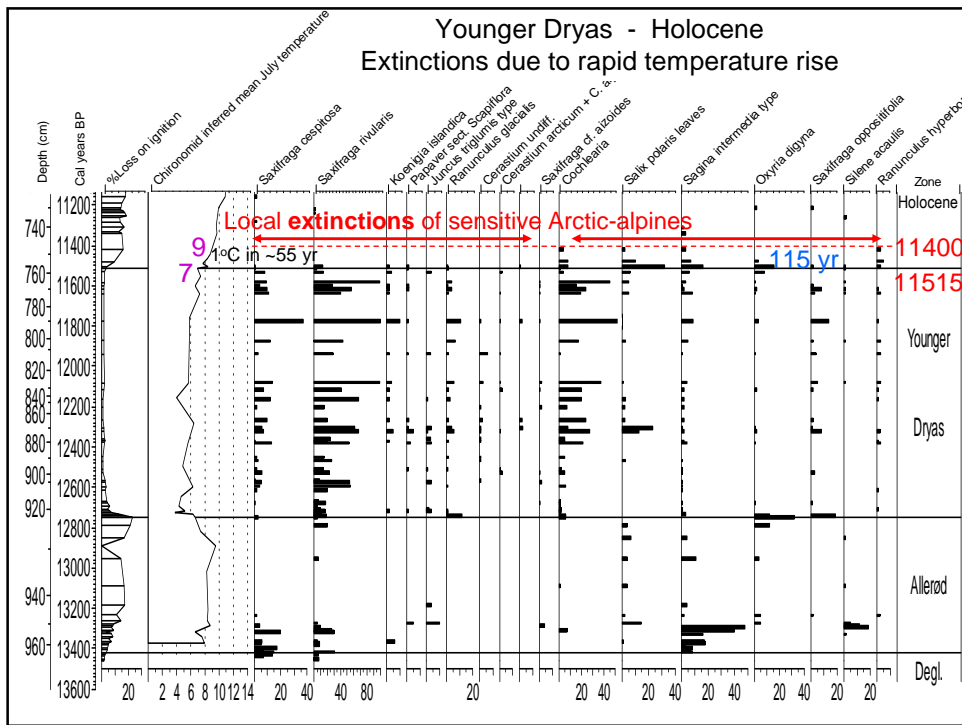
Use plant macrofossil concentration data; local dispersal and good taxonomic resolution give evidence of local vegetation. Concentrations are independent of each other.

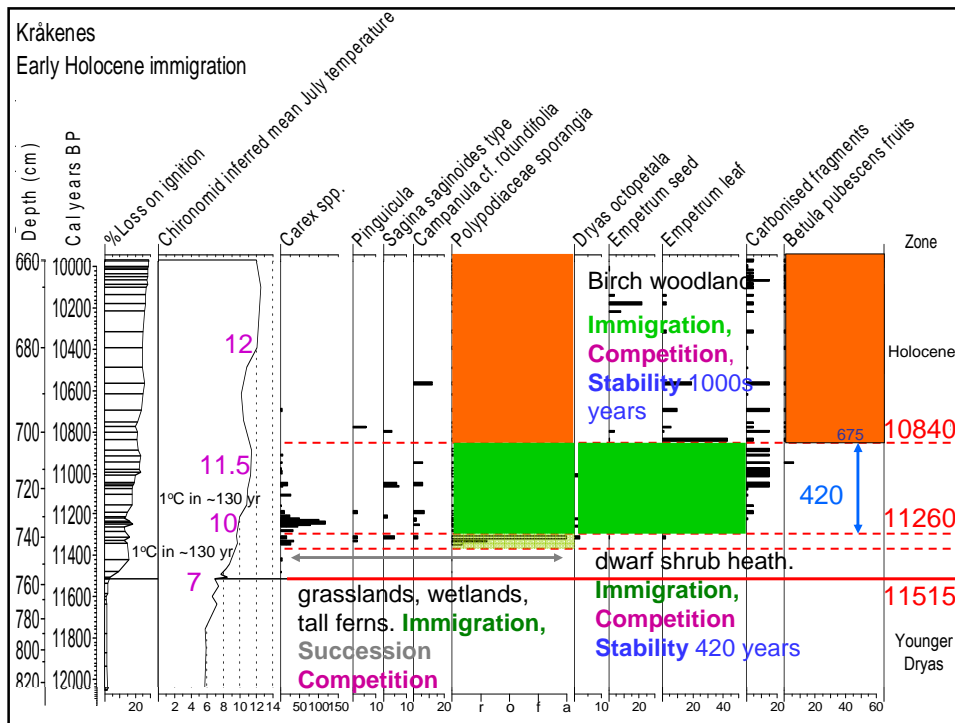
- Compare species and vegetation changes to temperature changes.



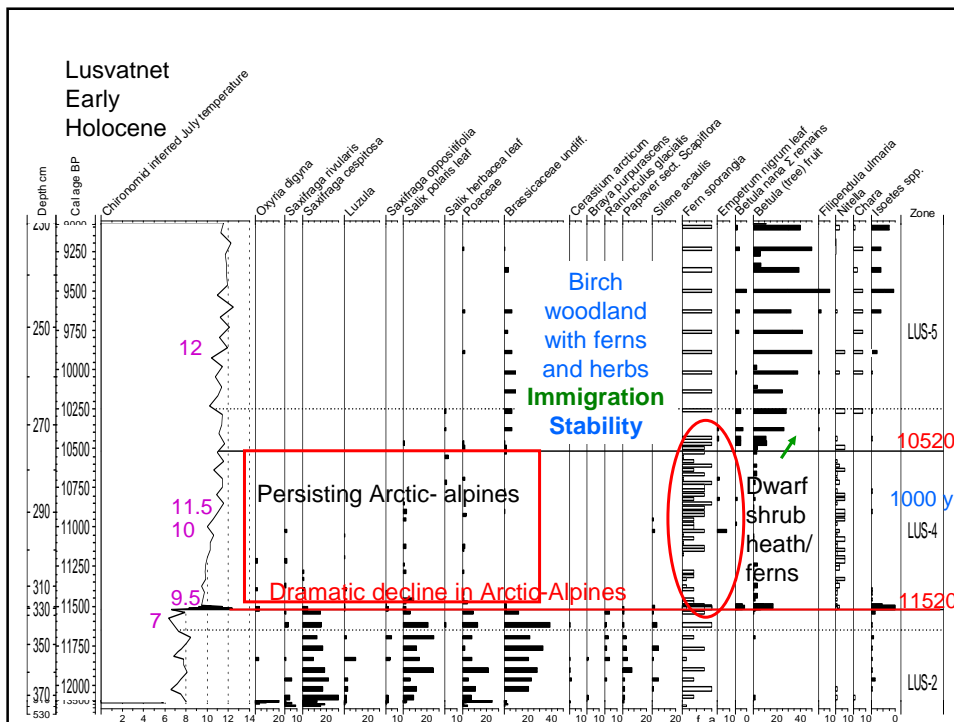
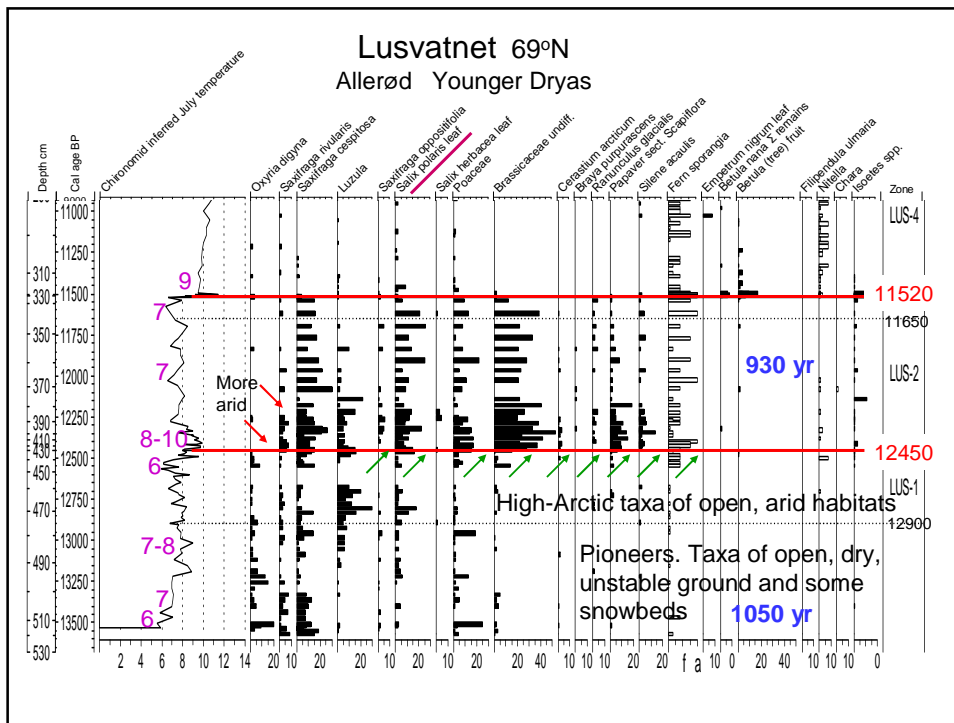


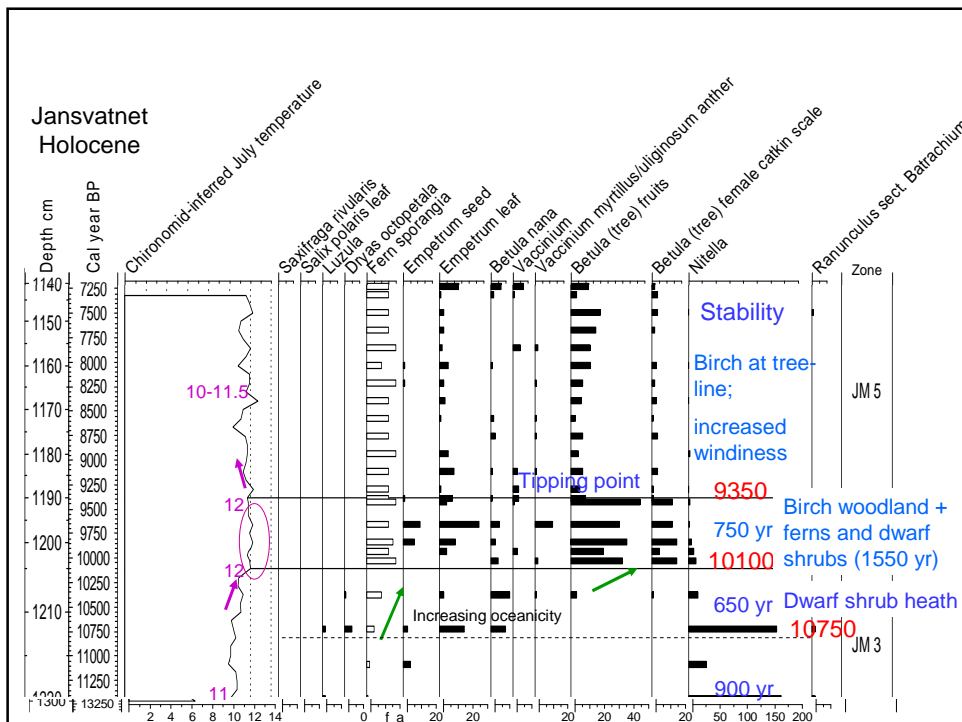
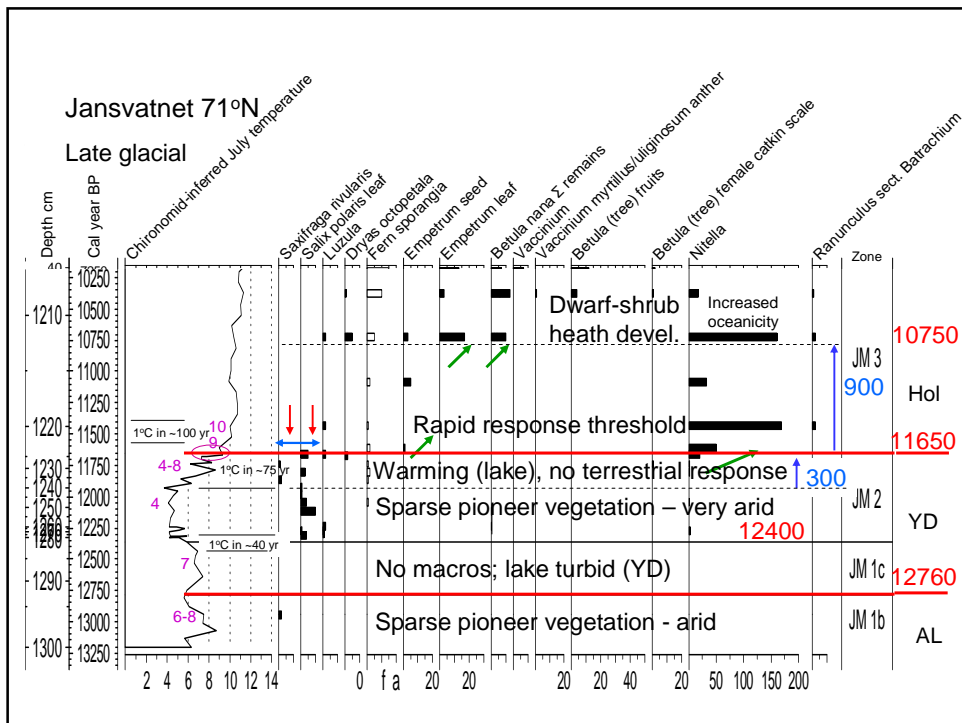






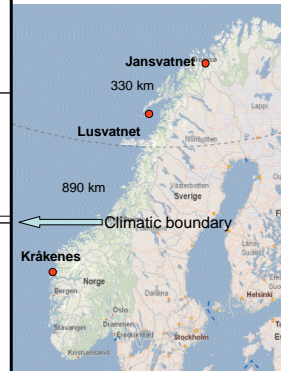
Period	Temp °C	Rate of change yr per 1°C	length yr	Plant response	Vegetation
E Hol	-11 - 12	+/- 0	1000s	Immigration, Expansion of Birch woodland 675 yr after YD-H Competition; Stability	Birch woodland
E Hol	10->11.5	190 yr	300	Immigration, Expansion of Dwarf-shrub heath (Empetrum) and tall fern (+Salix) dominance Stability	Dwarf-shrub heath (Empetrum) and tall fern (+Salix) dominance
E Hol	7->10	140 yr	255	Decline of remaining alpine; Extinction Immigration of grassland and flush species, tall ferns (145 yr after YD-H), and dwarf shrubs (255 yr after YD-H) Succession, Competition	Grassland, wetland, tall ferns
YD - Hol	7->9	75 yr	10-115	Extinctions of warmth intolerant alpine (over 10-115 yr). Expansions of warmth tolerant alpine S. herbacea + alpine herb grassland	S. herbacea + alpine herb grassland
YD	5-6	0	1240	Stability	High-alpine open vegetation
AL - YD	6->4	10 yr	10	Rapid decline of Salix over 10 yr; Vegetation break-up Expansion of alpine herbs	High-alpine vegetation
Allerød	8	0	575 60	Stability S. herbacea increase over 60 yr Competition	Stable S. herbacea snowbed vegetation S. herbacea dominance
Deglac.	8	0	60	Succession	Open alpine herbs; immigration Salix herbacea
Deglac.	8	0	-100	Immigration by pioneers	Open alpine herbs





Comparison of temperatures and rates; AL-YD

	AL temp	AL-YD fall	rate
Jans 11.1°C	6-8°C	0	-
Lus 11°C	7-8°C	0	-
Kråk 12.6°C	8-9°C	3°C	1°C in 75 yr Rapid 2°C cooling at <u>12745 BP</u>



AL gradient stronger than today
YD north-south contrast - aridity

Comparison of temperatures and rates YD, Holocene

	Mid YD Cooling	YD temp	YD – Hol rise	Initial rate	Temp at birch establishment
Jans 11.1°C	Rapid 3°C cooling at <u>12400 BP</u> aridity	4-7°C	5°C	1°C in 50 yr	12°C
Lus 11°C	Rapid 2°C cooling at <u>12450 BP</u> aridity	7-8°C	2.5°	rapid	11°C
Kråk 12.6°C	-	5°C	2°C	1°C in 55 yr	11°C

Comparison of Vegetation

	AL	YD	E Hol Dwarf shrub heath	Time to Birch woodland
Jans 11.1°C	High alpine – very arid <i>S. polaris</i>	High alpine – very arid <i>S. polaris</i>	Poor dwarf-shrub heath	1550 yr (Declined after 750 yr; 9350 cal yr BP)
Lus 11°C	High alpine – arid <i>S. polaris</i>	High alpine – very arid <i>S. polaris</i>	Poor dwarf-shrub heath	1000 yr
Kråk 12.6°C	snowbeds Mid alpine <i>S. herbacea</i>	Wet High alpine (glacier) <i>S. herbacea</i>	Strong <i>Empetrum</i> heath after 255 yr	675 yr

- Drivers of vegetation changes are Temperature and Precipitation (affected by sea-ice cover)
- The absolute climate values, the changes, and the balances between them determine vegetation development through:
Immigration Expansion Competition Extinction
- Under constant climate conditions, vegetation may show:
Succession Immigration Competition Stability

Emerging pattern

Increasing aridity

	AL	YD	EH	Birch
J	V. Cold Arid	V. Cold V. Arid	Arid to oceanic	Oceanic
L	Cold Dry	Cold Arid	Arid to oceanic	Oceanic
K	Cool Wet	Cold Wet (glacier)	Oceanic	Oceanic

Small gradient, as today

