Vegetation development in Czechia and Norway

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Agriculture
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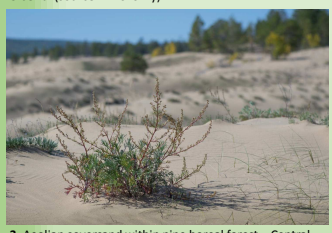
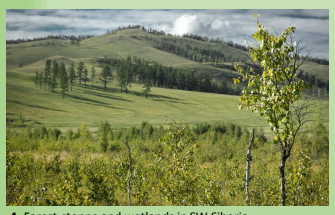
This poster illustrates the very basic differences and similarities in vegetation development in the centre of Europe (Czechia) and in its north (Western Norway) since the peak of the Last Glaciation. Until around 6000 years ago, differences are explained by natural causes such as variation in climate and soil. With the introduction of agriculture, people increasingly influenced the vegetation and their environment.

1. LGM loess accumulations covering Gravettian (pre-LGM) archaeological site at south Moravia. (source: P. Pokorný)

2. Thermokarst depression with lake, surrounded by cold steppe and boreal forest („taiga"). Central Yakutia, E Siberia. (source: P. Pokorný)

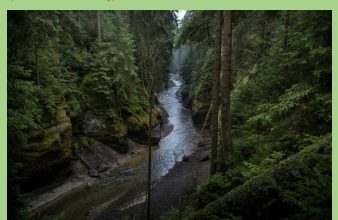


3. Aeolian coversand within pine boreal forest, , Central Yakutia, E Siberia. (source: P. Pokorný)

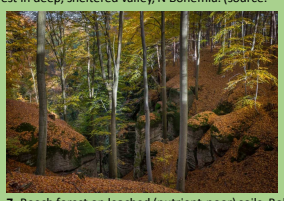


4. Forest-steppe and wetlands in SW Siberia. (source: P. Pokorný)

5. Thermophylous deciduous forest, Denmark. (source: P. Pokorný)



6. Spruce forest in deep, sheltered valley, N Bohemia. (source: P. Pokorný)



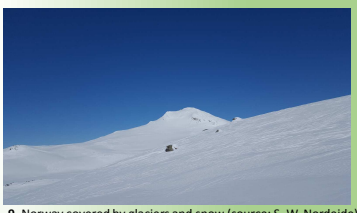
7. Beech forest on leached (nutrient-poor) soils, Bohemia. (source: P. Pokorný)

CZECH REPUBLIC *KY BC (Kilo Year Before Christ)*	NORWAY *AD (Anno Domini=After Christ)*
LAST GLACIAL MAXIMUM (LGM) 24 – 18 KY BC: Old steppe („mammoth steppe") with patches of boreal forests (pine, Swiss stone pine, larch, birch, …) and patches of tundra (dwarf birches and willows). All this on permanently frozen ground (permafrost). Wind-blown dust sedimentation and formation of loess. Only small glaciers in the mountains (above 1000 m a.s.l.). **[1]**	Western Norway was covered by ice. In interstadial periods prior to the Last Glacial Maximum, cold steppes existed in central Norway with mammoth present. **[9]**
LGM / LATE GLACIAL TRANSITION 18 – 13.6 KY BC: Progressive warming. Permafrost thaw resulting in the formation of thermokarst landscapes (with lakes and wetlands) in some areas. Cold forest-steppes, just like in the previous periods. **[2]**	Western Norway was still covered by ice. Ice free areas at the coast further south and in northern Norway. **[9]**
LATE GLACIAL INTERSTADIAL 13.6 – 11 KY BC: Warm period. Expansion of boreal forests (mostly pine and birch) at the expense of open steppes. Rapid decline of mega-herbivores. **[2]**	The ice retreated and pioneer vegetation developed on mineral soils in mosaic with snow-bed communities. Fluctuation between warmer periods with heath vegetation (*Empetrum*) and scattered tree birch, and colder periods dominated by herbs and grasses. **[10]**
YOUNGER DRYAS 11 – 9.5 KY BC: Cold period. Restoration of permanently frozen ground (resulting in discontinuous permafrost), sedimentation of wind-blown (aeolian) sands. New expansion of cold steppes. Increased fire activity in remaining forests. **[3]**	Cold period with ice advancing, covering much of the area. Open vegetation with snow-bed communities. *Artemisia* and *Huperzia selago* characteristic taxa. **[10,11]**
PREBOREAL 9.5 – 8.2 KY BC: Rapid warming, but less humidity. Rapid afforestation by poplar, pines and birch. Immigration of thermophilous trees (hazel, elm, lime, oak, …) from the south and east. **[4]**	Rapid warming and retreat of ice. Development from herb-rich grasslands to dwarf-shrubs and birch forests. Reindeer followed the ice front up to the Norwegian mountains. **[11]**
BOREAL 8.2 – 7 KY BC: Onset of the Holocene thermal maximum. Quick expansion of broadleaf thermophilous trees, forming mixed deciduous woodlands. More opened vegetation cover remains only in dry lowlands (pine-dominated forest-steppe) and on top of the highest mountains (blanket bogs and tundra roughly above 1400 m a.s.l.). **[5]**	Onset of the Holocene thermal maximum. Immigration of pine and the first thermophilous tree hazel. Towards the end also oak and elm were present and mixed deciduous forests developed. **[5]**
ATLANTIC 7 – 3.8 KY BC: Stable, warm and moist climate („Holocene climate optimum"). Mixed deciduous woodlands prevail in most locations. Norwegian spruce spreads in many areas, forming spruce forests in humid and sheltered positions (deep valleys with suitable micro-climate, wetland edges with humid soils). **[5,6]**	The Holocene climate optimum with broadleaved deciduous and mixed forests (elm, hazel, lime, oak, alder, birch and pine). Glaciers melted and tree line on its highest. Dense forests but also open areas on the western exposed coast. **[5,12]**
SUBBOREAL 3.8 – 0.6 KY BC: Progressive cooling - end of the „Holocene climate optimum". Erratic spread of beech, silver fir and hornbeam woods. Increased soil leaching resulting in expansion of acidophillous vegetation. First significant deforestation evidenced in the lowlands. **[7]**	Progressive cooling and soil deterioration. Stepwise opening of the forest, development of bogs and heathlands, cultivated fields and grass dominated pastures. Decrease in broadleaved deciduous forests and increase in mixed pine forests. **[12,13]**
OLDER SUBATLANTIC 600 BC – AD 1000: Widespread beech, silver fir and hornbeam woods. Partly deforested cultural landscapes in lowlands dominated by fields, pastures, meadows and managed (mostly oak-dominated) woods. **[7]**	Human impact on the vegetation large. Partly deforested cultural landscapes with pastures, hay meadows, cultivated fields and managed woodlands. The coast and mountains used for grazing by domestic animals resulting in expansion of coastal heathlands and summer farms. Small populations of Norwegian spruce and beech introduced. **[13,14]**
YOUNGER SUBATLANTIC AD 1000 – PRESENT: Urban landscapes formation and intensive agriculture adoption in the lowlands, all that resulting in massive deforestation. Colonization of inner peripheries of the country (altitudes higher then 400 m a.s.l., regions with poor soils). Acceleration of all these processes with the start of the Industrial Revolution (18th century). **[8]**	Utilization of the vegetation and landscape as in the previous period, but with increasing impact. Fruit cultivation, introduction of garden plants and urban landscapes. Summer farming resulted in decreased tree line in the mountains. During the last 70 years, increased modernizaton or abandonment and expansion of forested areas. **[13,14,15]**

Calibrated radiocarbon chronology by Walanus and Nalepka (*Radiocarbon* 52/4, 2010); partly modified.

8. Traditional cultural landscape in upland region of N Bohemia. (source: P. Pokorný)

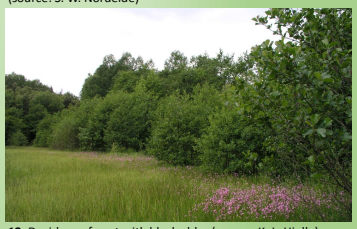
15. Modern and traditional cultural landscape (source: J. Berge)



9. Norway covered by glaciers and snow (source: S. W. Nordeide)

10. Retreating ice (source: S. W. Nordeide)

11. Reindeer and snow-bed communities (source: S. W. Nordeide)



12. Deciduous forest with black alder (source: K. L. Hjelle)

13. Coastal heathland with heather (*Calluna vulgaris*) (source: J. Berge)

14. Summer farm in the mountain (900 m a.s.l.) (source: K. L. Hjelle)

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