

# ESS 203 - Glaciers and Global Change

Monday February 01, 2021

## Outline for today

- Volunteer for today's highlights on Friday
  - Gavin Hamilton
- Highlights of last Friday's class
  - Alex MacKinnon
  
- Ice-Age World – the ice retreats

# ESS 203 - Glaciers and Global Change

No Writing assignment for Wednesday

You are (or should be 😊) preparing for the first midterm on Wednesday.

Study questions at:

Quizzes > Practice Quizzes > Midterm #1 Study Q

# Mid-term #1

It will be on Wednesday (February 3).

- 5 study questions are posted; 3 of these will form the actual test.
- I expect you are working through the 5 posted questions and talking about them with your.
- Quizzes > Practice Quizzes > Midterm #1 Study Q

## Study Sessions?

- Be sure to read the notes on “Writing a test”

[https://courses.washington.edu/ess203/TESTS/ESS203\\_writing\\_a\\_test.pdf](https://courses.washington.edu/ess203/TESTS/ESS203_writing_a_test.pdf)

# Mid-term #1

- No class on Wednesday
- The 3 questions forming the actual test will be released as a Quiz at 1:30 on Wednesday.
- The quiz will be open until 10 PM
  
- Please take ~1 hour to answer the quiz.
- Indicate when you start and when you finish.
- Please do not consult notes or contact classmates while you are writing 😊

# Term Projects

Update from Jessica?

## Where was the Ice 20,000 Years ago?

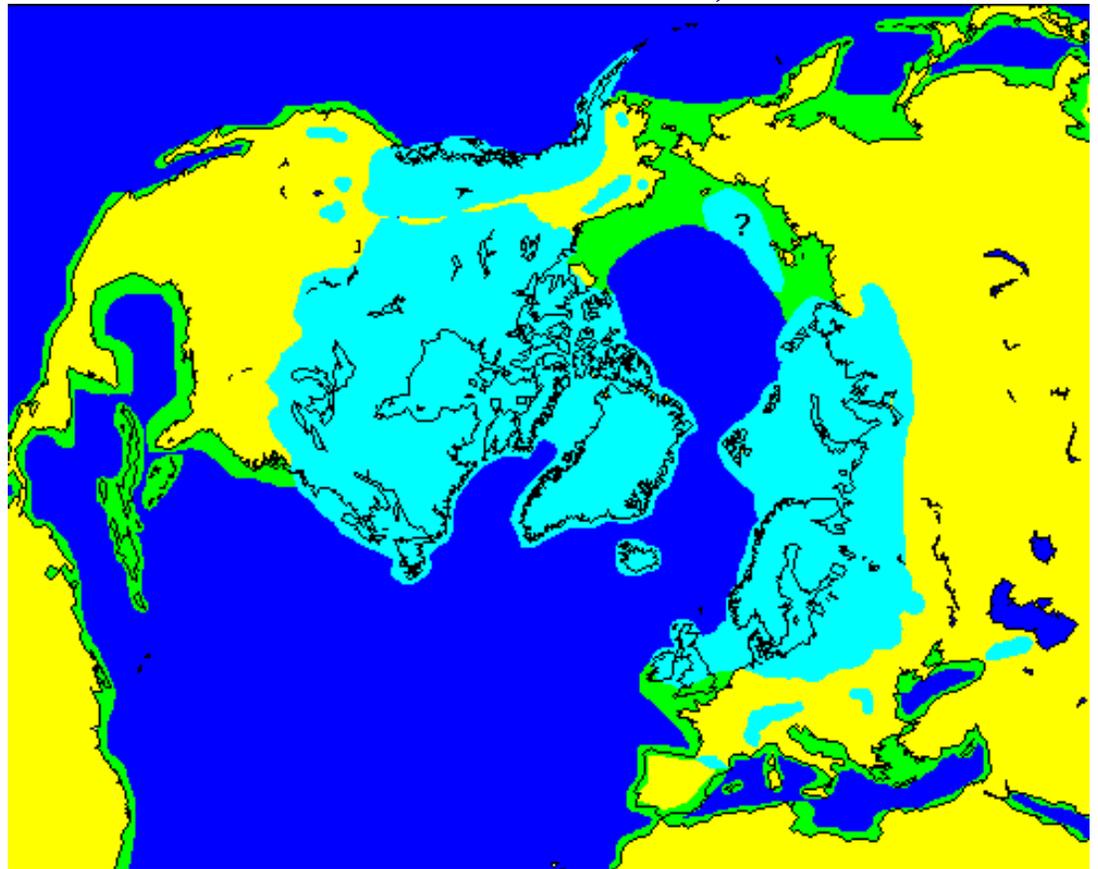
- Laurentide Ice Sheet
- Cordilleran Ice Sheet
- Fennoscandian Ice Sheet (Scandinavia)
- Siberian Ice Sheet (limited by low accumulation?)
- Barents Sea Ice Sheet (marine ice sheet - “wet feet” )

We know a lot about their retreat within the past 20 ka, but not so much about earlier history.

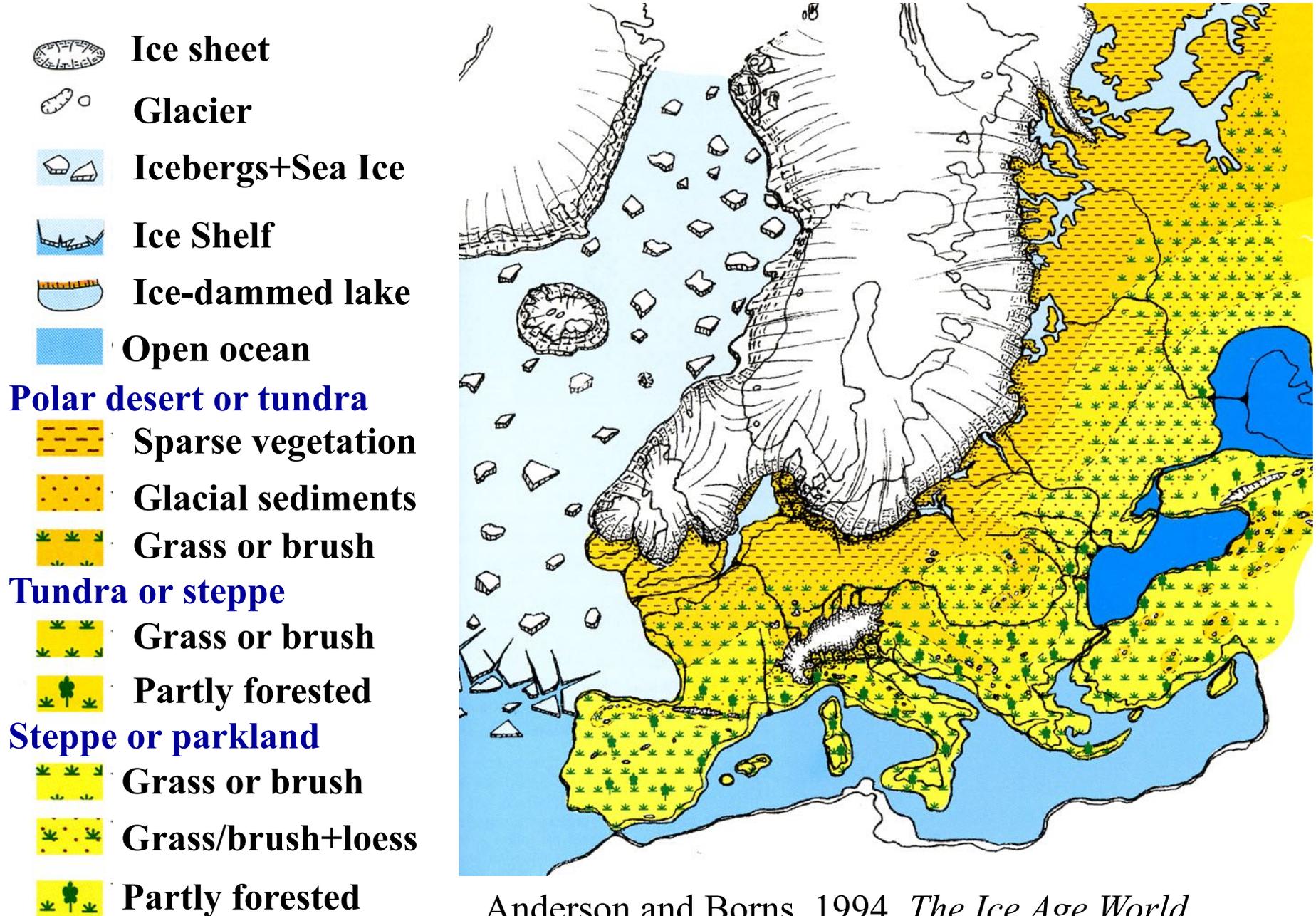
- Why not?

Sea level was much lower then  
(by ~120 meters)

- Why?



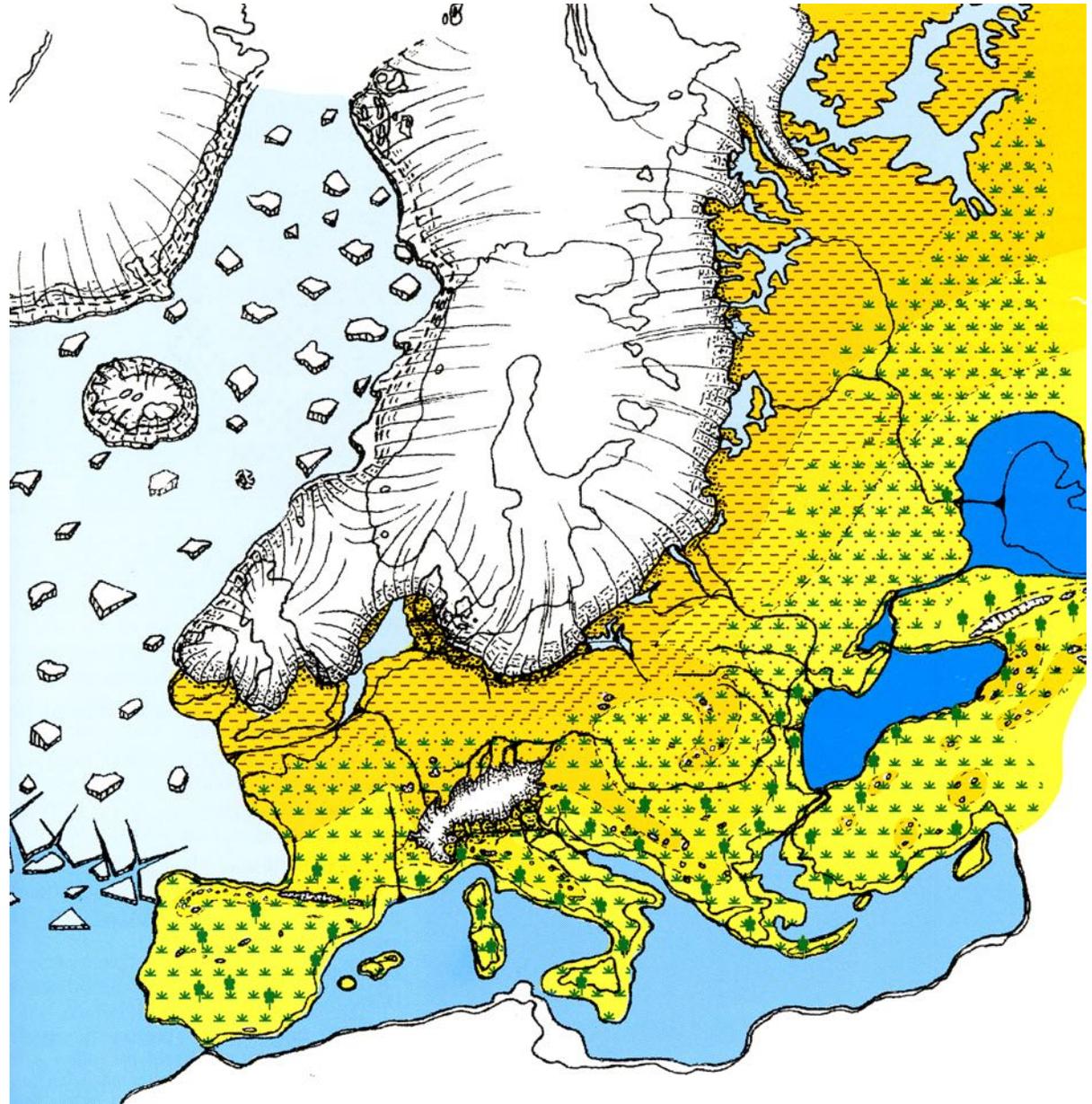
# Fennoscandian Ice Sheet - 20ka



Anderson and Borns, 1994. *The Ice Age World*

## Fennoscandian Ice Sheet - 20ka

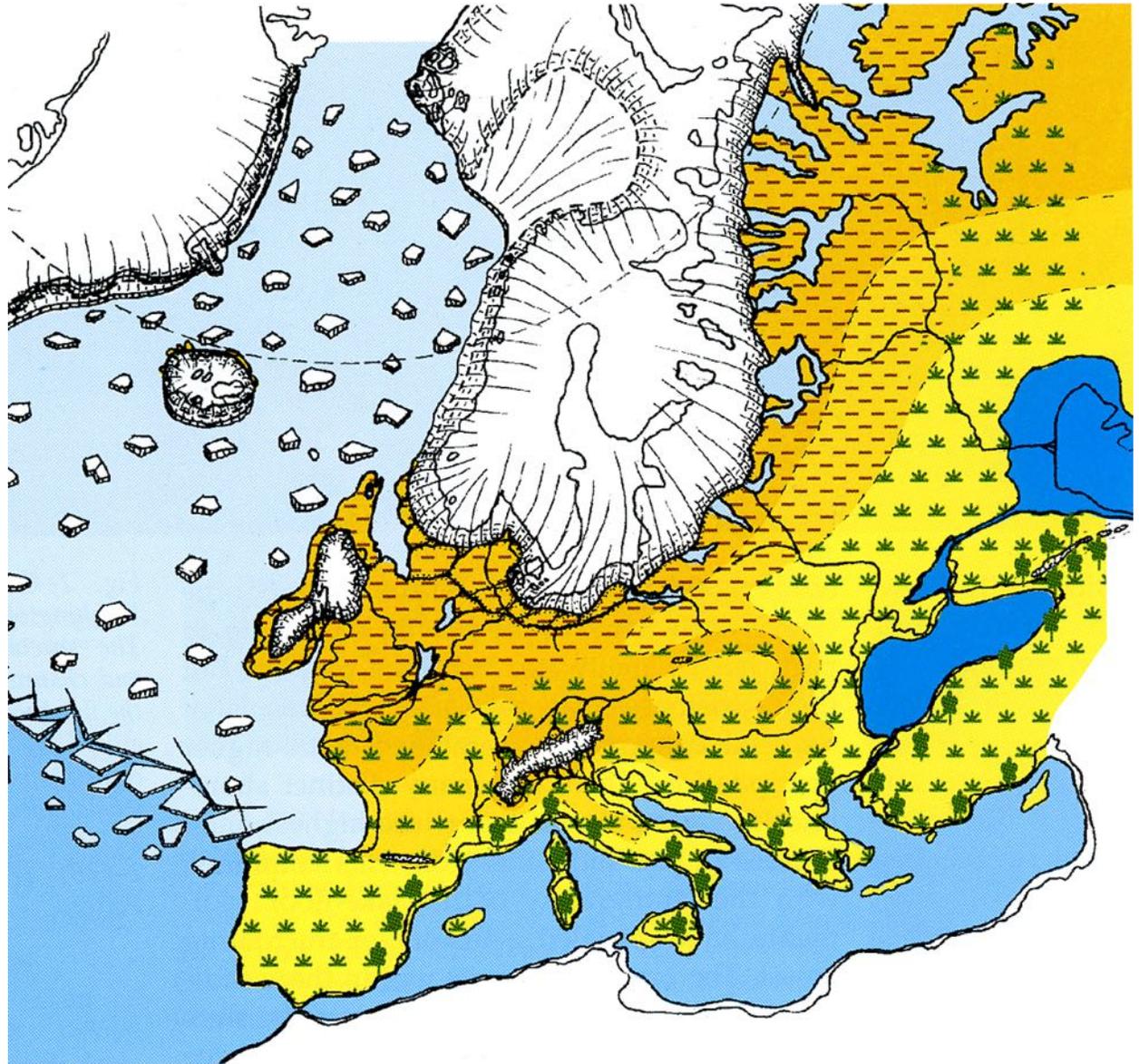
- Sea-ice cover to Spain (in winter).
- Fennoscandian and British ice sheets may have been joined.
- Europe covered by tundra and steppe, like northern Canada or Siberia today.
- Low sea level, English Channel dry. Why?
- Black and Caspian Seas are lakes. Why?



Anderson and Borns, 1994. *The Ice Age World*

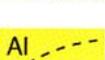
## Fennoscandian Ice Sheet - 15ka

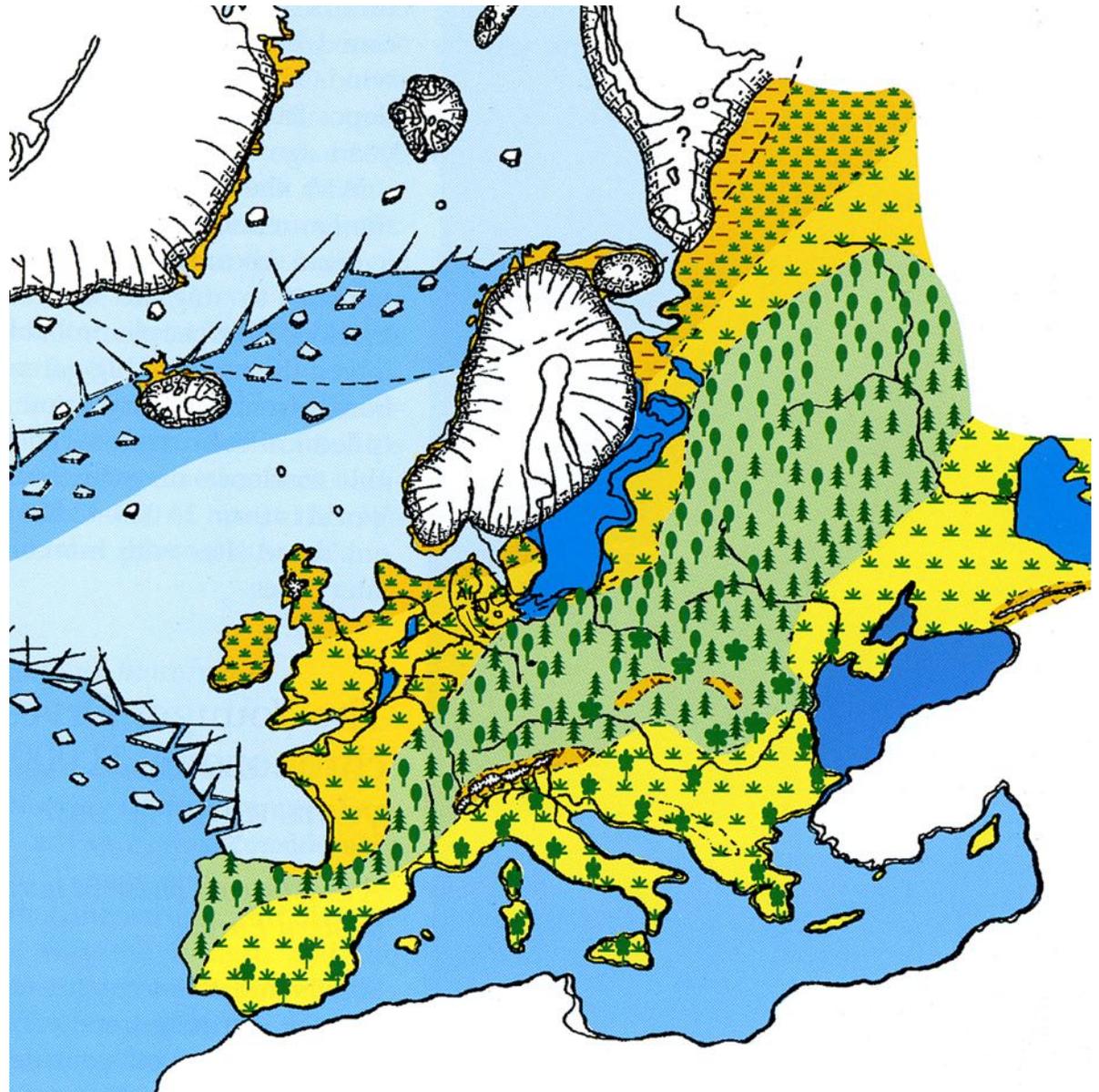
- Fennoscandian and British ice sheets have separated.
- Barents Ice Sheet is disintegrating.
- Sea level is still low.
- Black Sea is still a lake.
- Still few trees north of Pyrenees, Alps, or Caucasus.



Anderson and Borns, 1994. *The Ice Age World*

# Fennoscandian Ice Sheet – 12-11ka

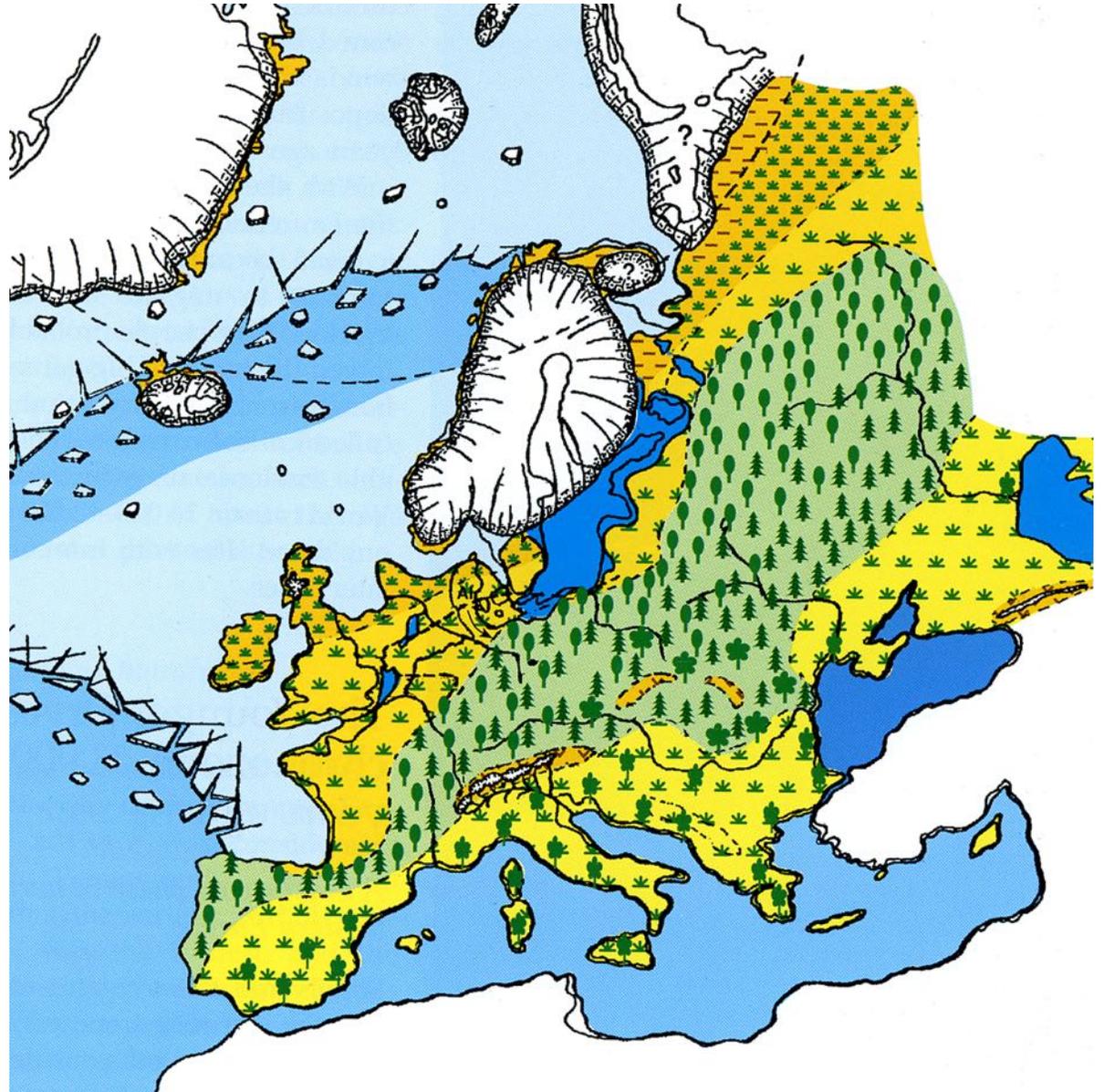
-  Tundra/park tundra
-  Tundra/steppe park
-  Alpine vegetation
-  Steppe/parkland
-  Parkland+forest
-  Birch forest
-  Allerod limit - birch
-  Birch/pine/spruce
-  Boreal:pine/spruce
-  Mixed boreal/broadleaf
-  Broadleaf /hazel



Anderson and Borns, 1994. *The Ice Age World*

## Fennoscandian Ice Sheet – 12-11ka

- North Atlantic open in summer ~12.5 ka.
- Sea ice re-advanced in Younger Dryas cold period 12-11 ka.
- British Ice Sheet is largely gone.
- Sea level is rising.
- Barents Ice Sheet disintegrating.
- Baltic Sea is a lake.
- Caspian Sea is now a closed basin.
- Black Sea still a lake.
- Forests re-occupy Europe.



Anderson and Borns, 1994. *The Ice Age World*

## Fennoscandian Ice Sheet – 9.5ka

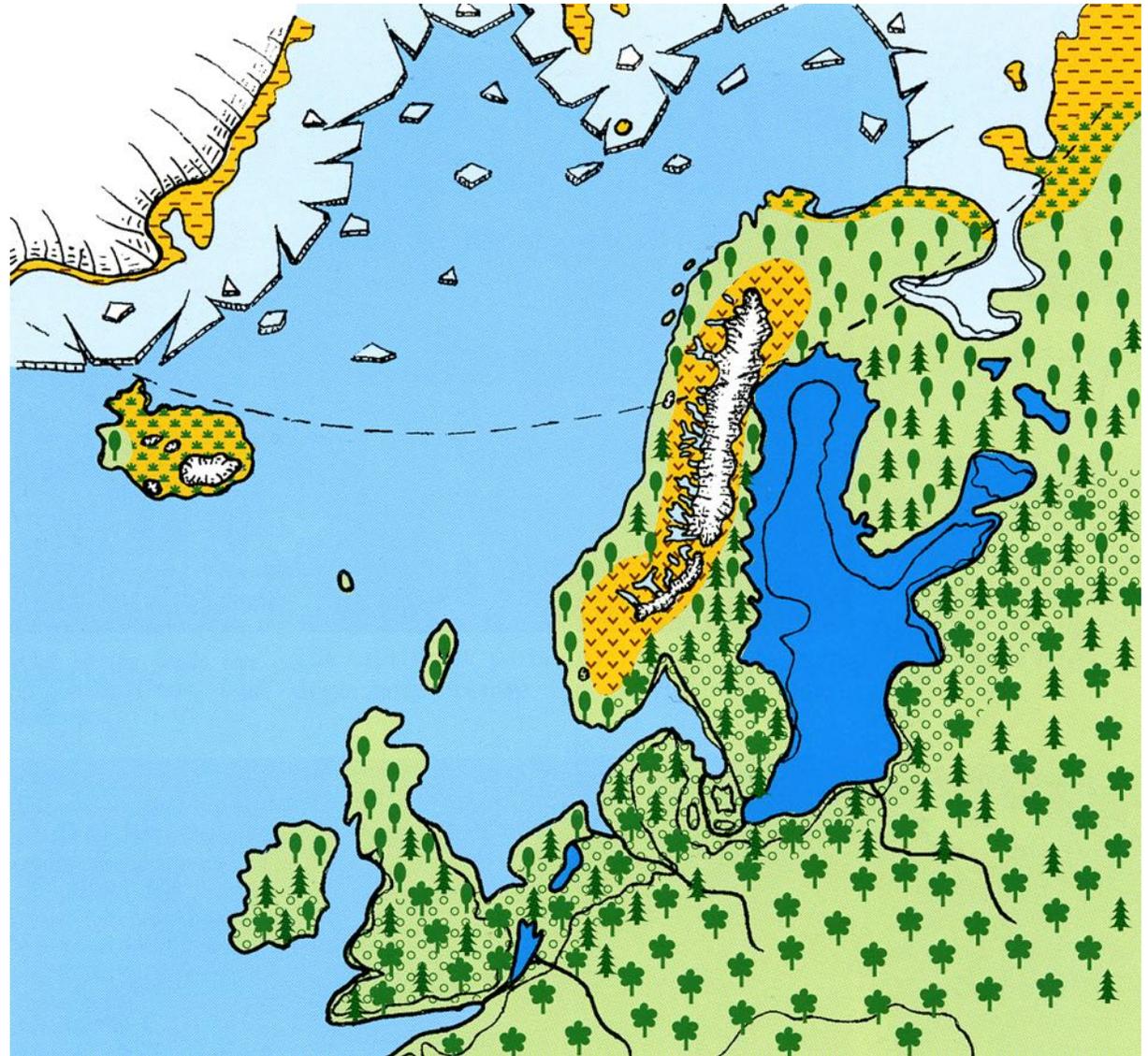
- Yoldia Sea in Baltic area
- UK still connected to Europe
- Sea ice rare around Europe
- Less ice on Iceland
- Forests moving north



Andersen and Borns, 1994. *The Ice Age World*

## Fennoscandian Ice Sheet - 8ka

- Only a small ice cap left on Norwegian mountain spine.
- Only a few small ice caps in Iceland.
- Sea ice rare around Europe.
- Baltic Lake
- Sea level still lower than today
- parts of North Sea and English Channel are dry



Andersen and Borns, 1994. *The Ice Age World*

# Ice Map - Fennoscandian Ice Sheet

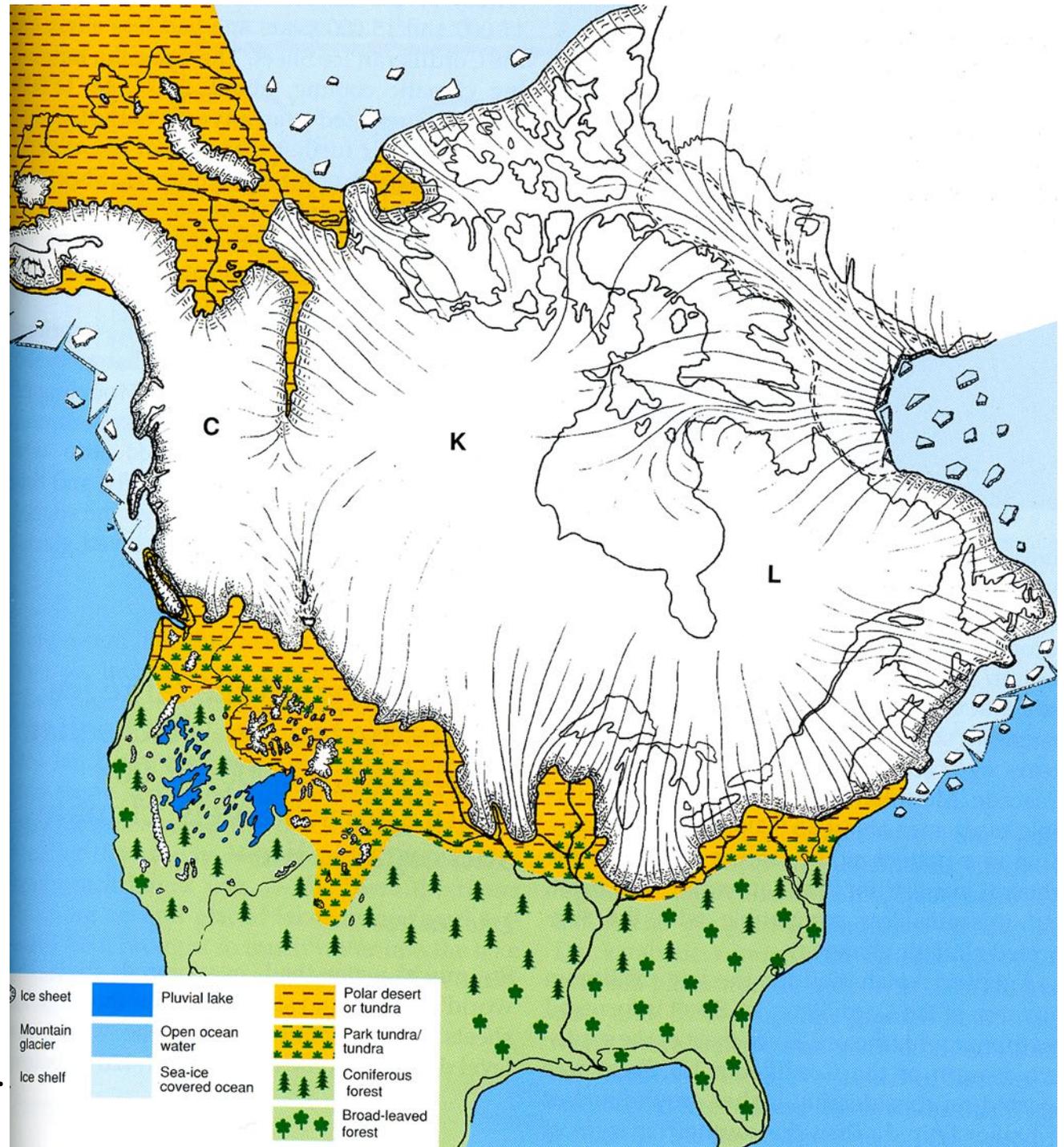
<https://icemap.rhewlif.xyz/>

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# North America 20-18ka

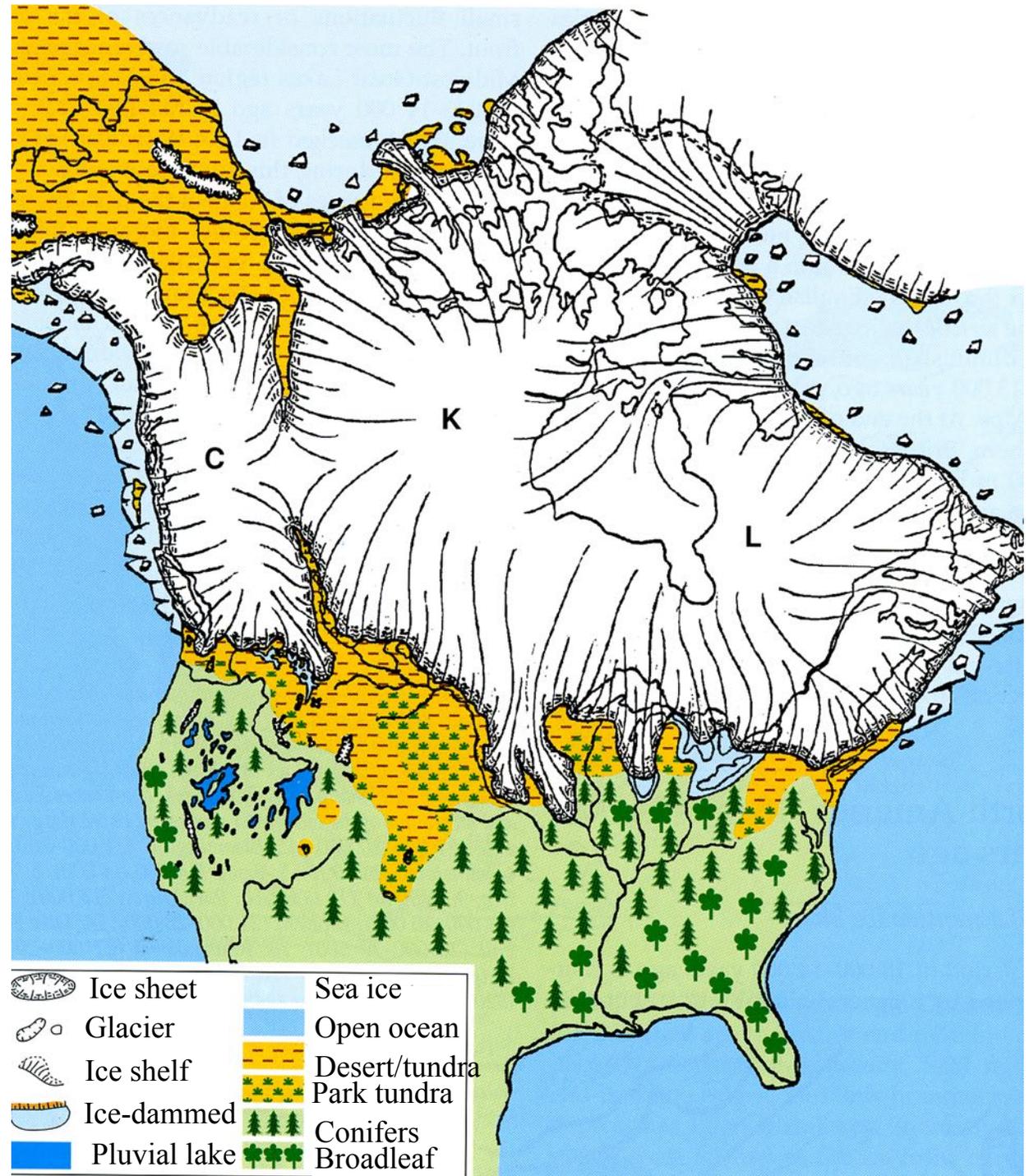
- Cordilleran ice sheet (C) operated independently from Laurentide (L) and Keewatin (K) domes.
- Connection to Greenland Ice Sheet(?)
- Ice-free areas in Alaska (why?)
- Bering Strait is dry.

Andersen and Borns, 1994.  
*The Ice Age World*



# North America 15ka

- Southern margin retreating.
- Surge lobes advance on soft wet bed
- Cordilleran and Keewatin Ice Sheets starting to separate (Why?)

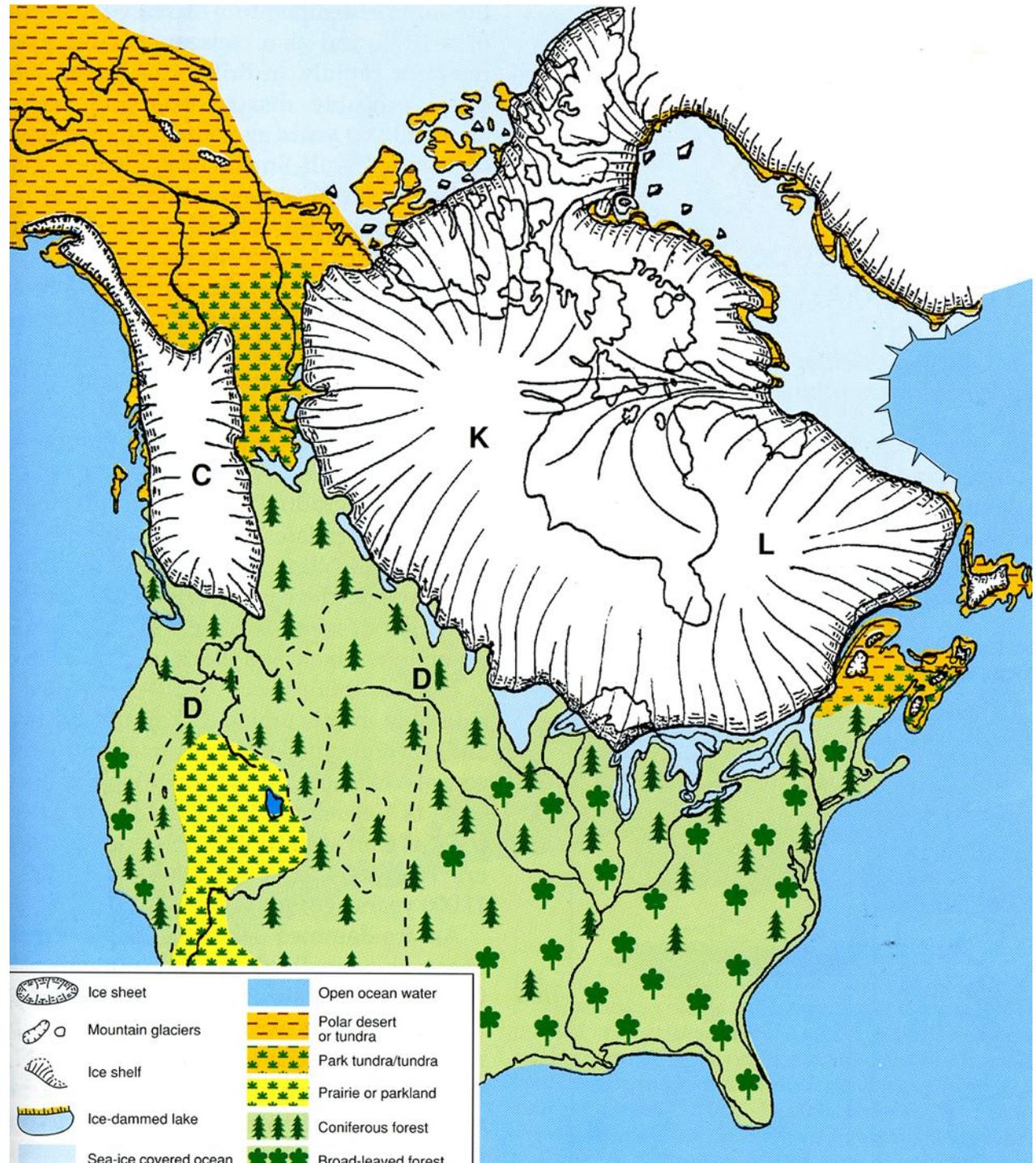


Andersen and Borns, 1994.  
*The Ice Age World*

# North America 11ka

- Forests advancing northward
- Baffin Bay free of glacier ice
- Ice-marginal lakes (Why?)
- Cordilleran and Keewatin/Laurentide ice sheets separated
- Importance for humans?

Andersen and Borns, 1994.  
*The Ice Age World*





### RESEARCH LETTER

10.1029/2018GL079419

#### Key Points:

- New exposure dating chronology presented for the central coast of British Columbia
- Western margin of the former Cordilleran Ice Sheet was retreating by 18.1 ka
- Numerous ice-free areas existed along the coastline earlier than previously thought

## Retreat of the Western Cordilleran Ice Sheet Margin During the Last Deglaciation

**C. M. Darvill<sup>1,2</sup> , B. Menounos<sup>2</sup> , B. M. Goehring<sup>3</sup> , O. B. Lian<sup>4</sup> , and M. W. Caffee<sup>5,6</sup> **

<sup>1</sup>Department of Geography, The University of Manchester, Manchester, UK, <sup>2</sup>Geography Program and Natural Resources and Environmental Studies Institute, University of Northern British Columbia, Prince George, British Columbia, Canada, <sup>3</sup>Department of Earth and Environmental Sciences, Tulane University, New Orleans, LA, USA, <sup>4</sup>Department of Geography and the Environment, University of the Fraser Valley, Abbotsford, British Columbia, Canada, <sup>5</sup>Department of Physics and Astronomy, Purdue University, West Lafayette, IN, USA, <sup>6</sup>Department of Earth, Atmospheric, and Planetary Sciences, Purdue University, West Lafayette, IN, USA

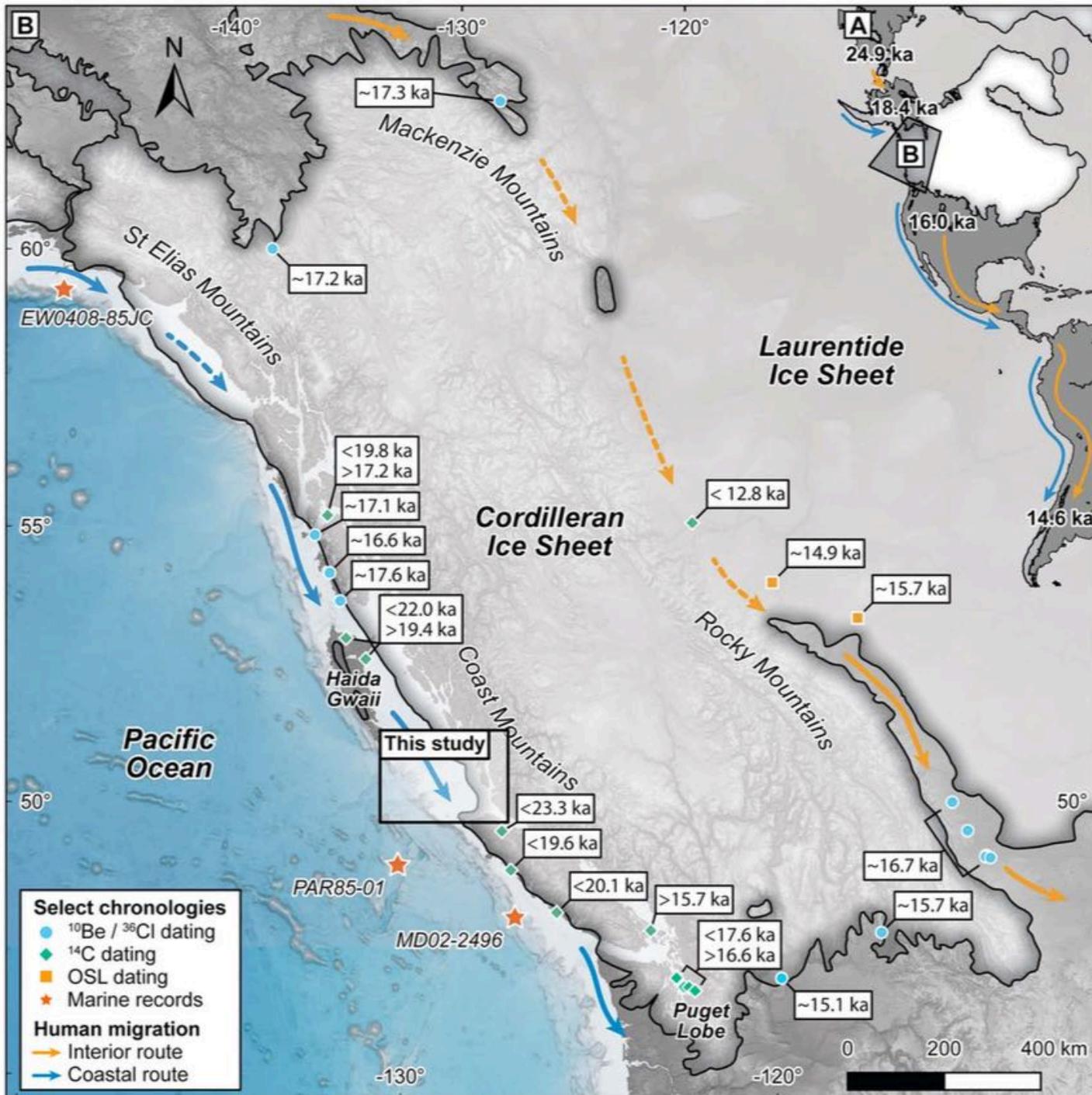
#### Citation:

Darvill, C. M., Menounos, B., Goehring, B. M., Lian, O. B., & Caffee, M. W. (2018). Retreat of the western Cordilleran Ice Sheet margin during the last deglaciation. *Geophysical Research Letters*, 45, 9710–9720. <https://doi.org/10.1029/2018GL079419>

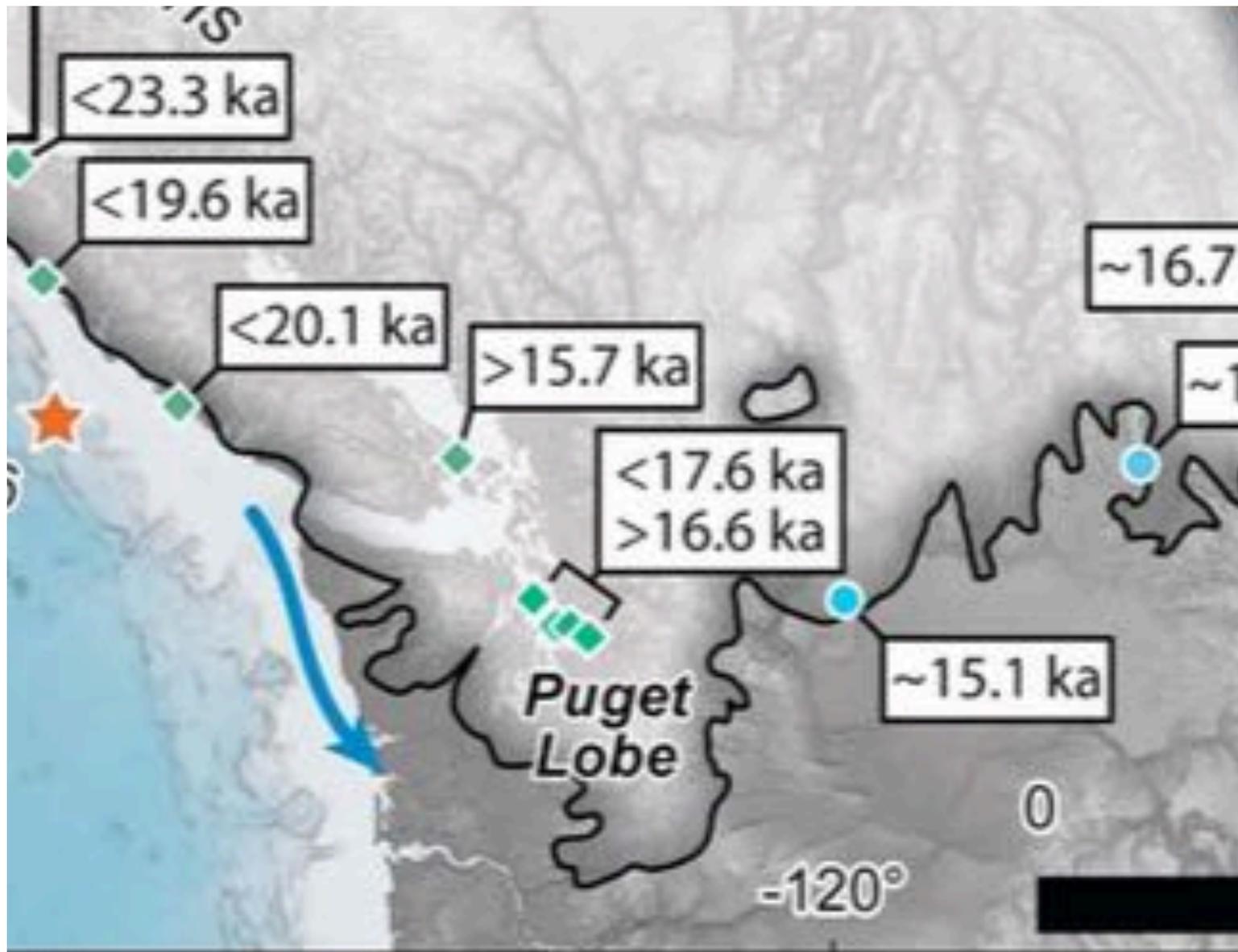
# Retreat of the Western Cordilleran Ice Sheet Margin During the Last Deglaciation

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**Plain Language Summary** Large ice sheets have advanced and retreated multiple times over the last several hundred thousand years in response to cyclical changes in incoming solar radiation. The Cordilleran Ice Sheet, which once covered much of western Canada, was thought to have advanced and retreated later than others during its last major cycle. **The retreat of this ice sheet also opened routes that allowed the first people to enter the Americas.** We show that the western margin of the ice sheet retreated earlier than previously thought. Other margins of the ice sheet advanced later, creating a complex picture through time. The early retreat of the western ice margin exposed numerous islands that could have been used by early people migrating southward.

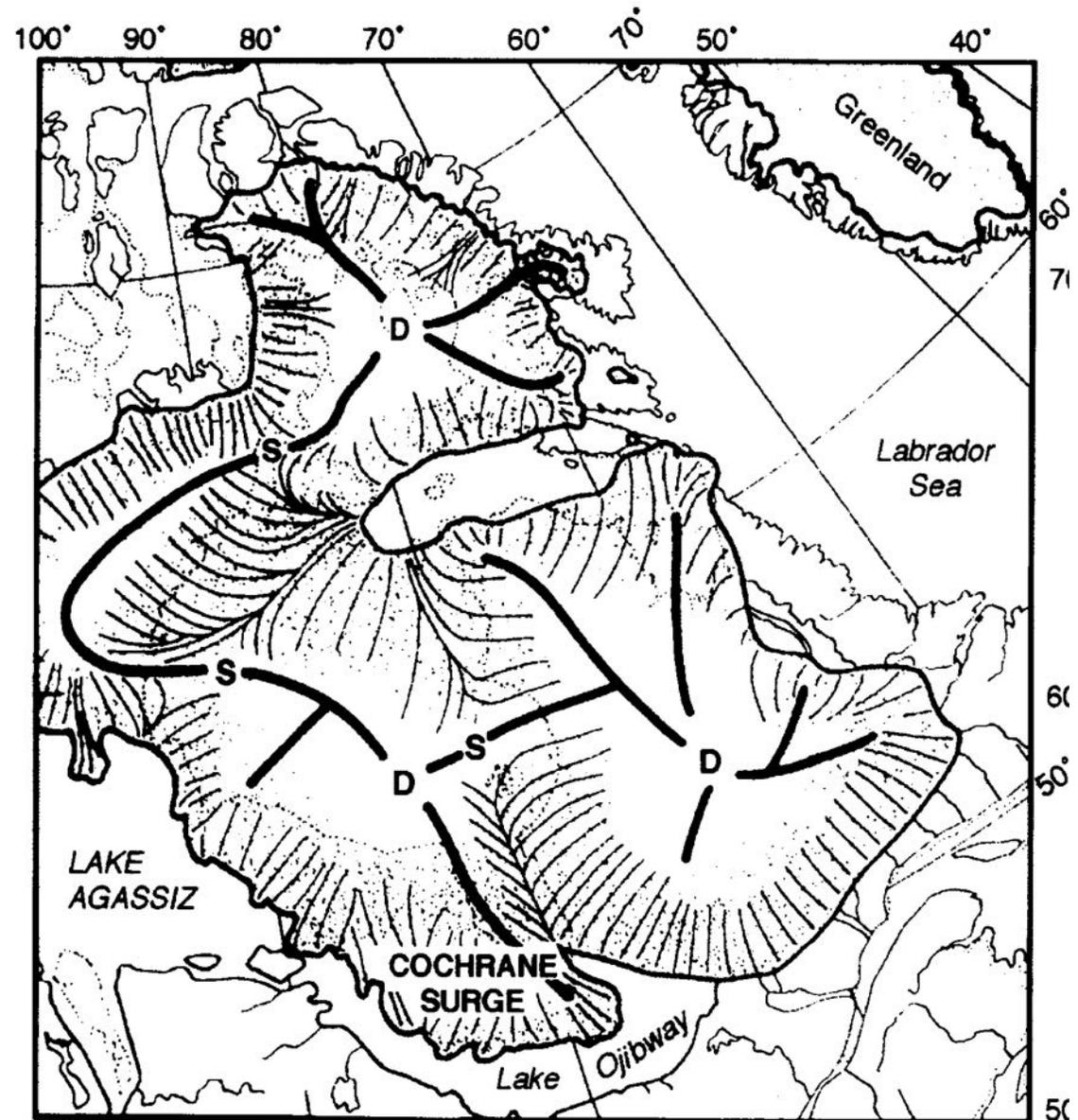


The Puget Lobe will be a topic in Lab this week



# Laurentide Ice Sheet – 8.4ka

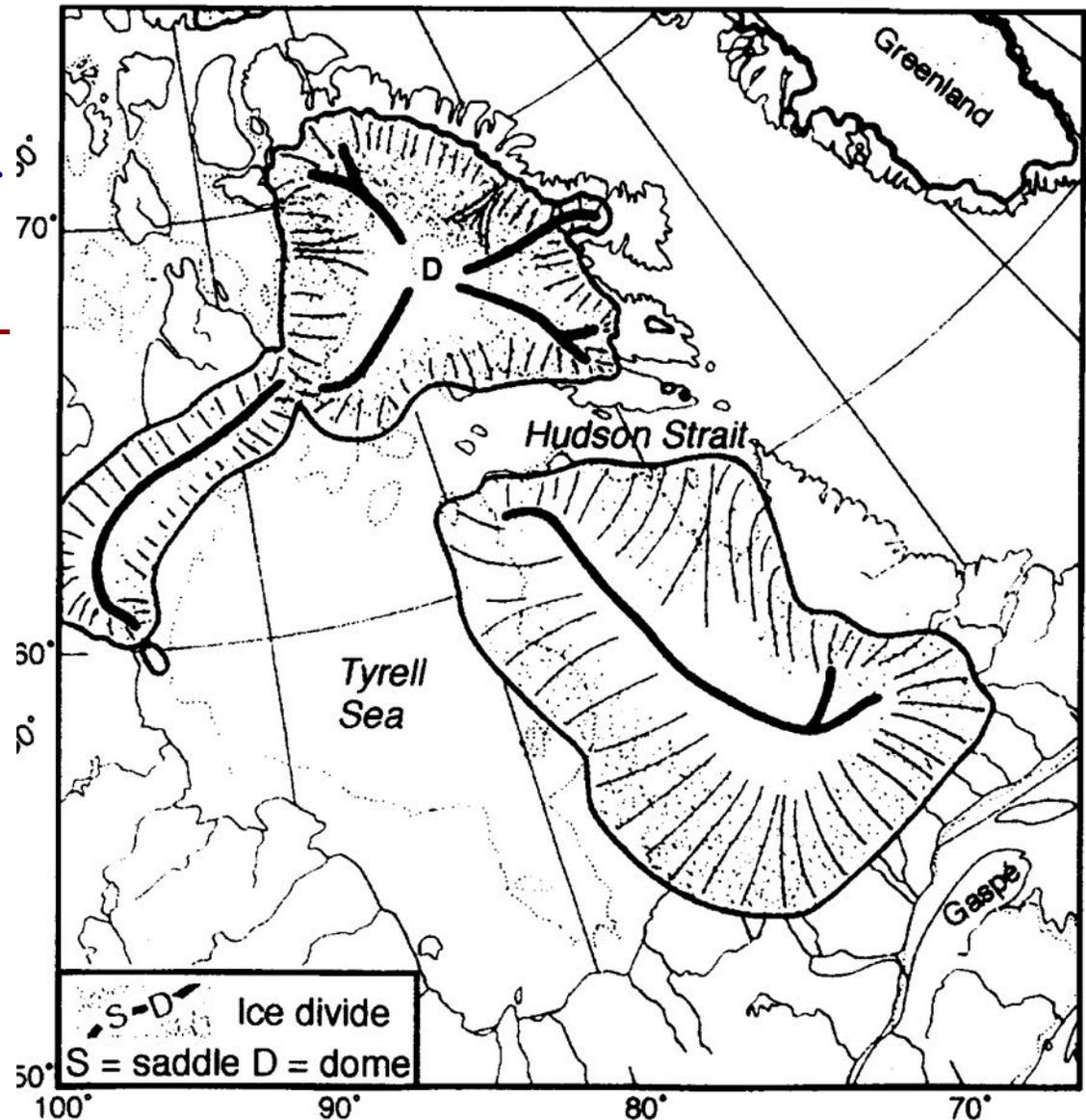
- Why are there big lakes along southern margin?
- Cochrane Lobe surge into Lake Ojibway.
- Hudson Bay Dome collapses.
- Drainage of marginal lakes Agassiz and Ojibway.



Dyke and Prest, 1989.

# Laurentide Ice Sheet – 7.9ka

- Sea level was still lower than today.
- Sea enters Hudson Bay - extensive flooding
- How could there be flooding?
- Remnants of ice sheet remain in Ungava (northern Quebec) and on Baffin Island/Foxe Basin.

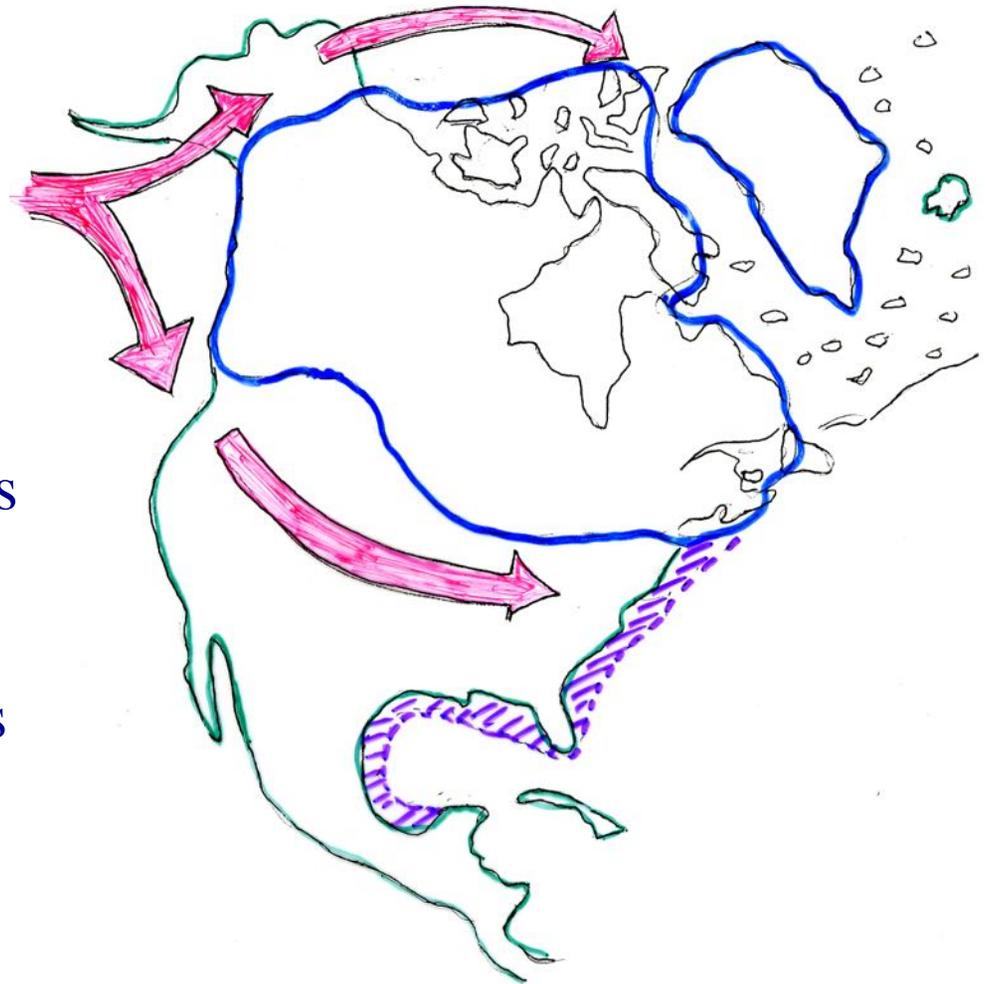


Dyke and Prest, 1989.

# Laurentide Ice Sheet and Climate

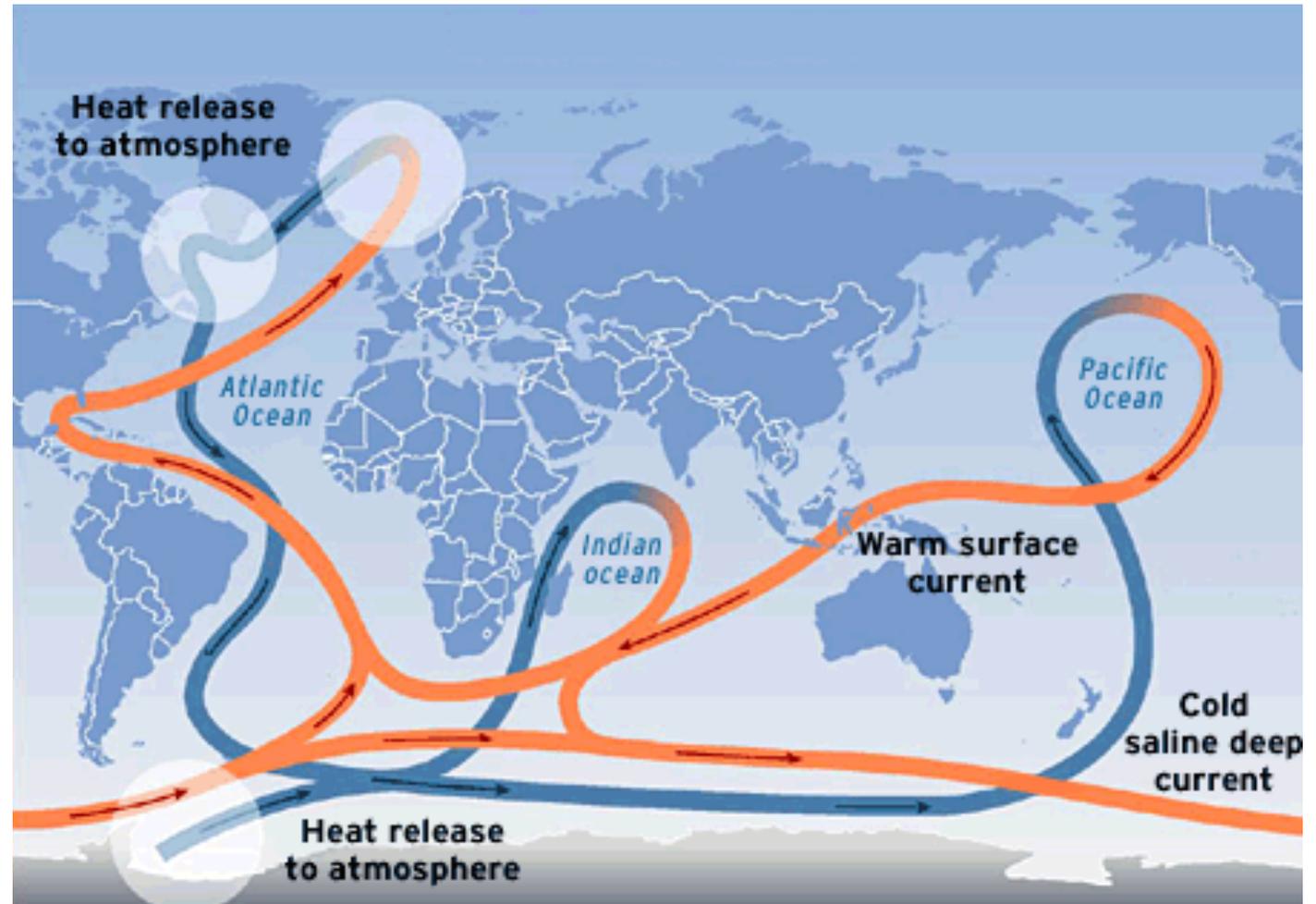
A huge lump of ice several km high can affect persistent low-pressure systems, wind patterns, and jet stream.

- Jet stream diverted south, takes Seattle weather to California.
- Jet diverted north, then sweeps south from Arctic down over Atlantic, cooling Europe even more.



## Conveyor is driven by formation of sea ice in North Atlantic

- Salt excluded from freezing sea ice makes the water dense.
- It sinks, and new warm water is drawn in to replace it.

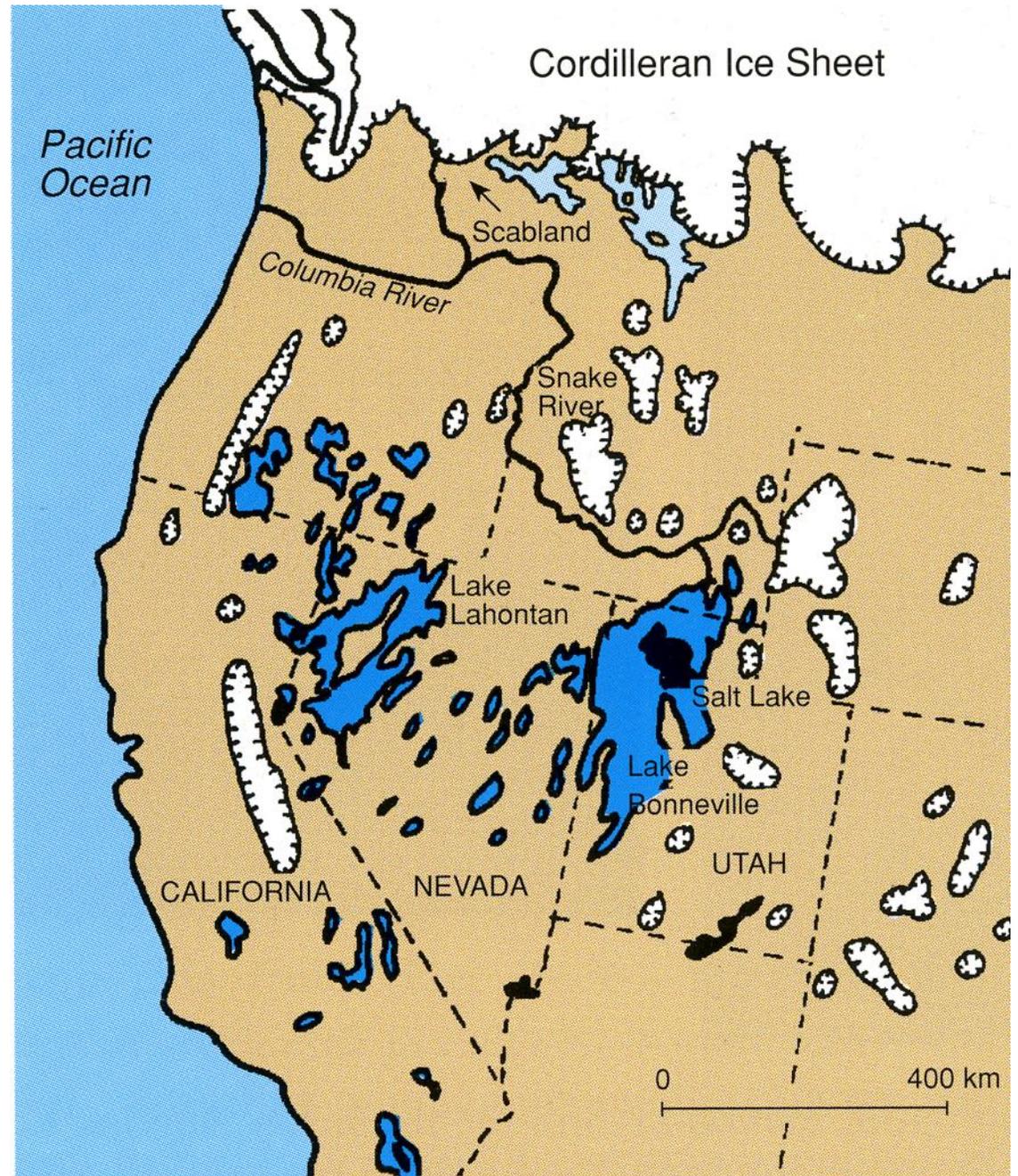


Conveyor may have been *off* during the Ice Age, contributing to very cold European climate.

(From the IPCC Report 2001)

## Western Lakes

- Large *pluvial lakes* (formed by rainfall) in USA where there are only deserts today.
- Lahontan, Bonneville (Salt Lake) drained to Columbia River.
- Their shorelines are still visible.
- Why was that area so different from today? (the continental ice sheet was hundreds of miles away, and did not drain into these lakes.)



Andersen and Borns, 1994. *The Ice Age World*

# Lake Bonneville and Lake Provo shorelines



Provo Valley, Utah

Andersen and Borns, 1994. *The Ice Age World*

About 17,400 years ago, 1,000 cubic miles of water was released from a massive ice age lake in Utah.

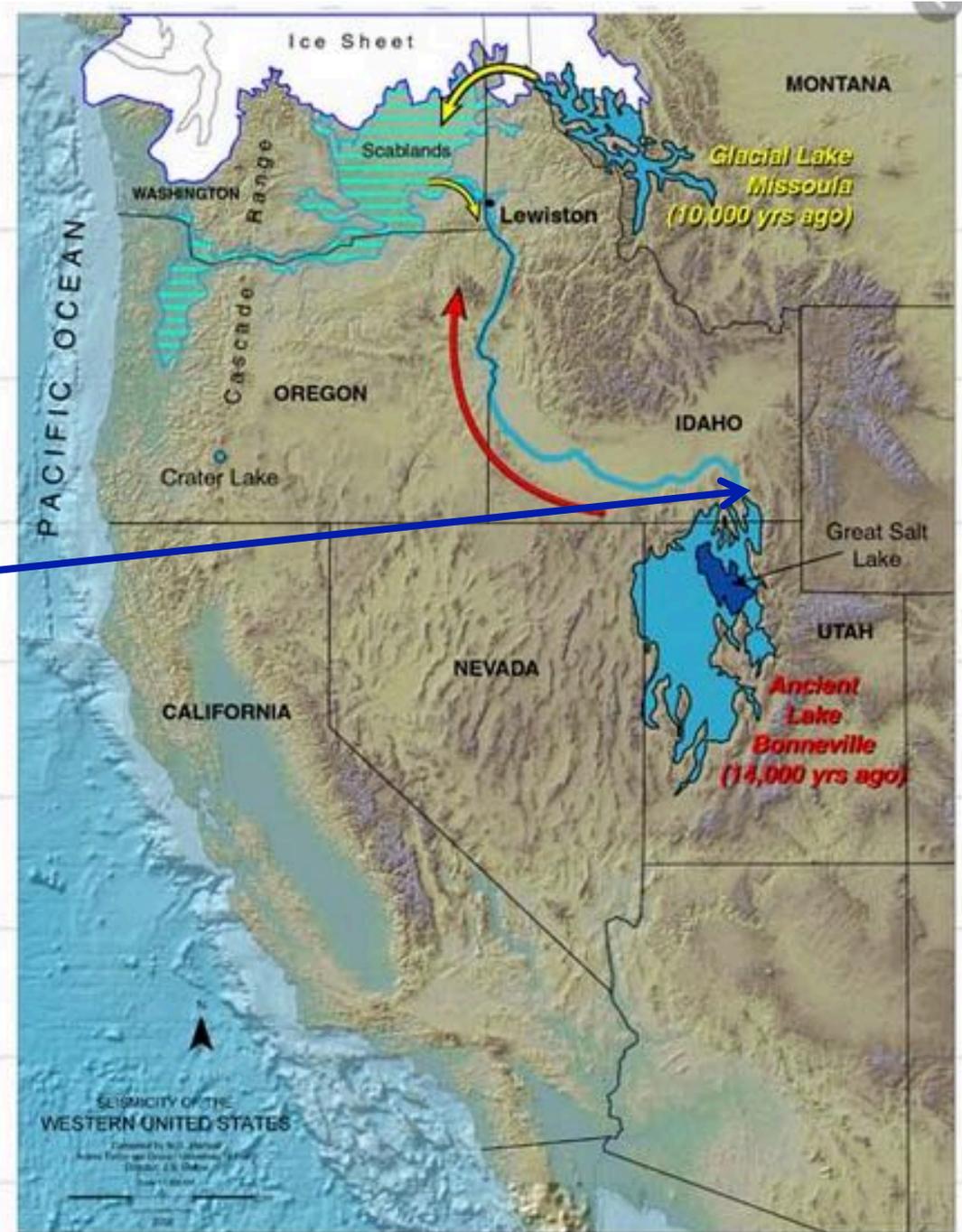
Floodwaters followed the course of the Snake River and its existing canyons across southern Idaho, then veered north through Hells Canyon. The flood scoured the walls and bed of the Snake's canyons from Pocatello to Pasco and also inundated a wide swath on the adjacent Snake River Plain across southern Idaho.

The current cut deep recesses in the canyon walls and gouged holes in the canyon floor, creating waterfalls, alcoves and gravel bars. The Snake River Canyon was deepened in places, creating the spectacular Shoshone Falls and Twin Falls northeast of the city of Twin Falls, Idaho. In Hells Canyon the floodwaters left gravel bars more than 100 feet above the modern river level.

<https://www.youtube.com/watch?v=ekpmCV5ZZU8>

# Lake Bonneville and the path to the Pacific

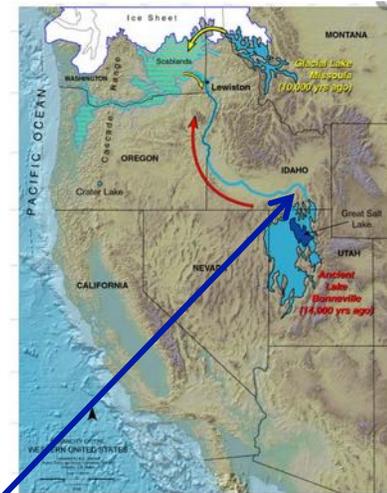
Red Rock Pass



# Alluvial Fan

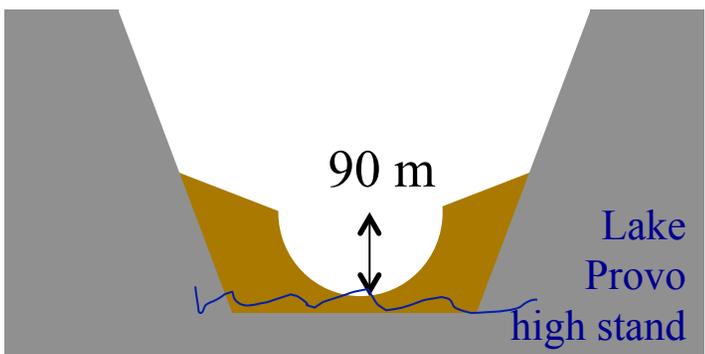
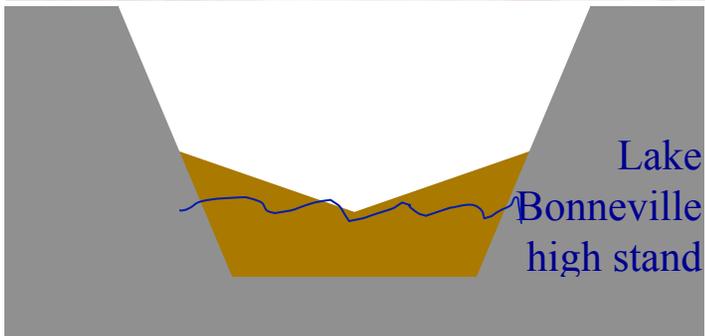


- not enough water to carry away all the sediment from a side valley



## Red Rock Pass

- Convergence of 2 alluvial fans
- Before Lake Bonneville drainage



## Red Rock Pass

- After Lake Bonneville drainage
- New level – Lake Provo

## Antarctica leaves the Ice Age

- Larger West Antarctic Ice Sheet (WAIS) at 20ka BP.
- Embayments with floating ice shelves today may have had thick, grounded ice (although recent research at UW questions this).
- West Antarctic grounding-line retreat may have been near-continuous ever since  $\sim 8$  ka BP, and it is likely to continue to shrink.
- (This topic can be a starting point for a group project topic.)
- East Antarctica saw little change, could not expand very far, because of narrow continental shelf.

