SOME APPLICATIONS OF PLANT MACROFOSSILS (2)

Lecture 5

Macrofossils in Radiocarbon dating
Atmospheric CO_2 reconstruction

Macrofossils and Archaeology

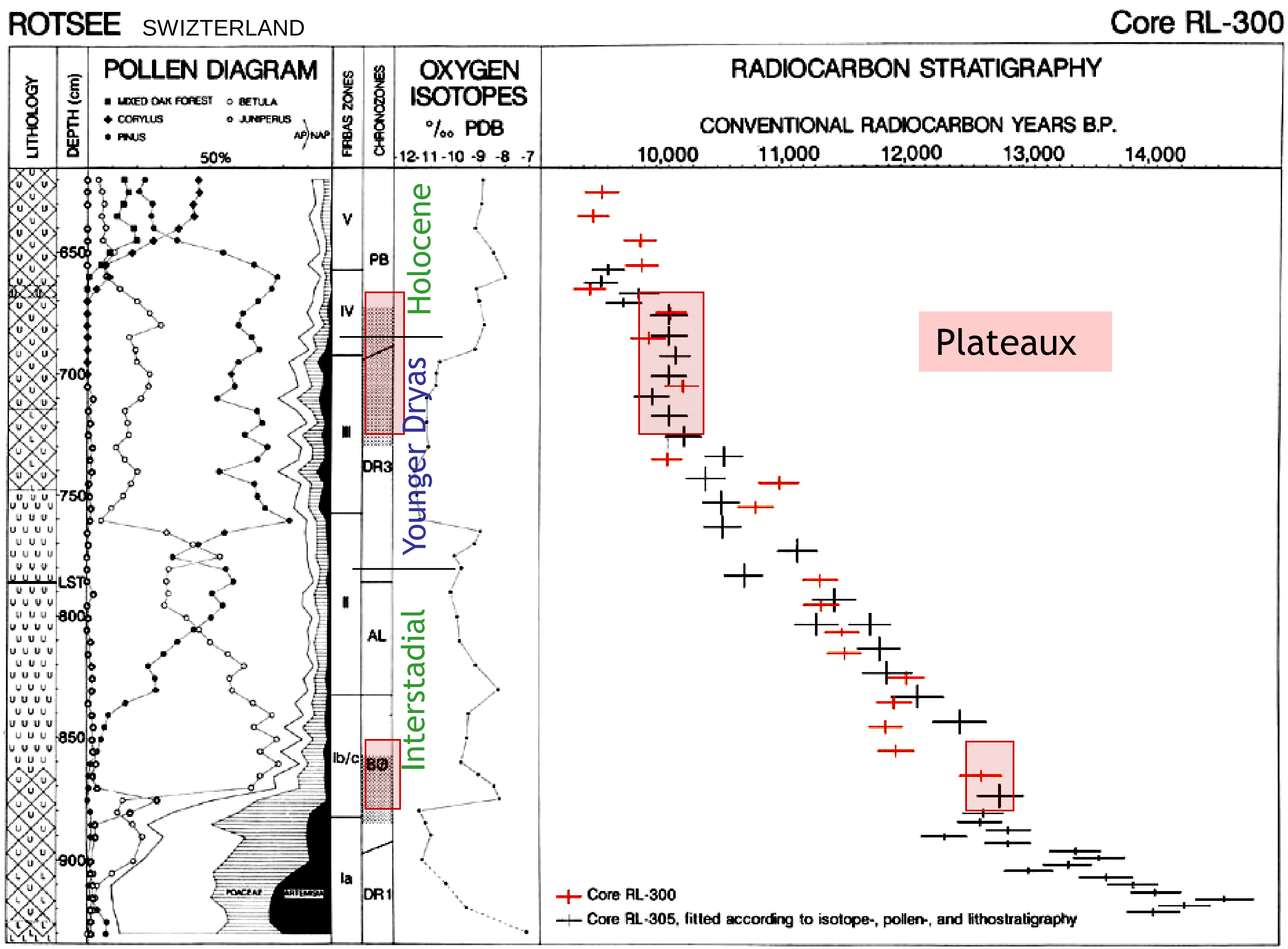
- **Macrofossils and radiocarbon dating**
  - Calibration
  - Holocene boundary
  - Tephra dating
  - Marine Reservoir Age
- **Macrofossils and atmospheric CO_2 concentrations**
- **Macrofossils and Archaeology**
  - Man in the landscape
  - Man's living environment and diet
  - The Iceman

Macrofossils and radiocarbon dating

- Sediments can have a reservoir age (older ^{14}C age than their real age)
  - lake sediments; old carbon from e.g. carbonates
  - marine sediments; marine organisms use ‘old’ carbon from sea water
  - peat; percolation of soluble humic compounds; younger age produced by roots growing down

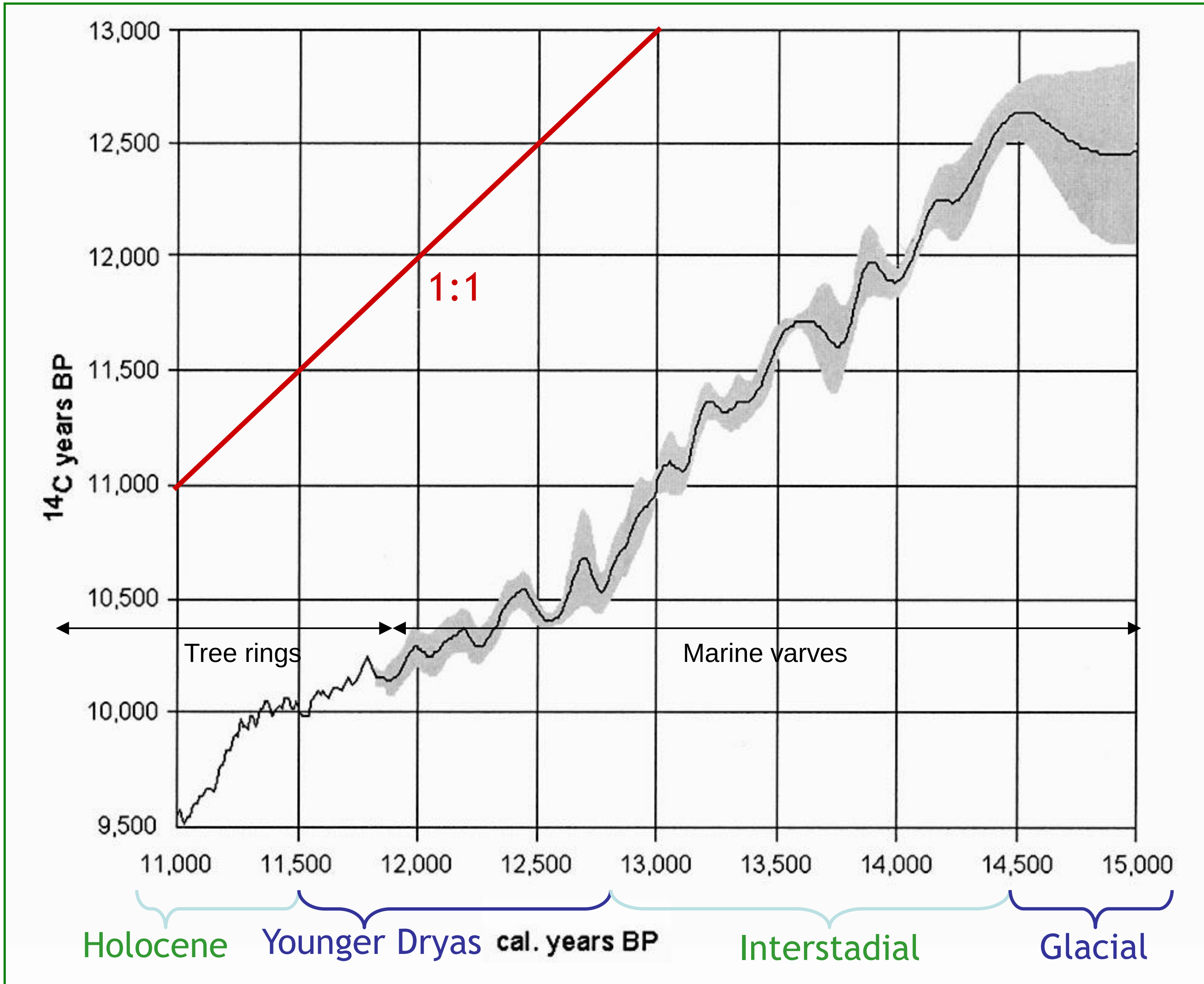
- Dating whole sediment
  - bulk sediment dating - problem in low carbon sediments, as need a lot of material which was deposited over a long time
  - AMS dating uses small amounts of material, can focus in on a level – narrow time span
  - Possible to date terrestrial plant remains; overcomes the problems of reservoir ages

Macrofossils used for AMS Radiocarbon Dating – discovered radiocarbon plateaux



Lotter (1991)

Radiocarbon Calibration Curve



Lowe *et al.* (2001)

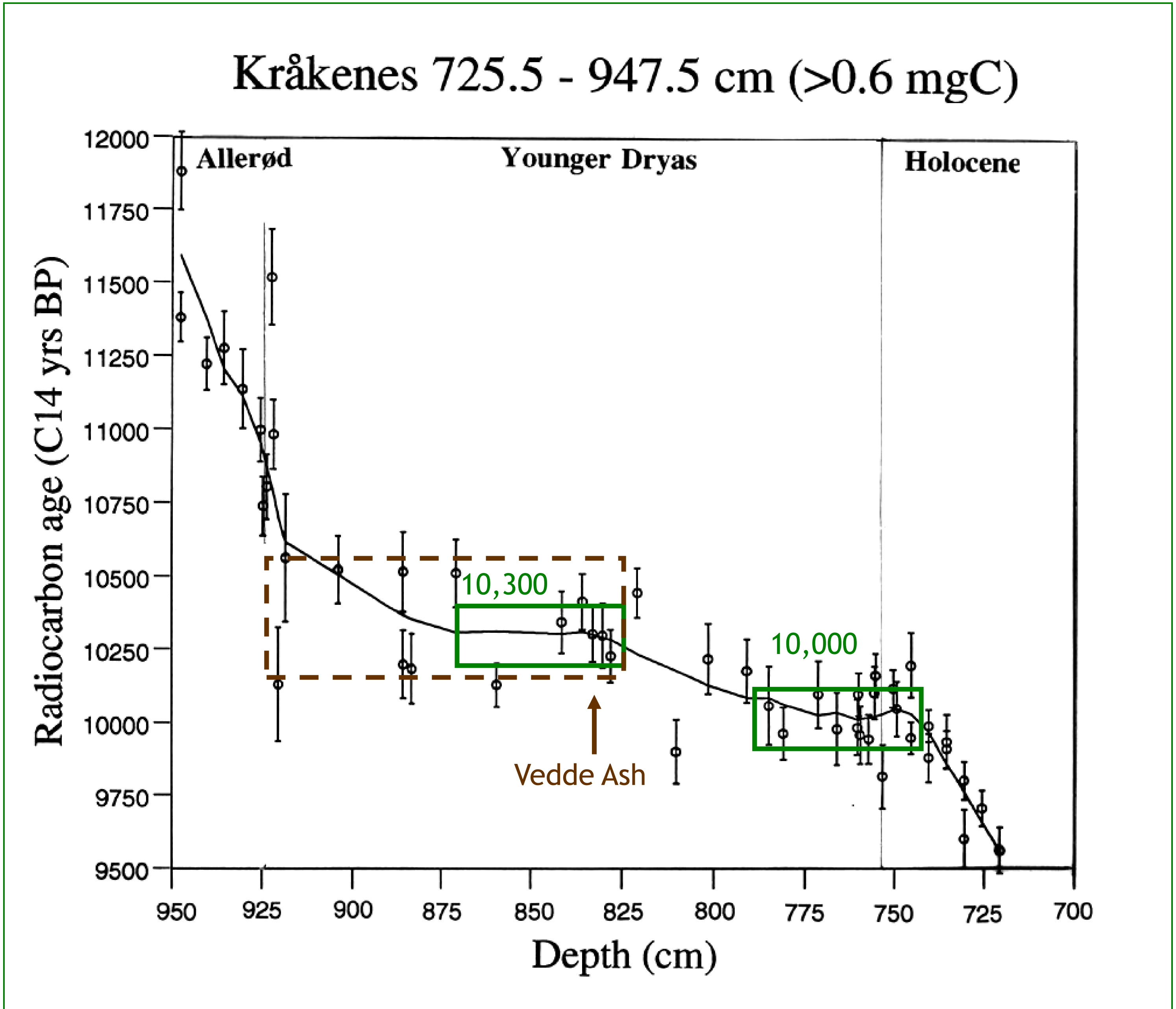
Salix herbacea – a key plant macrofossil

female

male

female

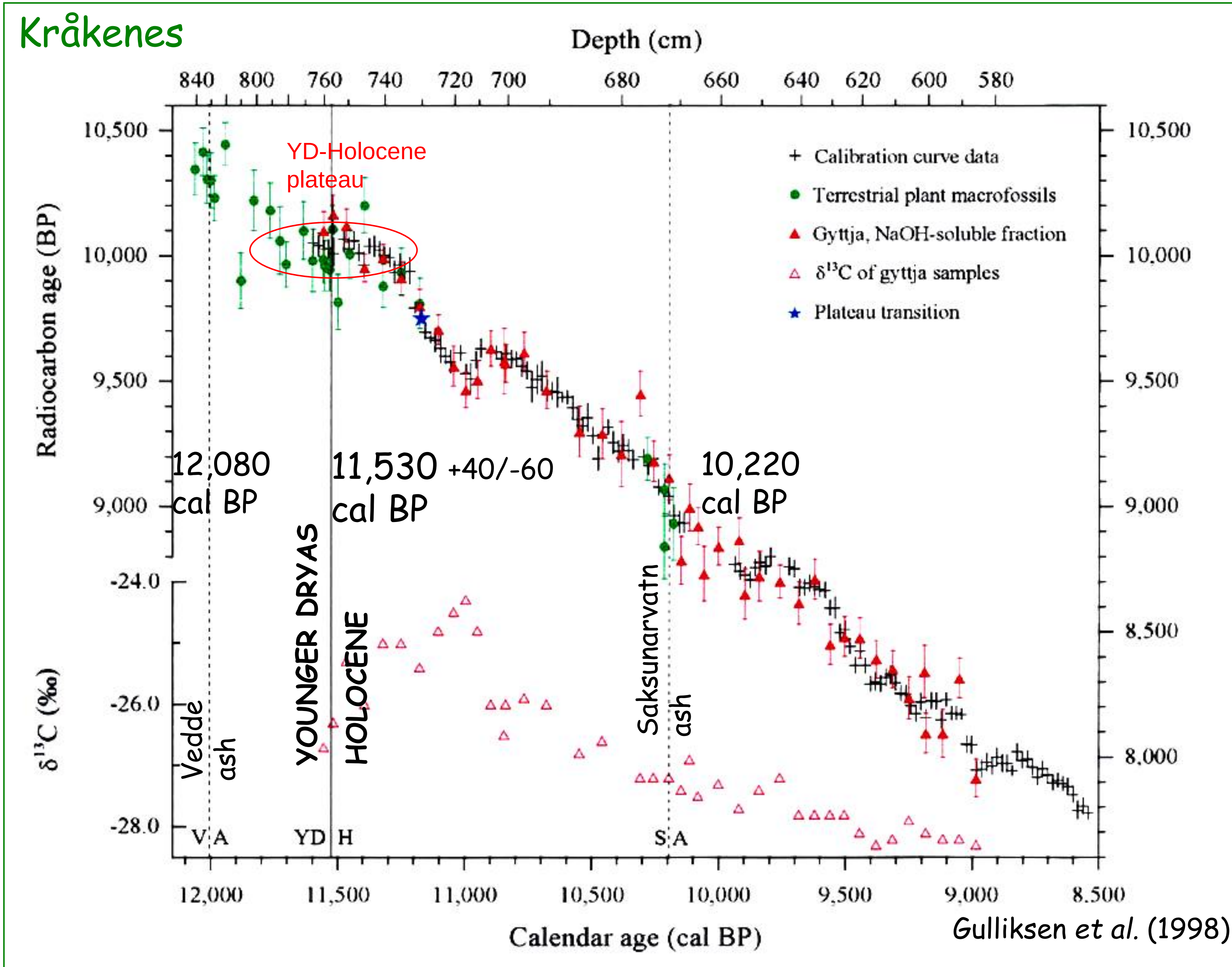
Dwarf-willow (musøre), locally abundant in snow-bed vegetation, leaves well dispersed by melting snow and well preserved in lake sediments



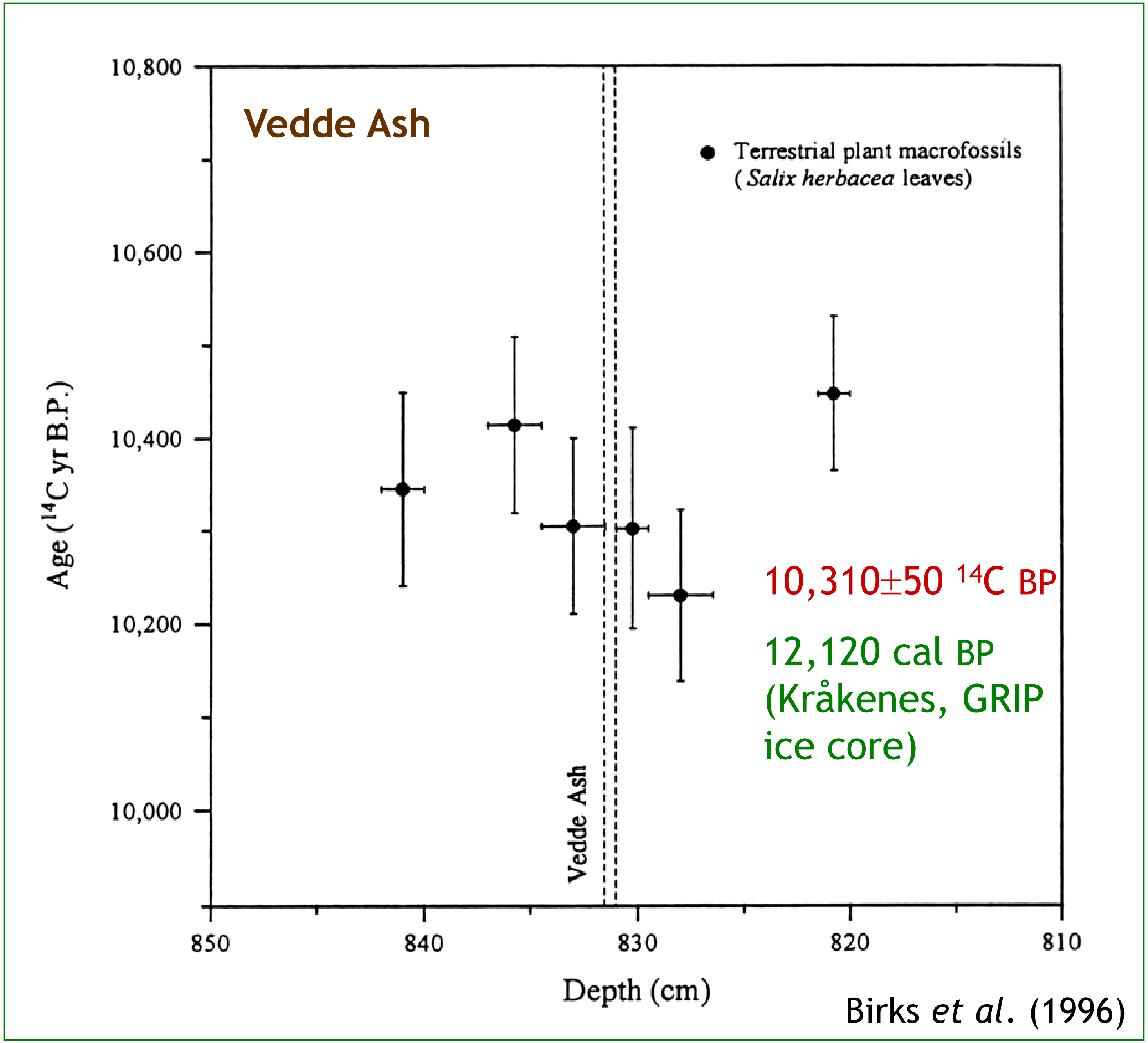
Kråkenes 725.5 - 947.5 cm (>0.6 mgC)
Allerød
Younger Dryas
Holocene
Radiocarbon age (C14 yrs BP)
12000
11750
11500
11250
11000
10750
10500
10250
10000
9750
9500
10,300
10,000
Vedde Ash
950
925
900
875
850
825
800
775
750
725
700
Depth (cm)

96 14C dates

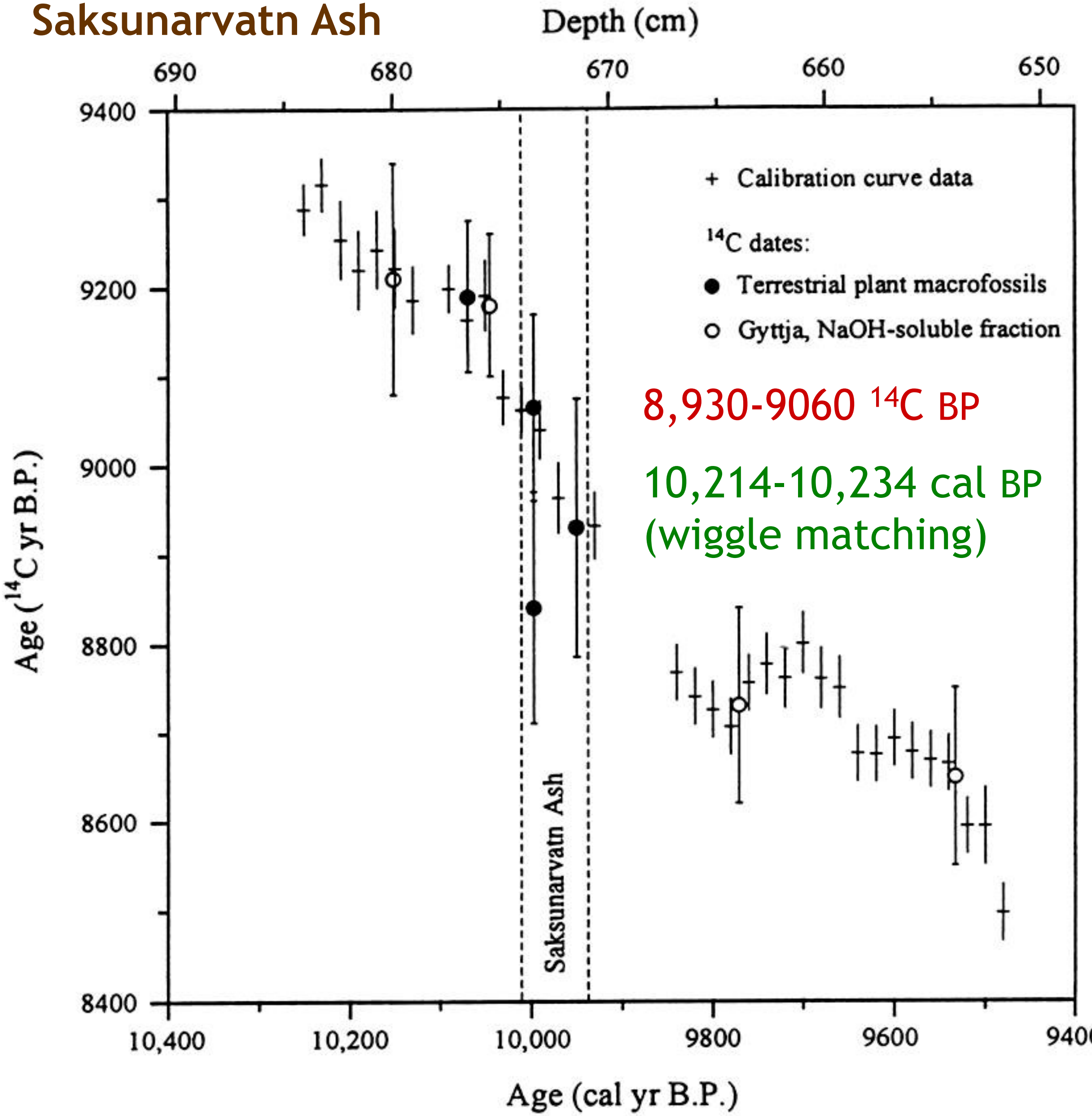
Age of YD/Holocene boundary; wiggle matching against tree-ring data



Absolute Dating of Tephras at Kråkenes



Saksunarvatn Ash

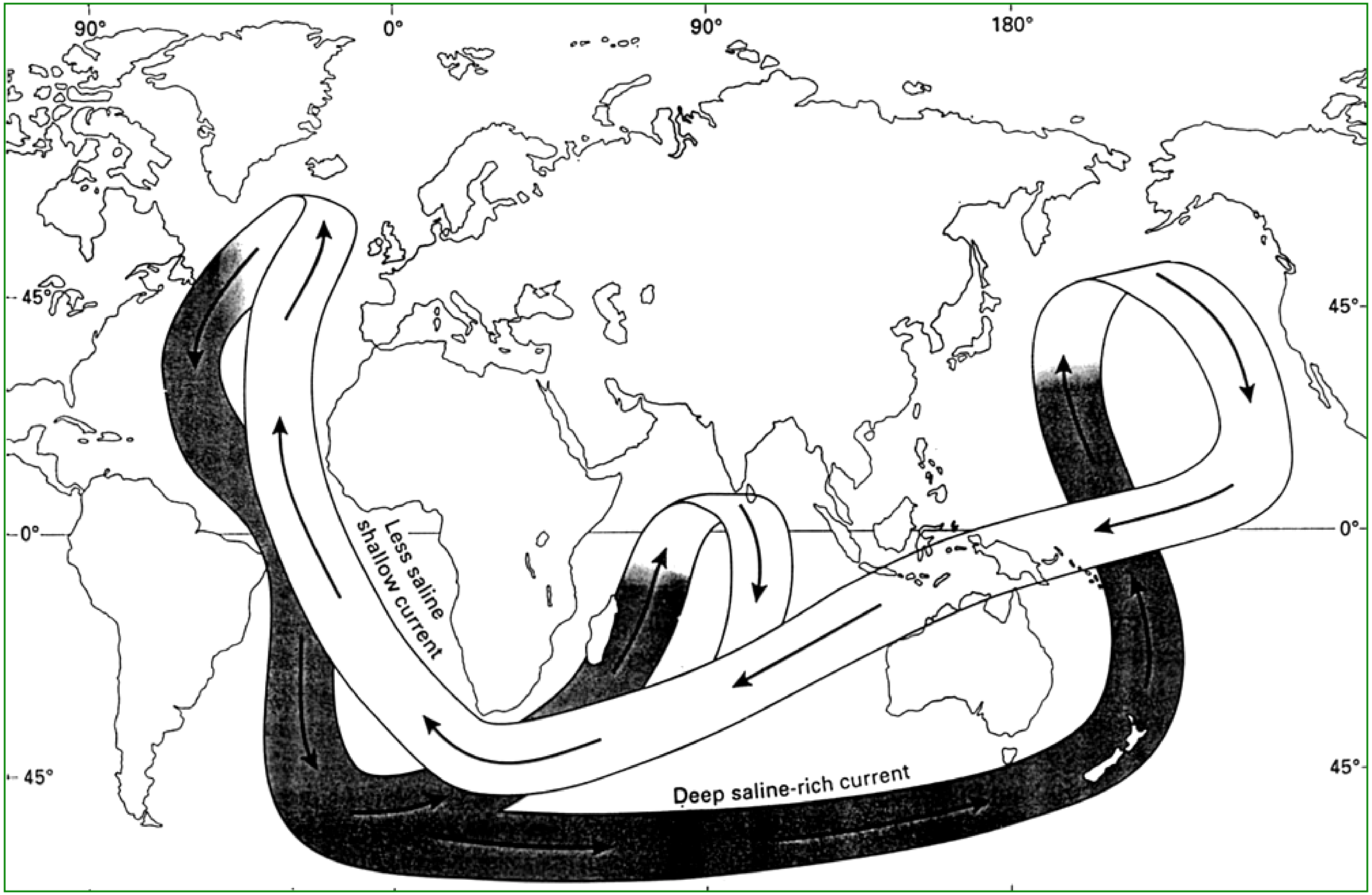


8,930-9060 ^{14}C BP

10,214-10,234 cal BP
(wiggle matching)

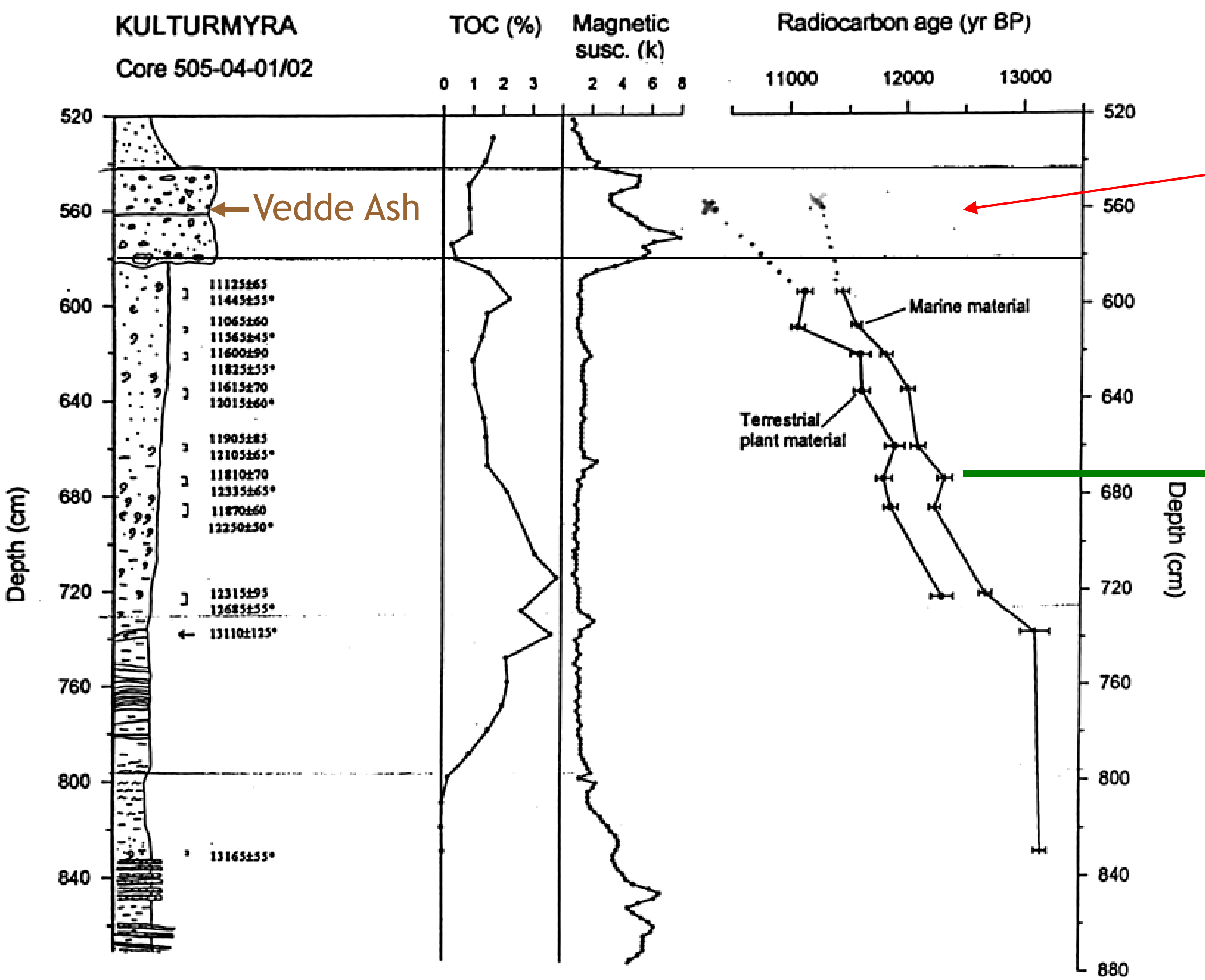
Marine Reservoir Effect

The large-scale salt transport system (Ocean/Global conveyor) operating in the present oceans.



J.J. Lowe & M.J.C. Walker (1997) Reconstructing Quaternary Environments, Longman

Dating Terrestrial and Marine Material from the same Core at the Norwegian coast

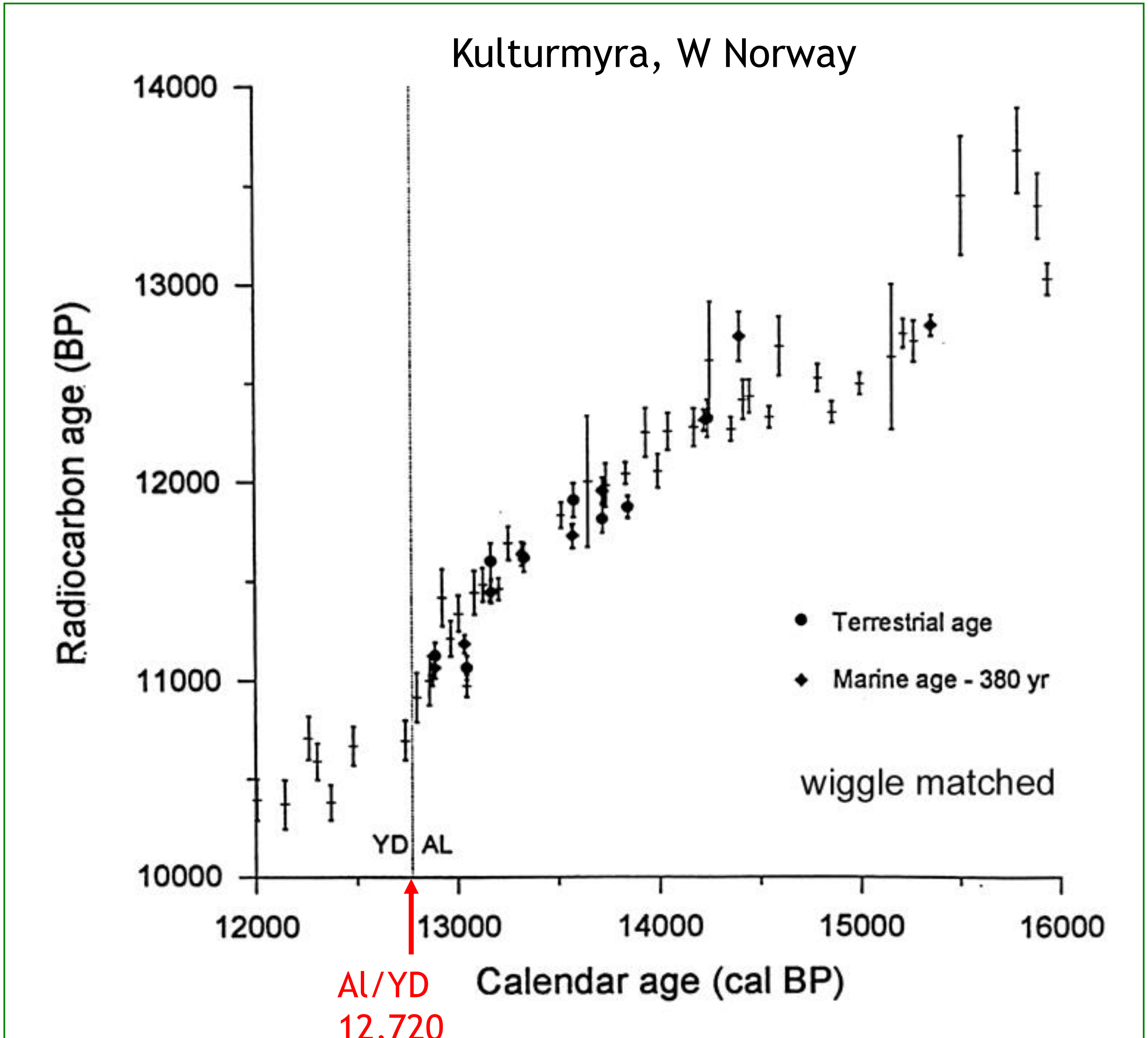


Bondevik *et al*. (1999)

MRA = 700-1000 (varies geographically)

610±55 Kvaltjern

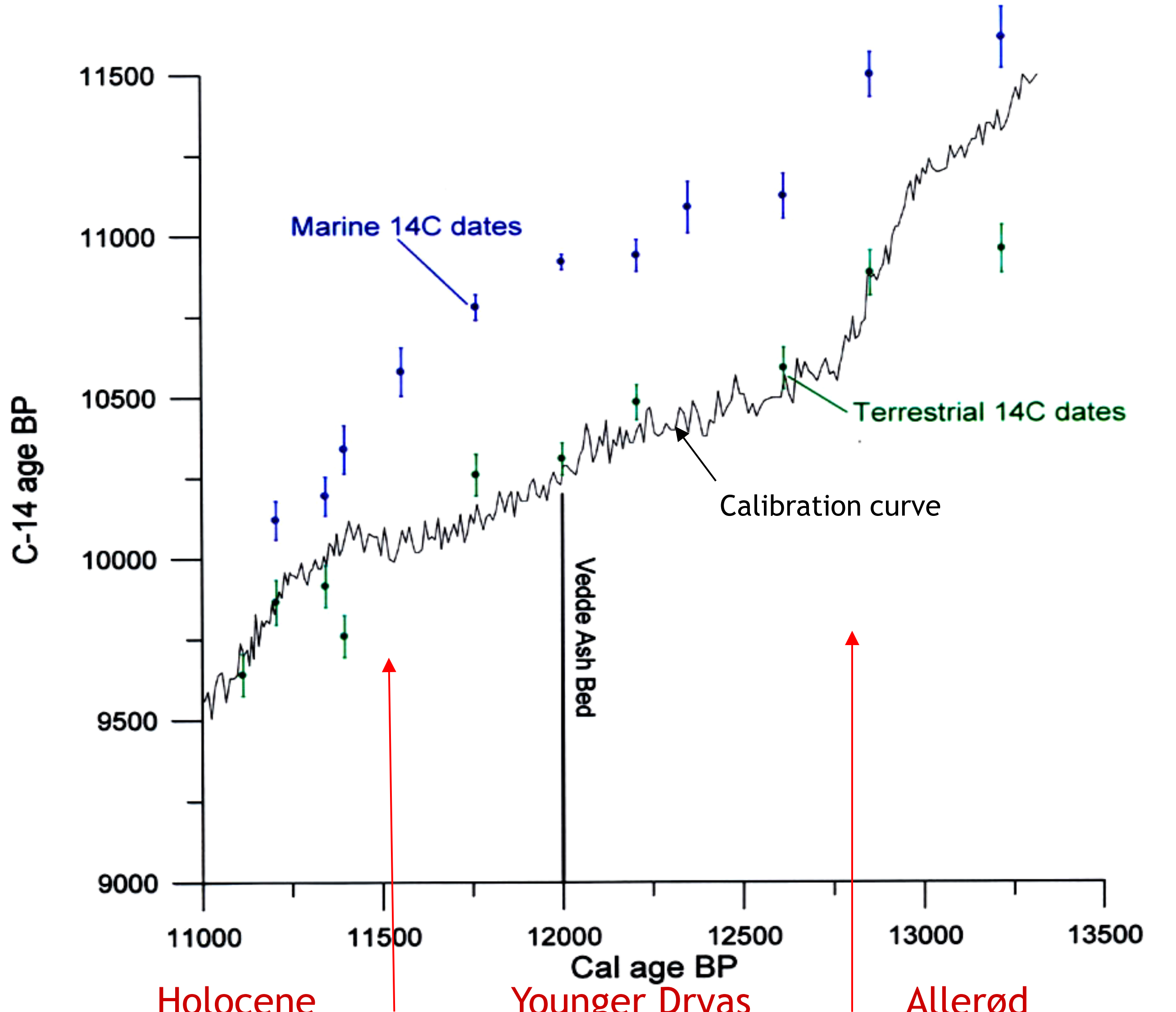
Marine Reservoir Age = 380 yr in Allerød



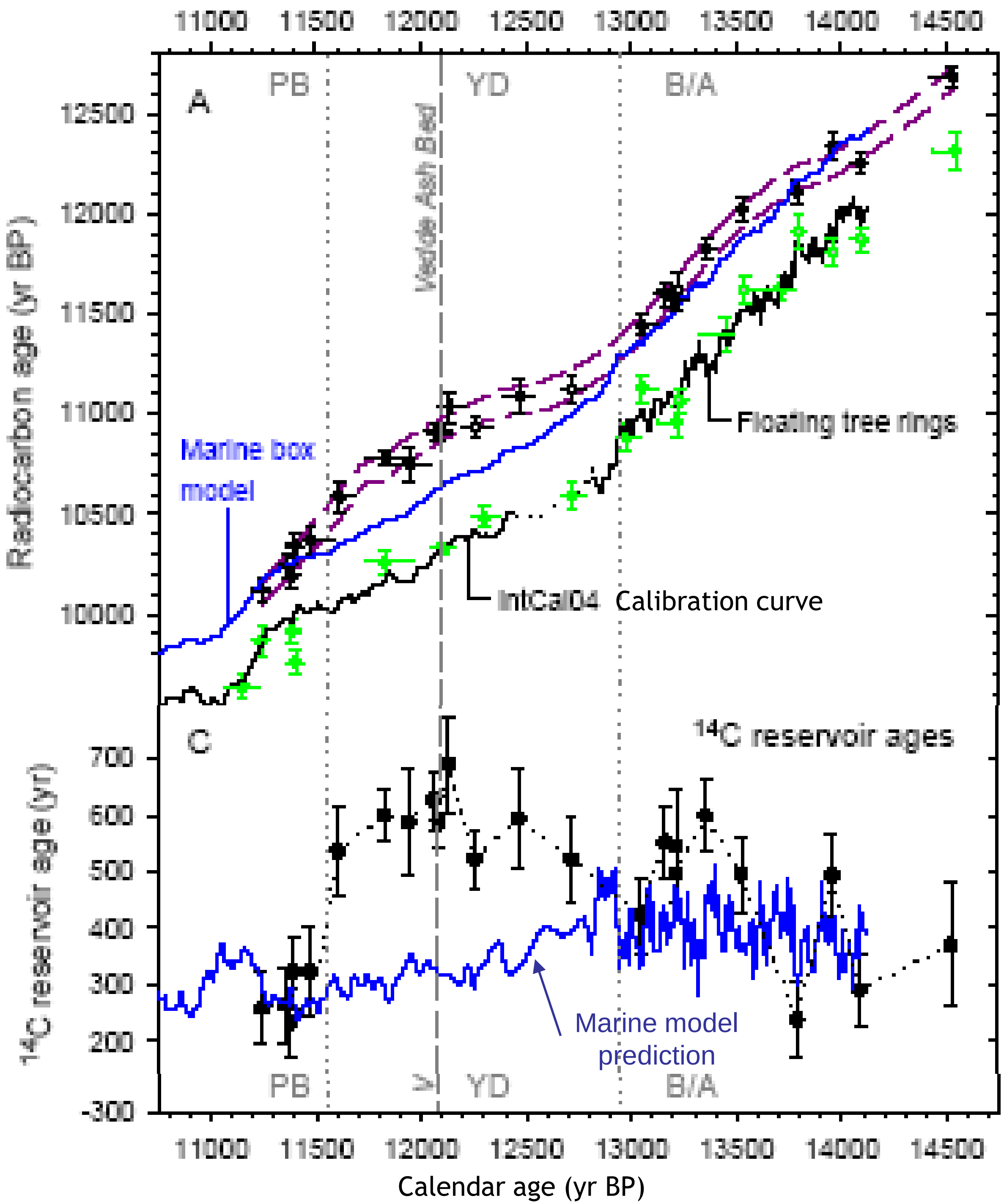
Bondevik *et al.* (1999)

Was the Marine Reservoir Age always the same?

Kvaltjern, Norwegian coast – a marine bay in the late-glacial



^{14}C dating of marine shells and terrestrial leaves at the same levels in the core



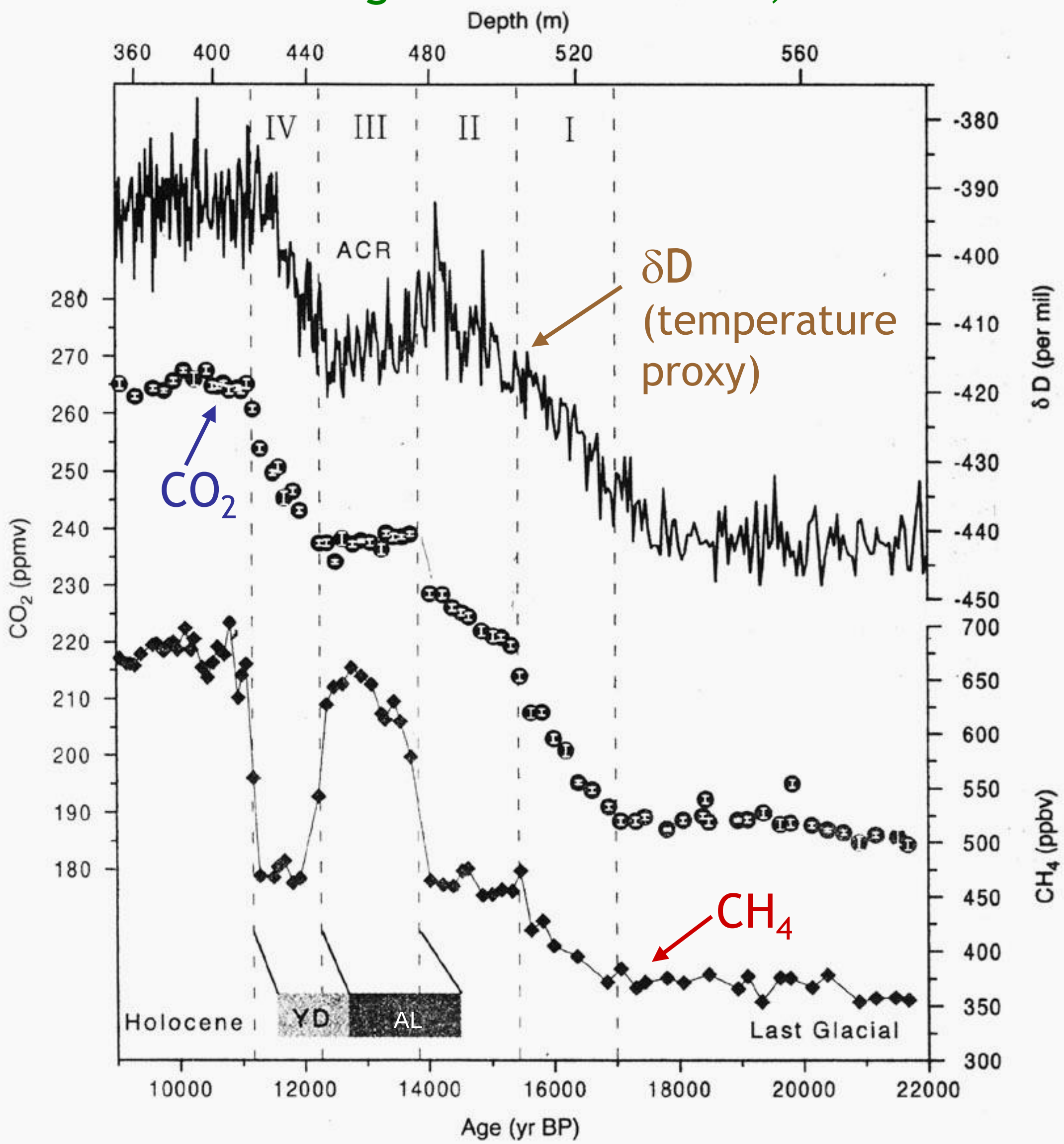
Reservoir age is a bit higher than the model in the B/A (inter-stadial), rises in YD to ca. 600 yr, stays at 600 yr for ca. 700 years, then decreases rapidly into the PreBoreal (Holocene).

Linked to changes in rate of ocean circulation

Bondevik et al. 2006, Science

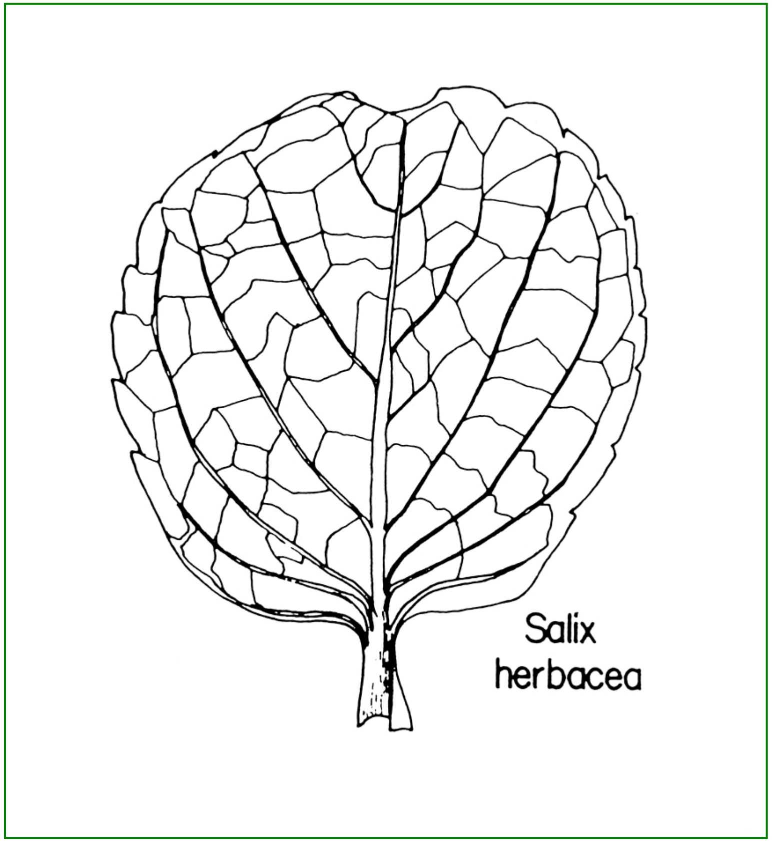
Reconstruction of Atmospheric CO_2

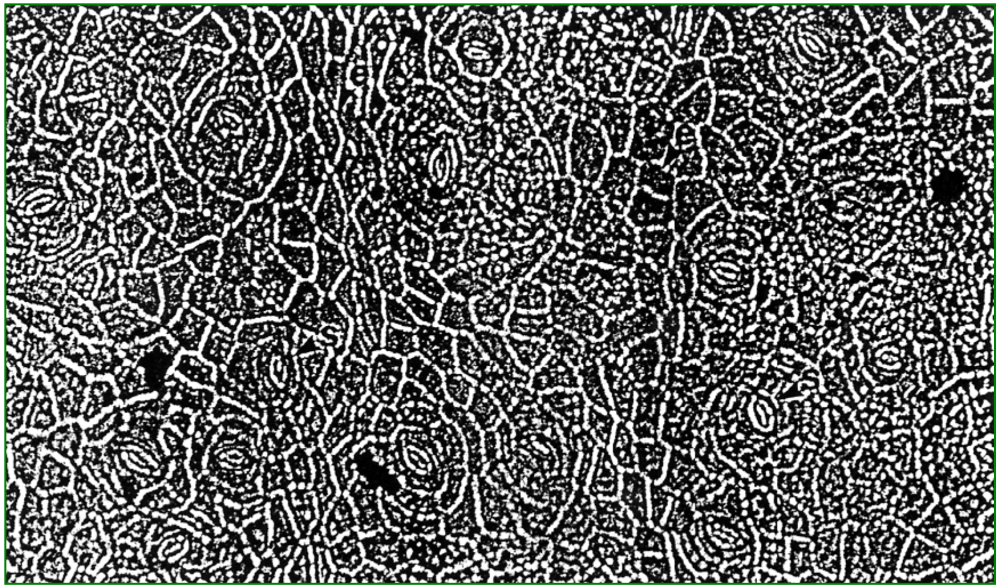
Ice-Core Record: e.g. Dome Concordia, Antarctica



E. Monnin *et al.*(2001)

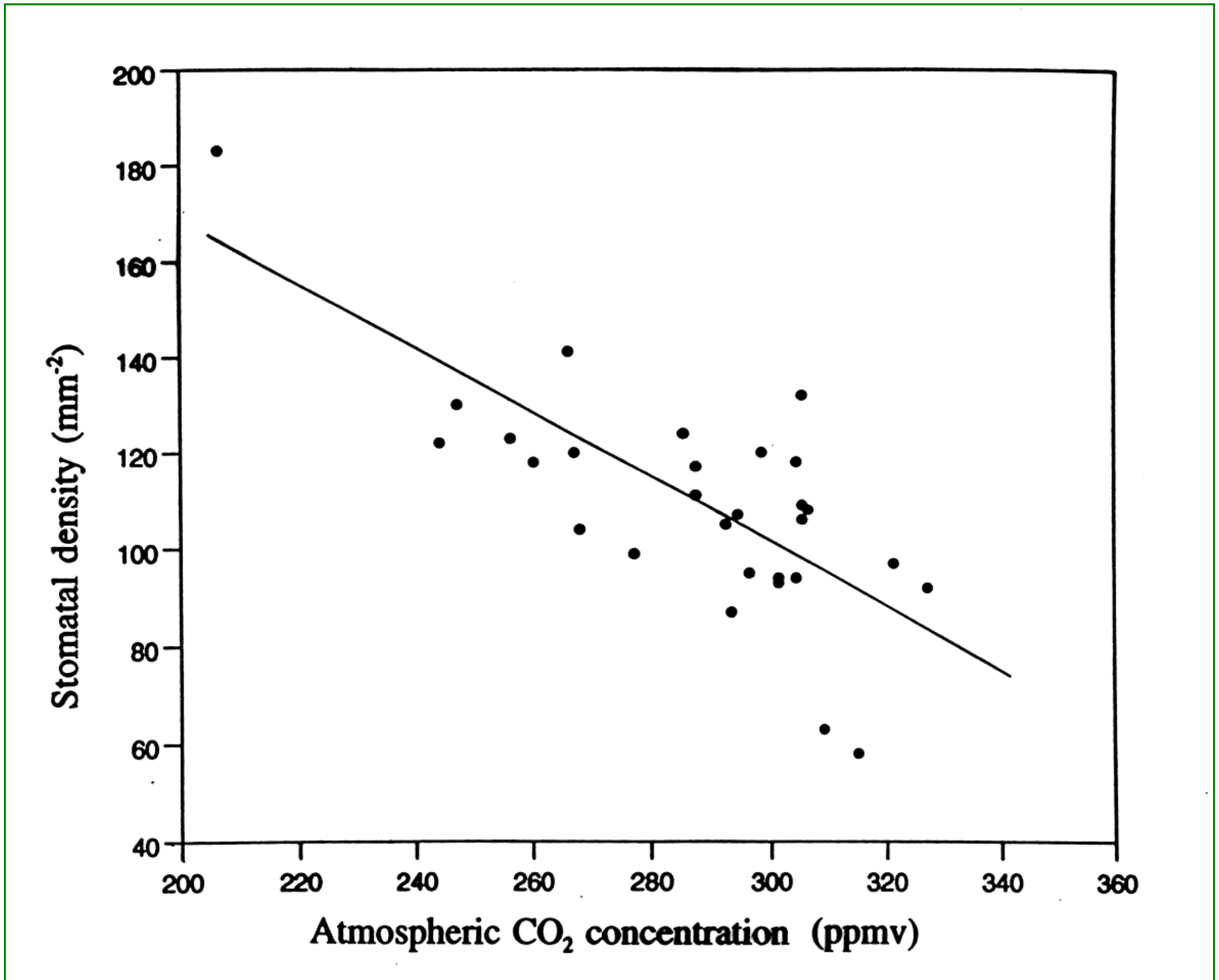
Salix herbacea stomata





Light micrograph of the cuticle of a Quaternary fossil *S. herbacea* leaf showing epidermal cells and stomata (x40). The cuticle was macerated in sodium hypochlorite (8% w/v) for 2 minutes and mounted in glycerol jelly with safranin.

Calibration of *Salix herbacea* stomatal density and CO_2 concentration

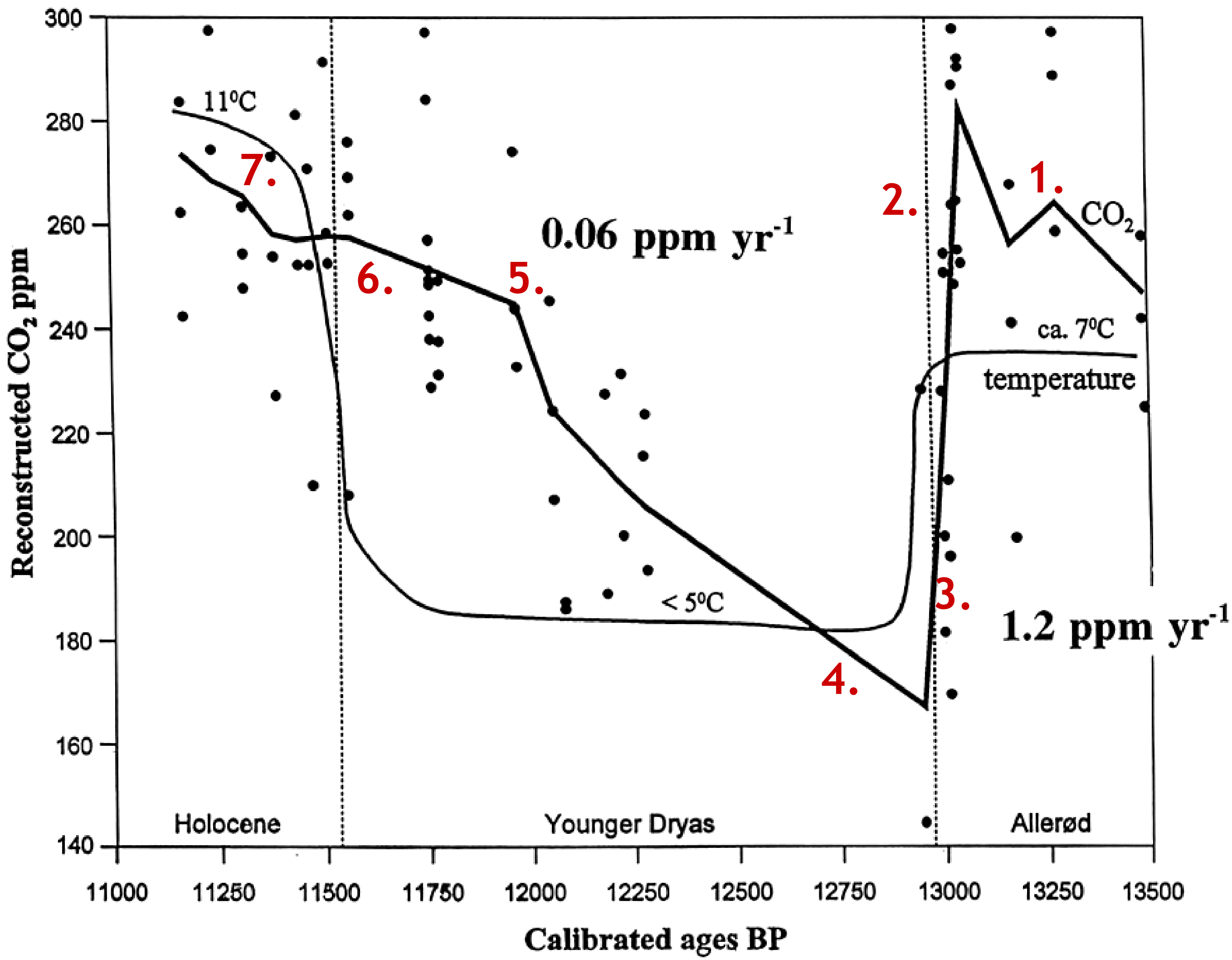


Samples taken from:

- Herbarium leaves of different ages (recent CO_2 increase)
- Different altitudes (lower partial pressure of CO_2 with increasing altitude)
- Fossil Weichselian (Beetley 16,500 BP) and ice-core CO_2 value (Byrd)

Beerling *et al*. (1995)

Late-glacial CO_2 reconstructions at Kråkenes, western Norway (38 m a.s.l.)



Rates of CO_2 and Temperature Changes

Allerød - Younger Dryas

- The rate of CO_2 decrease is ca. 1.2 ppm yr^{-1}
- The temperature falls about 2°C over the same time period
- The rate of biotic response is similar

Younger Dryas - Holocene

- CO_2 increases through the Younger Dryas at 0.06 ppm yr^{-1}
- CO_2 increases during the early Holocene at 0.08 ppm yr^{-1}
- Temperature increases ca. 6°C during ca. 500 yr of the early Holocene
- Biotic response to the temperature rise is immediate (5-10 yr)

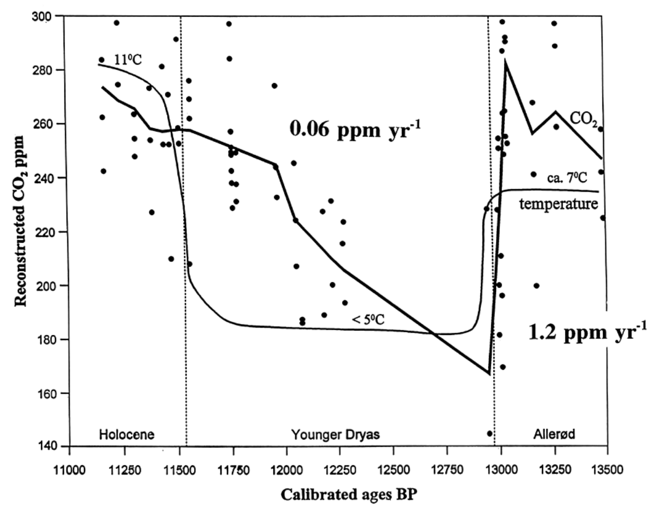
Modern

- The present rate of CO_2 rise is 1.25 ppm yr^{-1} (Mauna Loa data)
- Temperature has increased by ca. 0.5-1°C over the last century

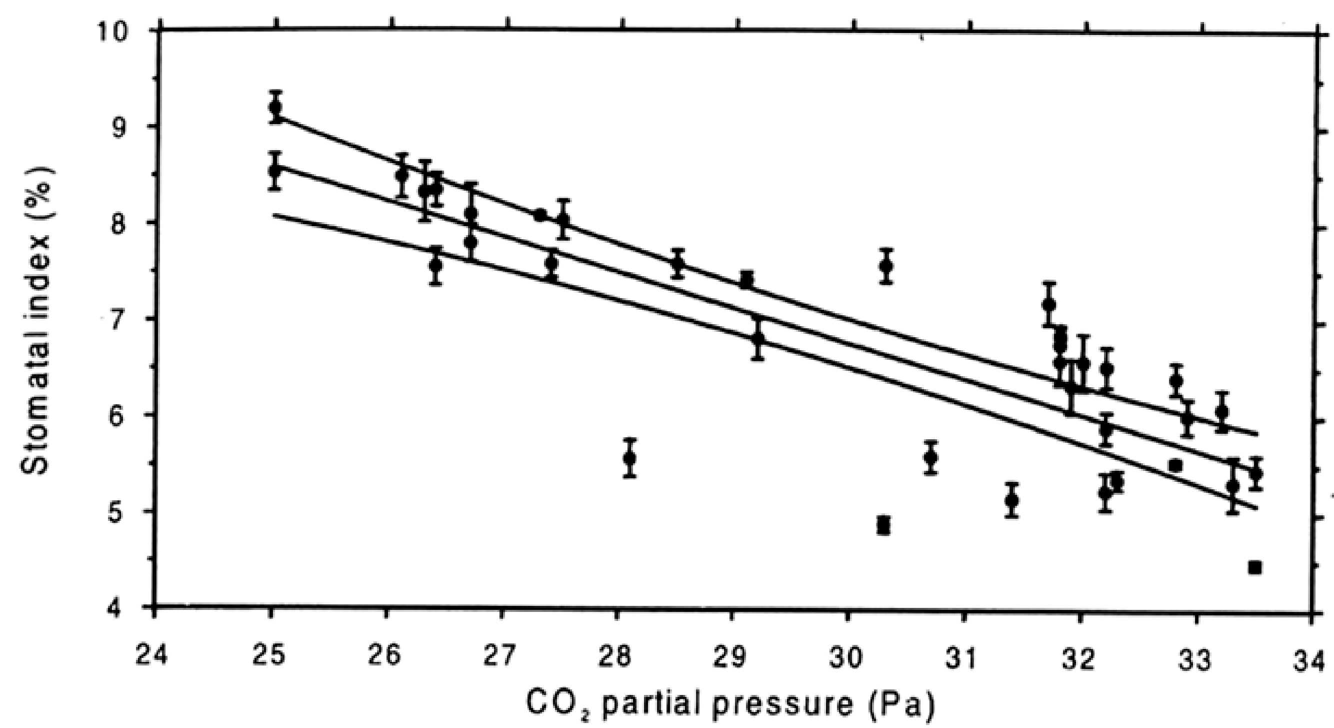
Comparison

- The rate of decline in the Allerød was similar to the rate of present CO_2 increase; i.e. large, rapid changes can occur naturally
- The Younger Dryas – Holocene rate of CO_2 increase was about 6% of that at present
- The temperature increase over the YD/Holocene boundary at Kråkenes was perhaps similar to the present rate of global warming. The CO_2 increase could not have been fully responsible for the rapid Holocene temperature increase

Late-glacial CO_2 reconstructions at Kråkenes, western Norway (38 m a.s.l.)

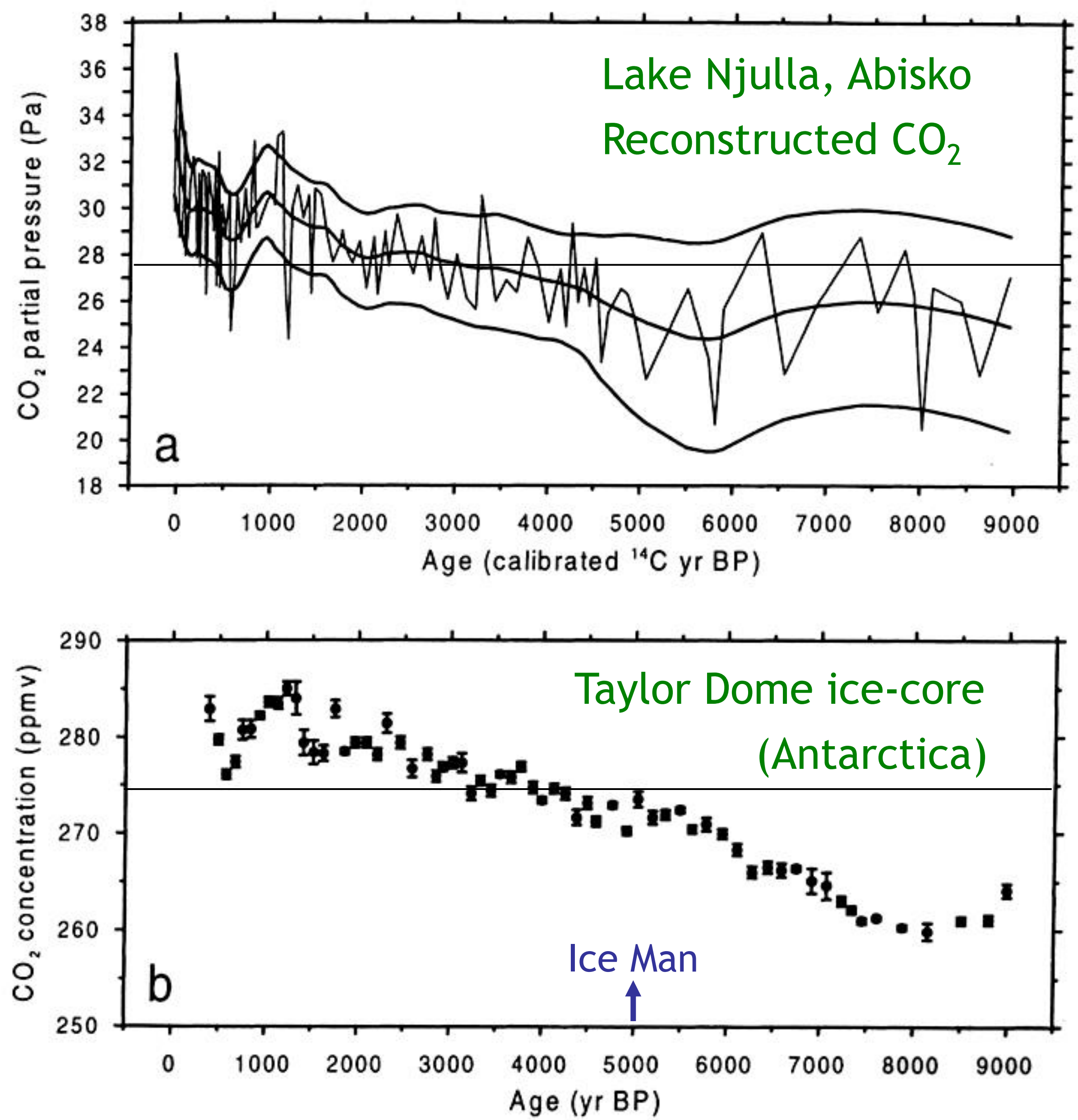


Holocene CO_2 and Stomata



Linear regression of modern *Salix herbacea* stomatal index (SI) versus atmospheric CO_2 partial pressure to make a modern calibration data-set, with 95% confidence intervals.

Rundgren & Beerling (1999); Rundgren (2007)

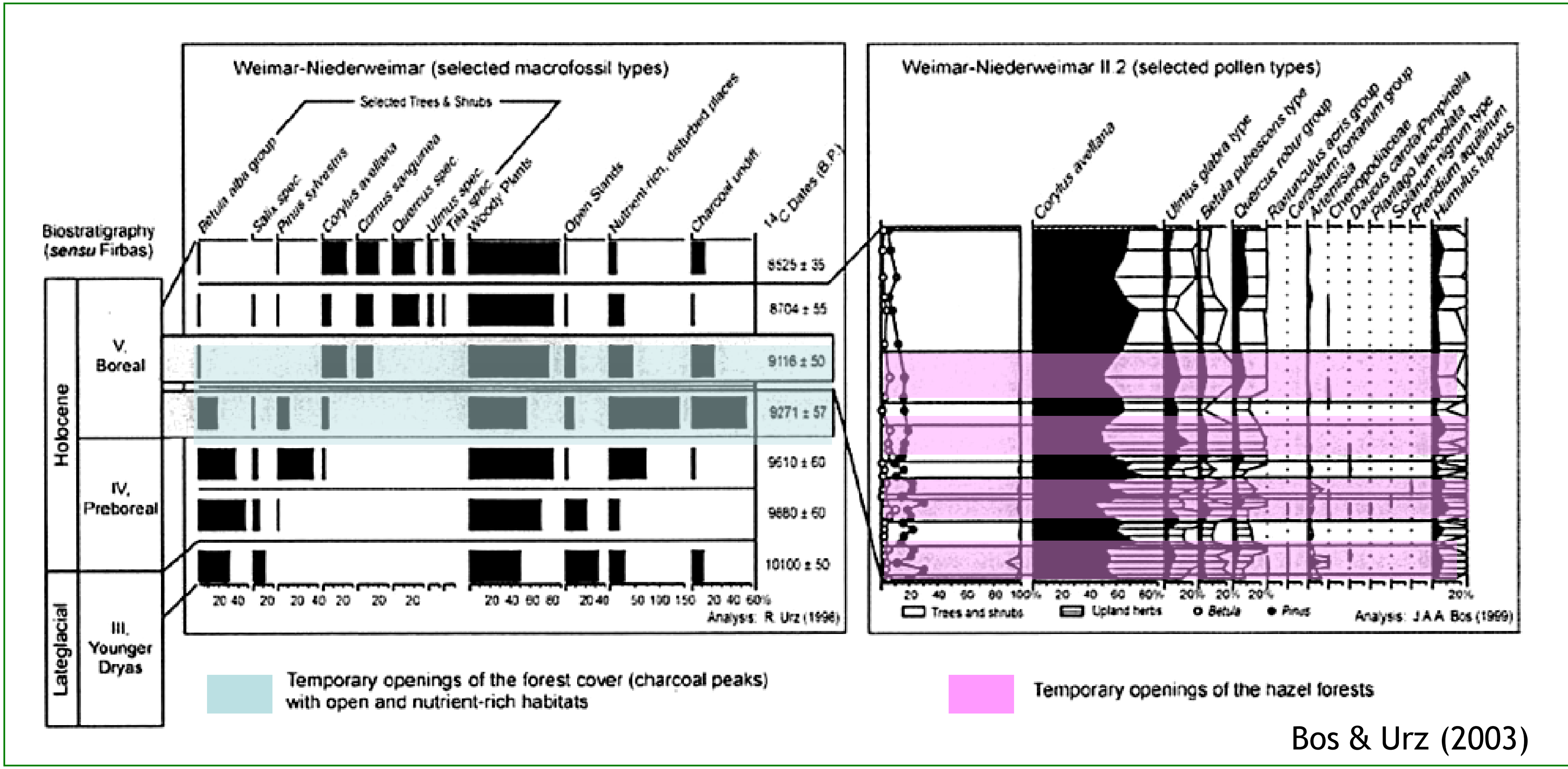


Lake Njulla, Abisko
Reconstructed CO_2
a
CO_2 partial pressure (Pa)
Age (calibrated ^{14}C yr BP)
Taylor Dome ice-core
(Antarctica)
b
CO_2 concentration (ppmv)
Age (yr BP)
Ice Man

Macrofossils and Archaeology

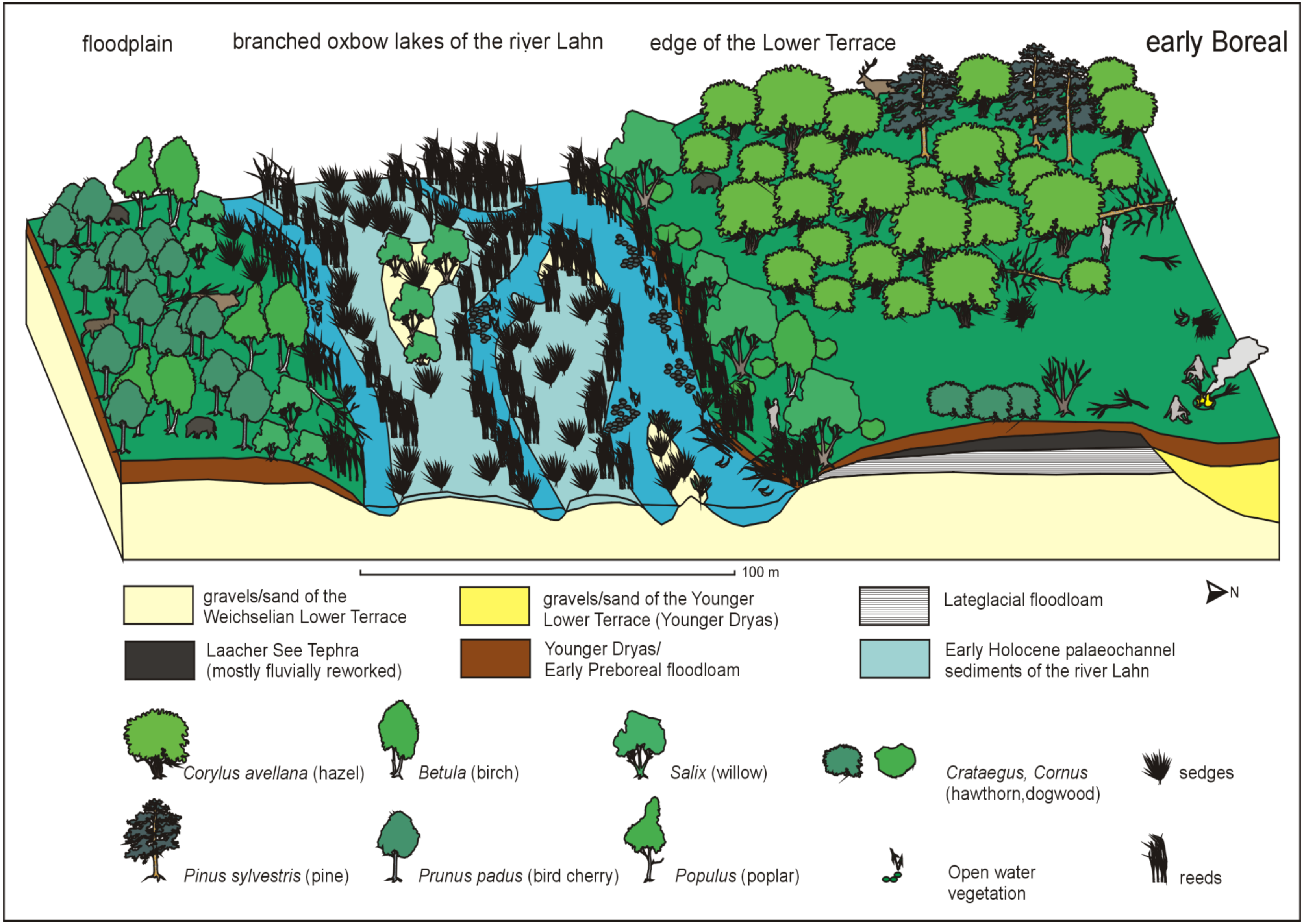
- Man in the landscape
- Man’s living environment and diet
- The Iceman

Mesolithic Impact (Germany)



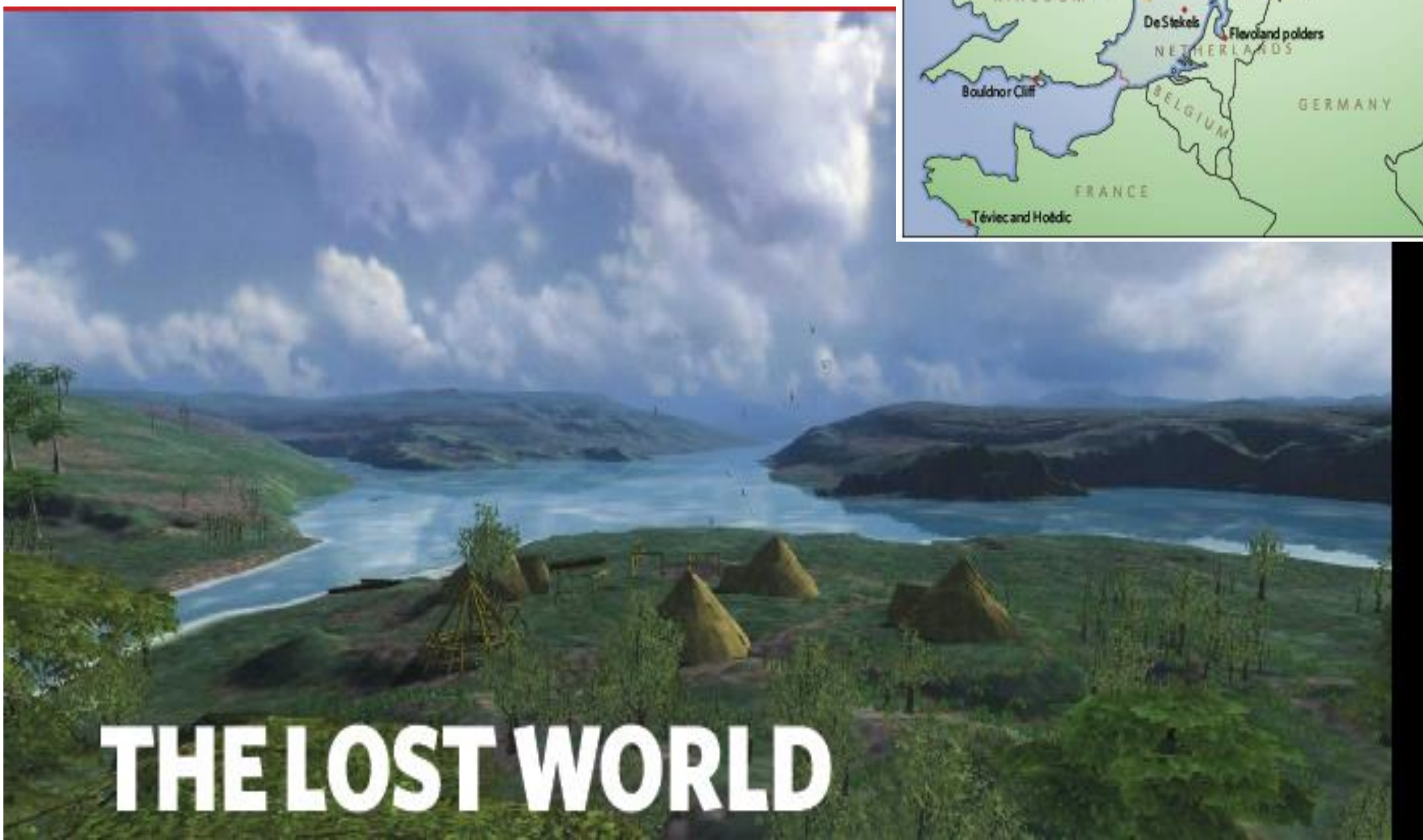
Bos & Urz (2003)

Combined pollen and macrofossil diagram, showing the two different phases of early Mesolithic human impact on the landscape.



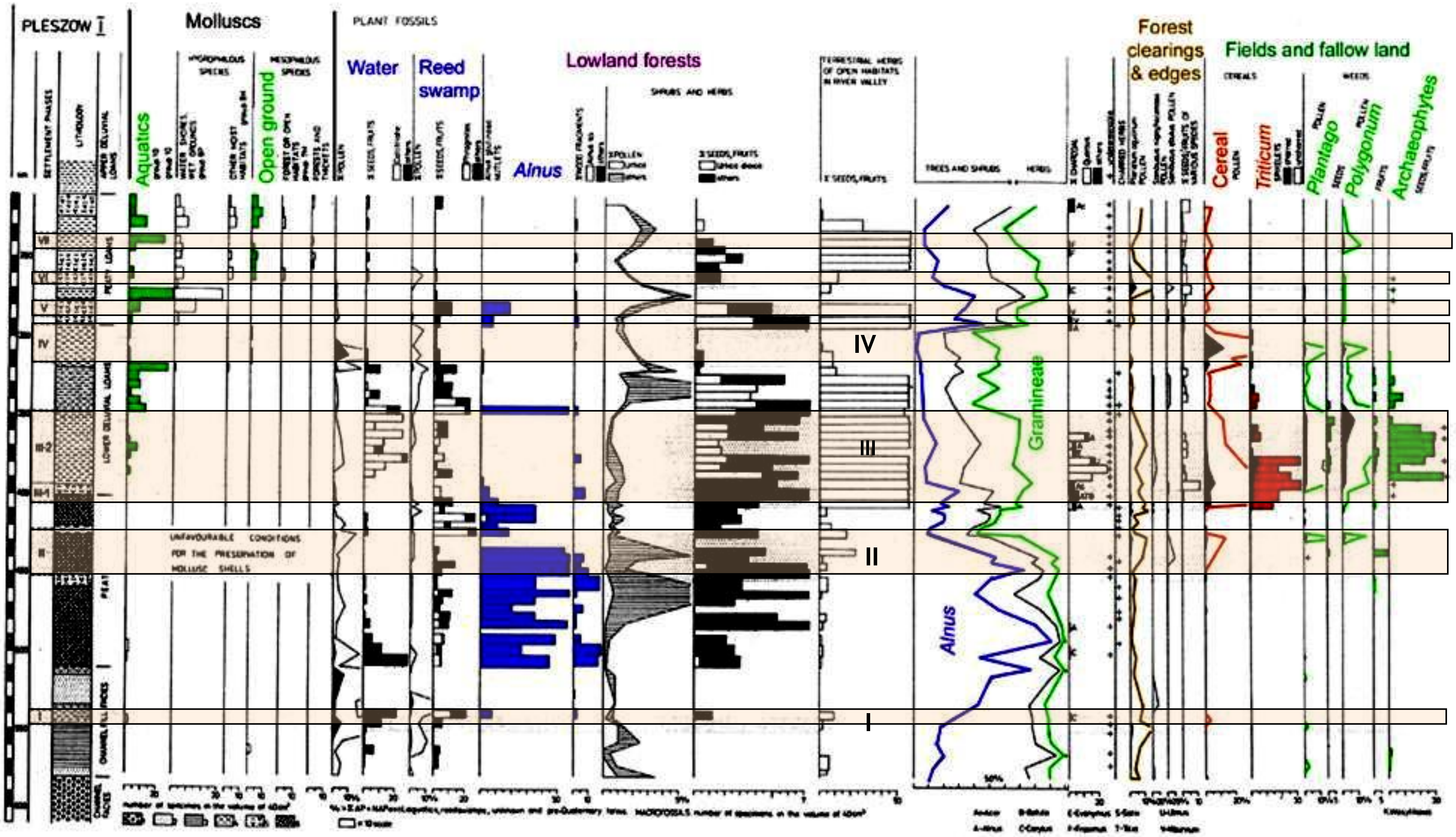
Palaeoenvironmental reconstruction of the fluvial landscape of the middle Lahntal during the second phase of Mesolithic occupation. *Weimar-Niederweimar, Bos and Urz, 2003*


MESOLITHIC SITES AROUND THE NORTH SEA
North Sea
NORWAY
SWEDEN
DENMARK
Howick
Extent of land roughly 10,000 years ago
DOGGERLAND
Outer Silver Pit
Study area
Vedbæk Bøgebakken
UNITED KINGDOM
De Stekels
Flevoland polders
NETHERLANDS
Bouldnor Cliff
BELGIUM
GERMANY
FRANCE
CZECH REPUBLIC
Téviec and Hoëdic

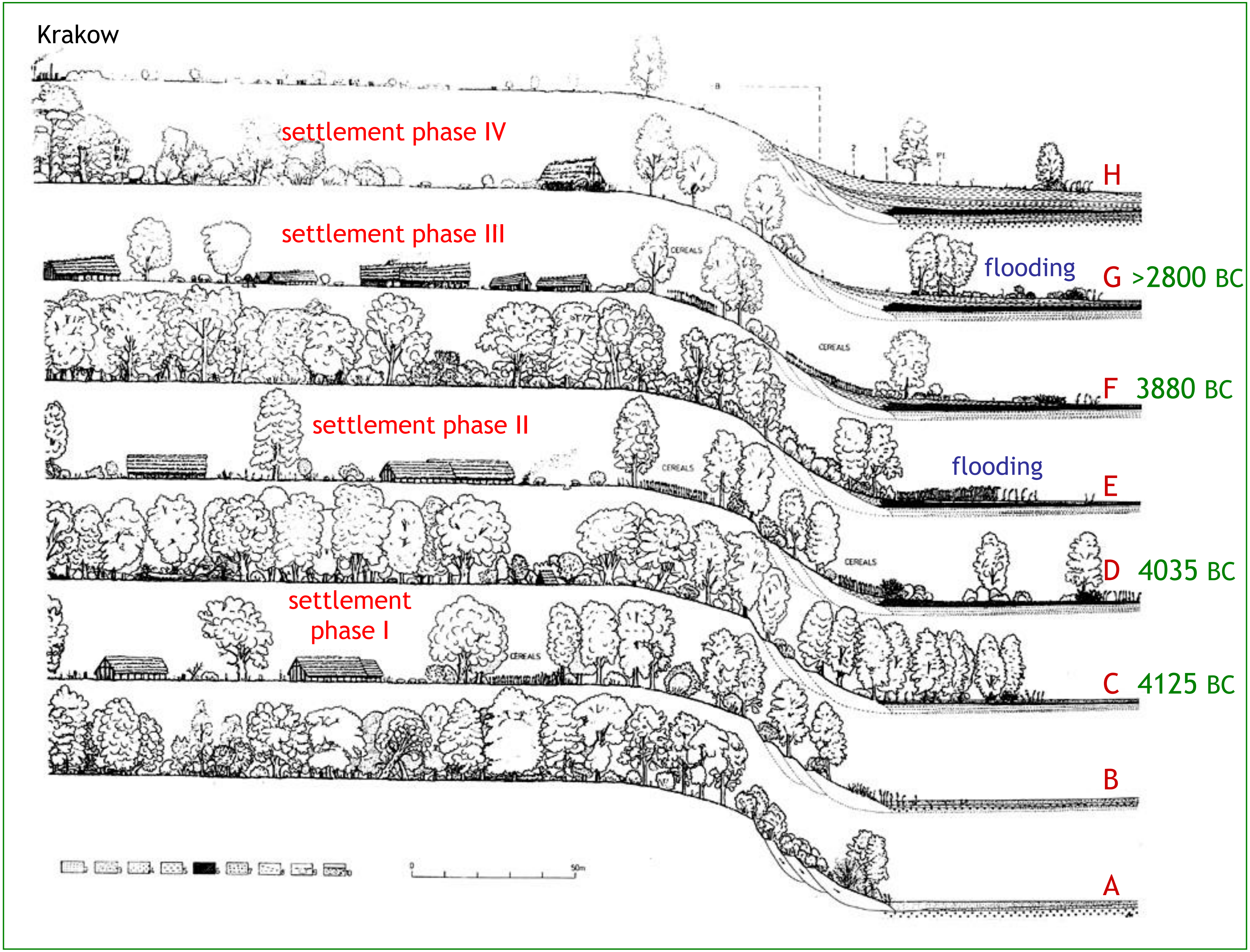

THE LOST WORLD

Neolithic settlement phases (Poland)

Oxbow lake at foot of river terrace of Vistula River



Wasylikowa (1989)



Krakow
settlement phase IV
H
settlement phase III
flooding
G >2800 BC
CEREALS
F 3880 BC
settlement phase II
flooding
E
CEREALS
D 4035 BC
settlement phase I
CEREALS
C 4125 BC
B
A
50m

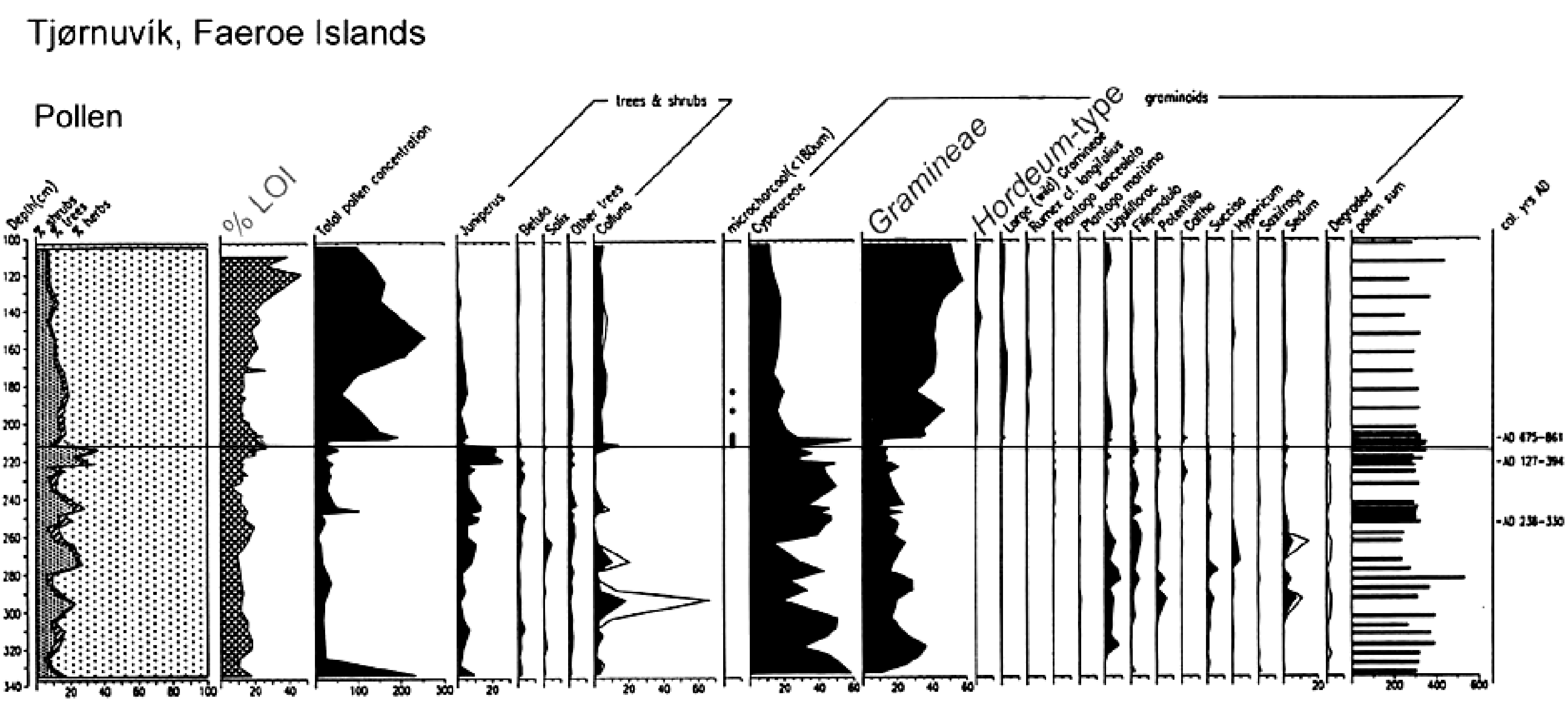
Vidøy, Faroe Islands

No trees, peaty slopes (peat piles), basalt bedrock

When did people impact the landscape on Faroe?

Turf-roofed house

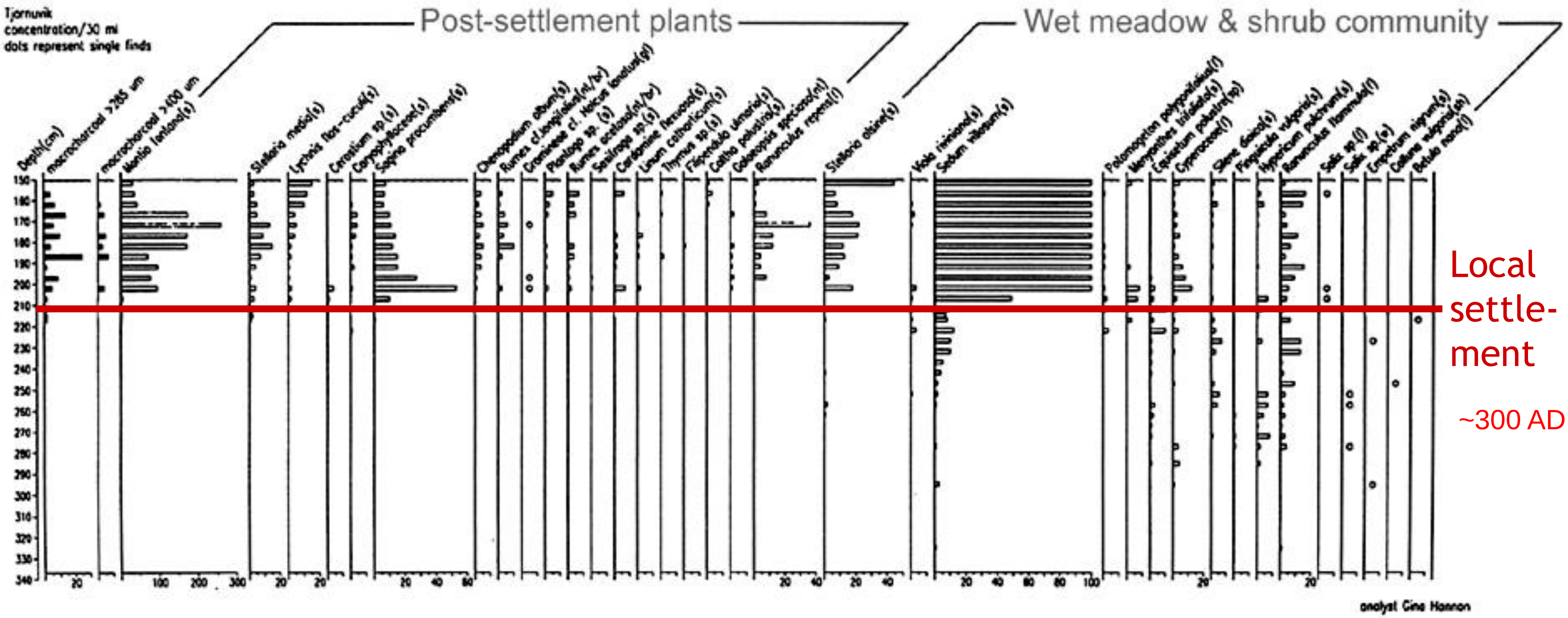
Impact of Human Settlement in the late Iron Age



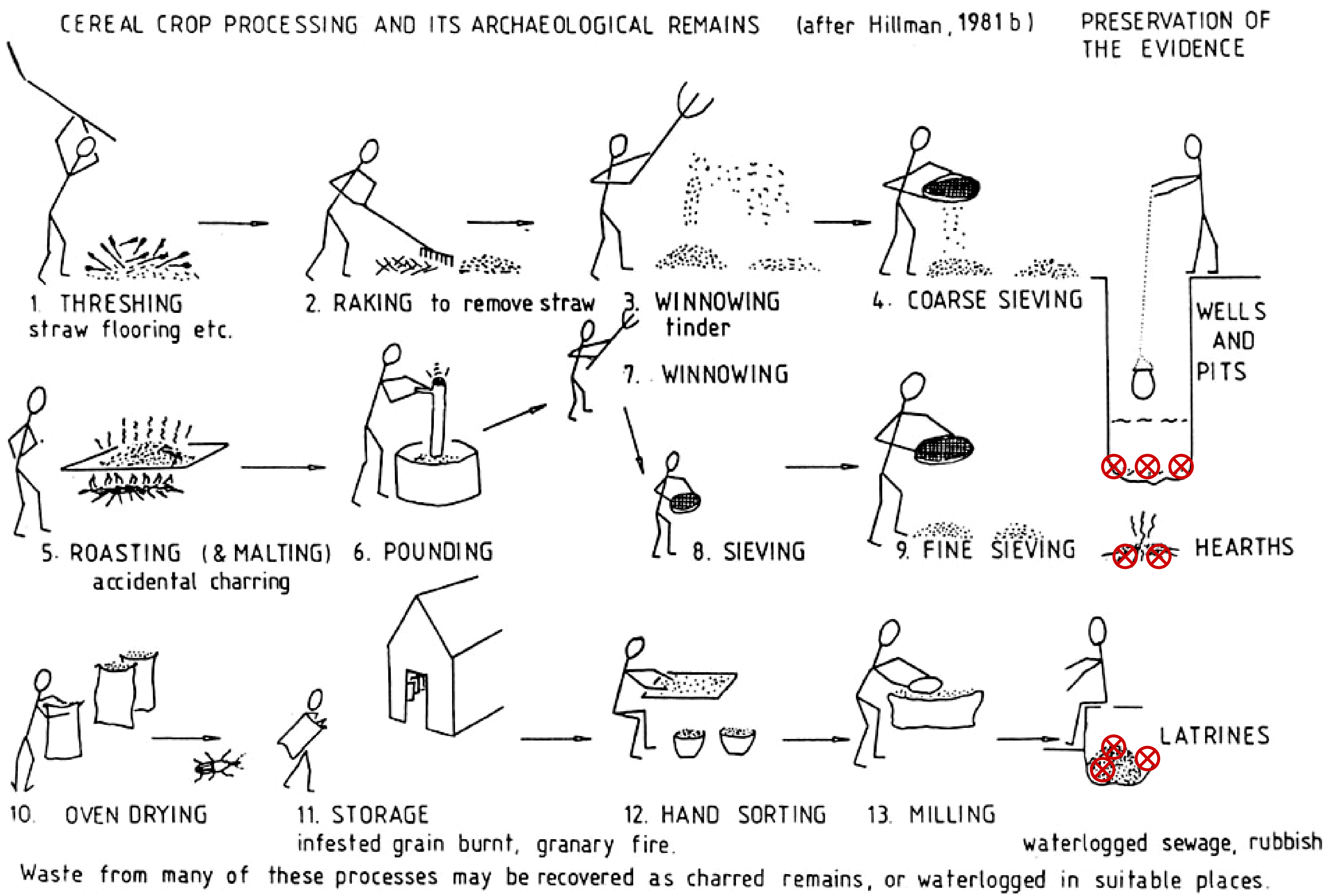
Hannon & Bradshaw (1999)

Tjørnuvík, Faroe Islands

Macrofossils

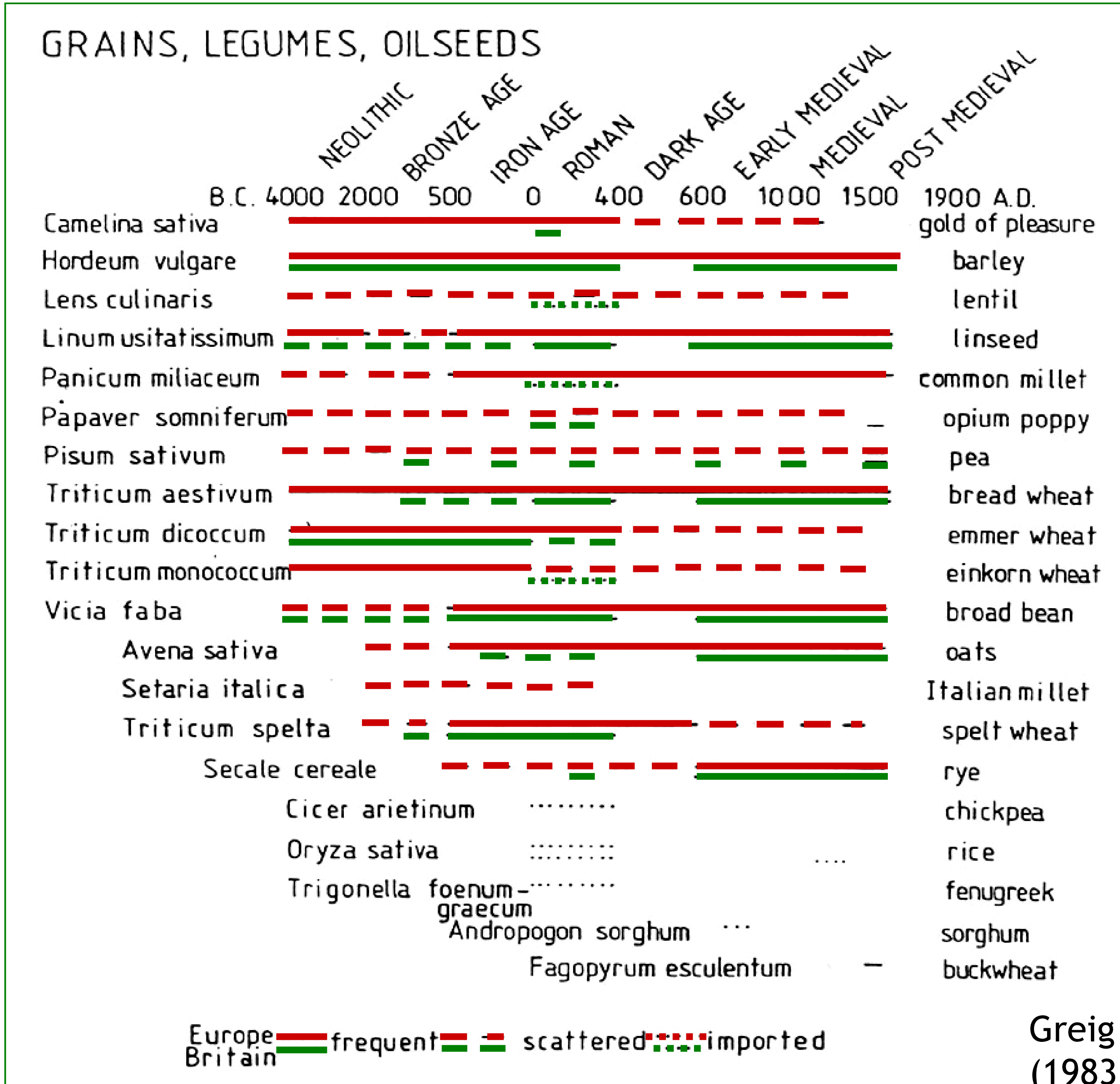


Living environments and diets



Food plants in Europe and Britain

A display of seeds of crop plants grown in N. Dakota in the 1880s



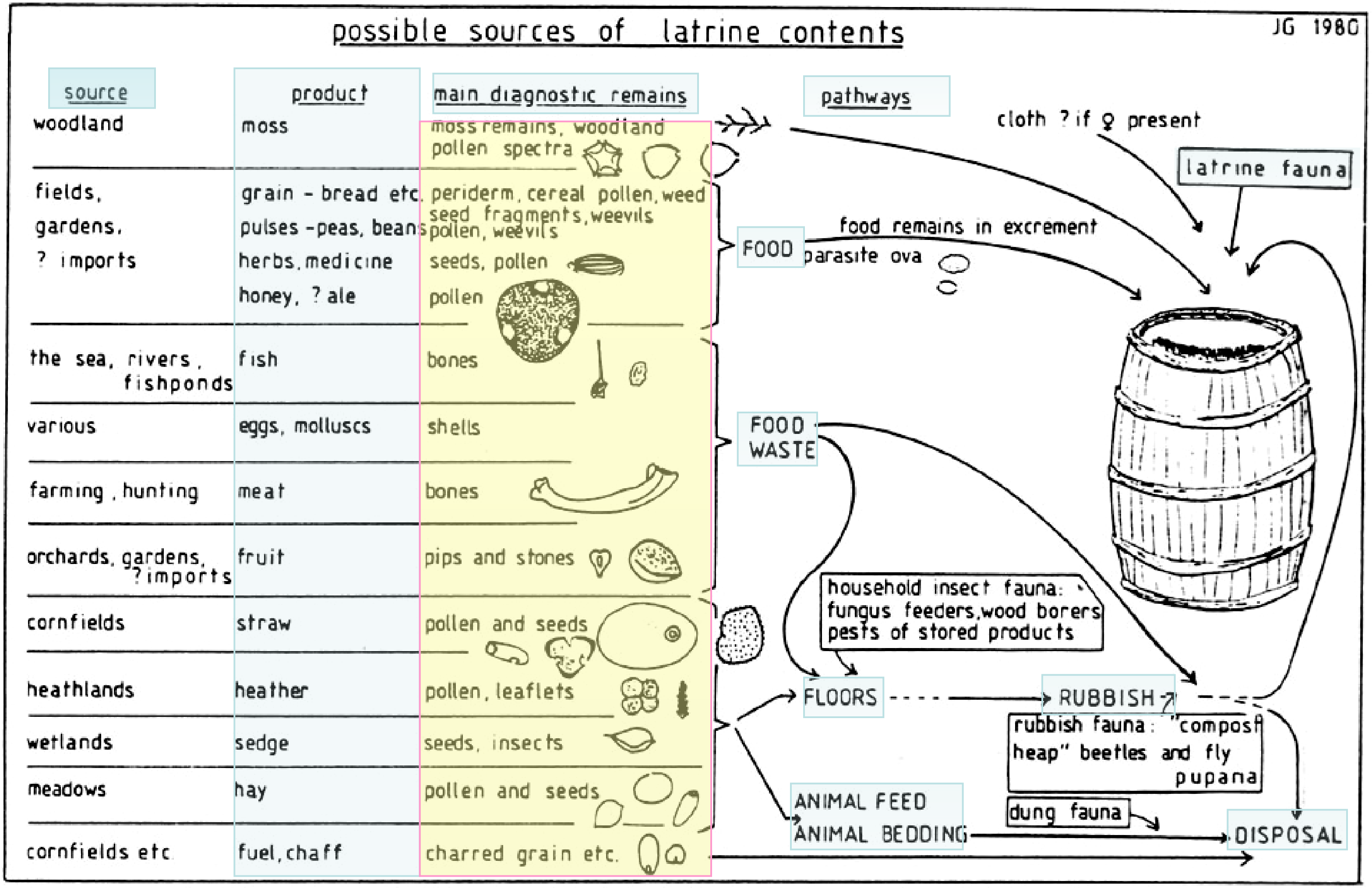
Greig (1983)

Calories and sources then and now

	Uppsala king's farm 1557	Rydboholm farm 1736	Swedish average 1920/29	Swedish average 1951
Cereals	61	81	37	25
Potatoes	-	-	11	8
Other vegetables	-	3	3	5
Sugar	-	-	11	13
Meat	20	4	10	15
Fish	18	2	2	2
Milk	-	9	13	13
Butter	1	1	6	13
Margarine	-	-	4	8
Cheese	0,1	-	1	2
Eggs	-	-	2	2

After Blix 1954:62.

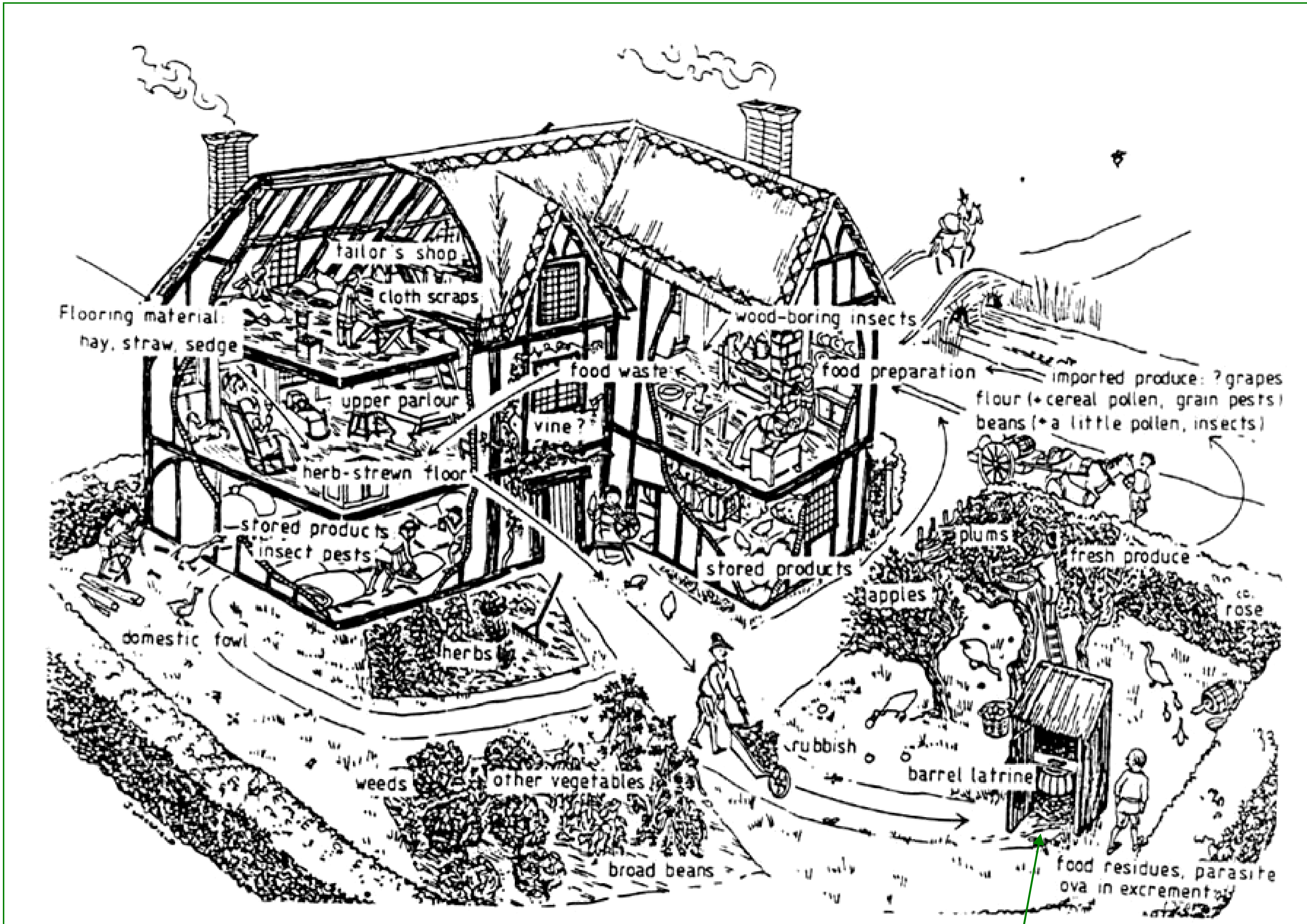
MEDIEVAL BARREL-LATRINE



Greig (1981)

Diagram showing some of the pathways of plant and animal products from the sea and countryside, through use(s) to eventual disposal as various types of rubbish, accumulating various kinds of insect fauna in the process.

Greig (1981)



Reconstruction of the living environment from the finds from a barrel latrine

Direct evidence of human food

- Coprolites – fossil faeces. Orkney; Bell & Dickson (1989)
- Stomach contents of preserved bodies

  Bog bodies

  The Iceman

Tollund Man and other Bog Bodies, Denmark and England.

Iron Age. Hung or strangled? Sacrificed? Criminals?

P.V. Glob (1971) The Bog People. Paladin

Last meal:

Vegetable gruel, or bread

Hordeum (Barley)

Polygonum lapathifolium (pale persicaria)

Linum usitatissimum (flax)

Camelina sativa (gold-of-pleasure)

Spergularia arvensis (corn spurry)

Rumex acetosa (dock/sorrel)

Chenopodium album (fat hen)

Many other weed seeds in smaller quantities.

General diet also contained meat and fish, and much bread, milk, and cheese.

Lindow Moss Bog Bodies (England)

Very similar diet; wheat (*Triticum dicoccum, T. spelta)* dominated; many weed species