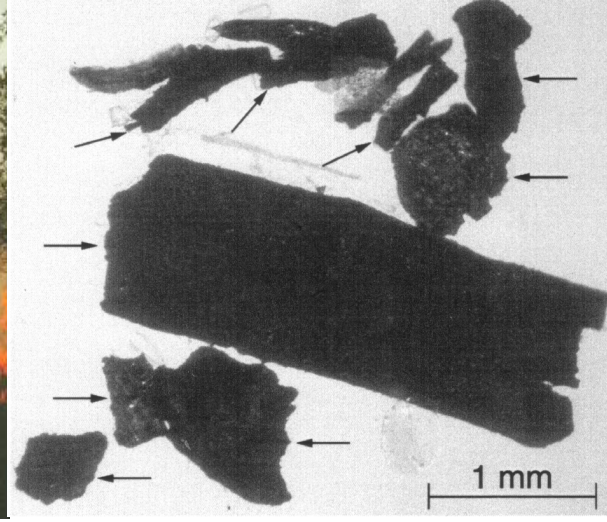




Charcoal data as paleoenvironmental proxies

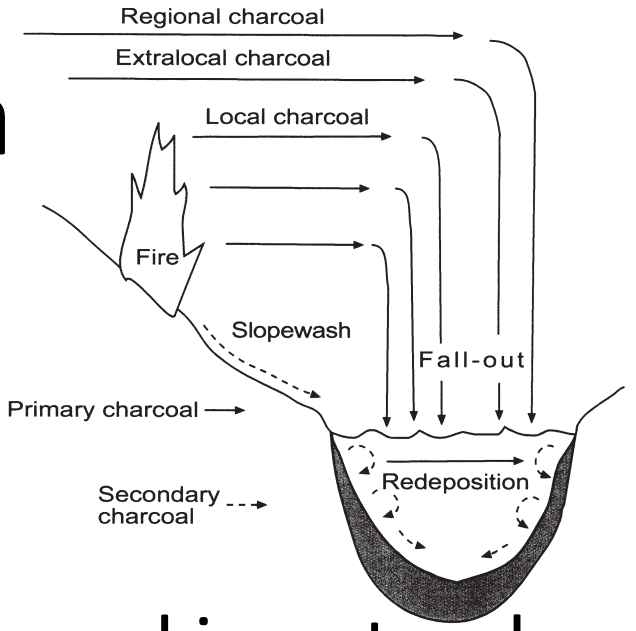
Julie Aleman

Yale University

Charcoal data

- Particulate charcoal is produced by the **incomplete combustion** of **organic matter** → *provide direct evidence of burning*

Charcoal data



- Charcoal transported and preserved in natural archives
  - Sediments: lacustrine, marine, fluvial, in bog
  - Soils, paleosoils

- Long-term reconstructions of fire history
  - Complement and extend reconstructions from dendrochronological and historical records

Taking sediment cores

Take cores at the center of the lake.

Lac Moulouomo, Congo

1. A coring platform (or ice)

Lac Miroir, France

Taking sediment cores

2. Sampling the water-sediment interface

Kajak – Brinkhurst corer

Lac Doukoulou, Central African Republic

Taking sediment cores

2. Sampling the water-sediment interface

Kajak – Brinkhurst corer

Taking sediment cores

2. Taking deep sediments

Russian corer

Mara River, Tanzania

Taking sediment cores

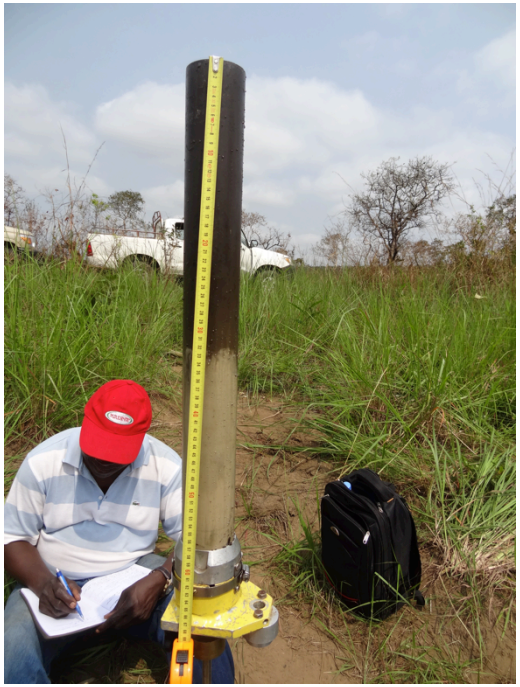
2. Taking deep sediments

Livingstone corer

Lac Moulouomo, Congo

Sediment dating

- For recent sediments < 200 years → ^{210}Pb dating
  - bulk



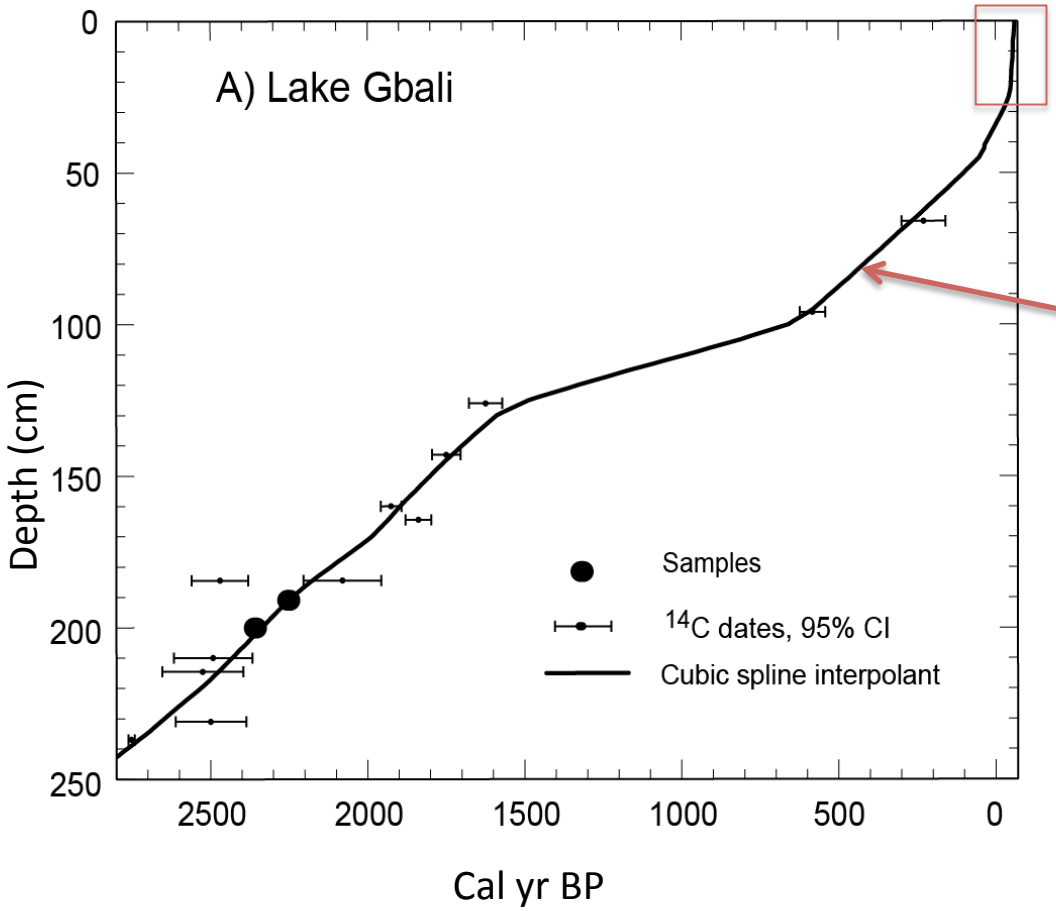
Sediment dating

- For recent sediments < 200 years → ^{210}Pb dating
  - bulk

- For > 200 years → ^{14}C dating
  - Charcoal, macroremains, bulk
  - Radiocarbon years are then converted to calendar years

- Sufficient chronological controls (= number of dates per paleosequence)

Age-depth models

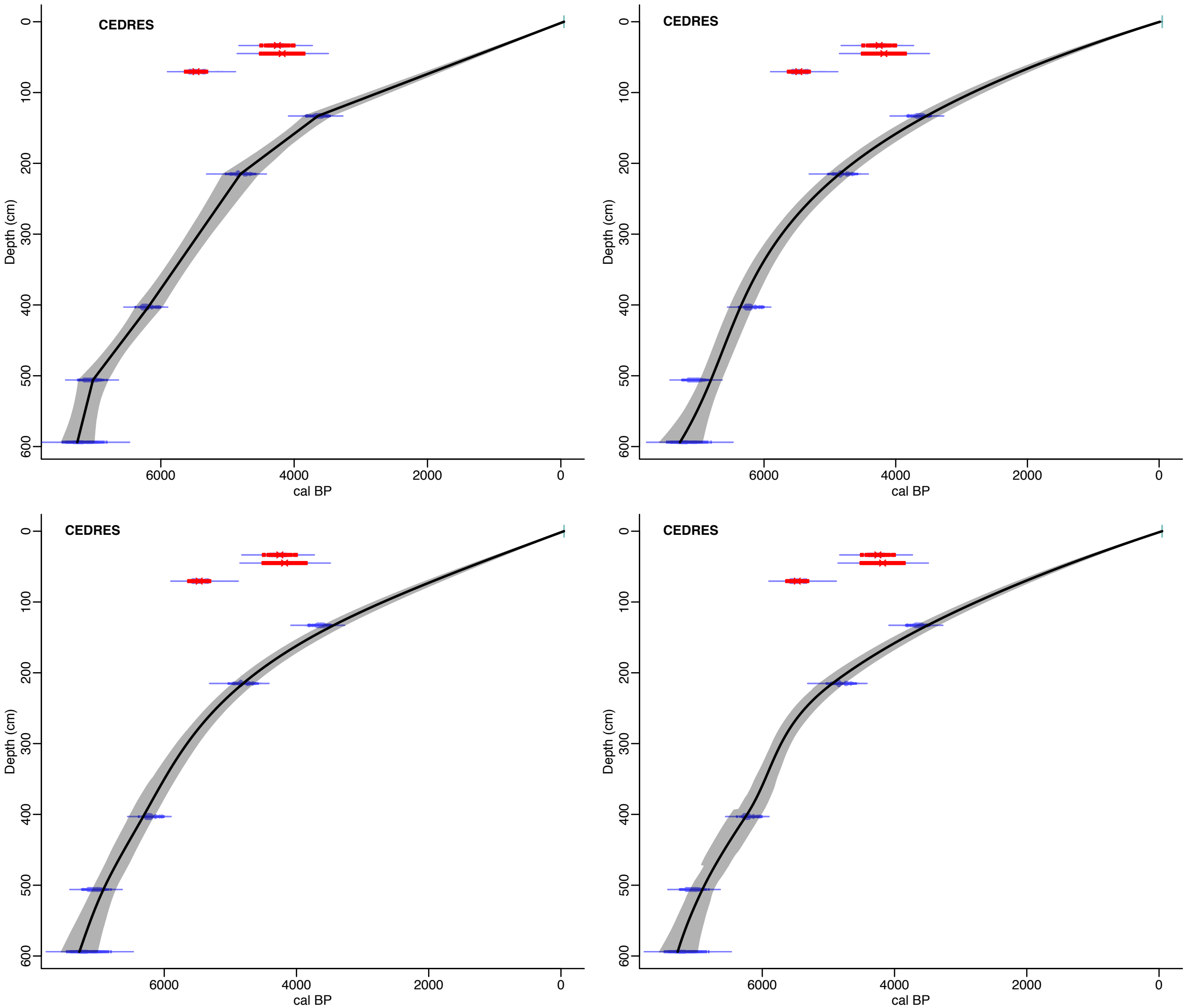


^{210}Pb age-depth model

Sediment accumulation rate

Computation of charcoal accumulation rate (**CHAR**)

Age-depth models



Different smoothing functions, optimization procedures and analytical choices

Clam R package, M. Blaauw

Charcoal typology

- Charcoal production

	combustion continuum			
uncharred biomass	slightly charred biomass	charcoal	soot and graphitic black carbon	graphite
	combustion residues		condensates	
properties, characteristics or parameters	typical value, range of values, and/or trend (shaded area)			
size	mm and larger	cm to micron	micron to submicron	
formation temperature	<300 °C	200-600 °C	>500 °C	

Conedera et al., 2009.

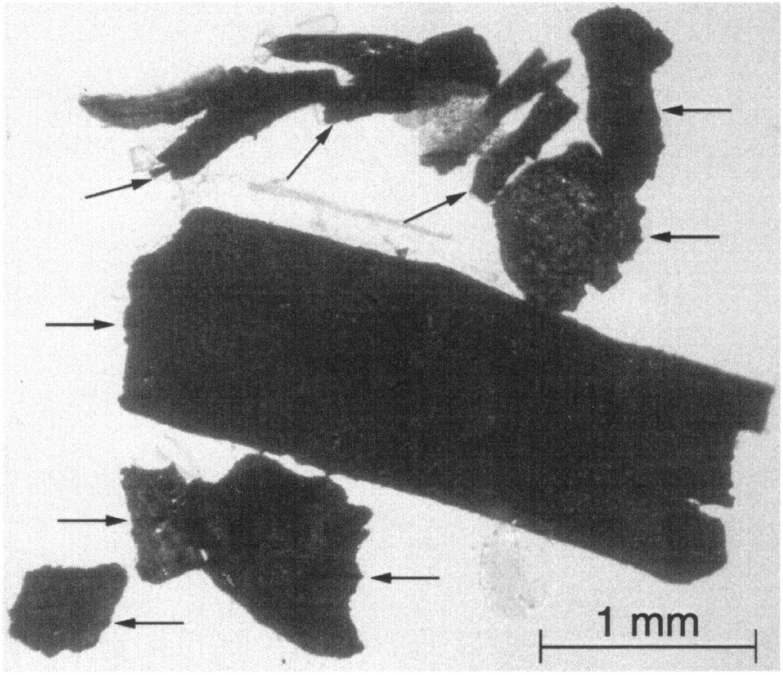
Charcoal typology

- Microcharcoal (< 100 µm)
  - Pollen-slide
  - Regional origin (windborne, > 20km)

Landcare Research

Charcoal typology

- Macrocharcoal (> 100 µm)
  - Sieved (contiguously)
  - Local to extra-local origin



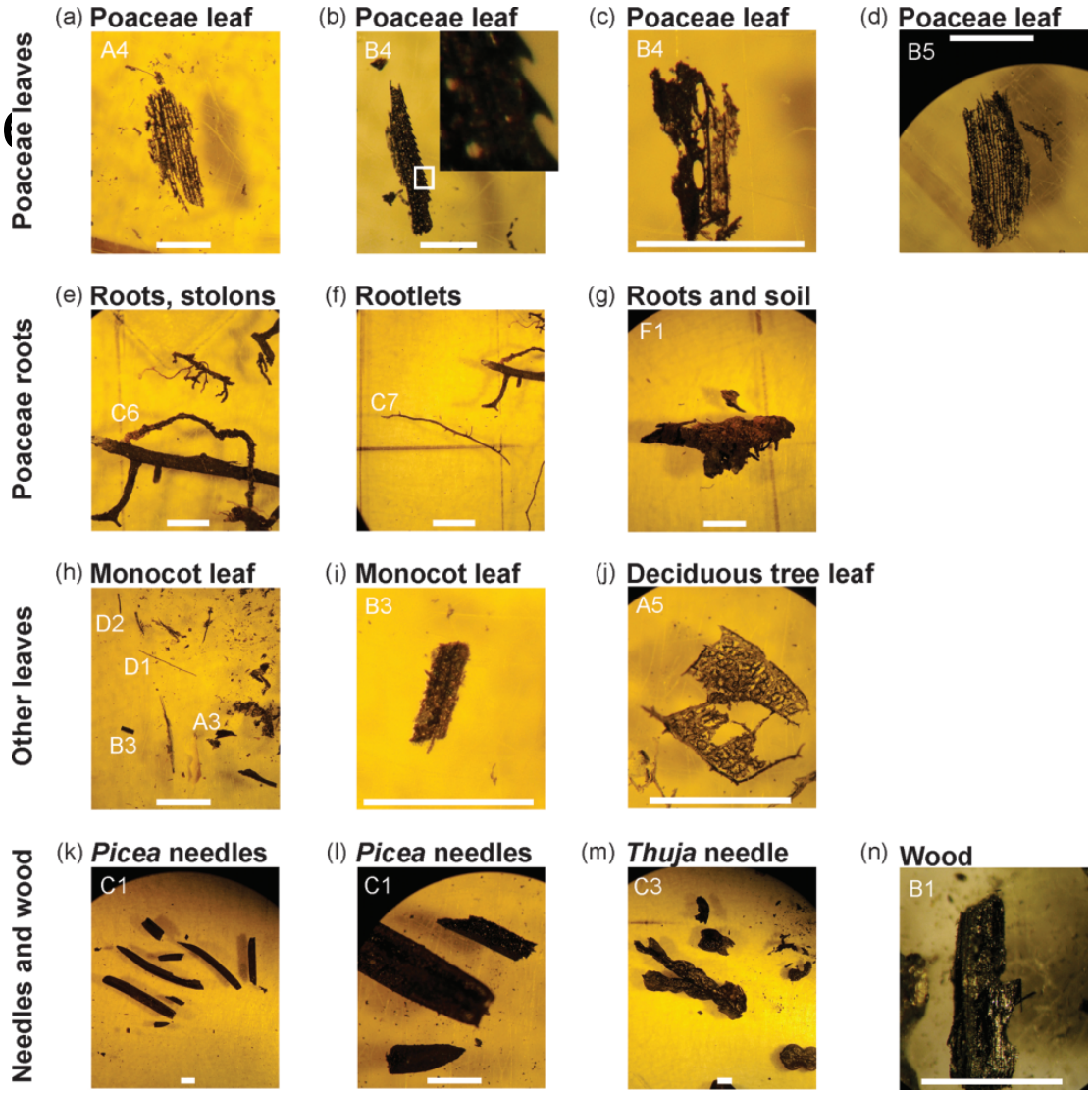
Whitlock and Larsen, 2001.

Charcoal morphology

- Reflects fuel type

Charcoal morphology

- Refl

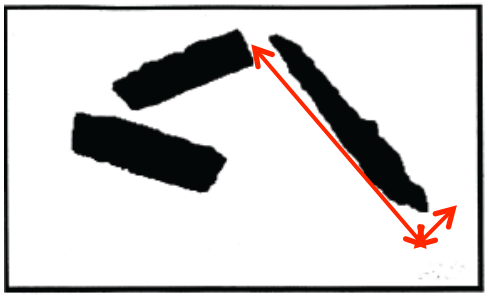


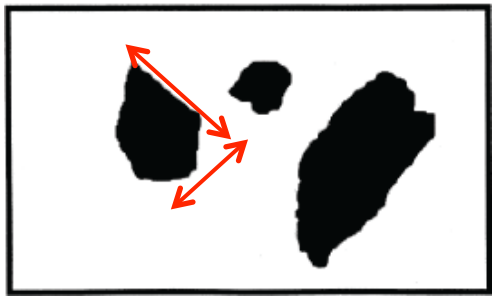
Courtney Mustaphi and Pisaric, 2014

Charcoal morphology

- Reflects fuel type: example in the tropics

Morphology
Width-to-length ratio (W/L)



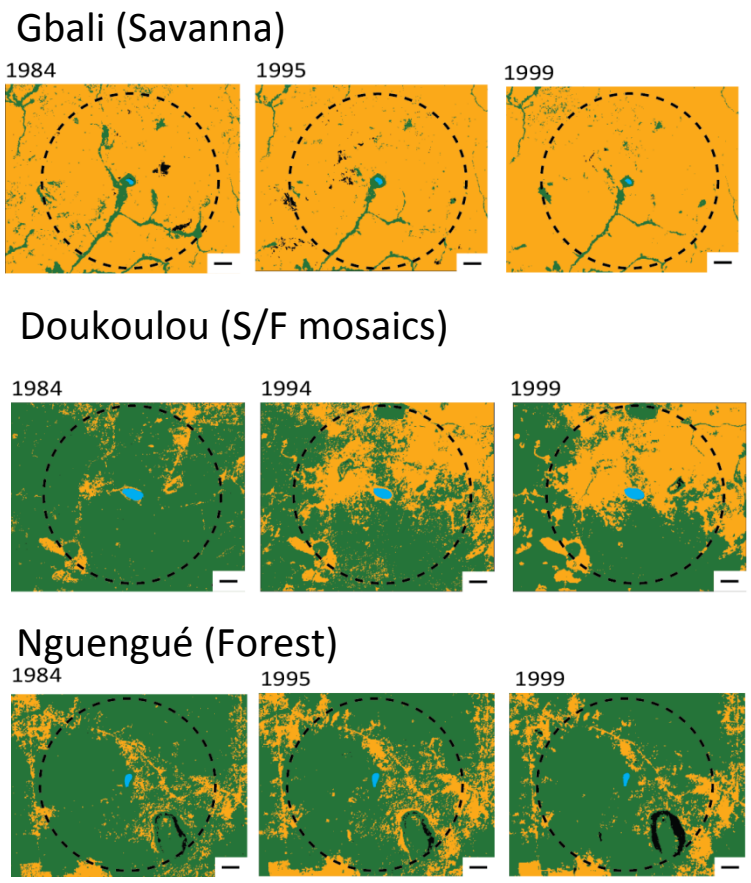


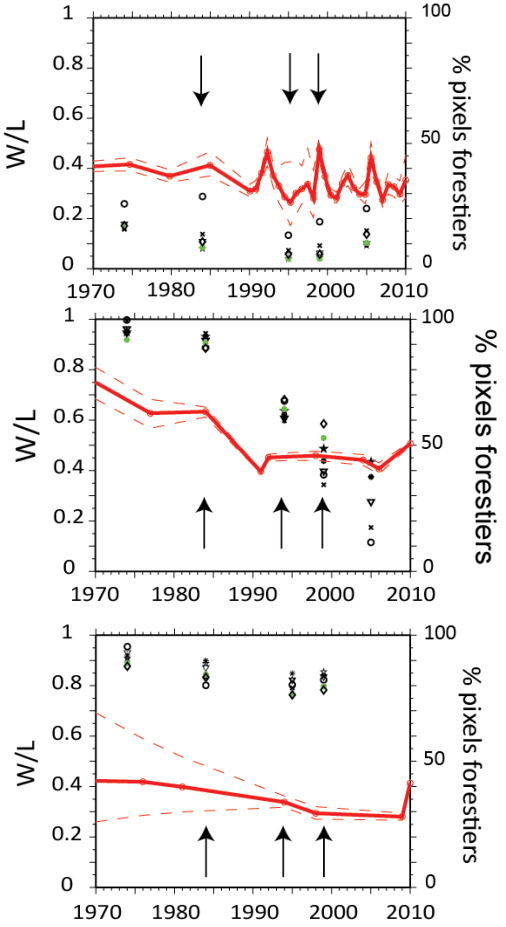
W/L < 0.5 → grassy fuel type

W/L > 0.5 → woody fuel type

Umbanhowar et Mcgrath, 1998; *The Holocene*
Jensen et al., 2007; *The Holocene*

Charcoal morphology





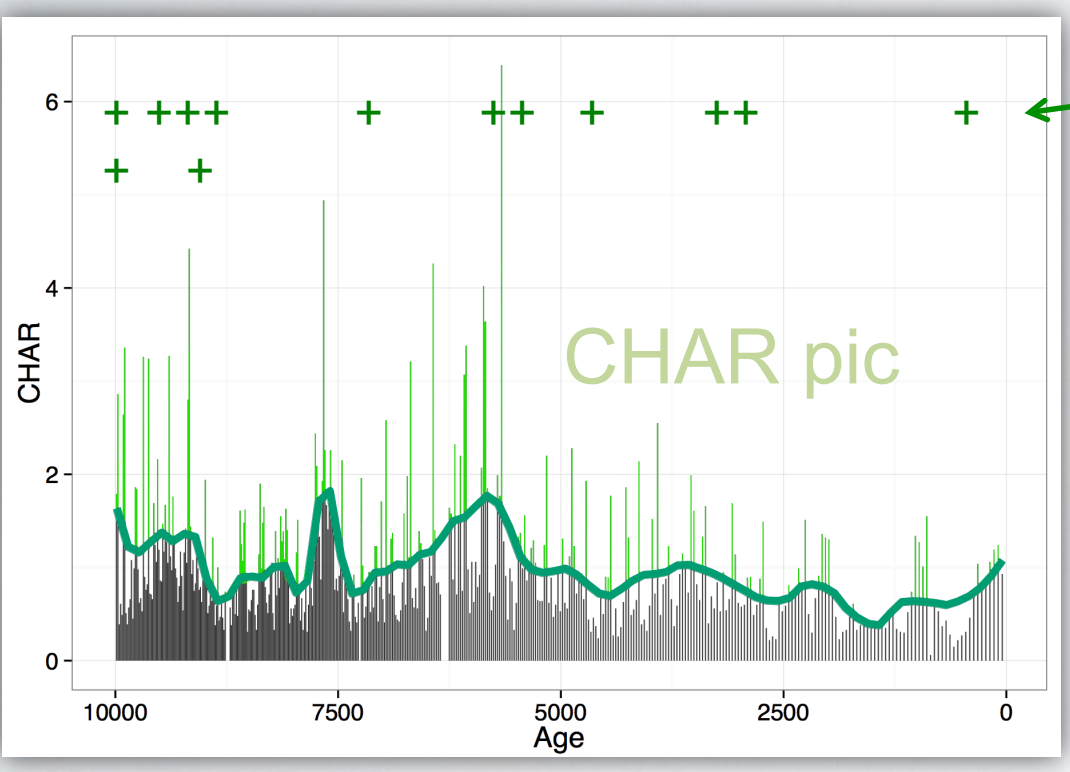
W/L < 0.5
Savanna burning
→ **Grass fuel type**

Before 1980:
W/L > 0.5
After 1980:
W/L < 0.5
→ **Deforestation**

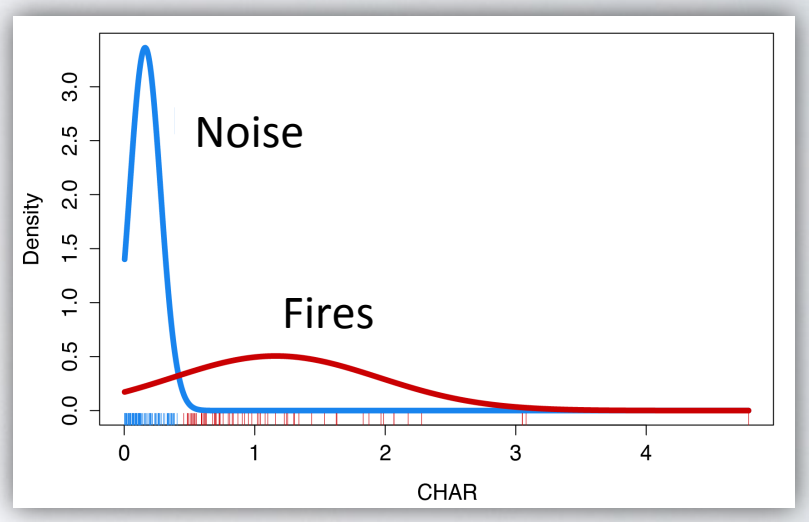
Before 1980:
W/L > 0.5
After 1980:
W/L < 0.5
→ **Deforestation**

CHAR time series

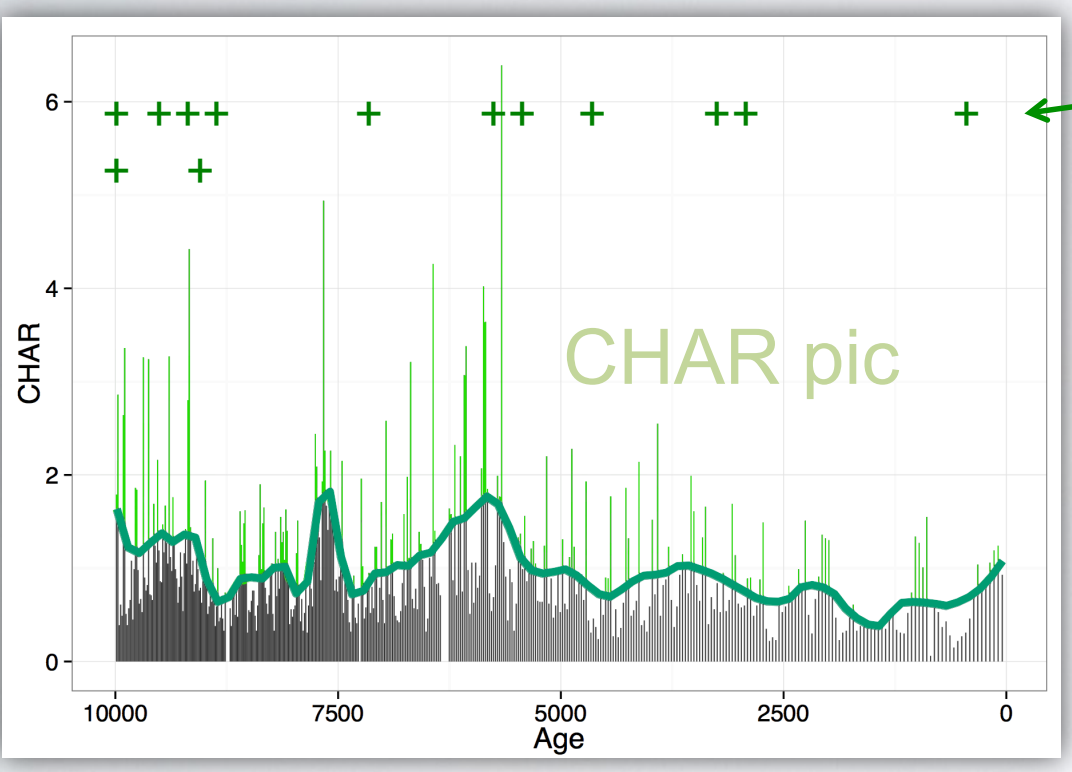
- 2 components:
  - Background (slowly varying trend)
  - Peaks -> Noise and Fire



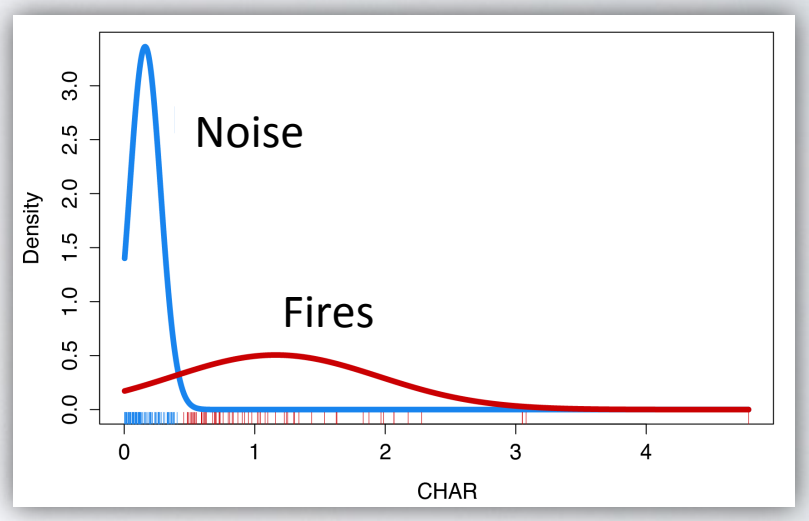
Fires



CHAR time series



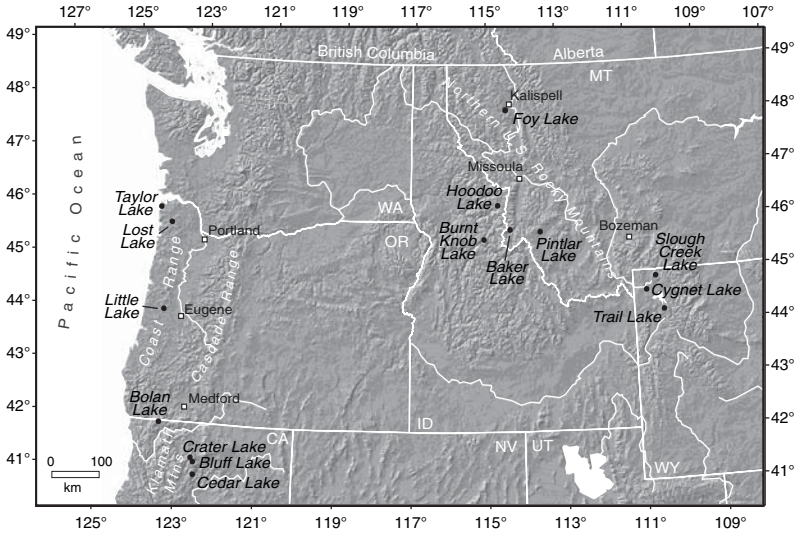
Fires



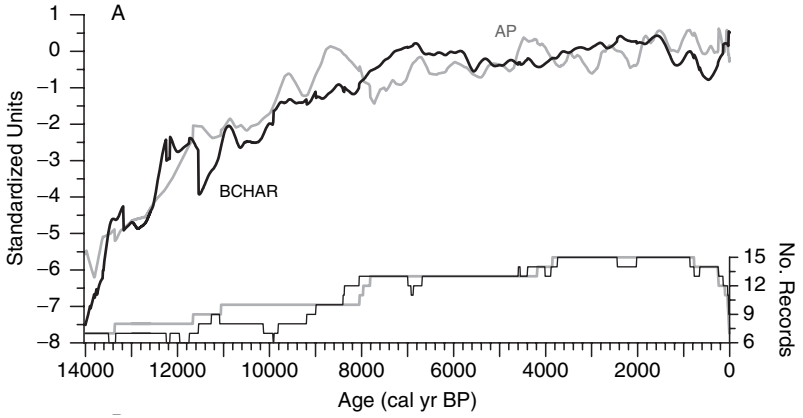
- Reconstructing fire events → fire frequency
- Parameterization of the procedures → Need for calibration

Calibration work

- **Background component** -> multiple sources (fire-related processes, redeposition…)?
  - Disentangling them to improve fire history reconstruction (identification of peaks)



Northwestern USA

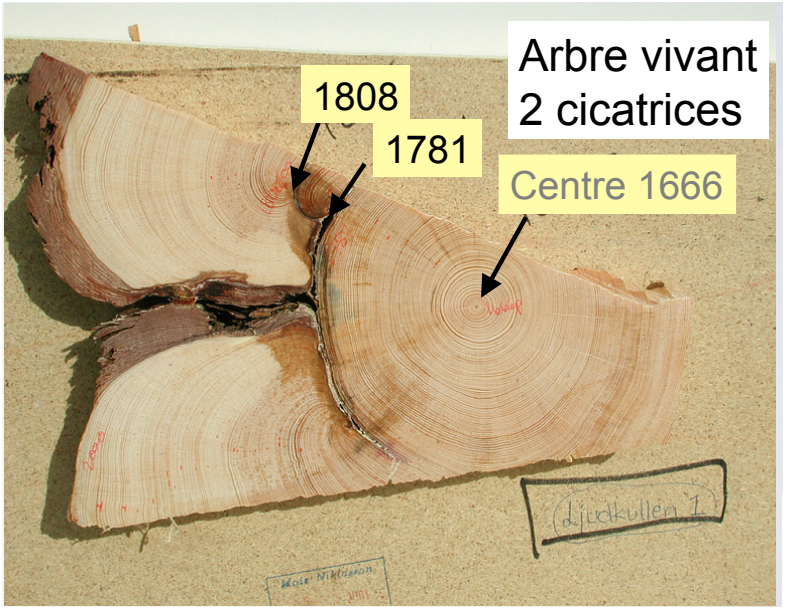


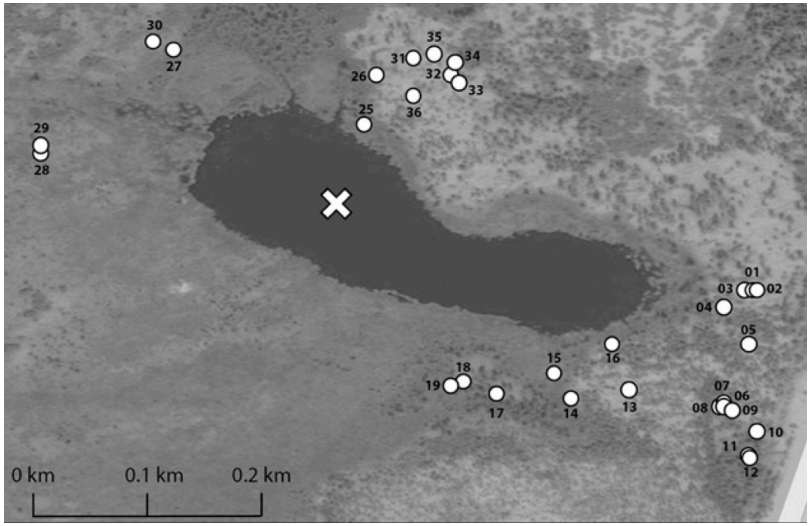
Similarity in trends of **BCHAR** and **woody pollen taxa** -> background charcoal influx is a function of fuel characteristics, which in turned is governed by climate and vegetation

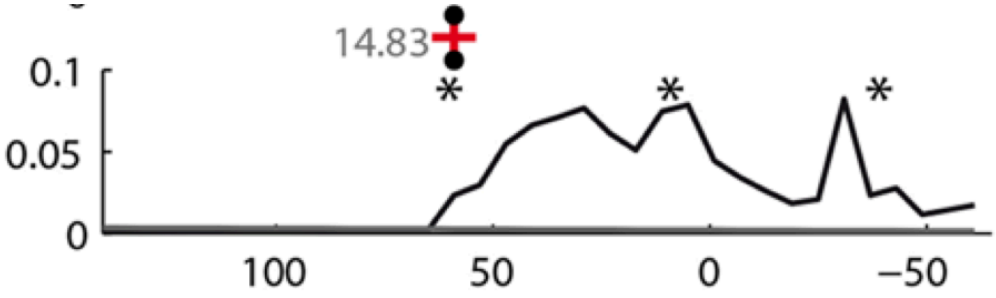
Marlon et al., 2006

Calibration work

- **Fire events**: comparing dendrochronological fire history reconstruction to CHAR in lake sediments







Brossier et al., 2014

Charcoal data

- Reconstructing long-term fire history
  - One site
  - Potential at large spatial scale

Thank you for your attention!