Máster Universitario en Cambio Global
Doctorado
Programa Oficial de Posgrado adaptado al EEES

2.09 The isotopic footprint of the global change

T10: Isotopic series of organic records

S1: The isotopic footprint of environmental change in a Mediterranean seagrass

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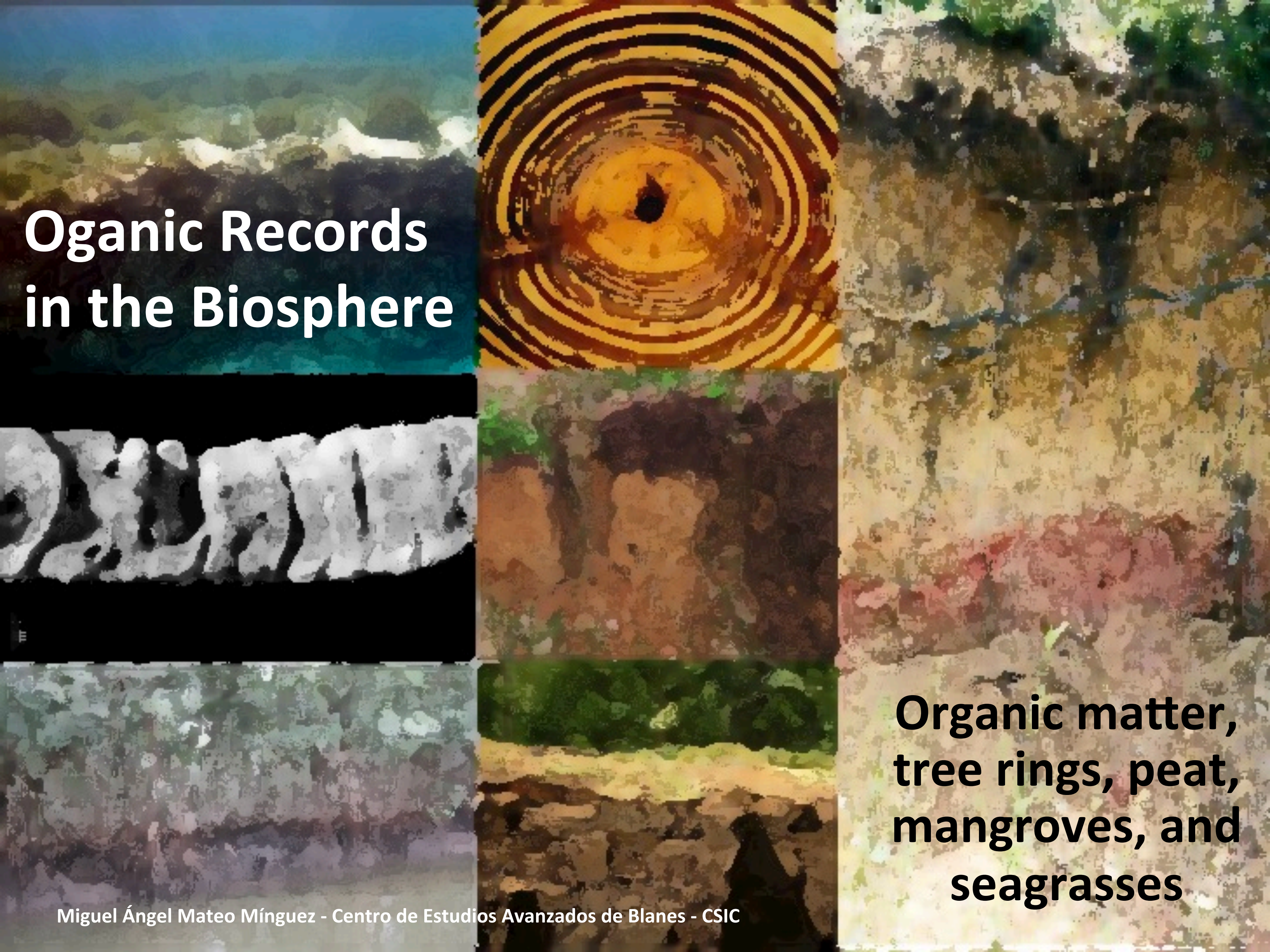

Oganic Records in the Biosphere

Organic matter, tree rings, peat, mangroves, and seagrasses

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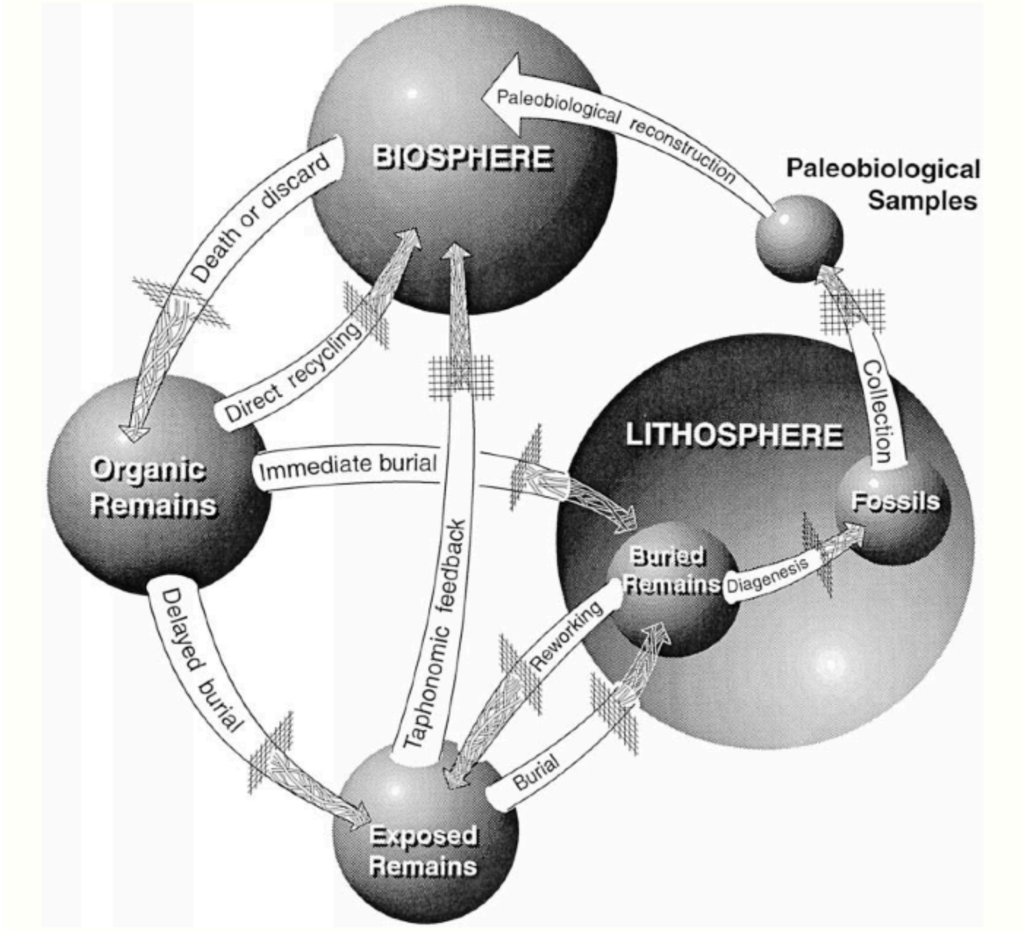
Organic records
Purpose and fundamentals

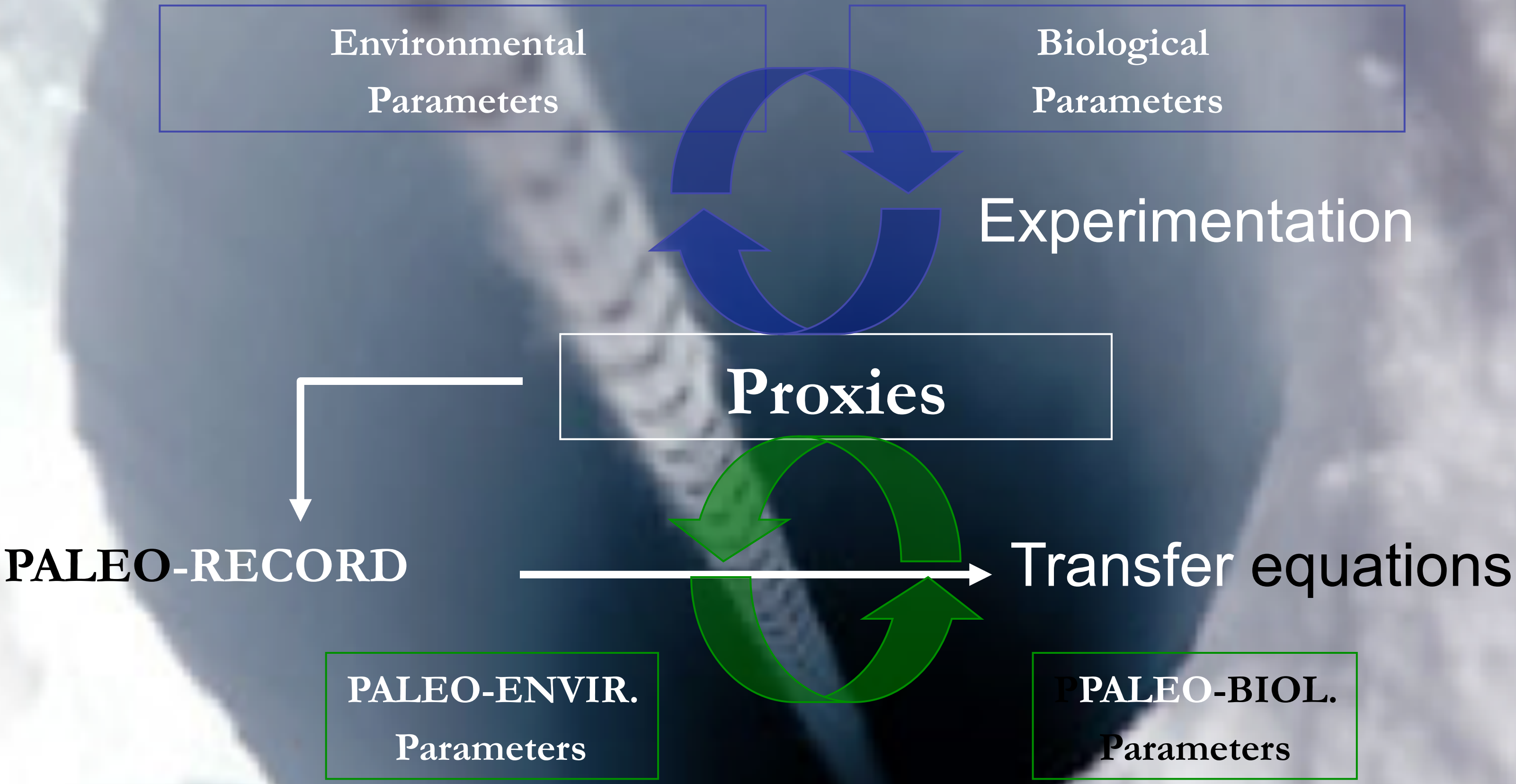
- We want/need to know about the past because we are interested/afraid of the future. **Forecasting**.
- Reconstructing past events, cycles and trends, provides invaluable information to forecast **change in our ecosystems. Long-term dataseries**.
- The Earth keeps organic and inorganic records of the past: **ice, shells, sediments, stems** (rings, rhizomes), **rocks** (varves, espelothems), etc.
- **The uniformitarian principle.**
- Biological, chemical, and physical processes preserve or destroy the remains in the records and affect information in the fossil record.
- The language in the elements and proxies preserved need to be learnt and the age determined.

"The present is the key to the past"



The main pathways for organic remains from death to paleobiological inference.

Basis for paleoreconstruction



Environmental
Parameters

Biological
Parameters

Experimentation

Proxies

PALEO-RECORD

Transfer equations

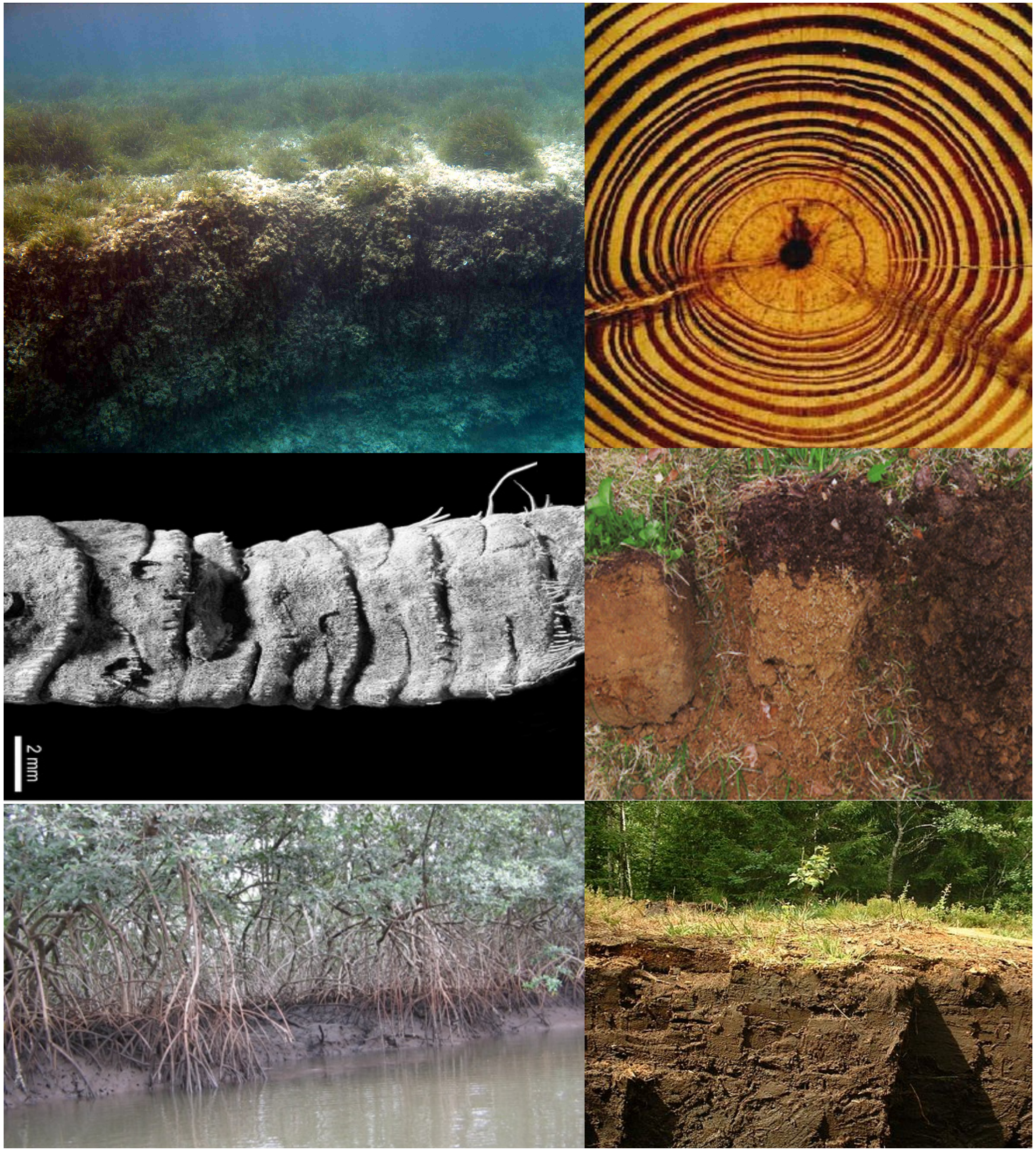
PALEO-ENVIR.
Parameters

PPALEO-BIOL.
Parameters

Organic records
Main records

- Organic matter
- Tree rings
- Peat
- Seagrasses (Rhizomes & Mat)
- Mangroves

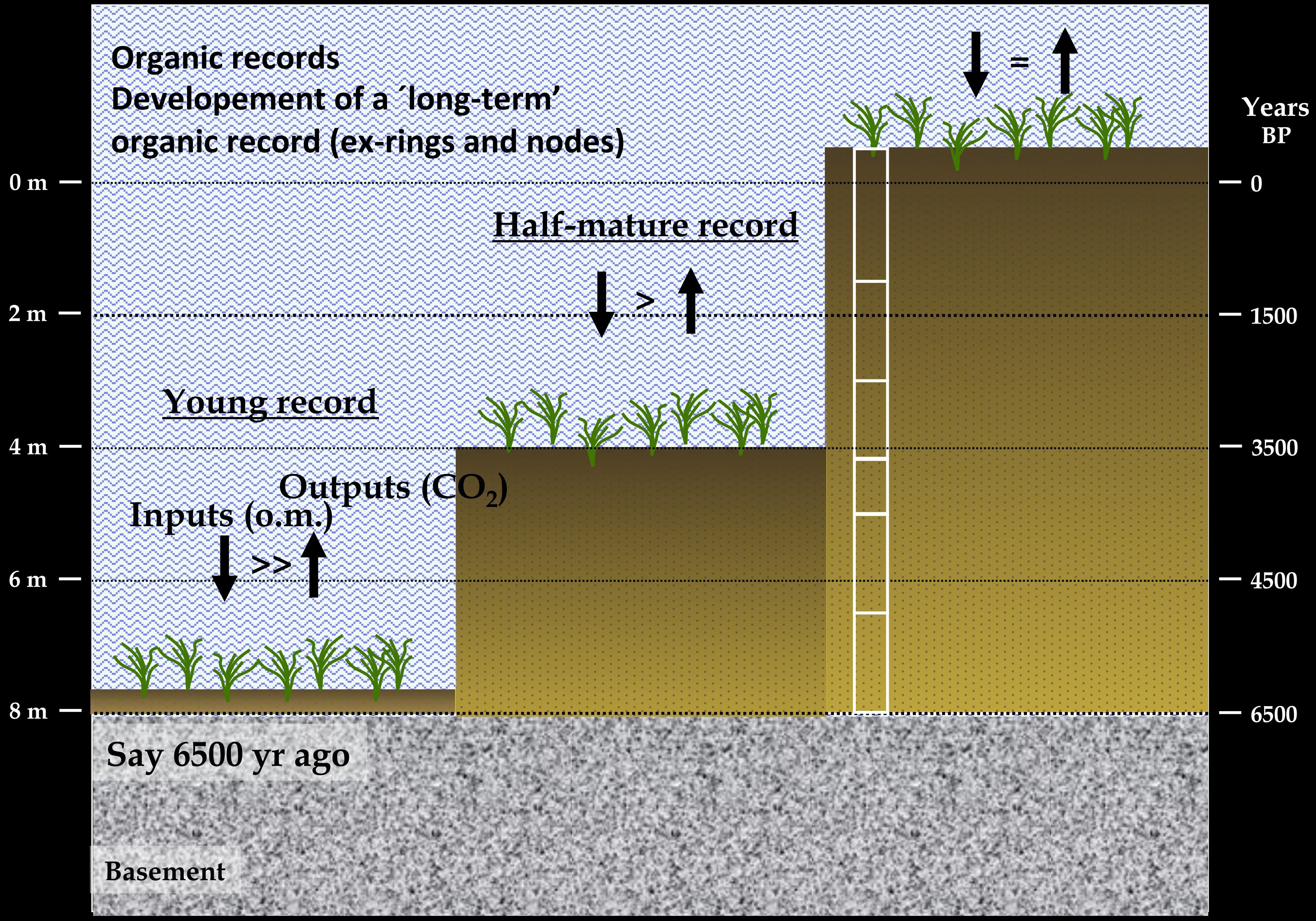
- Four last ones are a special case of the first one.
- All animal and plant detritus ends up in the soils or sediments.
- Visual and analytical techinques are used to retrieve the information contained in the records, e.g.,:
- Naked eye, binoculars, microscopy (**organic petrography**)
- Organic matter fracitonation (**pyrolysis**)
- Molecular or atomic analysis (**extractions, spectrometry**)



Organic records: a summary

Record	Spp.	Distrib.	Dating	Time range / resolution	Proxies	Info
Organic matter	Plant and animal debris	Almost omnipresent: Soils, lakes, oceans	Radiocarbon, Sediment radiometrics, Event markers	Recent-Holocenic-Millions of years (oil)/ annual to Kyr	Organic petrog. Inorganic petrog. Bulk matter Chemical comp. Stable isotopes Pollen grains	Climate, hydrology, ecology, human impacts, geological events and marine and atmospheric processes
Peat	Mosses, lichens, wet land vegetation	North Europa and North America, New Zealand, Patagonia, Indonesia	Radiocarbon, Sediment radiometrics, Event markers	0 – 15 000 yr Centennial / Decadal	Organic petrog. Inorganic petrog. Bulk matter Chemical comp. Stable isotopes Pollen grains	Climate, ecology, human impacts, geological events
Seagrasses	*P. oceanica* *P. australis* *E. Acoroides* Others	Coastal ocean except polar an circa-polar areas	Radiocarbon, sediment radiometrics, event markers, plastochrone, lepidochronology	Rhizomes: 0 – 40 yr /annual Mat: 8000 yr /decadal	Organic petrog. Inorganic petrog. Bulk matter Chemical comp. Stable isotopes Pollen grains	Climate, ecology, human impacts, geological events, oceanography, productivity, irradiance, nutrient status
Mangroves	Rhizophoraceae	Tropical areas of all 5 continents	Radiocarbon, Sediment radiometrics, Event markers	Some Ky (unknown)/ decadal	Organic petrog. Inorganic petrog. Bulk matter Chemical comp. Stable isotopes Pollen grains	Climate, ecology, human impacts, geological events, oceanography
Tree rings	Baldcypress, hemlock (tsugas). Oaks, poplars, cedars, conifers, larches, oaks	Everywhere ex-polar and dessertic areas	Dendrochronology Radiochronology Event markers	0 – 11 000 yr / Annual to seasonal	Width, missing/ multiple rings, stable isotopes, elemental composition, radiactivity, galleries, 'fire' rings, etc.	Climate change, seasonality, water sources, nutrient status, temperature, cloudiness, humidity, wind patterns, irradiance

Mangroves, peat, seagrasses, (salt marshes)



Organic records

Developement of a ´long-term' organic record (ex-rings and nodes)

Young record

Inputs (o.m.)

Outputs (CO_2)

↓ >> ↑

Half-mature record

↓ > ↑

'Mature' record

↓ = ↑

Say 6500 yr ago

Basement

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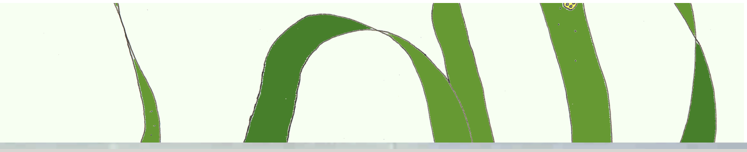
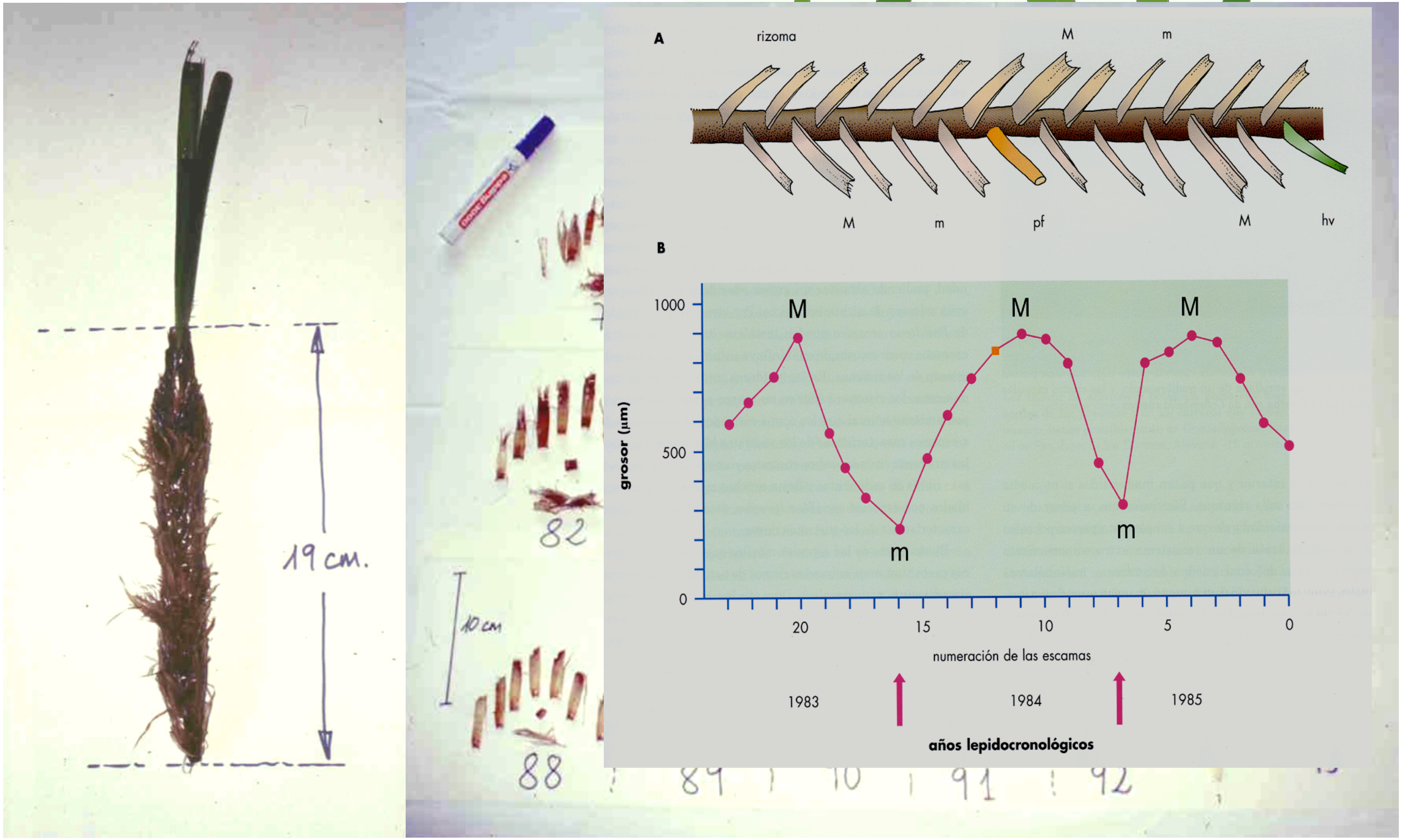
The 'short-term' organic record of seagrasses:
Lepidochronology and plastochron





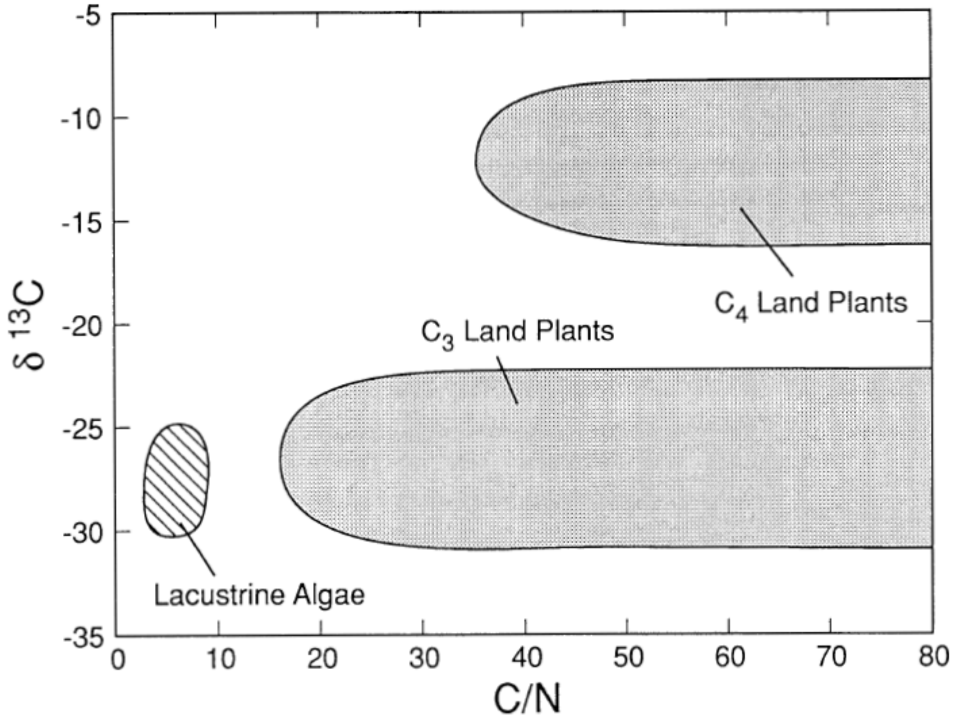
Oganic records
Proxies*

Proxies are ‘imprints’ left in the past by organism activity and climate change in many different forms:

- ‘**Diferent amounts**’, presence/ absence (entire organisms, parts, specific molecules – biomarkers).
- **Colours, forms, shapes and sizes** (degradation/ preservations, system energy).
- **Chemical composition, ratios** (elements, isotopes, state of preservation).

Multiproxy approach
Disambiguation

It is a very vast field open to creativity!



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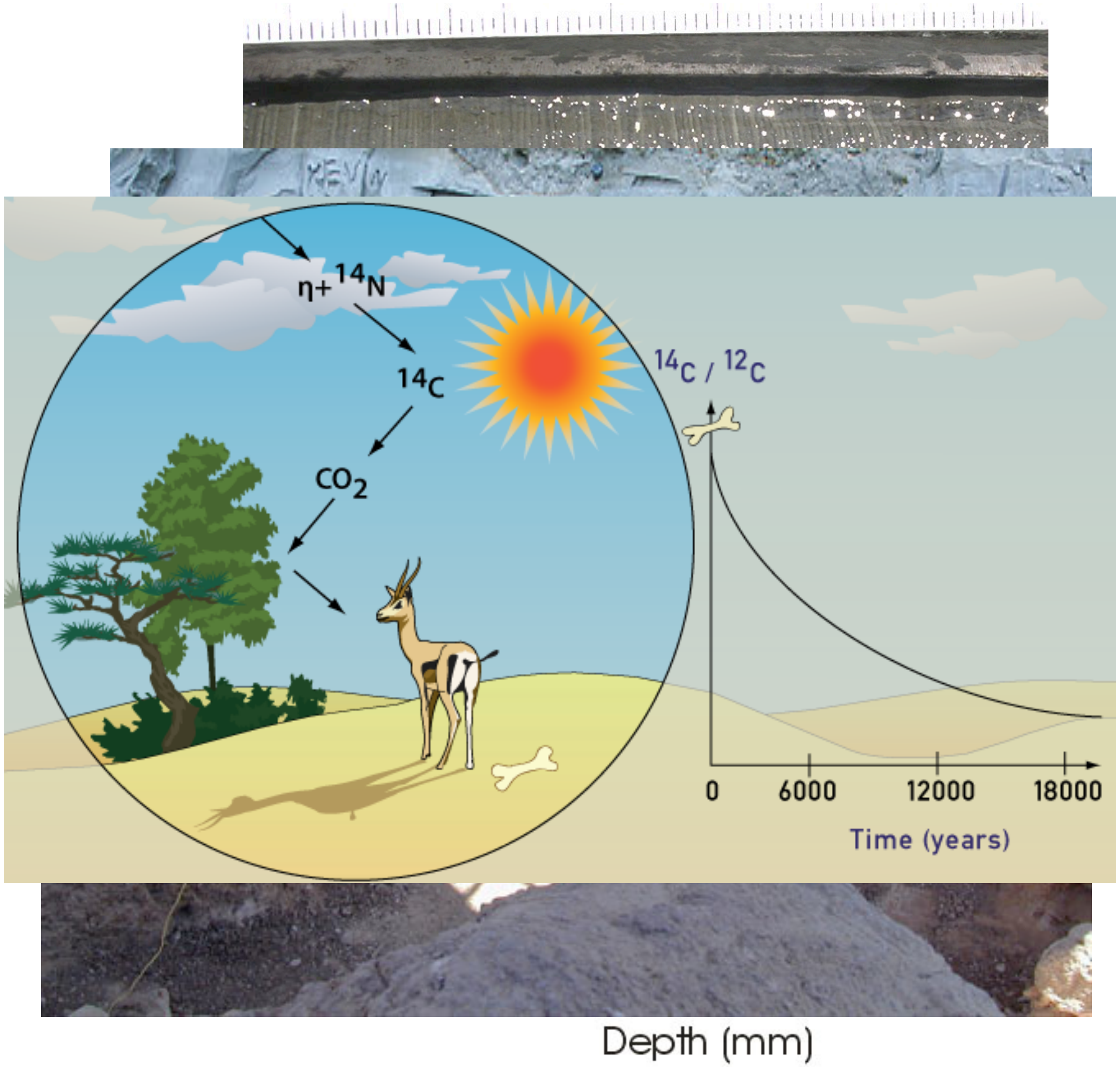
Type	Technique	Time range (max.)
Stratigraphic	Superposition principle	yr to Myr
	Varves	yr to Kyr
Biological	Fossils	yr to Byr
	Human documents/art	0 to 25 000 yr (palaeolithic)
	Biological ‘rithms’ (incremental dating):	
	- Varves (biol/lithol)	Yr to Kyr (12 000 yr)
	- Dendrochronology	yr to Kyr (11 000 yr)
	- Lepidochronology	yr to decades (40 yr)
	- Plastochrone	yr to decades (20 yr)
	- Lichenometry	Decades to 10 000 yr
	- Shell bands, Coral bands, ‘speleothelms’, etc.	Yr to Myr (? Kyr)
	Molecular clocks (genetic, evolutionary)	Evolutionary scale (Myr)
Structural	(Tectonic or magmatic relationships)	Geological scales
	(Craterization density)	Planetary scales
Physical and geophysical	(Exposure to cosmic rays)	Planetary scales
	(Fision imprints)	Typically 250 000 yr
	Paleomagnetism (correl.,relative dating)	-
	Stable isotopes (correl., relative dating)	-
	Radiometric (**^{14}C**, Rb/Sr, **Pb/Cs**, K/Ar, etc.)	**^{14}C,** 100-10 000 yr / **Pb/Cs,** 0 – 100 yr
Event markers	Tephras, pollen, radiactivity, pottery…	0 to Byr (?)

Organic records
Dating overview

- Dating can be done on the same organic matter or in any 'datable' material around (carbonate, minerals, bulk).
- Counting rings, nodes, bands, or varves (incremental).
- Use radioisotopes (radiometric and spectrometric methods)
- Usage geological/ geophysical properties (strat., magnetism…)
- Use of event markers (volcanism, atomic events, layers, mining, cultivation – pollen, pottery, art, documents)



Organic records
Sampling overview
Soils and Sediments

- Soils are typically sampled using **corers**.
- Both for soil testing and for preserving some proxies, cores should be as **undisturbed** as possible.
- Corers can be **manual** (typically up to 1 m depth) or **mechanical** (several meters, tens and hundreds of meters).
- **Disturbance/ contamination,** core '**shortening**', and **oblicuity**, are common problems and challenges.

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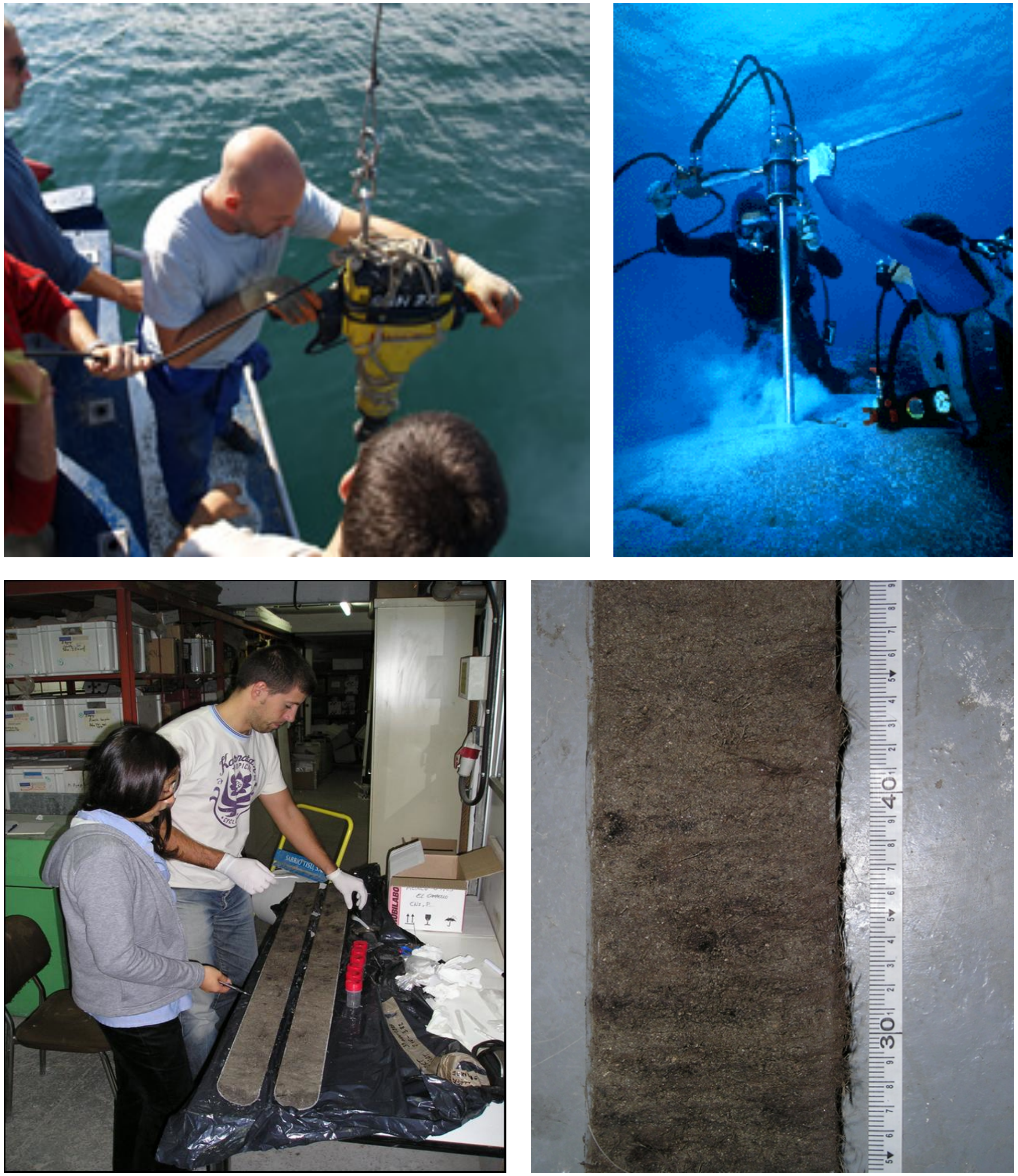
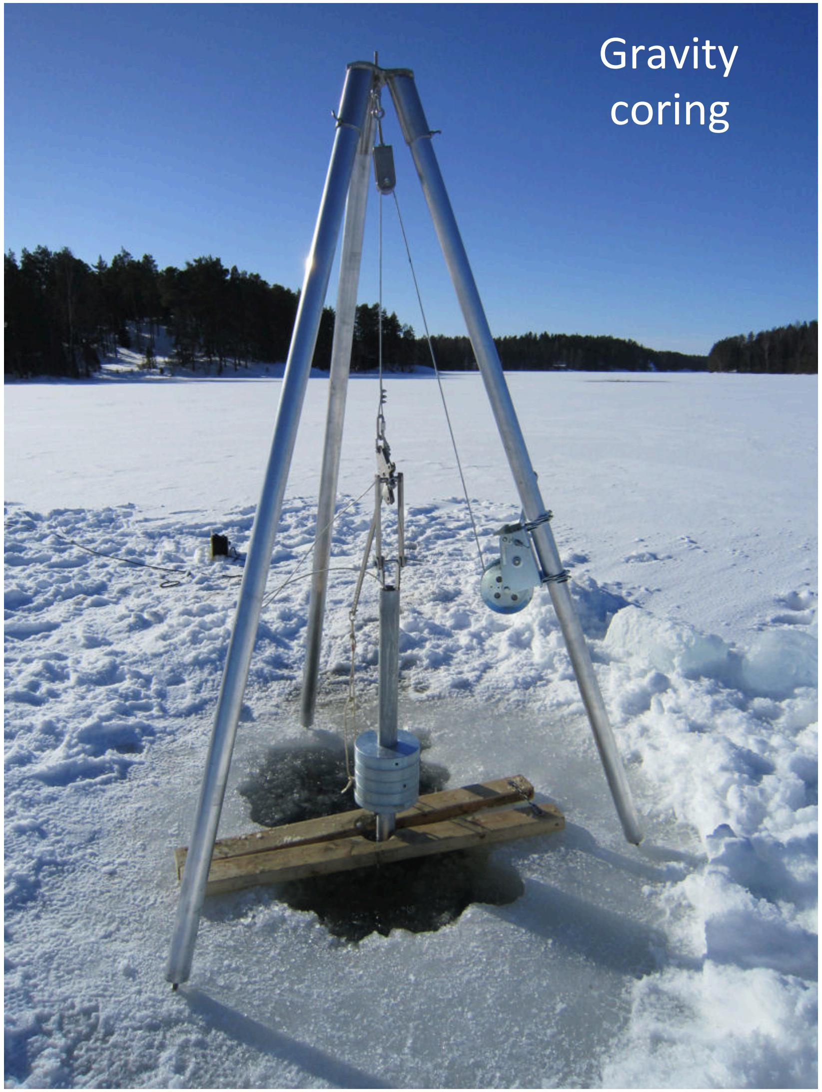
Organic records
Sampling overview
Soils and Sediments

Lakes, reservoirs, and marine sediments (soils), constitute a special challenge:

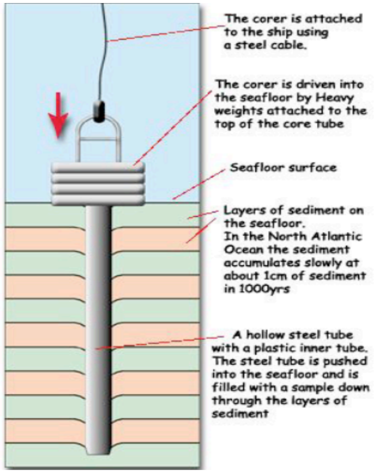
- The **aquatic envrionment** requires special equipement (floating platforms, platform stabilization on coring spots, sea state, watertight systems in pressurized environments, stainless steel construction, deployment systems).
- **Water column limits depth of coring** and constrains coring techniques.
- **Money!!**



Light floating platform



Gravity coring



The corer is attached to the ship using a steel cable.

The corer is driven into the seafloor by Heavy weights attached to the top of the core tube

Seafloor surface

Layers of sediment on the seafloor.
In the North Atlantic Ocean the sediment accumulates slowly at about 1cm of sediment in 1000yrs

A hollow steel tube with a plastic inner tube. The steel tube is pushed into the seafloor and is filled with a sample down through the layers of sediment

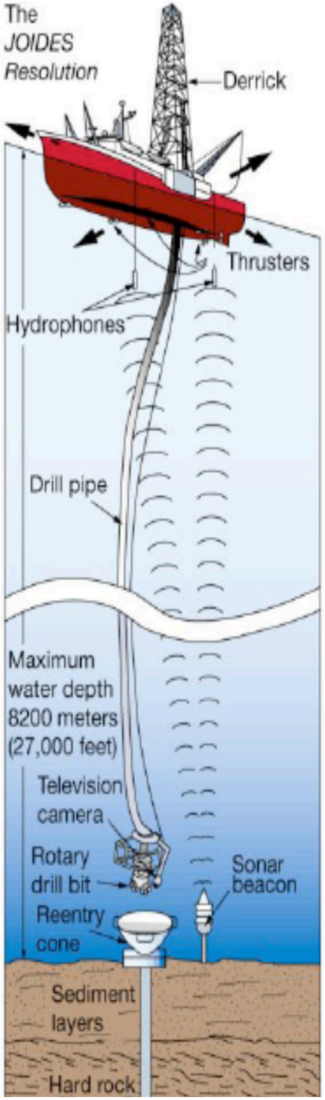
Gravity coring

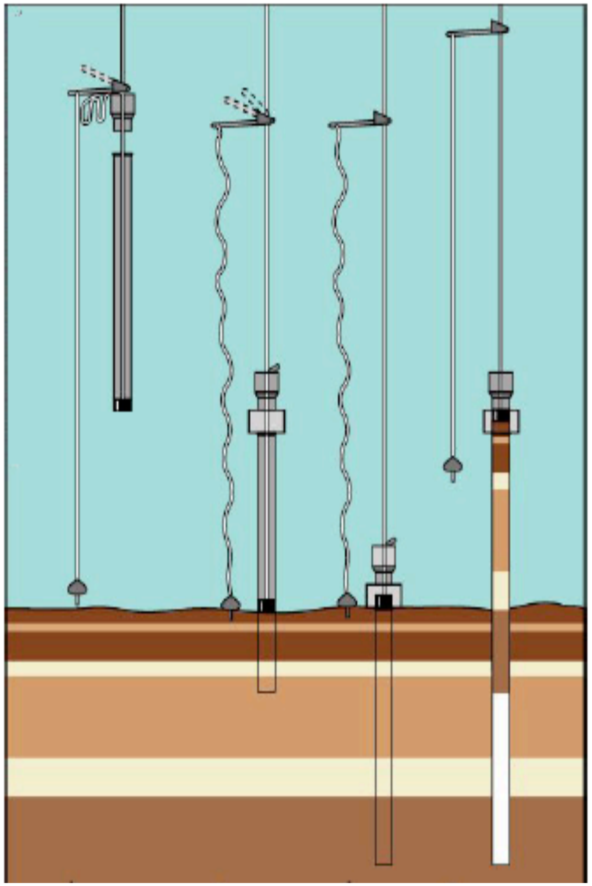
Organic records
Sampling overview
Soils and Sediments

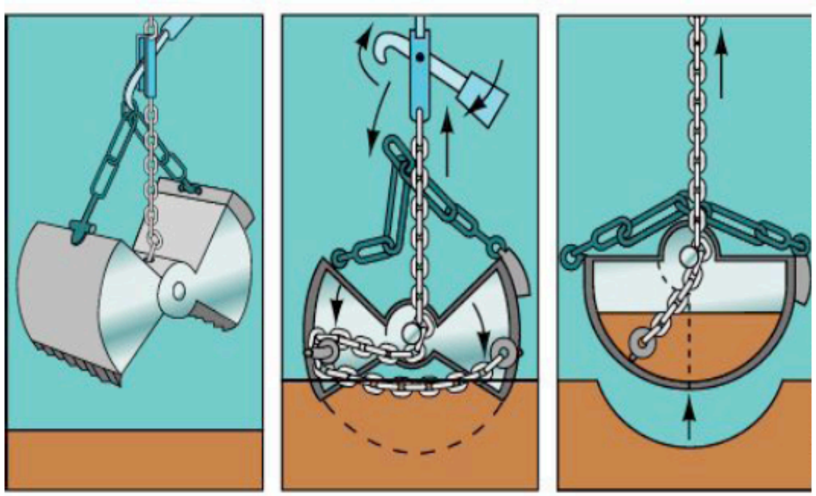
Piston coring

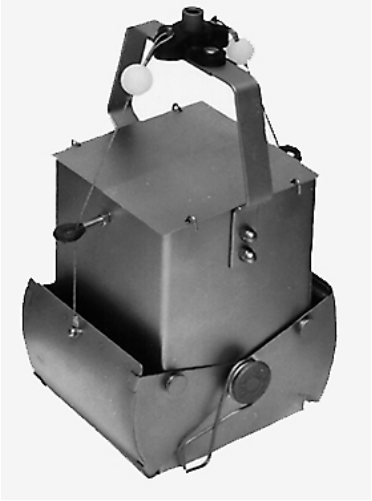
Piston coring

- Based on suction and gravity
- Good for deep coring
- Simple design
- Good for ‘soft’ sediments
- Allows penetrating tens of meters to hundreds!
- In Mediterranean, piston cores of 9m cover ca. 180 000 years of history.





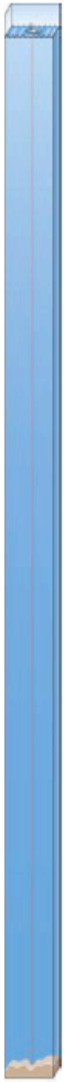




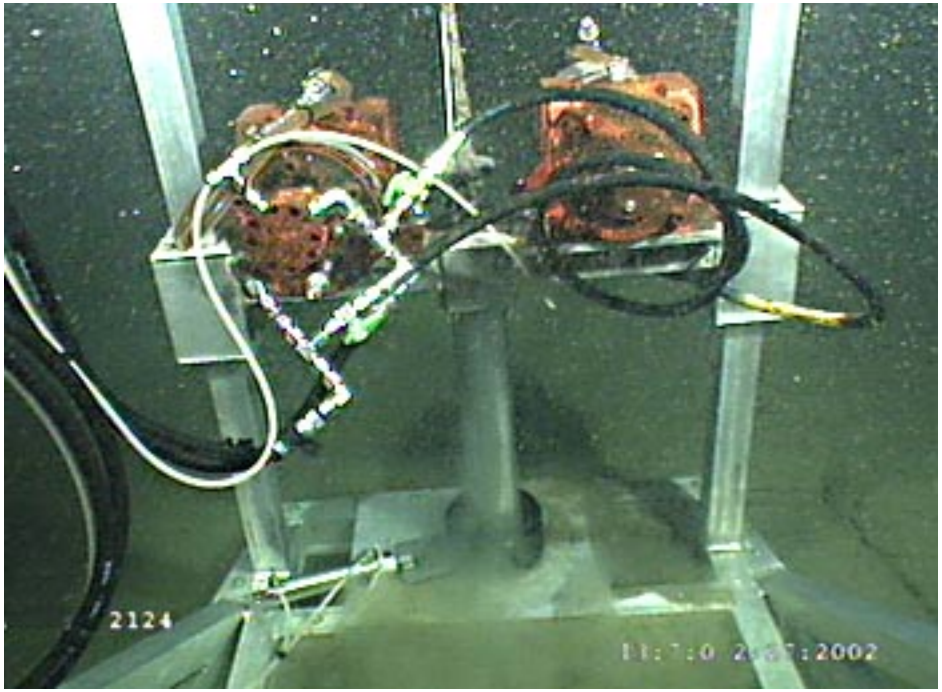
Box core or ‘clam shell’

- Good for shallow sampling of unconsolidated sediments.
- Keeps well vertical structure.
- Can cover the Holocene

“Deep + Deep” coring
Is the challenge



Vibracoring



"**High frequency hammering**"

- 3000-11000 vibrations/min
- Low friction
- Good for unconsolidated sediments
- Waterlogged, heterogenous sediments and soils.
- Bad for clay, packed sand or cemented sed.

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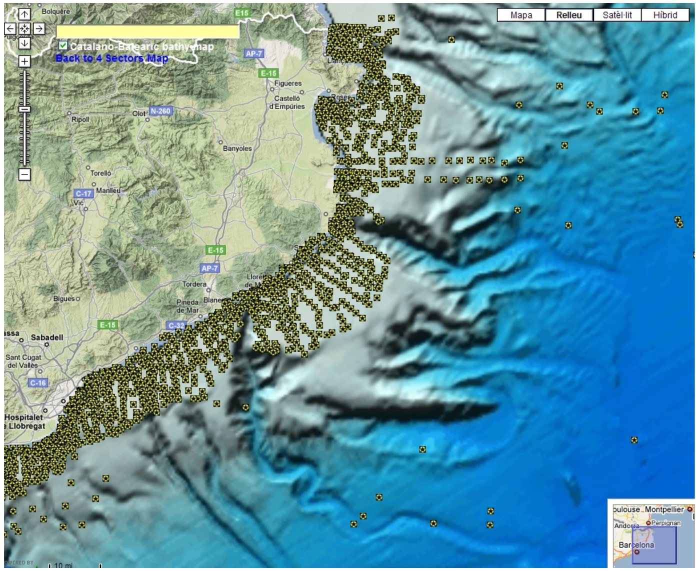

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http://www.icm.csic.es/gma/es/content/litoteca-del-icm

Organic records Limitations/challenges

◆ Main limitations/challenges:

1. **Changes in the proxies during aging.**

Decomposition, diagenesis.

2. **Interpretation ambiguities**

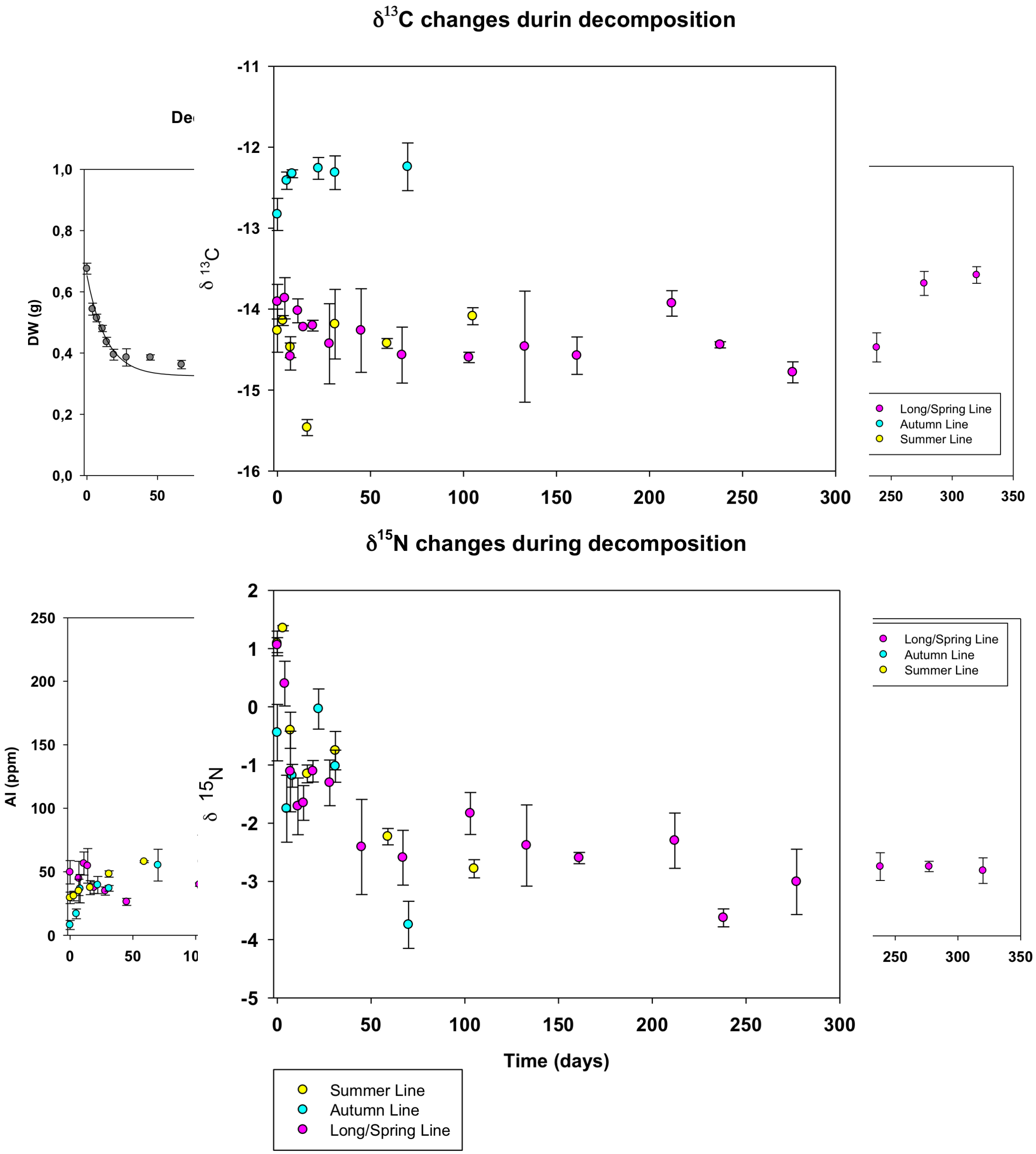
Influences in proxies by **various factors** (same or opposite directions).

3. **Linearity of the proxies**

◆ Others:

- Record datability
- Dataing accuracy and resolution
- Chronological alterations of the sequence
- Sampling/Analytical methods
- Unknown factors/actors

Scenarios vs ~~certainties~~



Organic Matter


Sandy rich


Sandy poor


Peat


Crop soil


***Posidonia* Mat**


Deep marine

Organic matter
Description of the record

- It originates from the complex **mixture of lipids, carbohydrates, proteins, and other biochemicals** produced by organisms that have lived in the soil, the land, the lakes, the oceans and their watersheds.
- During deposition, organic matter is subject to **microbial reworking**, with the result that much of its original molecular composition becomes altered.
- **Humic substances** end up consitutiting from **60 to 90%** of the OM in the sediments.

Humification: chemical and biological transformation of the organic matter. Plant **lignin** and its transformation products, **polysaccharides, melanin, cutin, proteins, lipids, nucleic acids, fine char particles**, etc., are important components taking part in this process.

Organic matter Distribution and description of the record

-Where? From the **Histosols** (>40% OM) to the **Aridisols** (<1% OM), excluding the polar areas, but including most sea and lake sediments, organic matter (OM) is **everywhere**.

-Composition:

Nitrogenous

Water Soluble eg. Nitrates, ammonical compounds, amides, amino acids etc.

Insoluble eg. Proteins nucleoproteins, peptides, alkaloids purines, pyridines chitin etc.

Non Nitrogenous:

Carbohydrates eg. Sugars, starch, hemicellulose, gums, mucilage, pectins, etc.

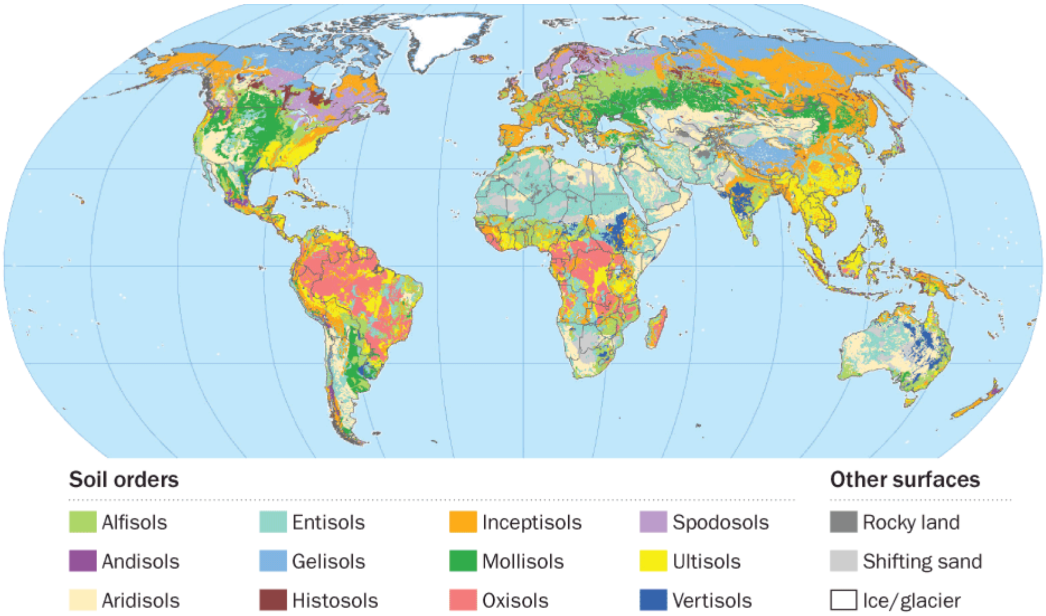
Micellaneous: eg. Lignin, tannins, organic acid, etc.

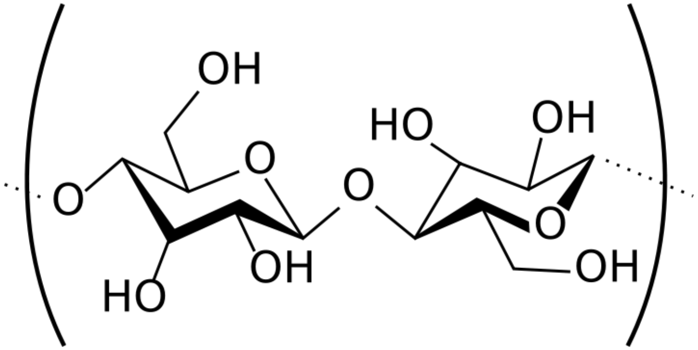
Ether Solube: eg. Fats, oils, wax etc.

-Bulk vs specific compounds:

Bulk broad first picture; Specific: 'dissection'

Land





Cellulose

Oceans

Organic matter Distribution and description of the record

Types of marine sediments:

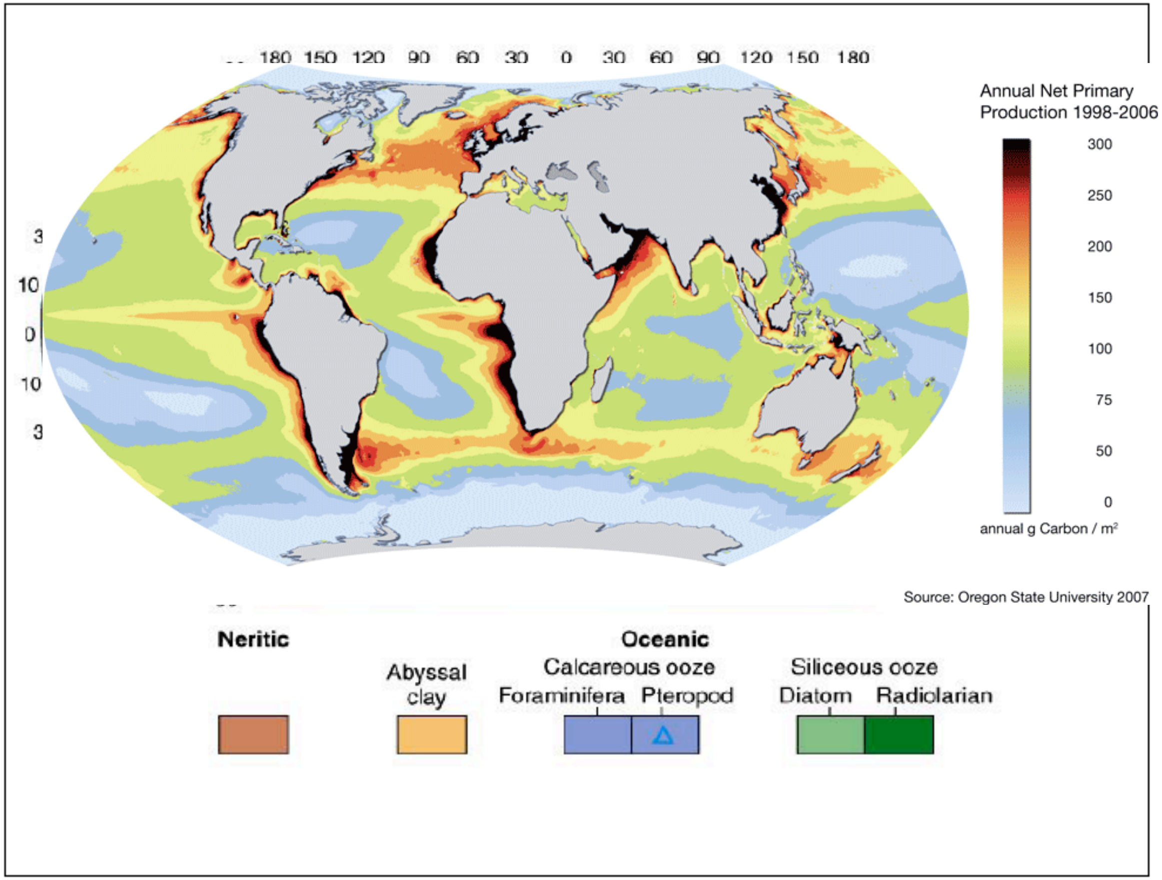
- **By particle size (texture)**
- **By origin (formation):**

– **Terrigenous** (Lithogenous)

– **Biogenous** (Biogenic)

– **Hydrogenous** (Authigenic)

– **Cosmogenous** (Cosmogenic)



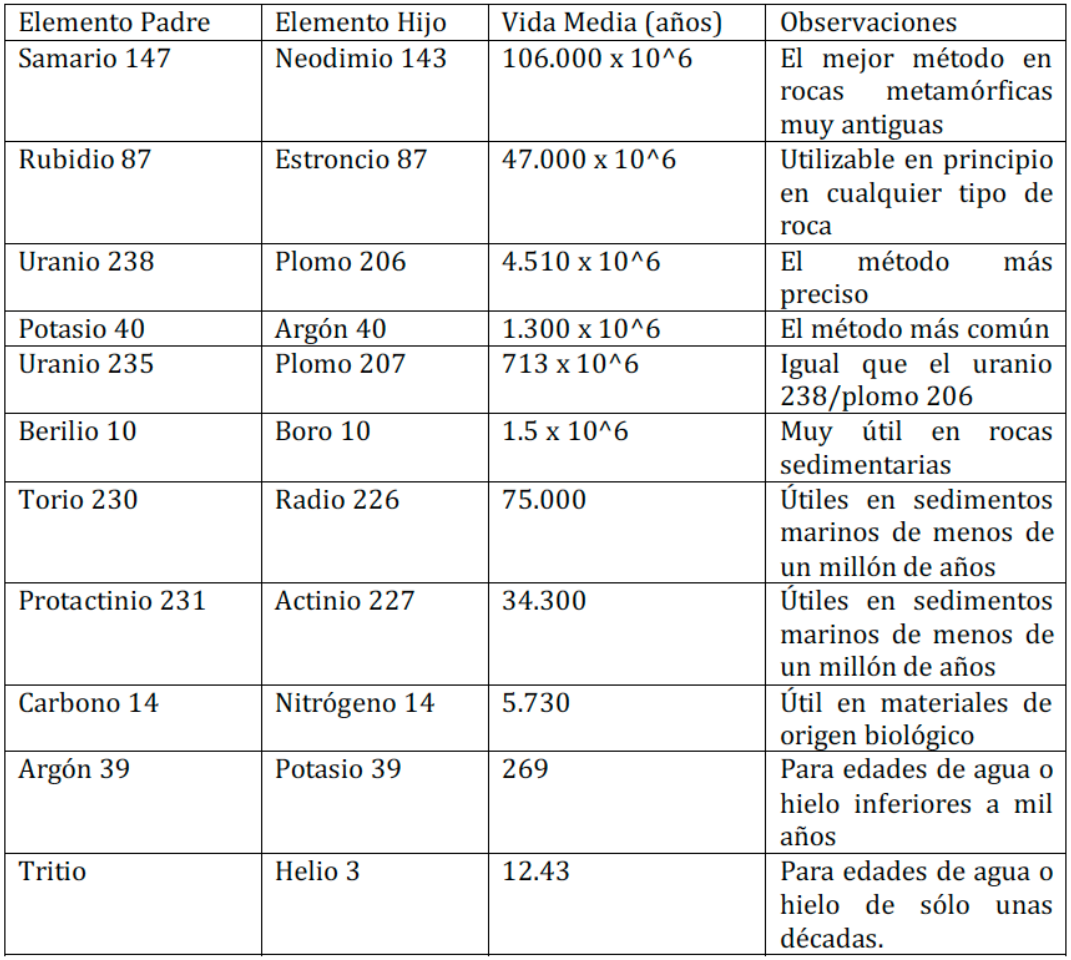
Source: Oregon State University 2007

The organic content of the sediments is closely related to the submarine topography. It is relatively small on ridges, which are exposed to currents, and it is considerable in basins, which are protected. It is also related to the texture of the sediments. Sands contain relatively little and clays contain considerable organic matter.

Dating: Radiometric methods

Organic matter
Dating the record
What should we date?

- Lake sediments bulk organic matter may be 1000 to 2000 years older than the actual sediment age, due to retention and recycling of DIC.
- Corrections are complicated, so is better to use twigs, leaves or similar intact OM particles.
- Oceans reservoir effect.



Elemento Padre	Elemento Hijo	Vida Media (años)	Observaciones
Samario 147	Neodimio 143	106.000 x 10^6	El mejor método en rocas metamórficas muy antiguas
Rubidio 87	Estroncio 87	47.000 x 10^6	Utilizable en principio en cualquier tipo de roca
Uranio 238	Plomo 206	4.510 x 10^6	El método más preciso
Potasio 40	Argón 40	1.300 x 10^6	El método más común
Uranio 235	Plomo 207	713 x 10^6	Igual que el uranio 238/plomo 206
Berilio 10	Boro 10	1.5 x 10^6	Muy útil en rocas sedimentarias
Torio 230	Radio 226	75.000	Útiles en sedimentos marinos de menos de un millón de años
Protactinio 231	Actinio 227	34.300	Útiles en sedimentos marinos de menos de un millón de años
Carbono 14	Nitrógeno 14	5.730	Útil en materiales de origen biológico
Argón 39	Potasio 39	269	Para edades de agua o hielo inferiores a mil años
Tritio	Helio 3	12.43	Para edades de agua o hielo de sólo unas décadas.

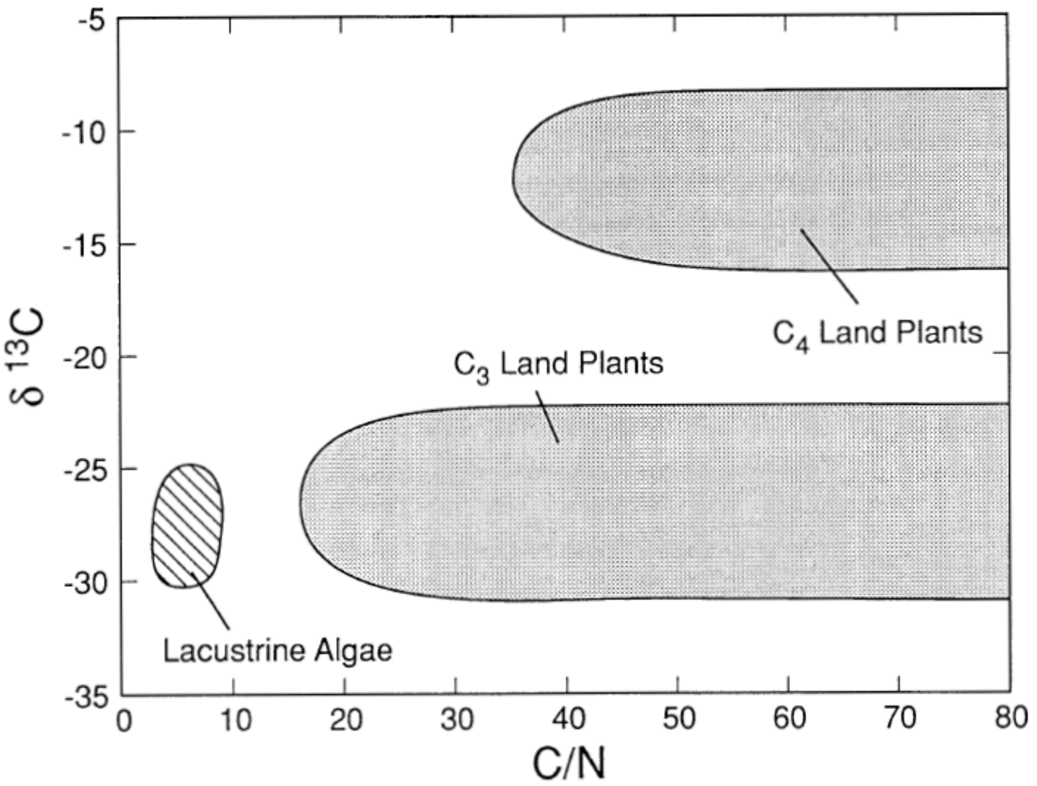
^{210}Pb (half-live 22 yr)
^{7}Be (half-live 53d)

Short-lived isotopic chronometers

Organic Matter Proxies d13C and C/N

- Representative elemental and carbon isotopic compositions of organic matter from lacustrine algae, C3 land plants, and C4 land plants that use CO2 as their source of carbon during photosynthesis. Deviations from these generalized patterns occur and provide paleolimnologic information.
- Representative atomic C/N ratios and organic d13C values (‰ PDB) of different types of primary organic matter sources to sediments of lakes, and some examples of the C/N and d13C signatures of bulk organic matter in modern lake sediments.

Organic Matter Source	Location	C/N	$\delta^{13}C$	Reference
C_3 Land Plants				
willow leaves	Walker Lake, Nevada	38	–26.7	Meyers (1990)



Pyramid Lake	Nevada, USA	9	–26.9	Tenzer et al. (1997)
Lake Baikal	Russia, Siberia	11	–29.9	Qiu et al. (1993)
Coburn Pond	Maine, USA	12	–28.4	Ho and Meyers (1994)
Lake Baikal	Siberia, Russia	13	–27.4	Prokopenko et al. (1993)
Lake Bosumtwi	Ghana, Africa	14	–26.4	Talbot and Johannessen (1992)

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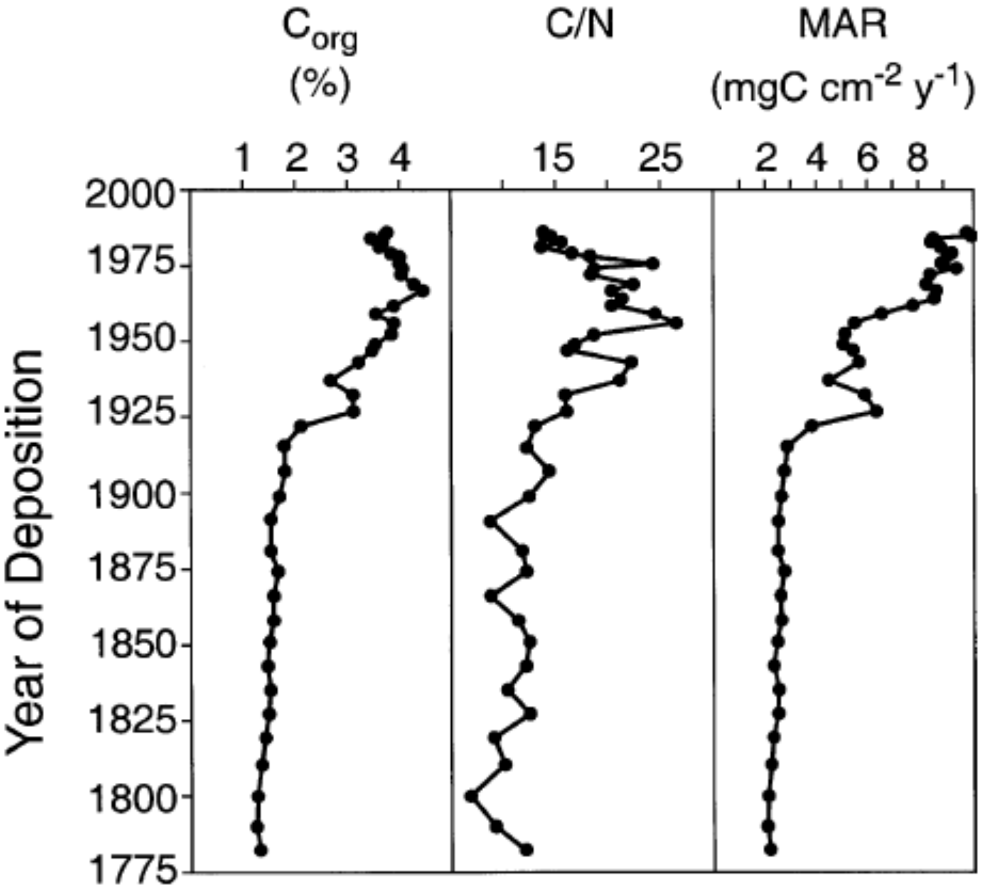
Organic Matter
Application examples

Post IR changes

Concentrations and **mass accumulation rates** (MAR) of organic carbon and **Corg/Ntotal** atomic ratios in sediment from Lake George (water depth 13 m) on the Michigan–Ontario border (Fig. 2). Changes in these parameters reflect increased delivery of land-plant organic matter and increased algal productivity since 1925. Data from Tenzer et al. (1999).



MAR compensates for **bulk sedimentation** and **sediment compaction**

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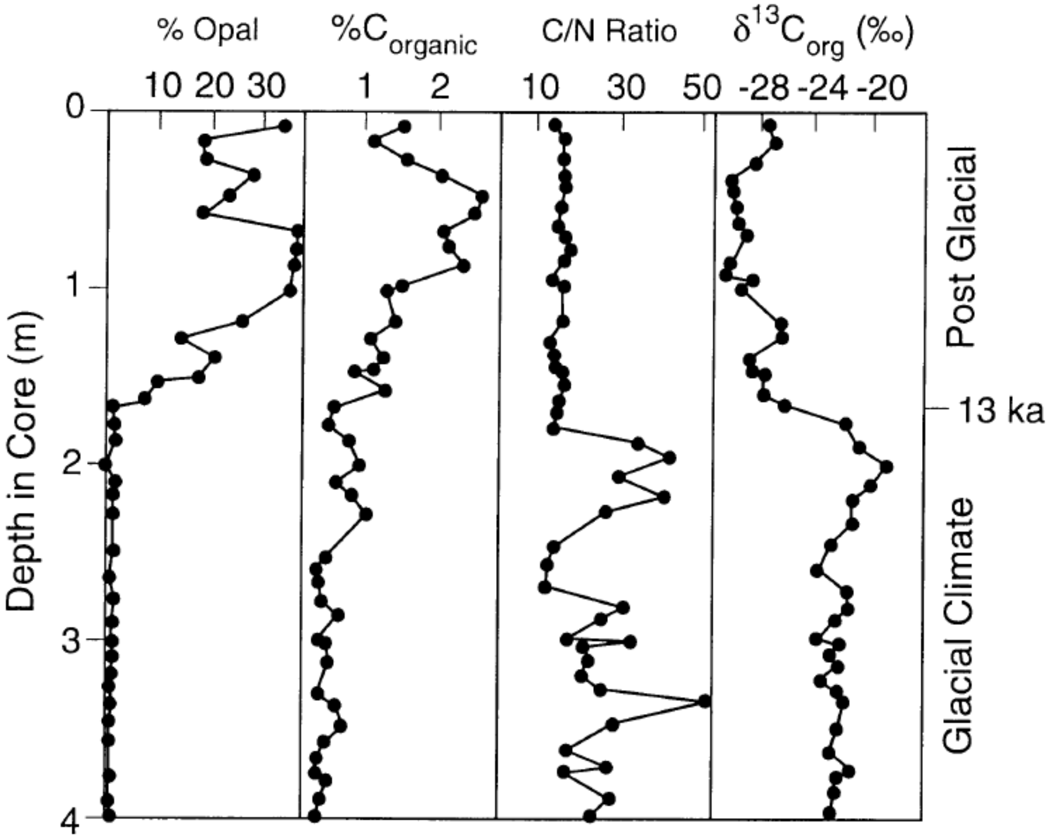
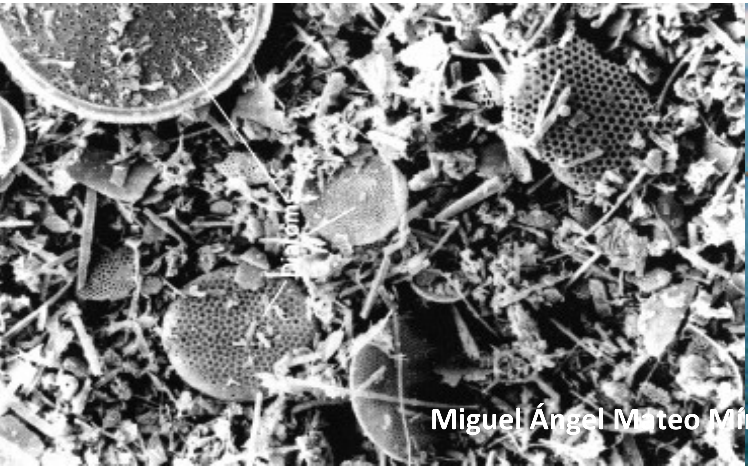
Organic Matter
Application examples

Post-glacial paleoclimate record

- Evidence of organic matter source change **from tundra vegetation to algal production** at the **glacial-postglacial boundary** in sediment record from Lake Baikal, Siberia.
- Decreases in C/N ratios and in organic d13C values at the **mud/diatom ooze** transition record the transition from **tundra to forests around Lake Baikal** and an **increase in algal productivity** starting ca. 13 ka.

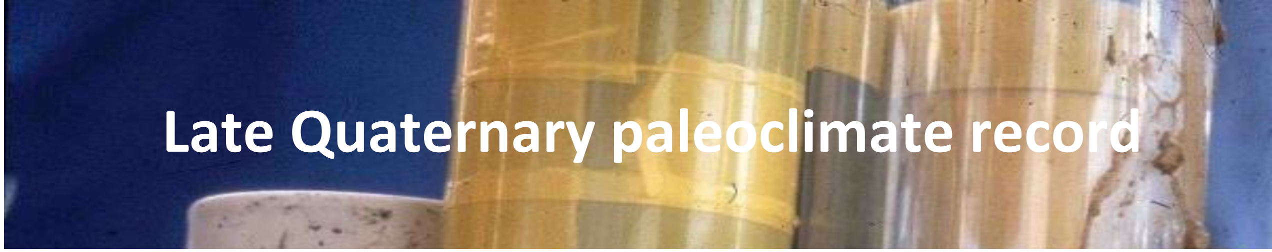




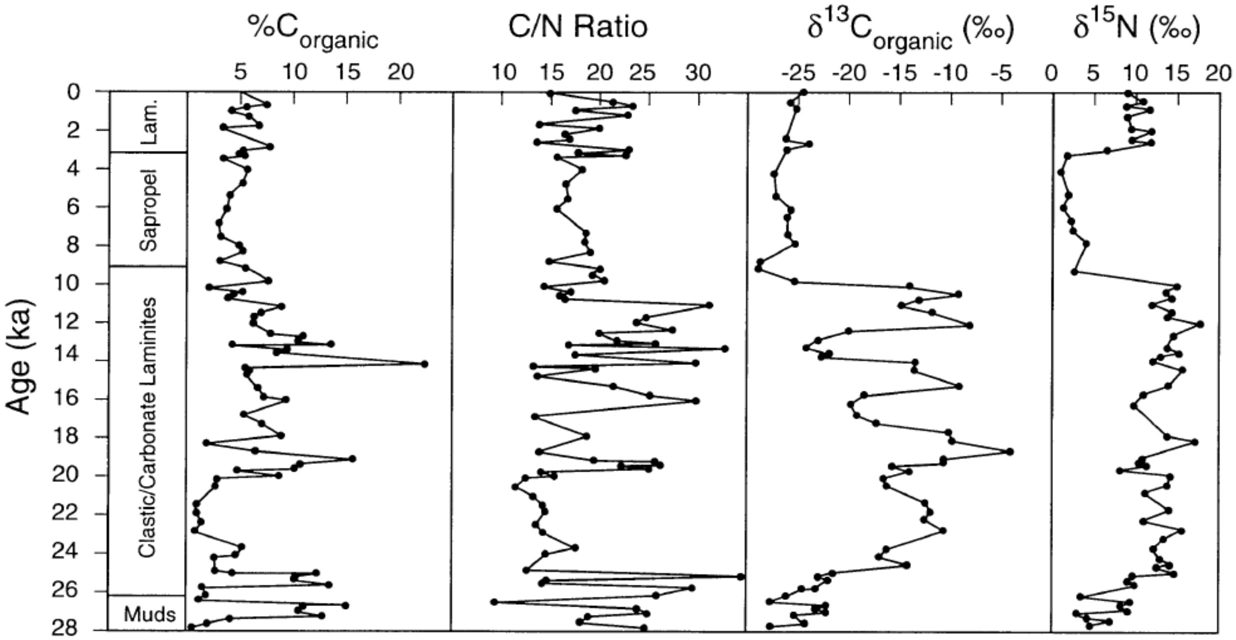
Organic Matter
Application examples
Productivity

Organic carbon concentrations, atomic C/N ratios, and organic d13C and d15N signatures of sediments from **Lake Bosumtwi, Ghana.**

Decreased C/N ratios and d13C and d15N values in the **sapropel layer record** a period of **enhanced lake productivity** (not shown) and postulated wetter climate between 9 and 3 ka. Glacial-age **savannah-forest fluctuations** are evident in organic d13C values between 26 and 9 ka. From Talbot & Johannessen (1992).



Late Quaternary paleoclimate record



Sapropel layer

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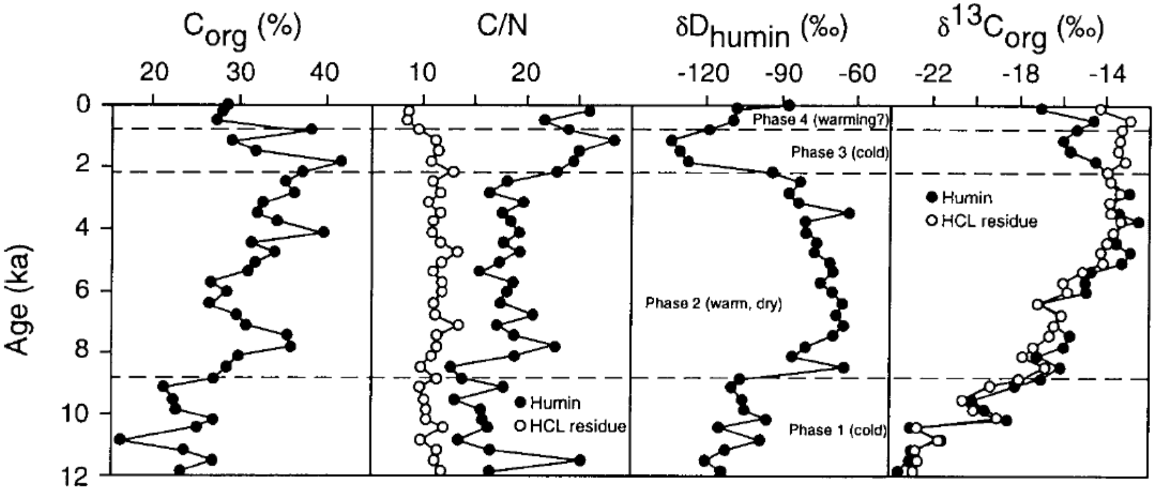
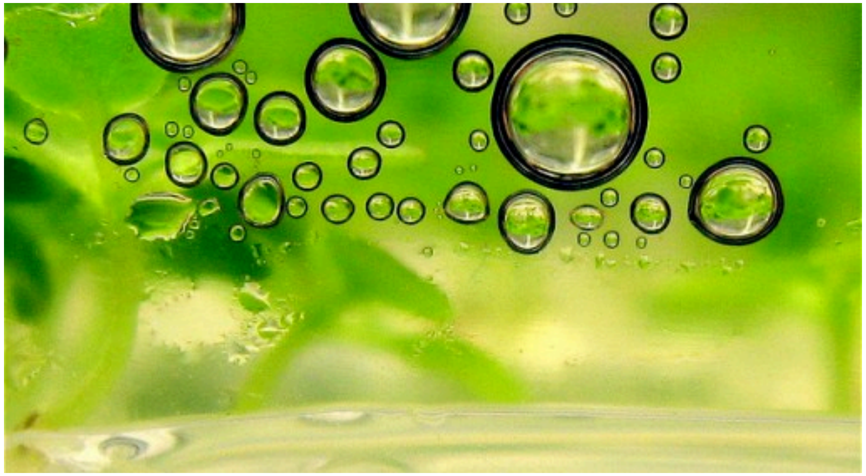
Organic Matter
Application examples
Precipitation, δD_{humin}

Holocene precipitation record

Record of **postglacial climate change in hydrogen isotope contents of organic matter** in sediments of **Austin Lake**, Michigan. Bulk C/N ratios indicate that **most of the organic matter is from algal production** (9–2ka) **and therefore humin dD values reflect lake water isotopic composition**. Variations in dD values record **changes in sources of meteoric water and in precipitation/evaporation ratios as local climate changed**. The progressive upcore change to less negative d13C values may result from **isotopic aging of the lake**. From Krishnamurthy et al. (1995).





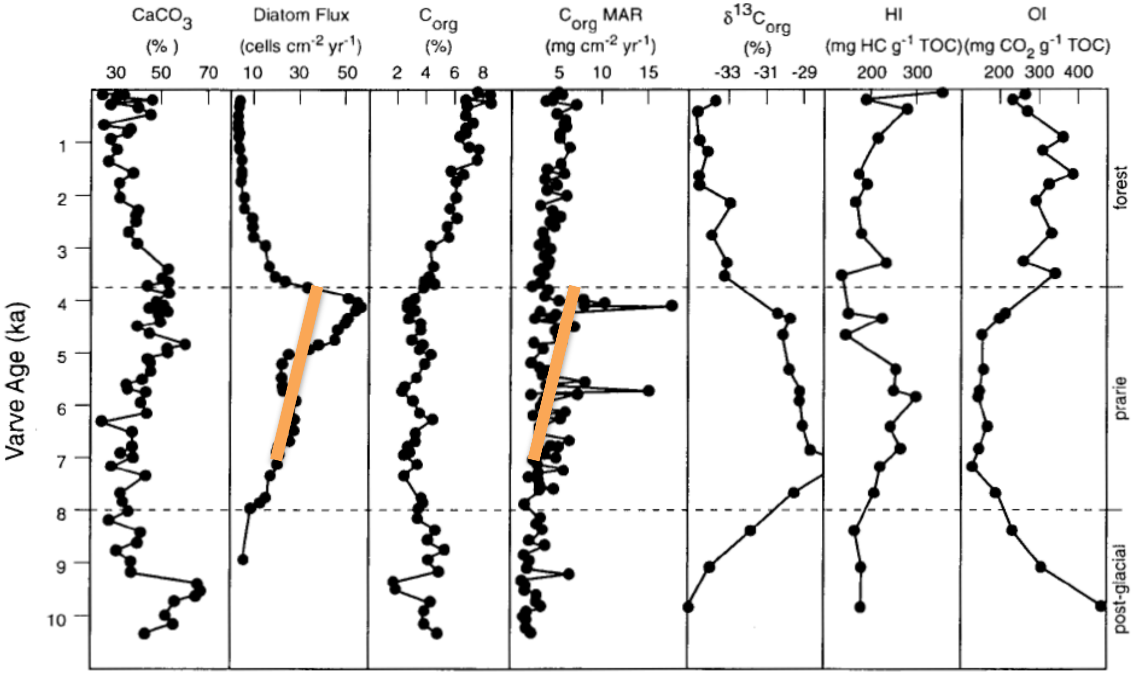
Organic Matter
Application examples
Concepts of Flux and MAR

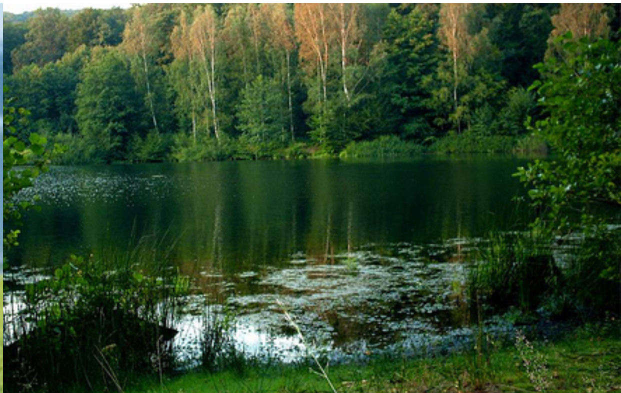
Holocene paleoclimate record

Vegetation alternance

History of Holocene climate changes recorded in **calcium carbonate concentrations, diatom fluxes, organic carbon concentrations and mass accumulation rates, d13C values, and Rock Eval HI and OI values of bulk organic matter** in sediments from Elk Lake, Minnesota.

The climate of the prairie period was drier and windier than earlier or later periods, and both production and preservation of organic matter were enhanced. From Bradbury & Dieterich-Rurup (1993) and Dean & Stuiver (1993).





Seagrasses and *Posidonia oceanica* distribution

- All world coasts, excluding polar regions. They occupy ca. 0.33 Million km2.
- From calm (*Cymodocea spp*), to highly exposed areas (*Phyllospadix*)
- Many unexplored areas of the world!! (west coasts of South America; Africa)

  - *Posidonia oceanica* Mediterranean endemism
  - From 0m to 40m in well illuminated oligotrophic water
  - Occupies around 35 000 km2

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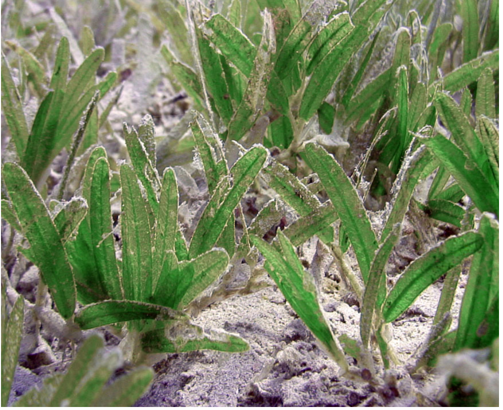
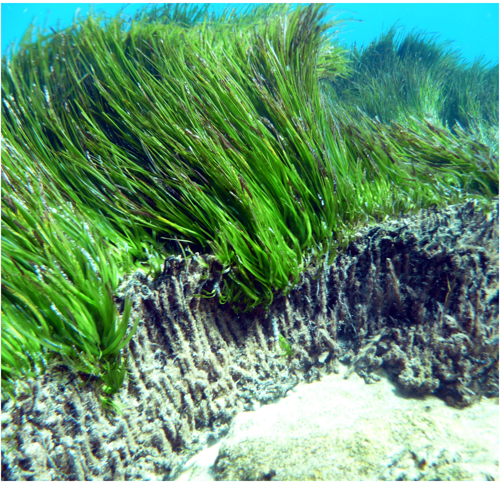
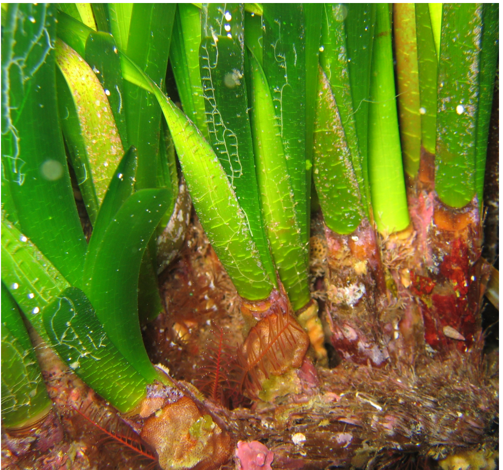
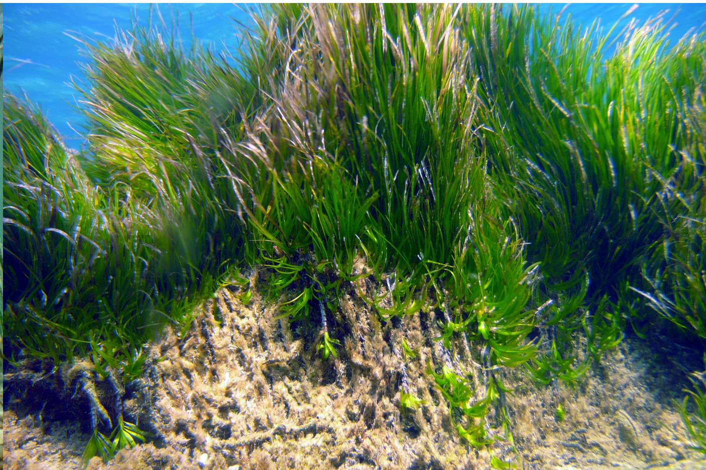








Seagrasses
Description of the record

Rhizomes, scars, sheaths.

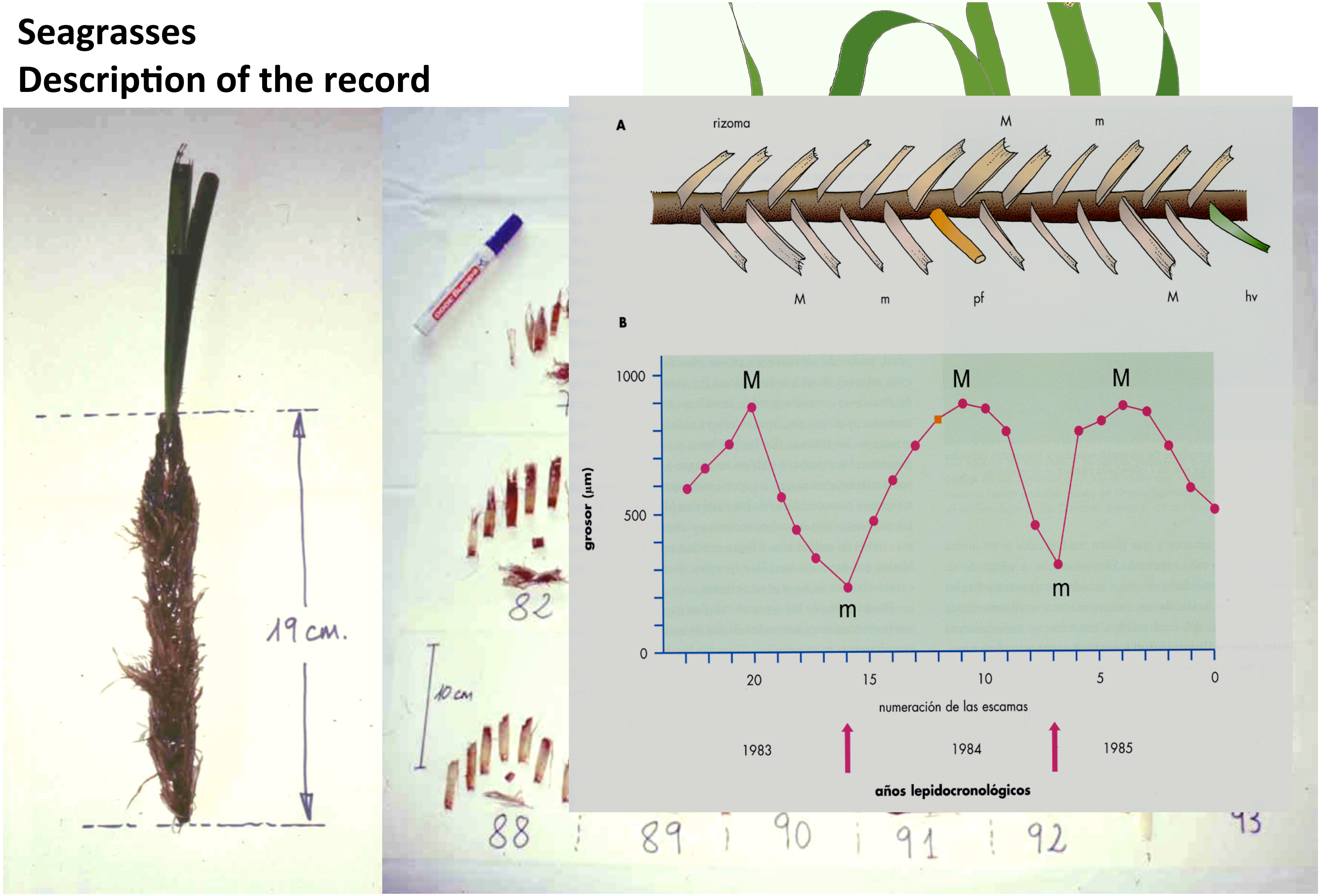
- Most seagrasses show **scars along the stems left after leaf detachment**. Some even keep the **sheath** (leaf protecting tissue).
- Scars and sheaths are arranged chronologically allowing retrodatation.
- For scars, the technique is known as **plastochrone interval**, for sheats, **lepidochronology**.
- 30-50 year cycles have been reconstructed. 10 is the usual range. Resolution is annual.

NATUURLIJKMOOT.NET 12-04-2008

Cymodocea nodosa roots, rhizomes, sheaths, and leaves

Posidonia oceanica roots, rhizomes, sheaths, and leaves

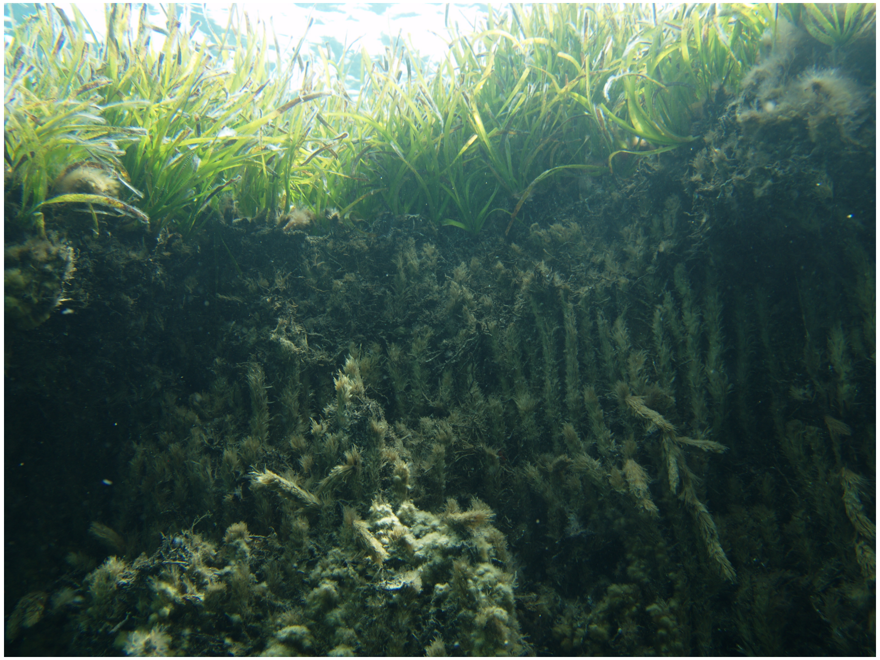
Seagrasses
Description of the record

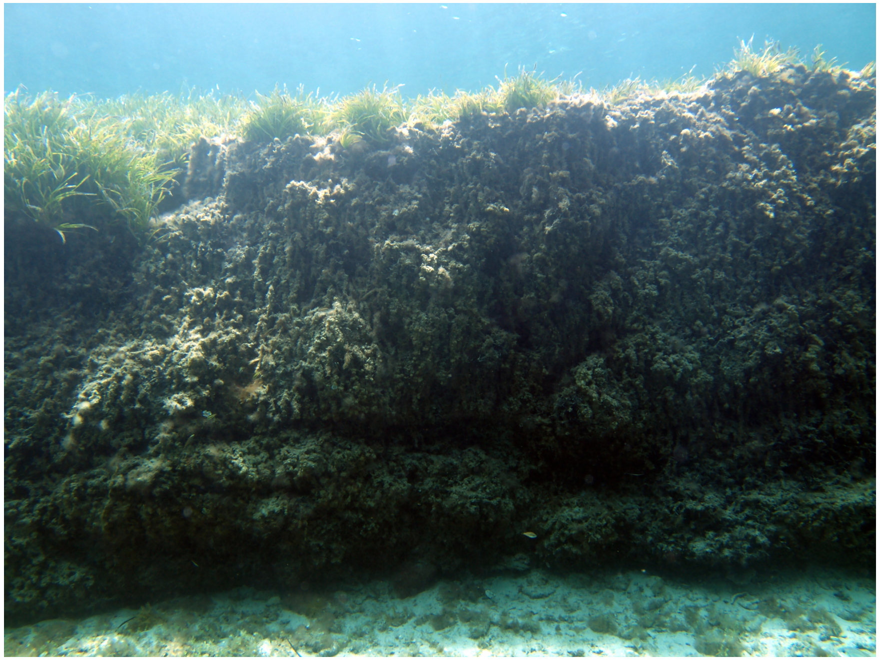


Posidonia
Description of the record

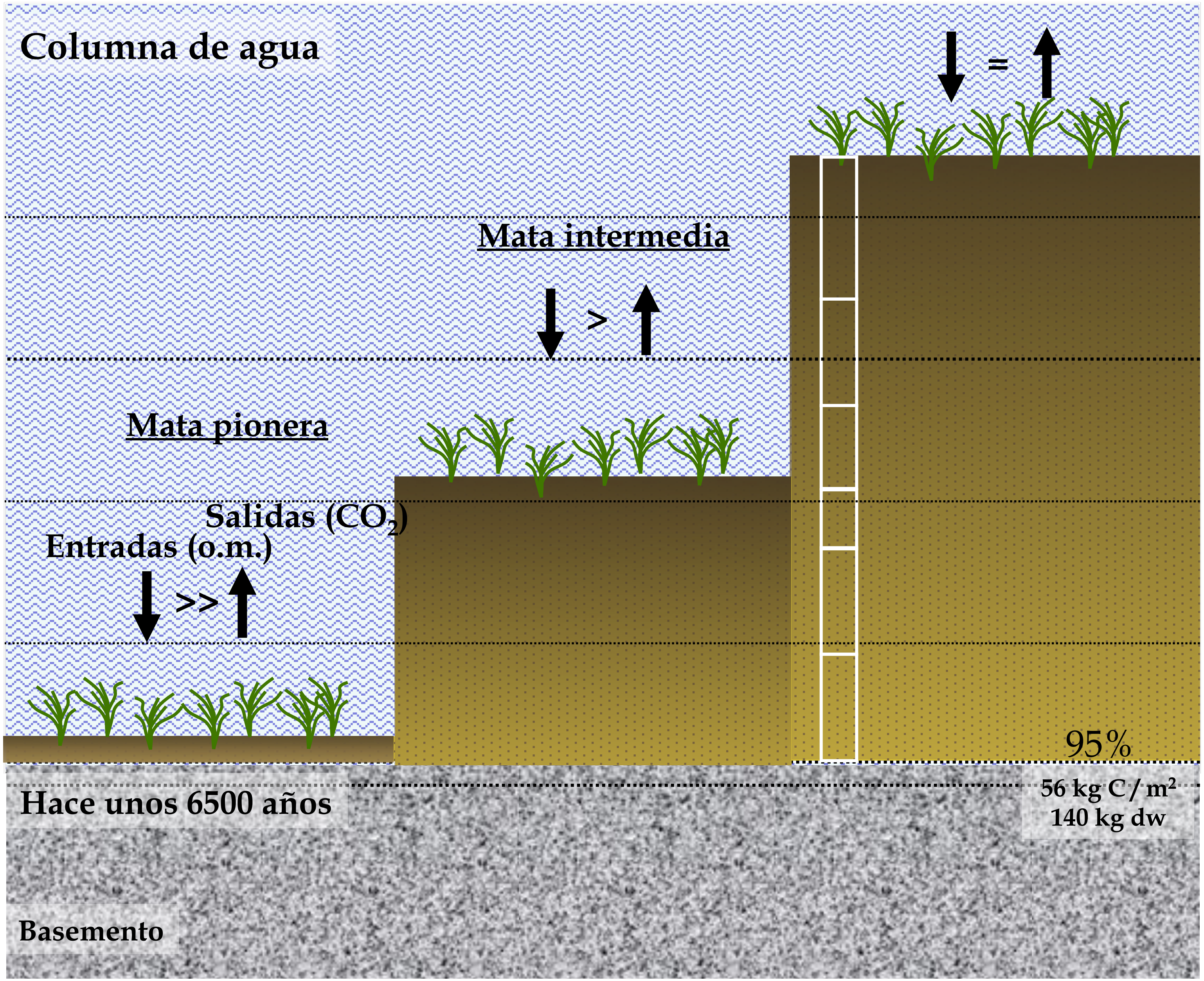
The mat (*Matte*, Mata).

- Integrated by belowground organs of the plant + OM from other sources + sediments.
- Can reach up to 8m in thickness recording 6000 years with ca. 10 years of resolution (as far as we know!). Grows a ca. 1mm/yr (1m = 1000 yr).
- First 50 cm are highly organic (Histosol, peaty). Then organic content declines but stays high down the mat.
- The origin of the debris thousand years old can be identified under binocular!





Posidonia. Mat formation



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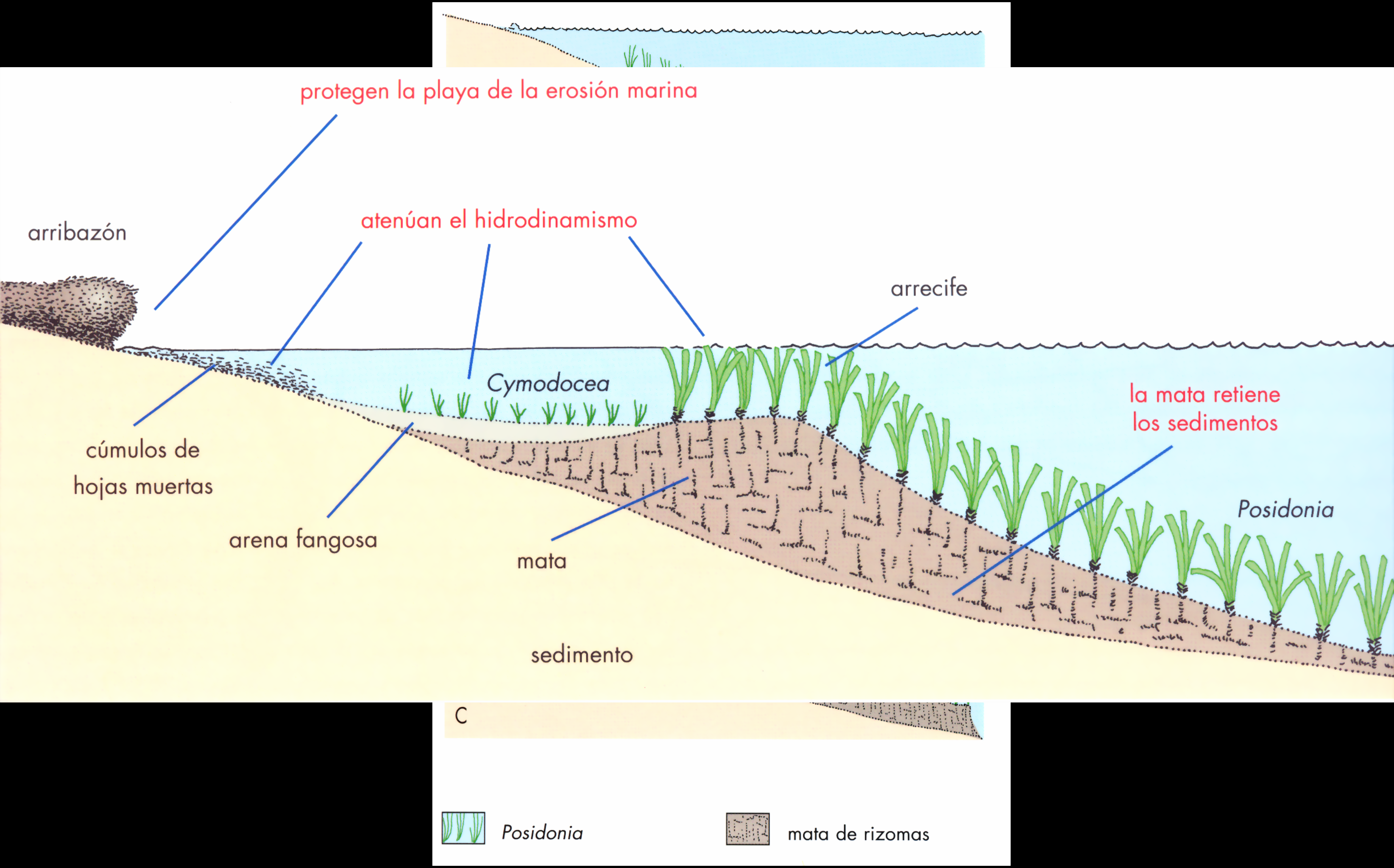

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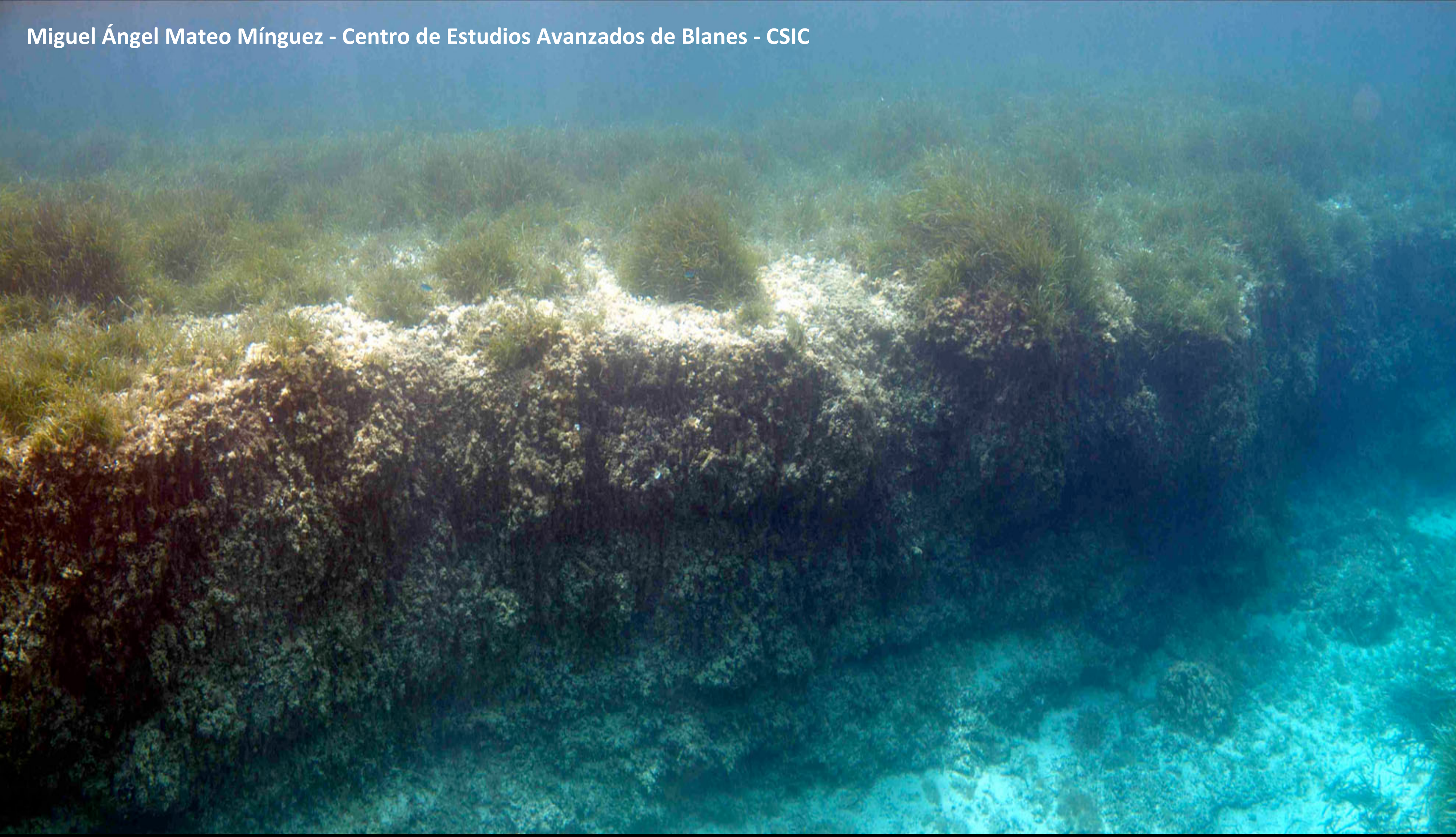
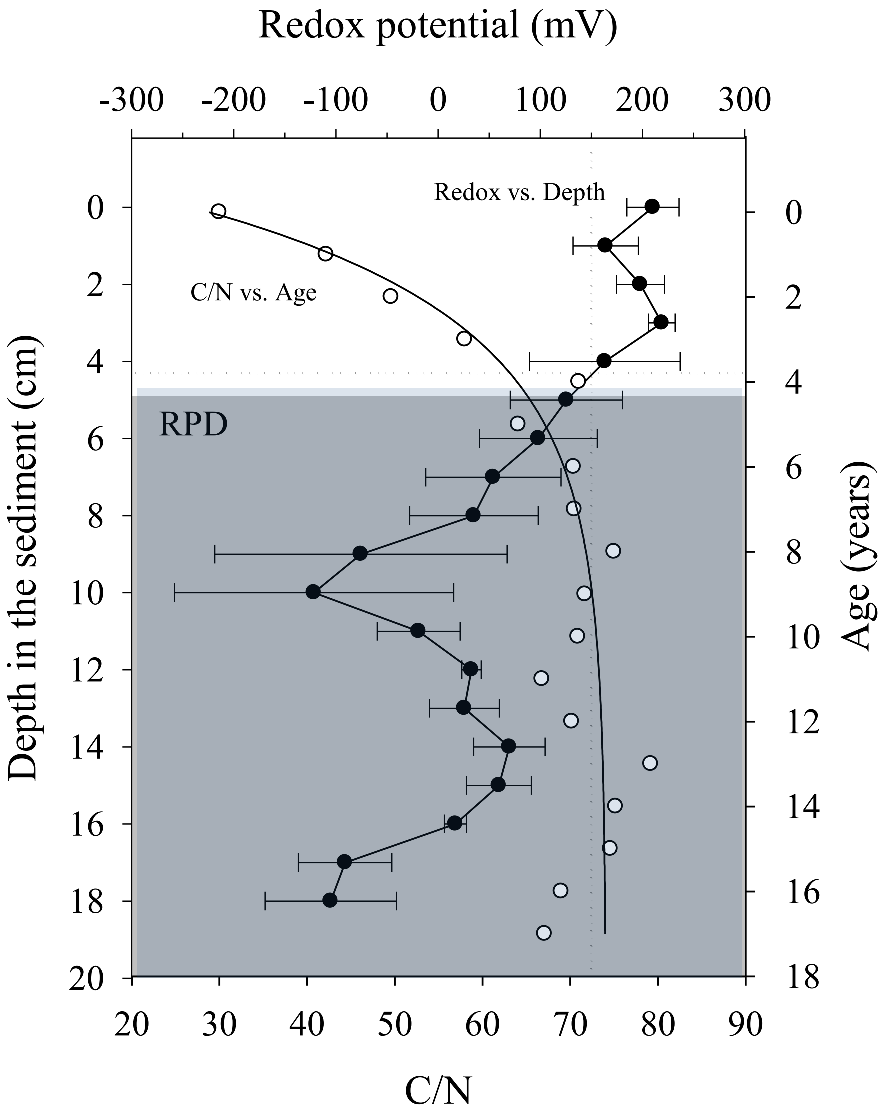
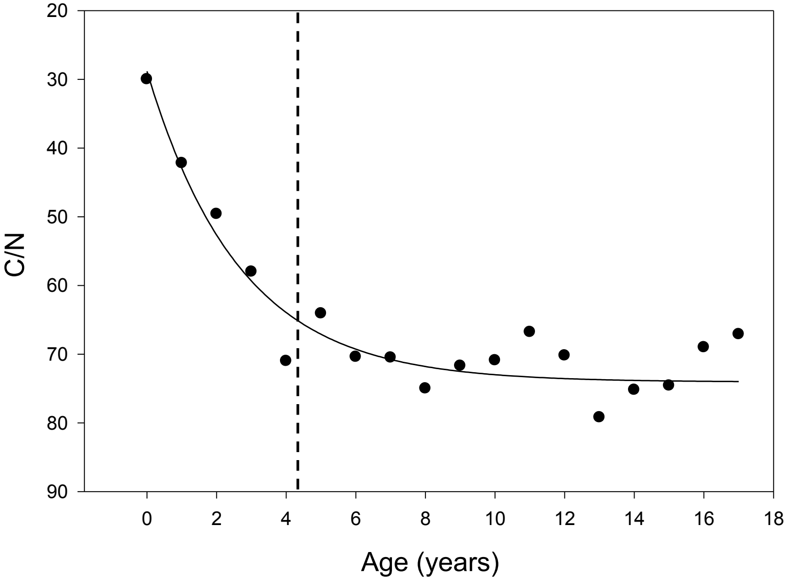


100 yr

3000 yr

Posidonia oceanica. Preservation of the record





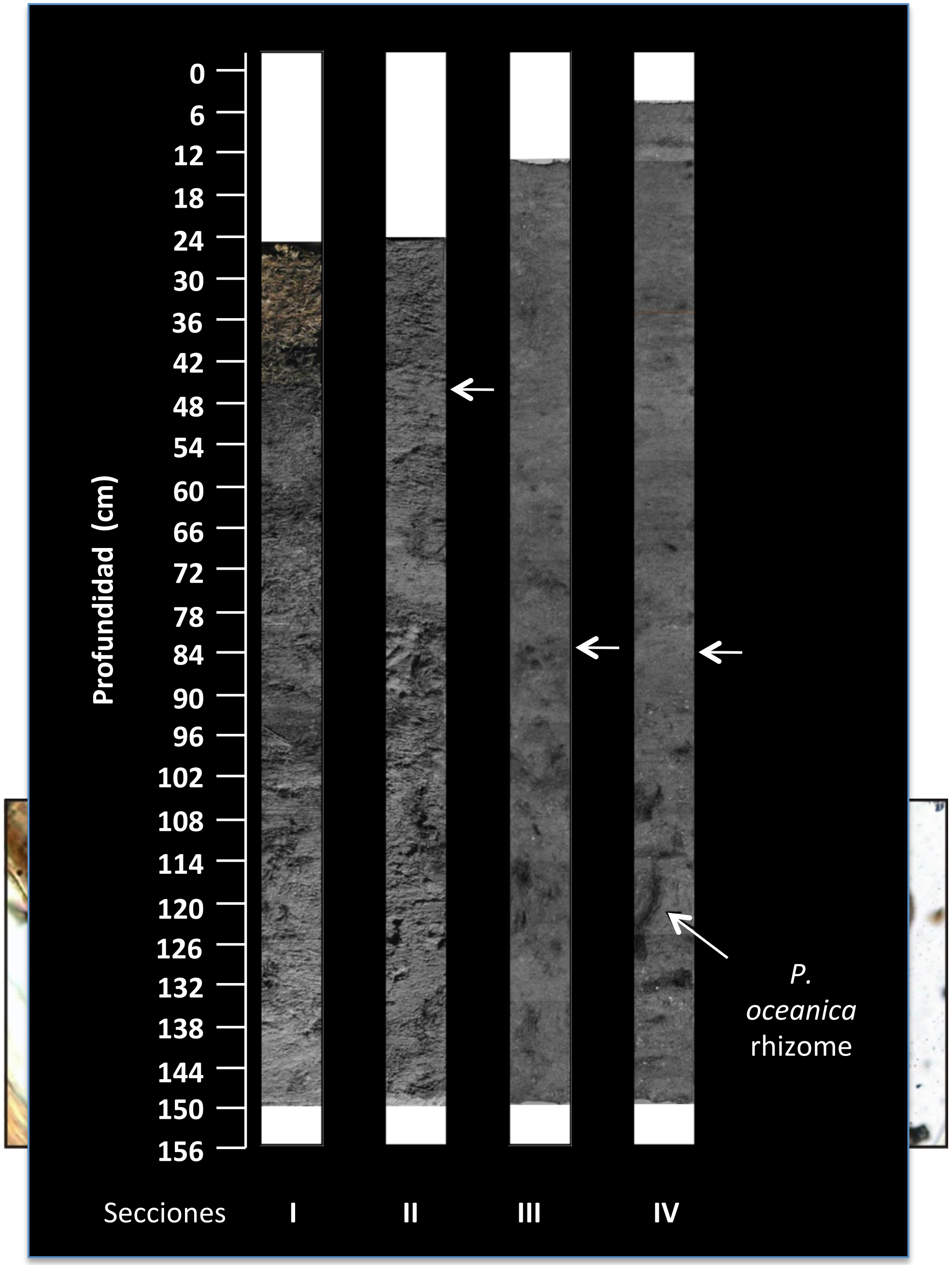
Posidonia
Sampling the record

- **Rhizomes** for lepidochronology and plastochrone need to be orthotropic and are found in central areas of well-developed patches. It is a **time-consuming task!**
- The mat can be sampled using **natural blow outs** or by **coring.**
- So far **roto-percusion** and **manual coring** has been successfully used. **Vibracoring** is believed to be an adequate method.

Horizontal coring of the *Posidonia oceanica* organic record in a natural front face of a 'reef' in Es Pujols, Formentera.

Posidonia
Description of the record
Chronological model

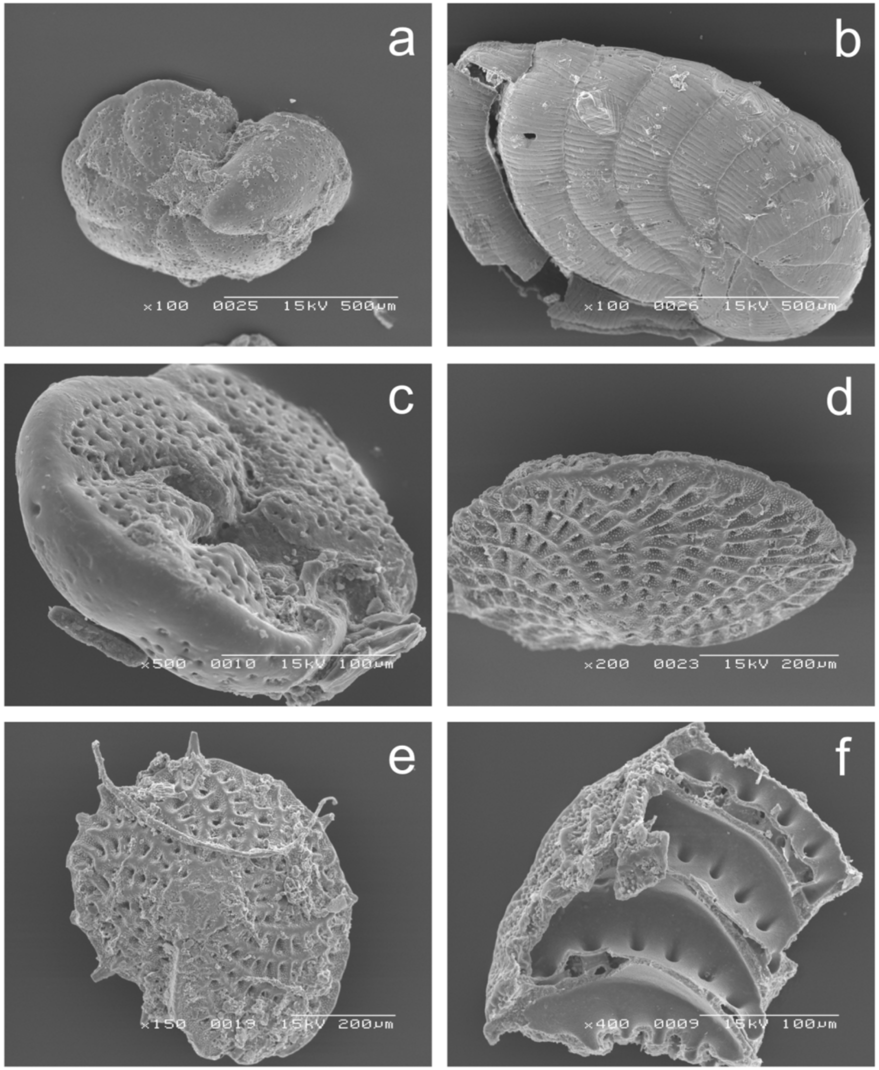
- Core shortening correction.
- Discard displaced debris.
- Carefull selection of sheath debris (no roots).
- Spectrometric AMS dating.
- Correction for isotopic discrimination (d13C).
- Dendrocalibration.
- Reservoir effect correction.
- Smooth-spline model.



Posidonia
Proxies

This is a pioneering research lilne. So far, the following proxies have been used:

- Mass accumulation rates
- OM content
- TOC
- Grain size
- Mineralogical analysis
- Stable isotopes (C,N,H)
- Compound specific isotop.
- Foraminiferans
    - Abundance
    - d18O, d13C
- Pollen grains
- Heavy metals content
- Biomarkers: fatty acids, sterols, Aliphatic hydrocarbons.
- Pyrolisis (OM fractionation)

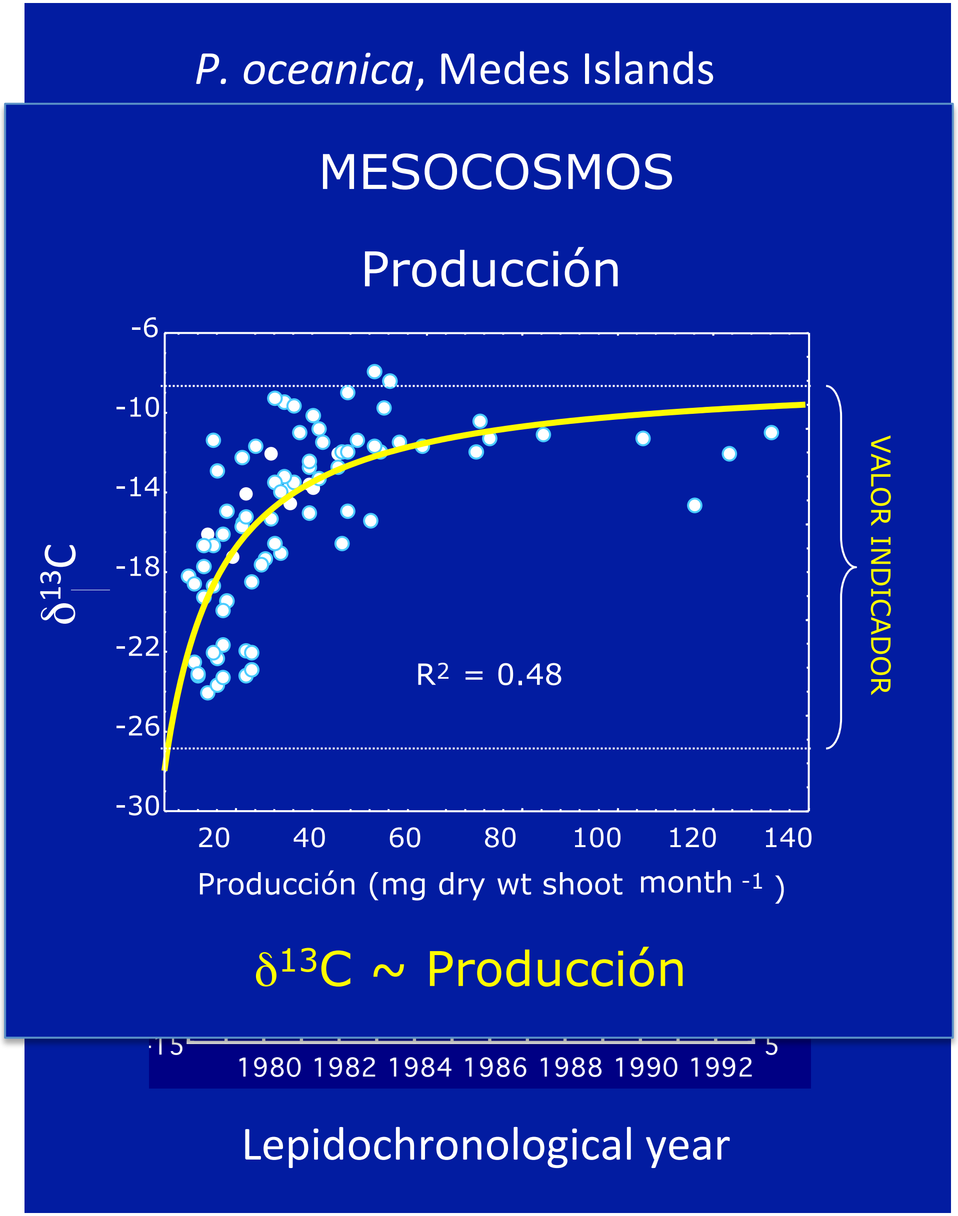


By Oscar Serrano

Sheath d13C records productivity

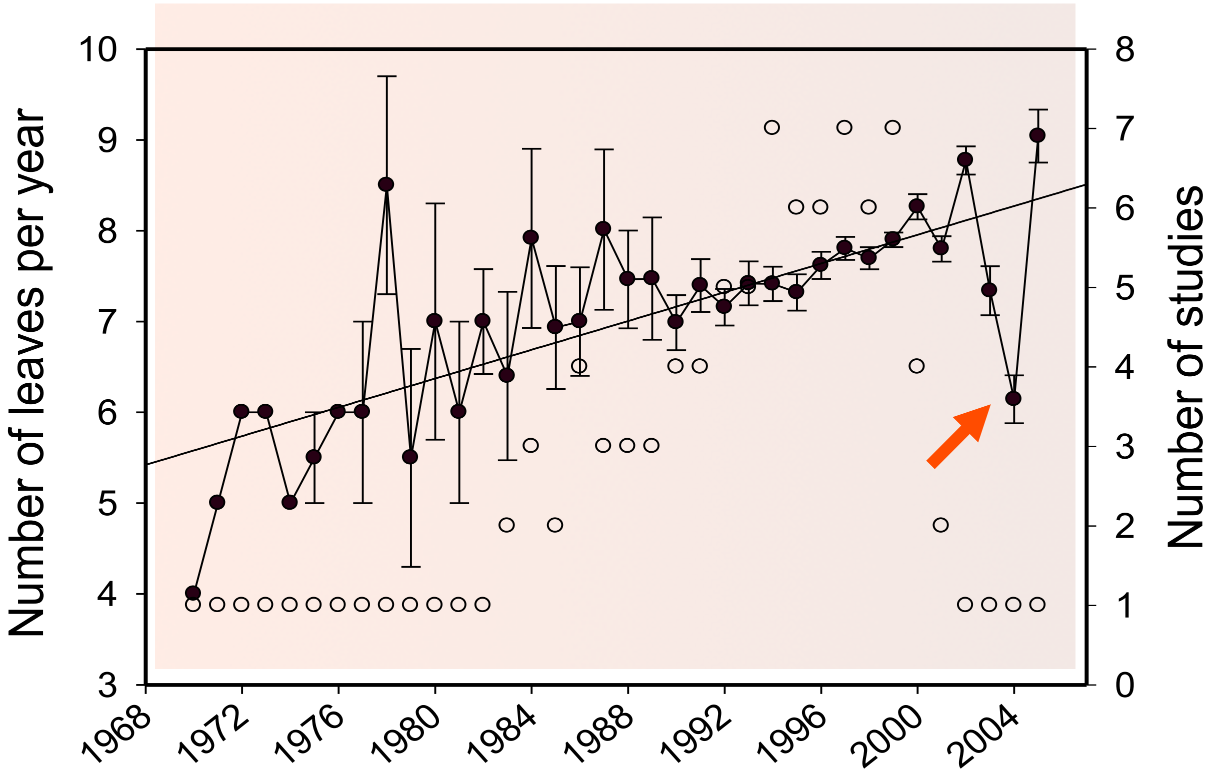
Posidonia
Application examples

- Lepidochronological dating identifies 13 years.
- Sheat isotopic composition is determined for all sheaths (=leaves) produced each year.
- Number of leaves/yr is recorded (equals # of sheaths).
- The rhizomes studied where sampled in the upper and lower depth limits of distribution in the Medes islands meadow
- D13C and production only correlated in the lower limit.



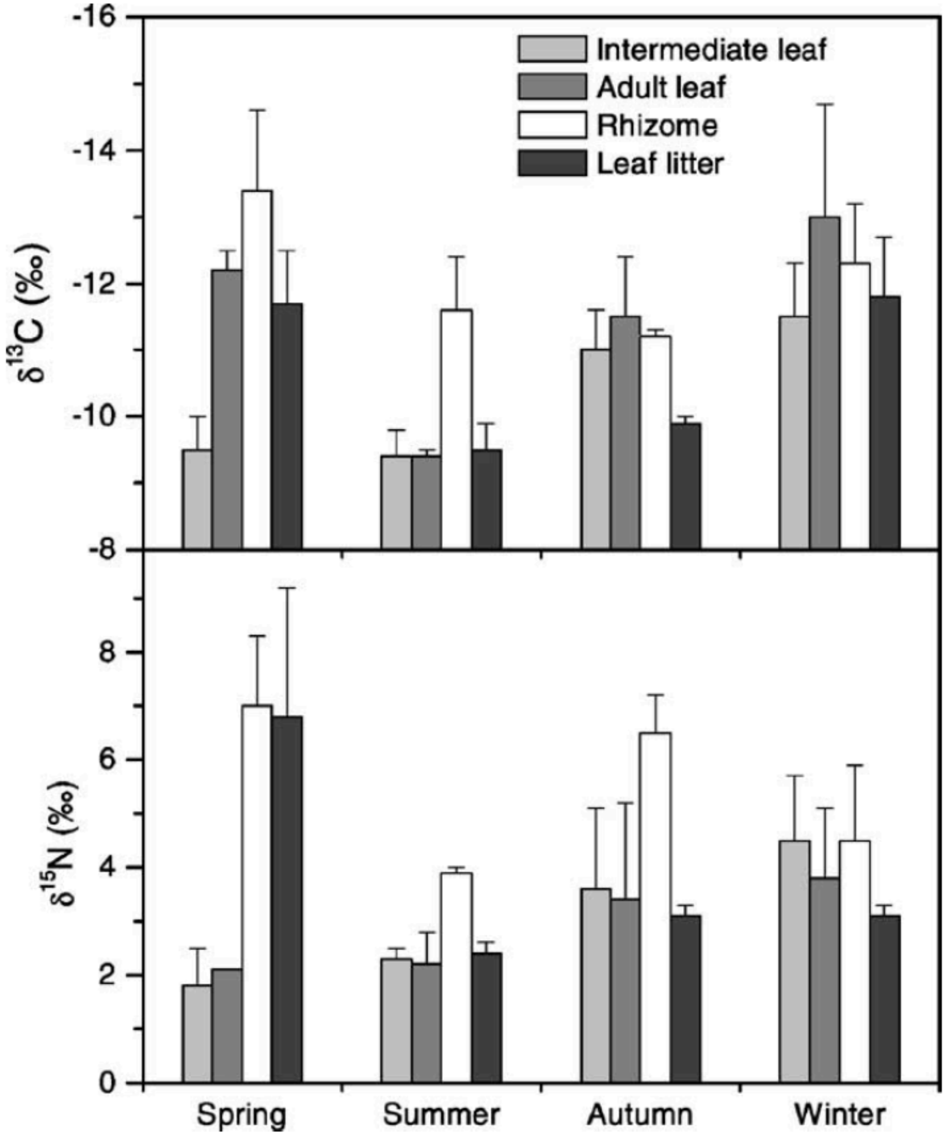
The rhizome archive records thermic extremes

Own and literature data



Seagrass organic record
Inter-organs variability
Isotopic imprints: seasonality and reserves dynamics

- Age-asociated $\delta^{13}C$ variability: consequence of the different photosynthetic capacity.
- Same rational for seasonal variations. Applicable to all organs.
- *Posidonia oceanica* is a sucrose-storing plant. Sucrose is ^{13}C depleted.
- *P. oceanica* stores nitrogen mainly as soluble proteins and aminoacids.
- Applicable to the 'decadal' seagrass organic record.



Vizzini et al 2003

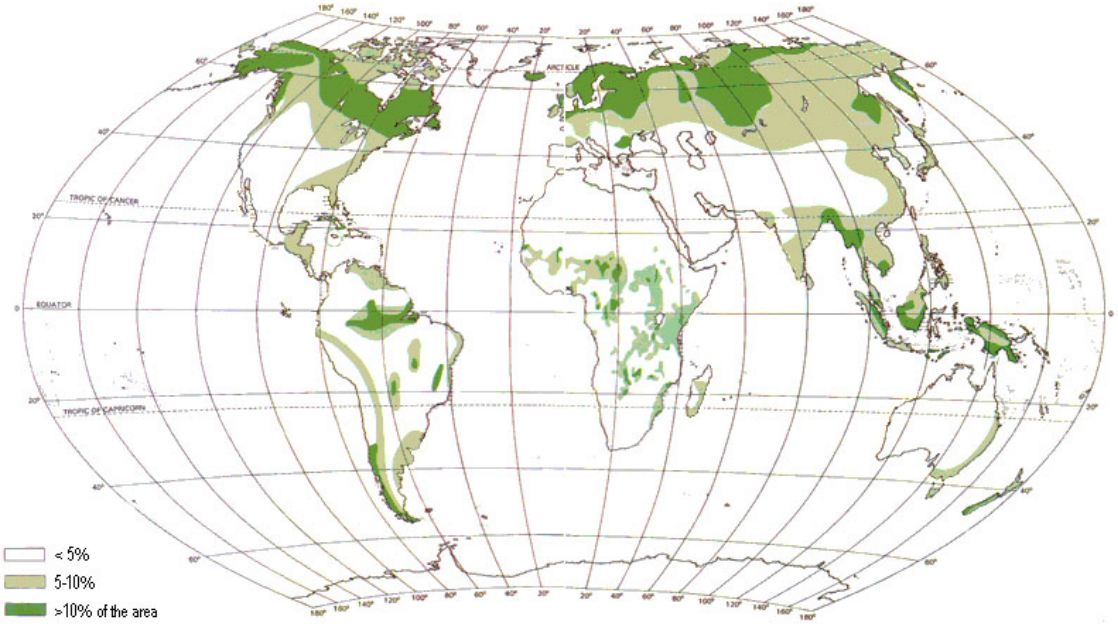
Peat
Description

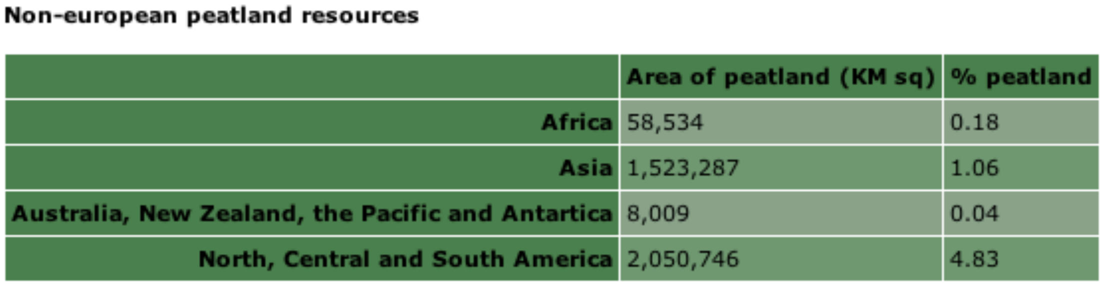
- Peat accumulates at a rate of about **0.5 - 1 mm per year** (or 5-10 mover 10,000 years) with strong local variations. Peat can be formed from mosses, lichens, sedges, grasses, shrubs (heather) or trees. In northern regions, mosses are the main peat-forming plants while trees are the main ones in the tropics. Most peatlands that exist today formed in the last 15,000 years since the last Ice Age.
- Peat consists of accumulated dead plant material of which at least 50% is carbon.
- Water saturation means that plant remains decompose slowly and form peat

Sphagnum spp. Moss peat with sedges of *Carex spp.*

Peat
Distribution of the record

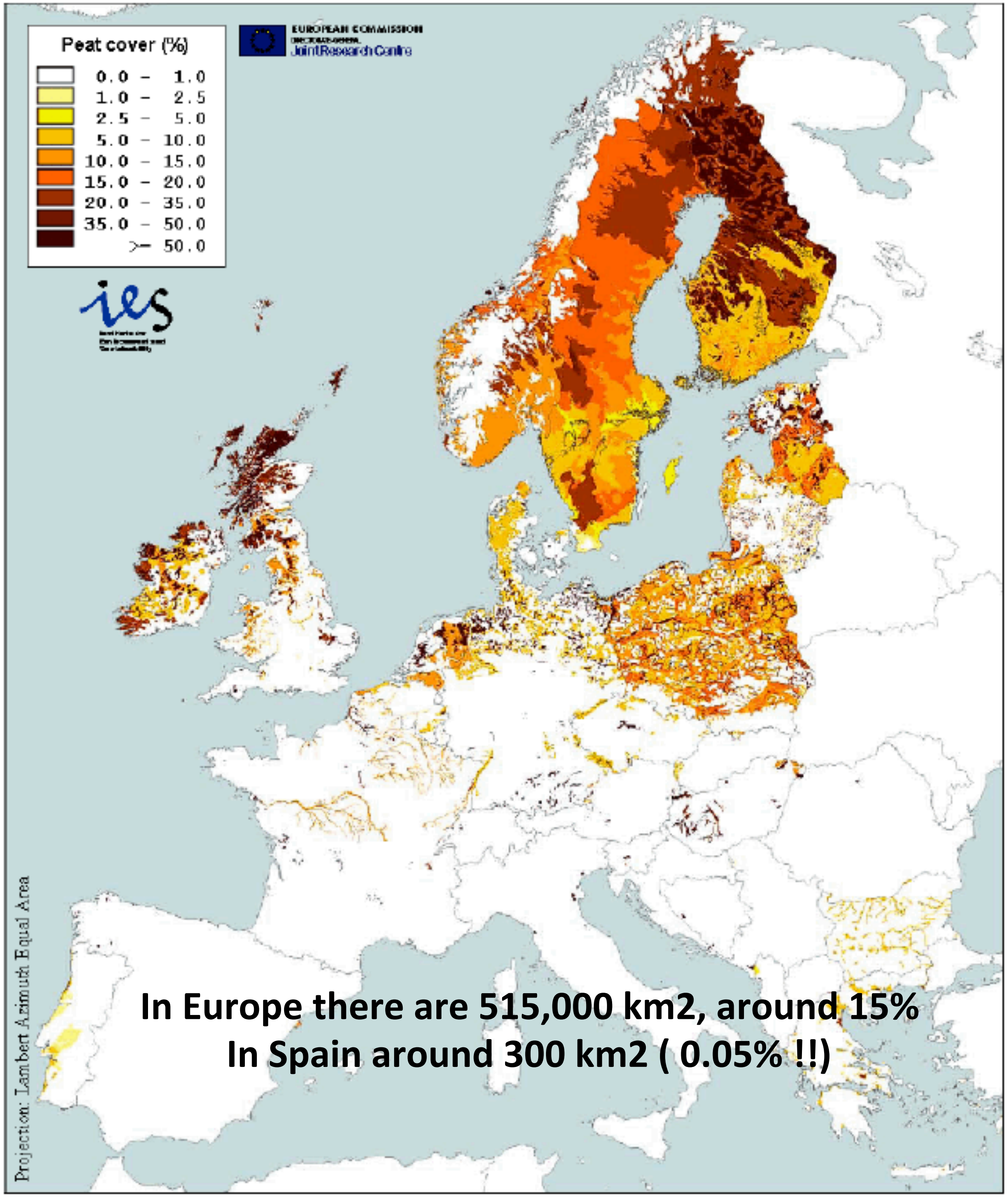
- Peat has been forming in the planet during the last 360 Million yr and nowadays holds 550 Gt of carbon (10^{15}g).
- Worldwide peatlands cover about 500 million hectares of land, some 5-8% of the world's surface.
- They are most extensive in North America, Asia and Europe.
- The remainder are found in tropical areas the most extensive in south-east Asia.
- Overall, hold 10% of freshwater world's resources.





Non-european peatland resources

	Area of peatland (KM sq)	% peatland
Africa	58,534	0.18
Asia	1,523,287	1.06
Australia, New Zealand, the Pacific and Antartica	8,009	0.04
North, Central and South America	2,050,746	4.83



In Europe there are 515,000 km2, around 15%
In Spain around 300 km2 (0.05% !!)

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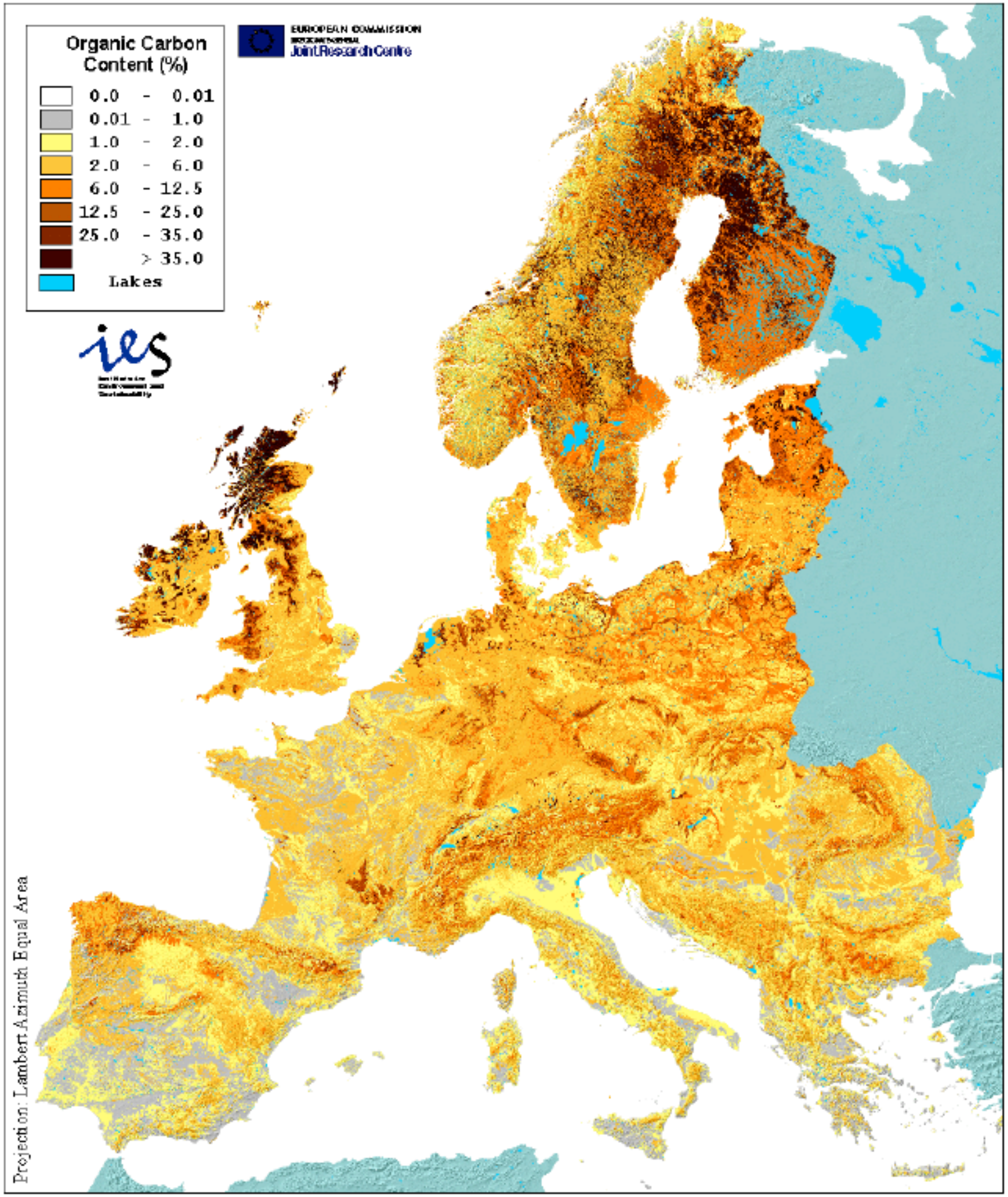

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Peat (=turf, e.g, in Ireland)
Peat types

Peatland
an area with a naturally accumulated peat layer at the surface

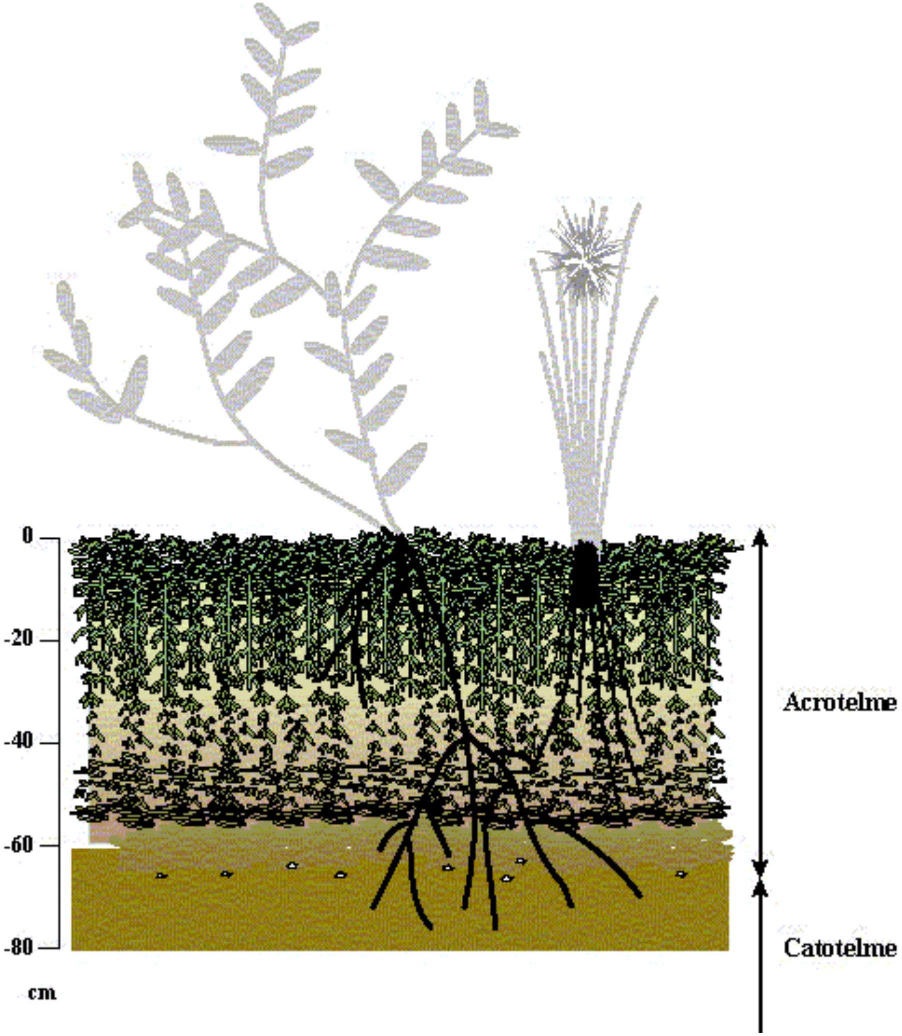
Mire
a peatland where peat is currently forming and accumulating

Bog, pH 3.2 to 4.2; Ash 3%
a peatland which receives water solely from rain and/or snow falling on its surface. **Poor trophic status.** Up to **12 m thick**!!

Fen pH 7 to 8; Ash 10%
a peatland which receives water and **abundant nutrients from the soil**, rock and groundwater as well as rain and/or snow. Up to **2 m**.

Peat
Structure

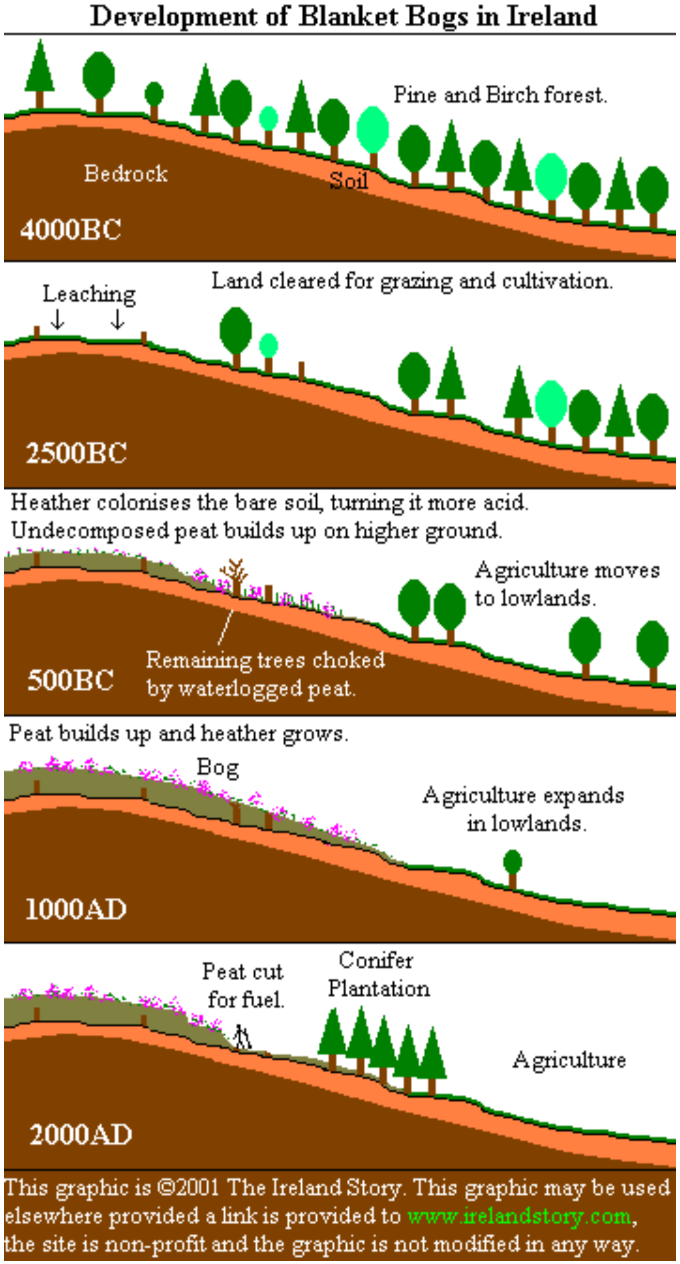
- Bogs: 98% water! Only 2% solids.
- Fens: 85% / 15%
- A bog consists of two layers:
  - **the upper**, very thin layer, known as the **acrotelm**, is only some 30cm deep, and consists of upright stems of the Sphagnum mosses, largely still alive and colourful with their red, yellows and ochre. Water can move rapidly through this layer.



  - **Below** this is a very much thicker bulk of peat, known as the **catotelm**, where individual plant stems have collapsed under the weight of mosses above them to produce an amorphous, chocolate-coloured mass of Sphagnum fragments. here the water slowly seeps down through the bog over several weeks or even months.

Peat
Peat formation

Peatlands are composed of deep layers of waterlogged peat and a surface layer of living vegetation. Peat consists of the **dead remains of plants** (and to a lesser extent of animals) that have accumulated over thousands of years. Peat accumulates in areas where the rate of plant **production exceeds the rate of plant decomposition**. Complete plant decomposition is prevented in areas where waterlogging occurs.


Development of Blanket Bogs in Ireland

This graphic is ©2001 The Ireland Story. This graphic may be used elsewhere provided a link is provided to www.irelandstory.com, the site is non-profit and the graphic is not modified in any way.

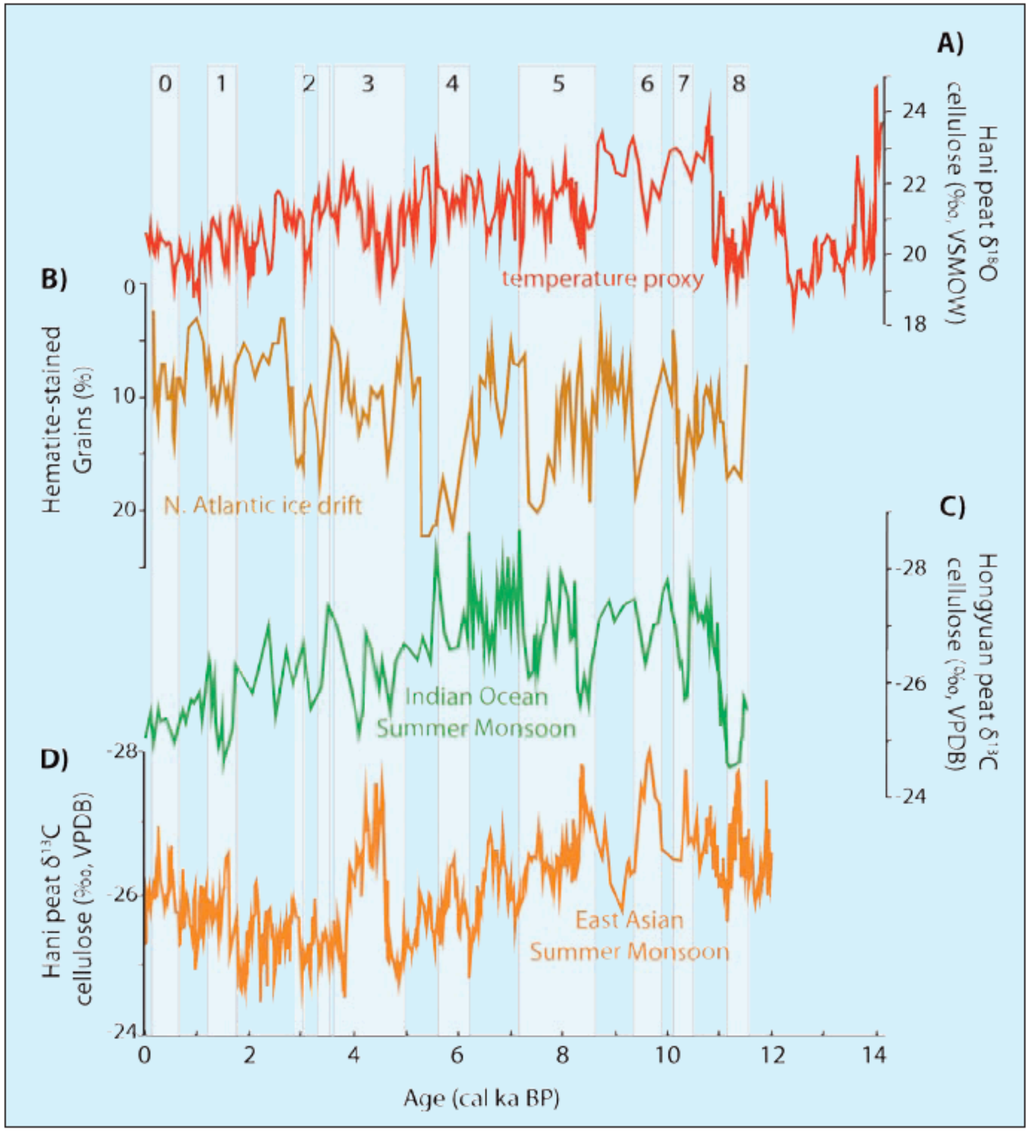
Peat
Holocene isotopic series

- Oxygen isotopes (δ^{18}O) in water molecules undergo temperature-dependent fractionation during condensation. Variations in δ^{18}O of meteoric water are generally positively correlated with atmospheric temperature (Dansgaard, 1964).

- During photosynthesis, the δ^{18}O signature of the source water is recorded in cellulose molecules.

- The amount of rainfall is negatively correlated to the plant δ13C value; the larger the amount of rainfall, the smaller the δ13C value (Lee et al., 2005; Wang et al., 2008).

Peat cellulose isotopes as indicators of Asian monsoon variability

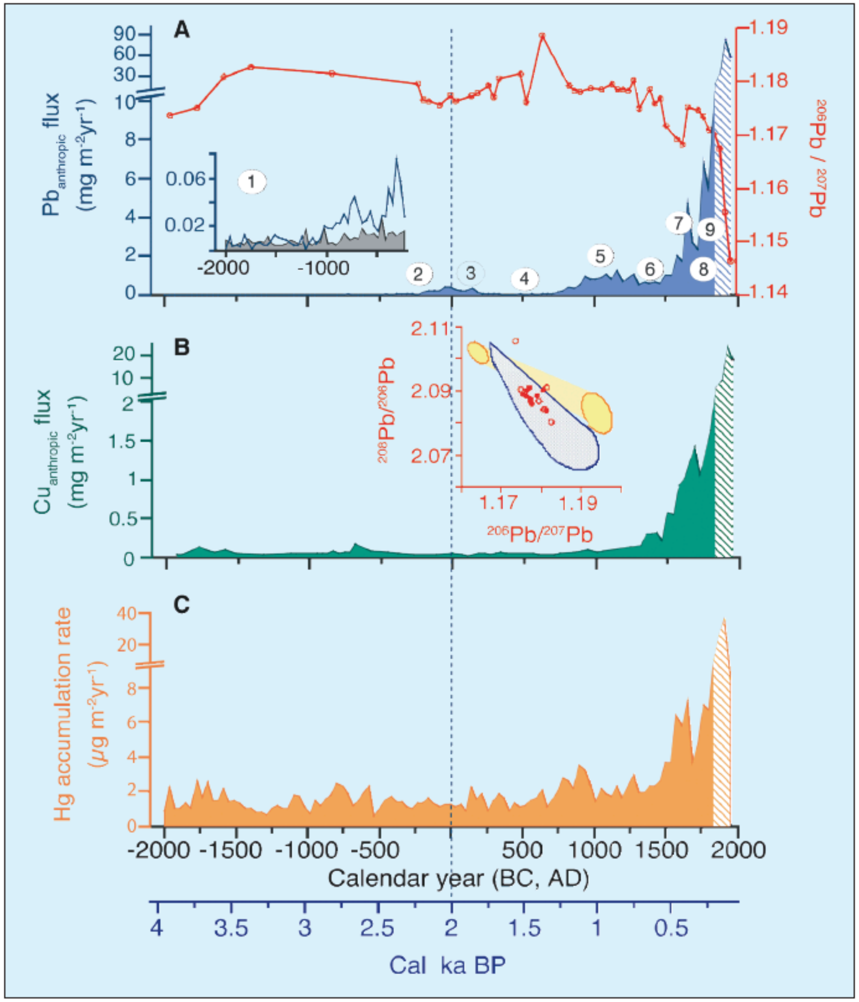


Hong et al 2010

Peat
Application examples

- Some bogs are uniquely suited to natural and anthropogenic airborne particles because their surface layers are only fed by atmospheric inputs (rain, snow, fog, dust).
- Pb is well retained by bogs (adequate pH).
- Stable isotopes allow discriminating between natural and anthropogenic metal abundance, and its origin.
- Metal/Titanium (conservative metal), allows such discrimination.

Peat as an archive of atmospheric pollution



De Vleeschouwer et al 2010

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Mangroves as organic records

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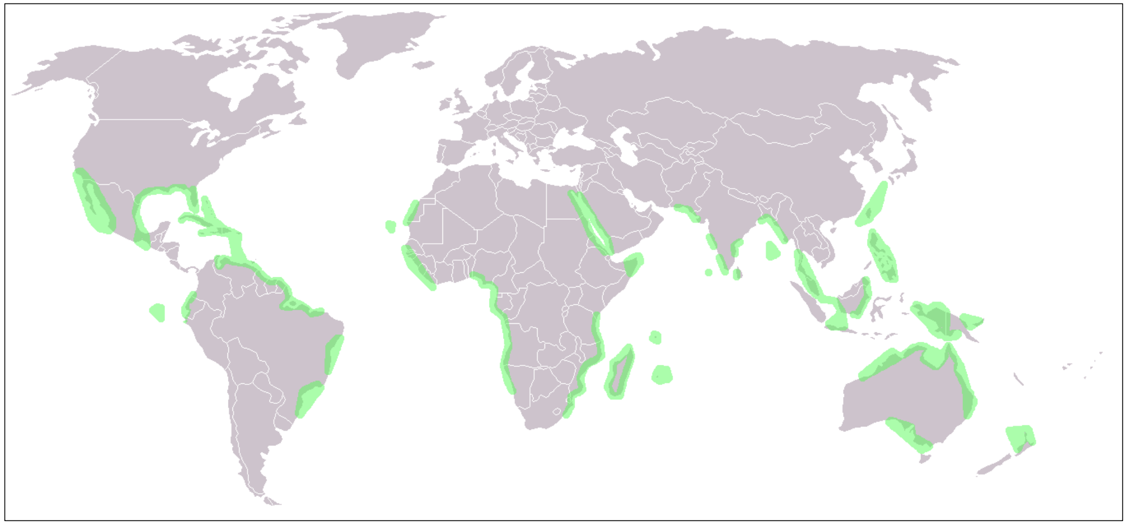
Mangroves
Distribution of the record

Mangroves:
The word 'Mangroves'' refers to a diverse group of unrelated plants that share a common ability to live in waterlogged **saline soils** subjected to regular flooding. They are highly specialised and adapted plants in order to survive in unstable conditions.



Global Mangrove distribution:
Mangroves are distributed circumtropically, and are largely restricted to latitudes between 30° N and 30° S. Total mangrove coverage is 18 million hectares, which represents only 0.45% of world forests & woodland.

Mangroves
Mangrove types

Of the **80 different species** most common are:

Red Mangrove:

It usually grows near the shore of the water, has red roots that raise over the water.

Black Mangrove:

It grows in higher areas than the red mangrove and its roots spread near the trunk in shapes of fingers.

White Mangrove:

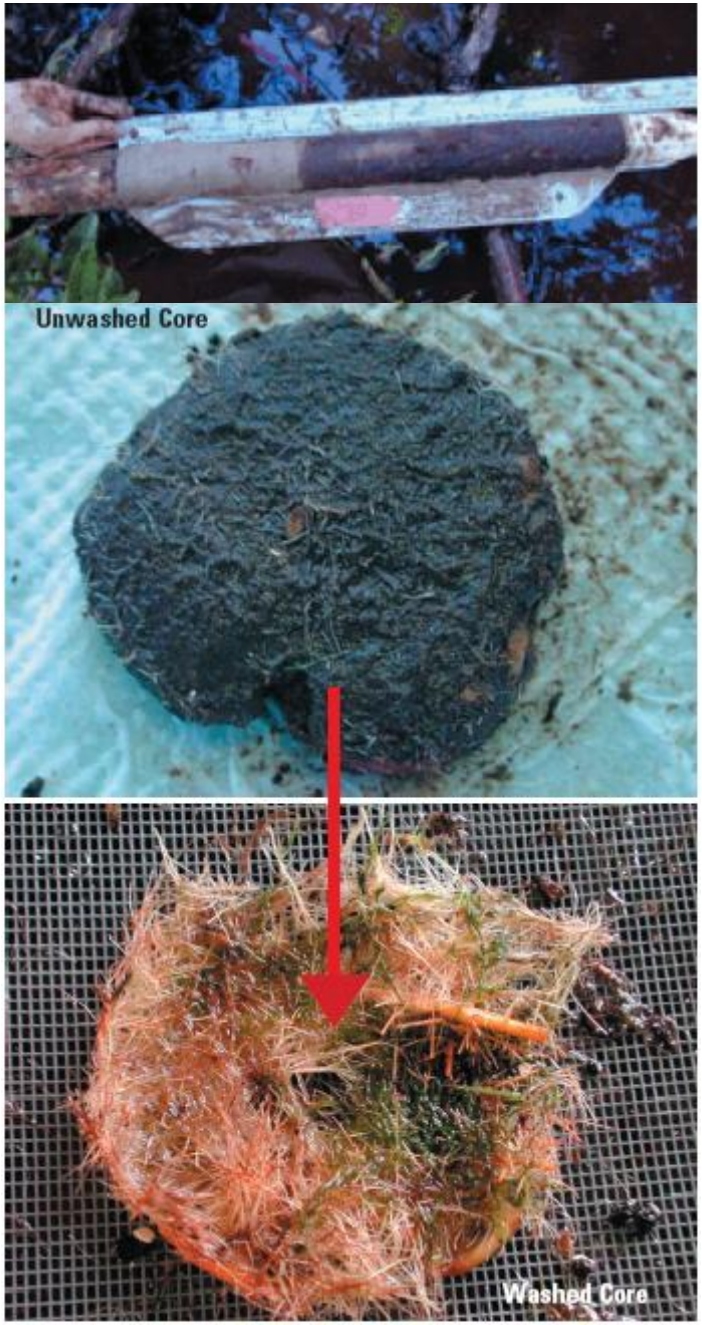
It grows in higher areas than the black mangrove and the roots are not visible.

Mangroves
Structure, formation, dynamics

Mangrove soils develop through a combination of mineral sediment deposition and organic matter accumulation.

The mangrove peat is composed primarily of refractory roots.

Because mangrove soils are waterlogged and nutrient availability is low, decomposition of mangrove roots and other plant tissues is extremely slow (only a few mm per year).



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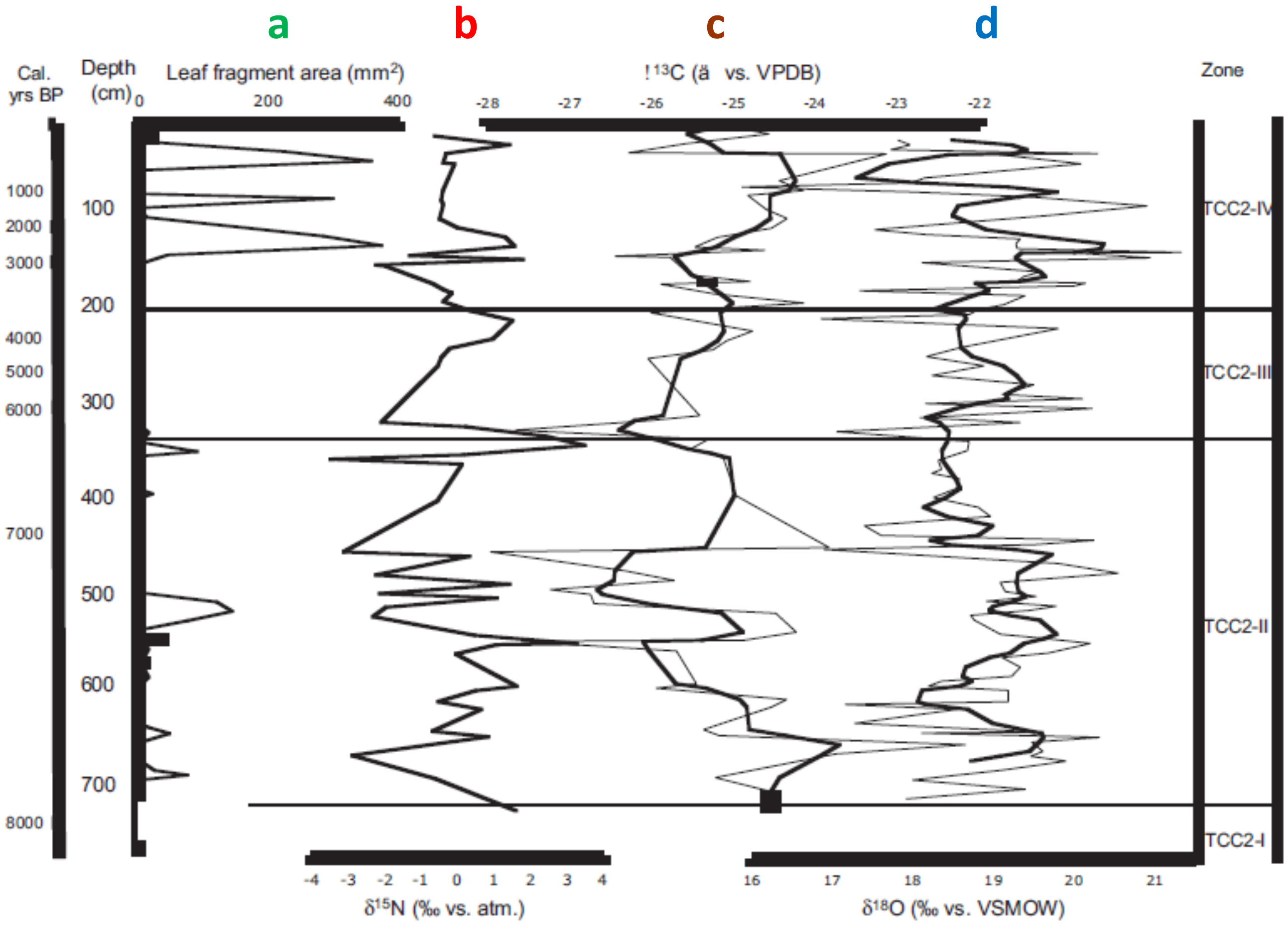
Mangroves
Application examples

Stable-isotope (C, N and O) :

Stable carbon and nitrogen isotope analyses are useful to track past changes in mangrove floral composition, stand structure and nutrient limitations.

Stable-oxygen-isotope composition recorded variations in the proportion of seawater versus precipitation taken up by past mangroves → due to changes in sea-level rise



a Leaf fragment area (mm²)

b stable nitrogen-isotope

c stable carbon-isotope

d stable oxygen-isotope

} Composition of leaf fragments

Wooller et al. 2007

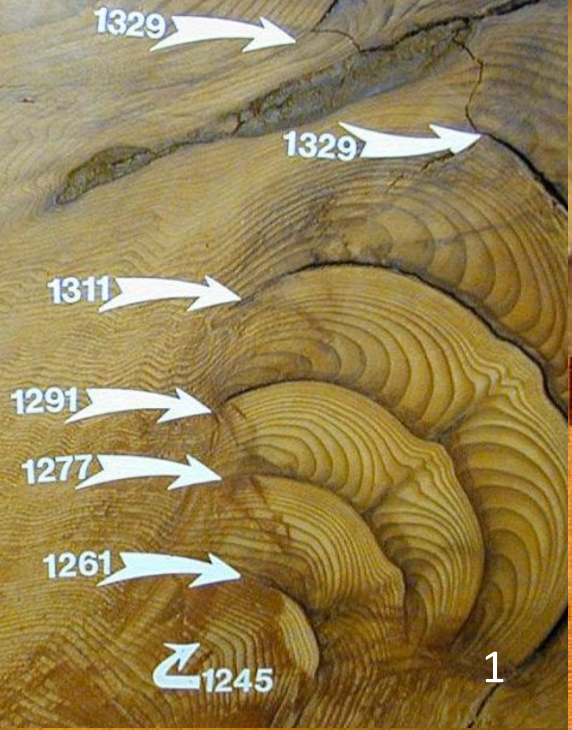
Featuring

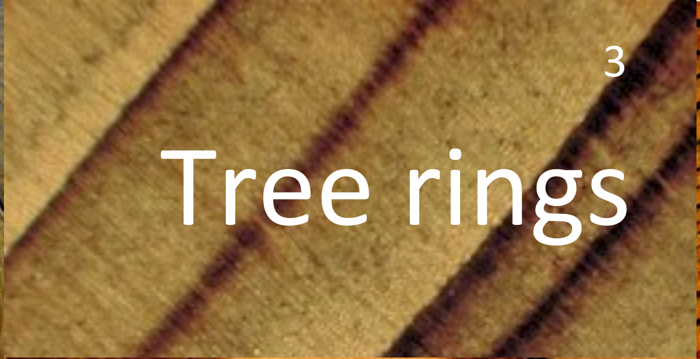
Karen L. McKee - Research Ecologist

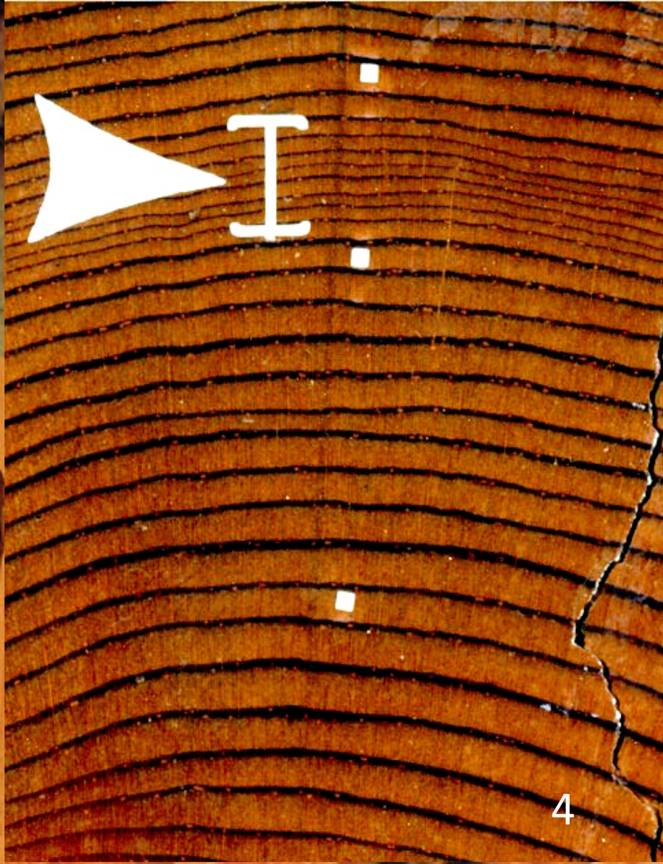
and

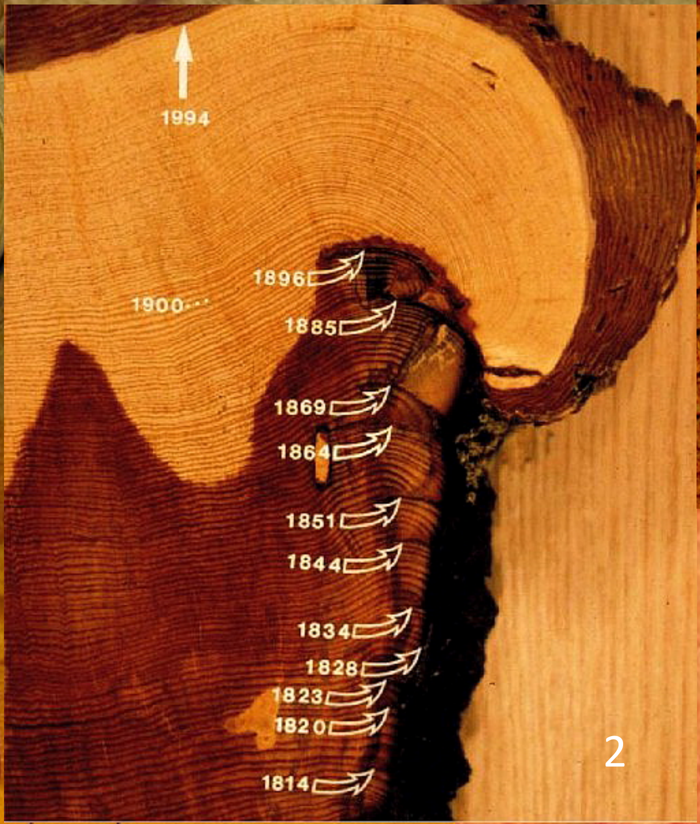
William C. Vervaeke - Ecologist

Tree rings









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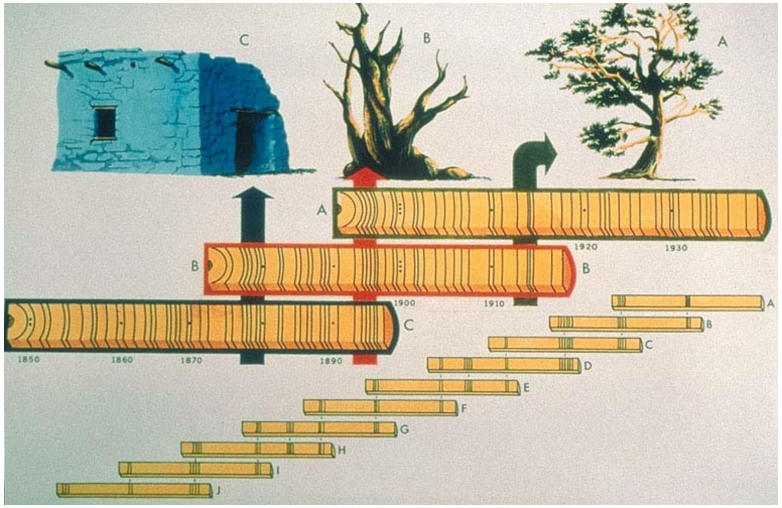
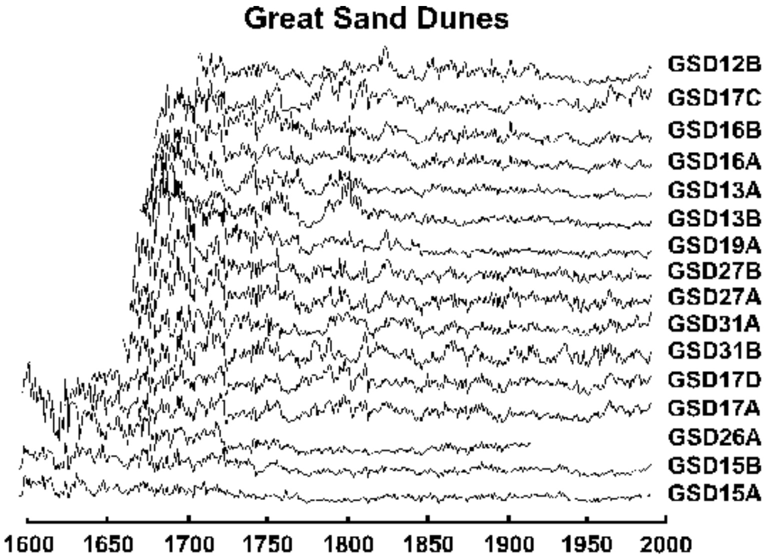
Tree rings
Principles of dendrochron.

Crossdating: matching patterns in ring widths or other ring characteristics (such as ring density patterns) among several tree-ring series allow the identification of the exact year in which each tree ring was formed. without the precision given by crossdating, the dating of tree rings would be nothing more than simple ring counting!

Replication: the environmental signal being investigated can be maximized, and the amount of "noise" minimized, by sampling more than one stem radius per tree, and more than one tree per site.

Crossdating
The fundamental principle of dendrochronology





Organic records
Sampling overview
Tree rings

Some genera are more suitable than others (Pines, Tsugas vs . In aridity or semi-aridity conditions, the techniques of dendrochronology are more consistent than in humid areas.

Rings can be sample from:

- Living trees
- Wood from constructions, furniture, musical instruments
- Fossil trunks

Tree rings are counted under the binoculars from either:

- Full slices of a trunk or
- Cores taken with small drills

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Tree rings
Proxies

-Stable isotopes: the basis of the application of the stable isotopes in dendrochronology lies in the assumption that seasonal and climatic patterns directly or inversely affect the isotopic compositions laid down in the structural tissues produced by the tree.

-Typical **parameters** affecting studied include: **temperature, precipitation, sunlight, daylength, and atmospheric CO_2.**

-Most common proxies used are **d13C, d18O, dD, d15N**

-**Trace elements, metals, pesticides, etc.**

-**Cellulose** is a common compound used for isotopic analysis

Evapotranspiration

d18O, records oscillations wet/ dry seasons.

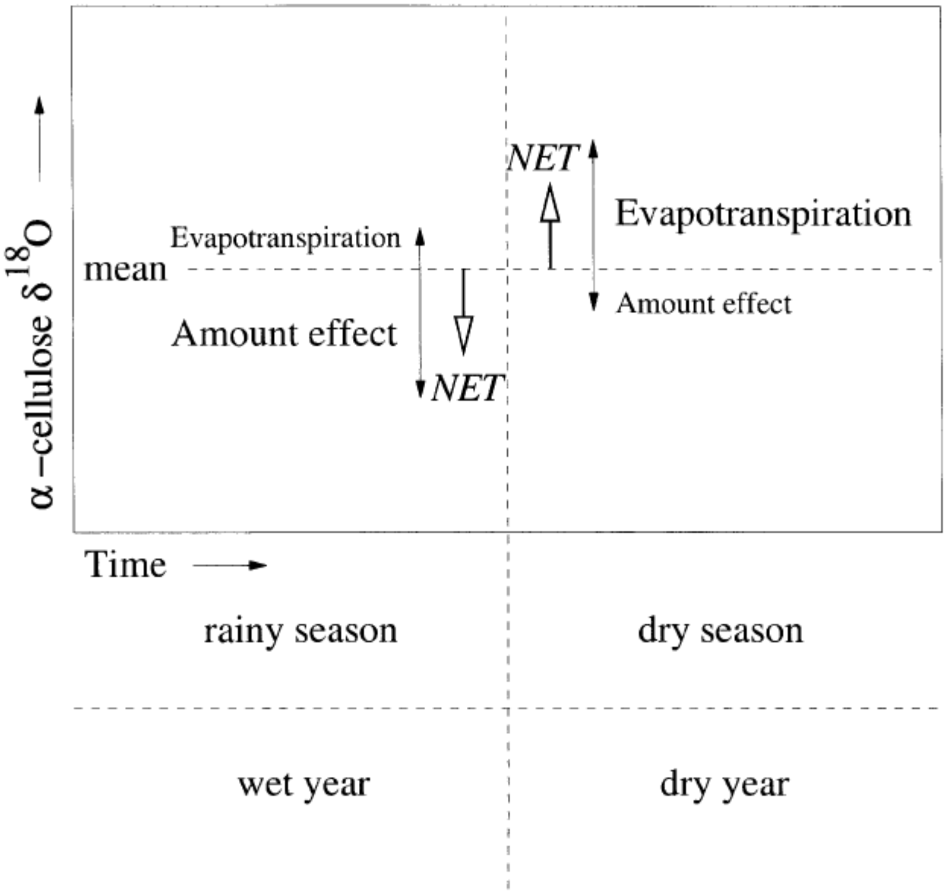
California Red Wood forest fog

dD, records oscillations rain/ fog water use. Fog and rain have different origins.

Tree rings
Application examples

Dendroclimatology/ecology/hydrology

- During the rainy season the amount effect in tropical convective rainfall should dominate over weaker leaf evaporation, leading to lower xylem δ18O values.
- During the dry season, leaf evaporation will dominate over the amount effect, leading to higher xylem δ18O values.
- Analogous situation in dry vs. wet years.



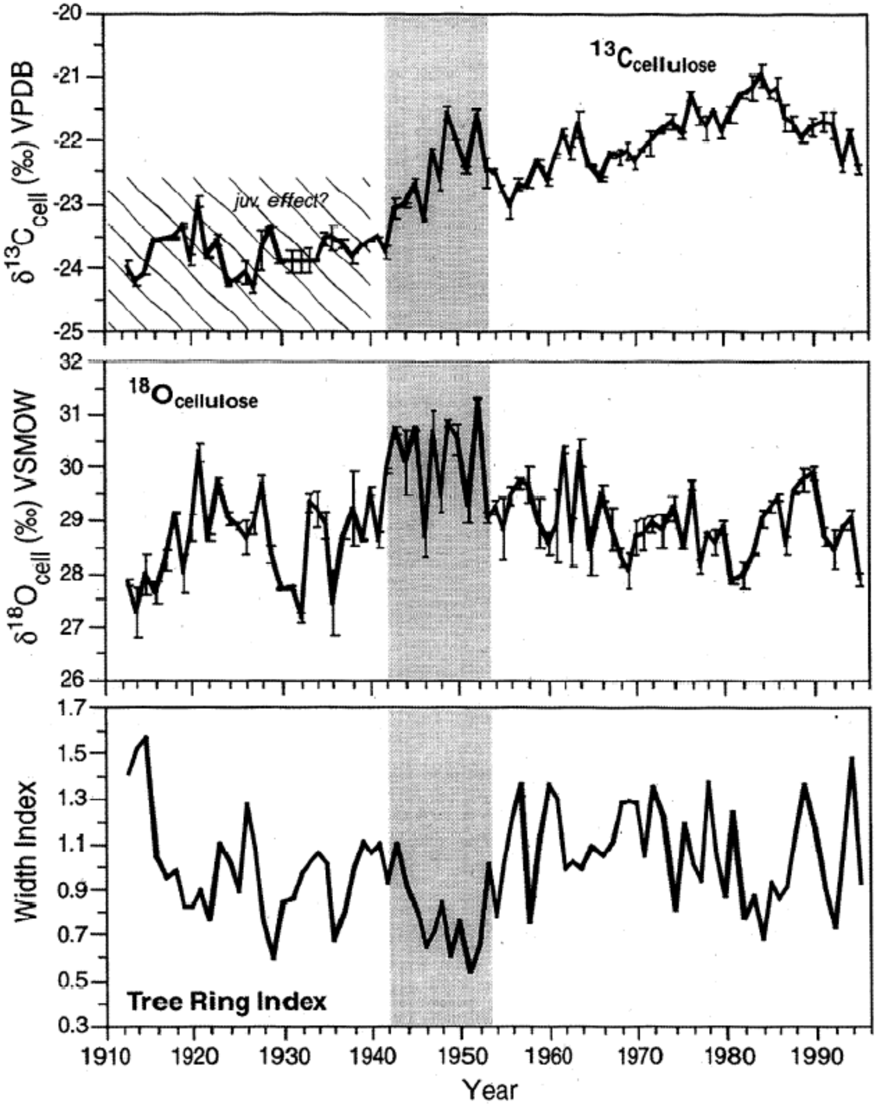
Evans and Schrag 2004

Tree rings
Application example

-D13C and d18O from wood cellulose and tree ring distances. A period of possible **juvenile effect (soil-respired CO_2)** is shown (hatched line section). Shaded section indicates the warmest period in Switzerland (1940-1950).

-D13C and d18O increase following a **decrease in the gas exchange** (stoma closure).

-Why does d13C increse after the dry period? It should decrease in an anthropogenic atmospheric CO_2 increase scenario…



Anderson et al. 1998

Organic matter Limitations/challenges

- Limitations are many, and based in the fact that **OM components partially transform during aging** and that **multiple factors can have opposed effects on the proxies** making it difficult to interprete their resulting values.
- **Microbial reworking** of organic matter during early diagenesis can potentially modify its bulk carbon isotopic content because organic matter is a mixture of different types of compounds that have different isotopic contents.
- **TOC dilution** by clastic sediment particles or **concentration** by carbonate redisolution: multifactors affecting the proxy.
- Use of $d^{13}C$ to distinguish C4 (or even C3) from algae, can be precluded when the availability of dissolved CO2 is limited and algae begin to use dissolved $HCO3^-$ (d13C = 1 ‰) as their source of carbon. The **C3 signatures approach to C4** due to a DIC 'source effect'.
- While d13C is quite conservative, d15N experiments discrimination during both uptake and recycling. This makes interpretations very complicated.

Organic matter record Literature and web sites

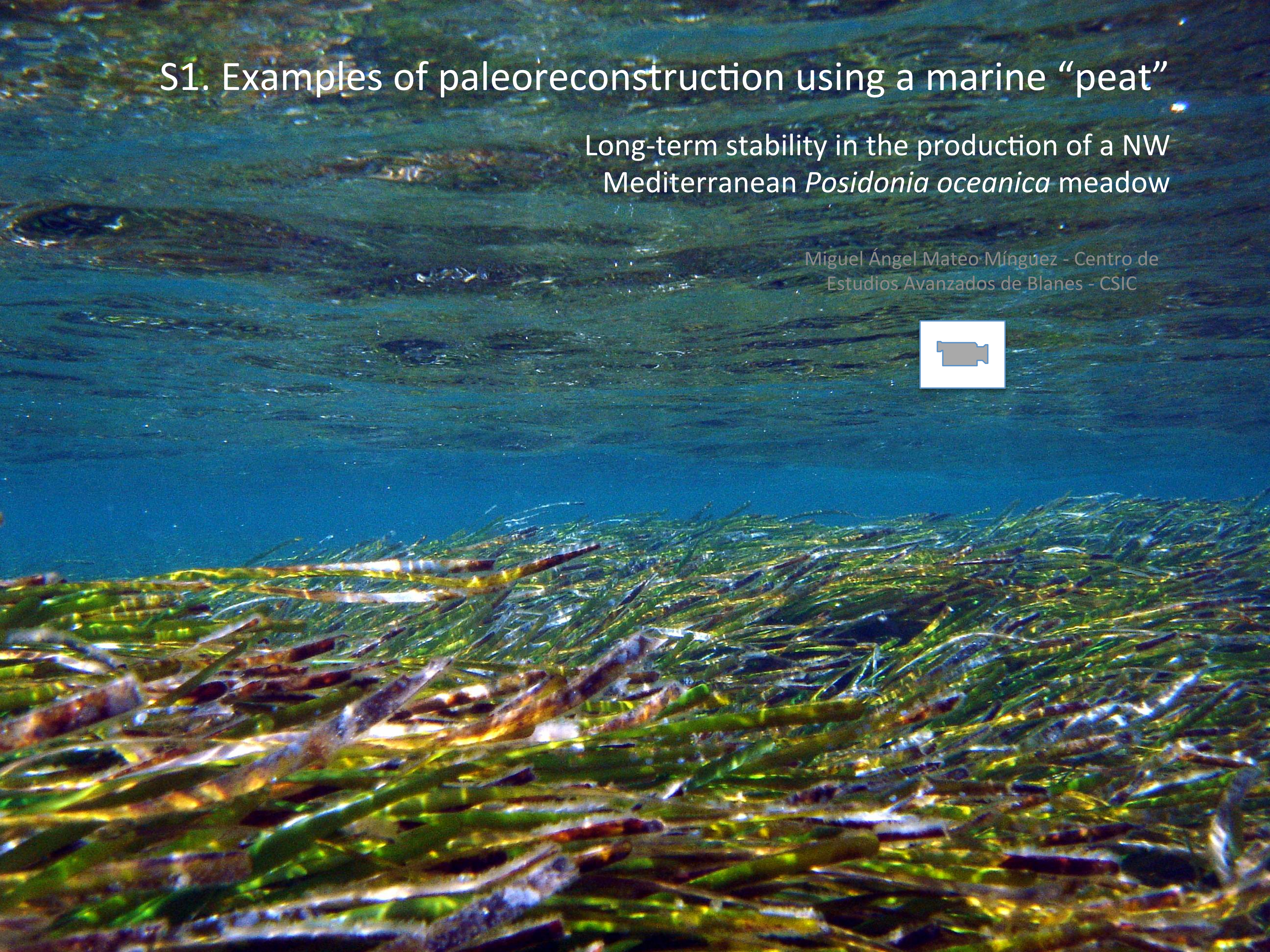
- **Meyers 2003. Applications of organic geochemistry to paleolimnological reconstructions: a summary of examples from the Laurentian Great Lakes. *Organic Geochemistry* 34: 261-289.**
- Engel, M. H. & S. A. Macko, 1993. Organic Geochemistry: Principles and pplications. Plenum, New York, p. 861.
- Killops, S. D. & V. J. Killops, 1993. An Introduction to Organic Geochemistry. Longman, London, p. 265.
- Tyson, R. V., 1995. Sedimentary Organic Matter. Chapman and Hall, London.
- Rossignol-Strick et al, 1982. After the deluge: Mediterranean stagnation and sapropel formation, *Nature* 295, 105 – 110.

There are no real specific web sites devoted to paleoreconstructions using organic matter in soils and sediments, as other proxies ('non-organic') are normally used in combination.

Organic records
Literature and web sites

There are no specific texts globally addressing the organic records of the biosphere.
There are many for each specific one.

- http://www.globalchange.umich.edu/globalchange1/current/lectures/kling/paleoclimate/index.html
- http://www.ncdc.noaa.gov/paleo/paleo.html
- http://en.wikipedia.org/wiki/Proxy_(climate)
- http://en.wikipedia.org/wiki/Paleoclimatology#Reconstructing_ancient_climates
- http://www.ncdc.noaa.gov/paleo/education.html
- http://scidiv.bellevuecollege.edu/gj/Ocean101-Ch05.pdf
- http://www.noc.soton.ac.uk/soes/staff/ejr/DarkMed/dark-title.html
- http://fl.water.usgs.gov/PDF_files/fs73_98_holmes.pdf
- http://www.vibrocoring.com/
- http://www.vibrocoring.com/VCconcepts.html
- http://en.wikipedia.org/wiki/Geochronology

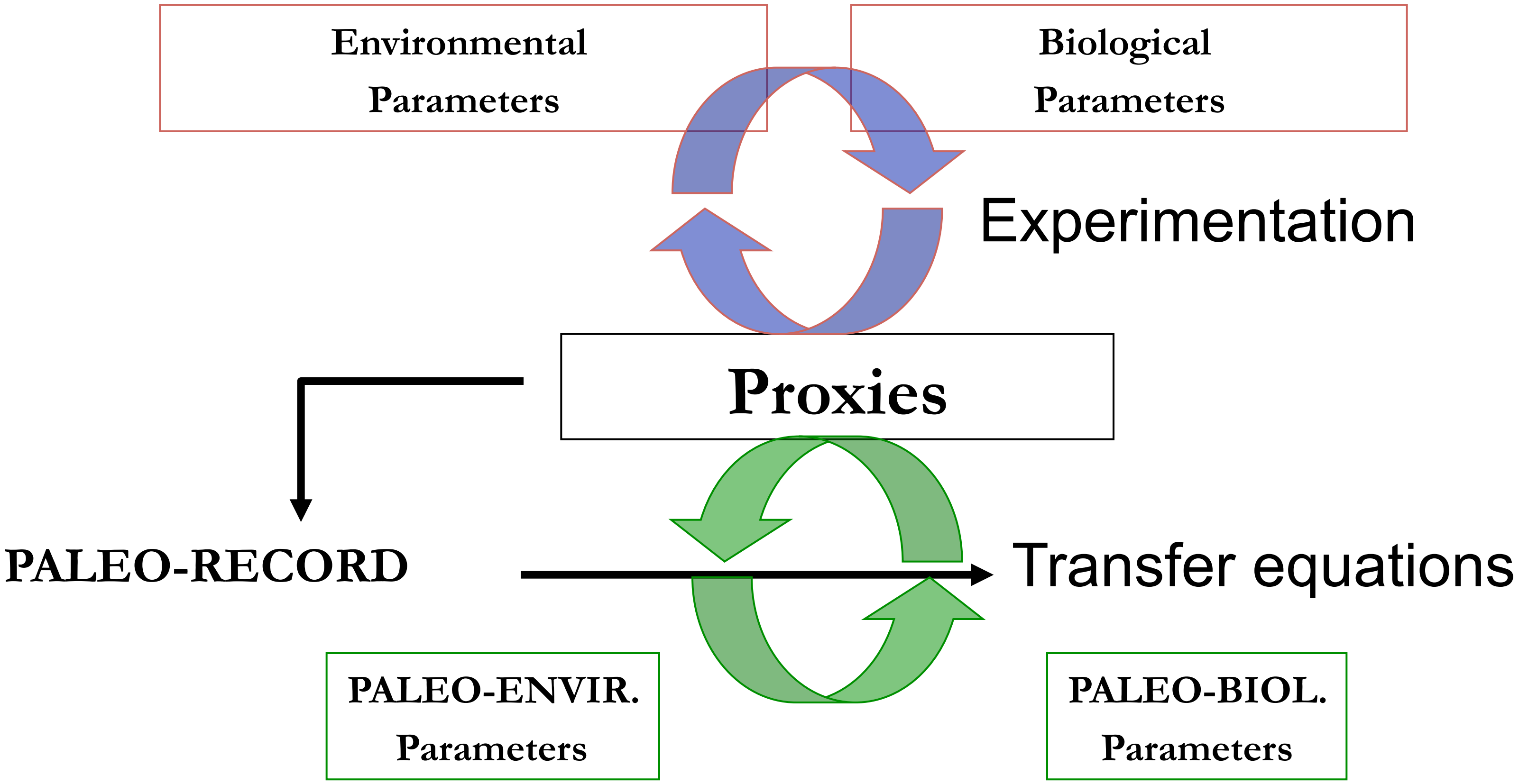


S1. Examples of paleoreconstruction using a marine “peat”

Long-term stability in the production of a NW Mediterranean *Posidonia oceanica* meadow

Miguel Ángel Mateo Mínguez - Centro de Estudios Avanzados de Blanes - CSIC

Basis for paleoreconstruction



Environmental Parameters

Biological Parameters

Experimentation

Proxies

PALEO-RECORD

Transfer equations

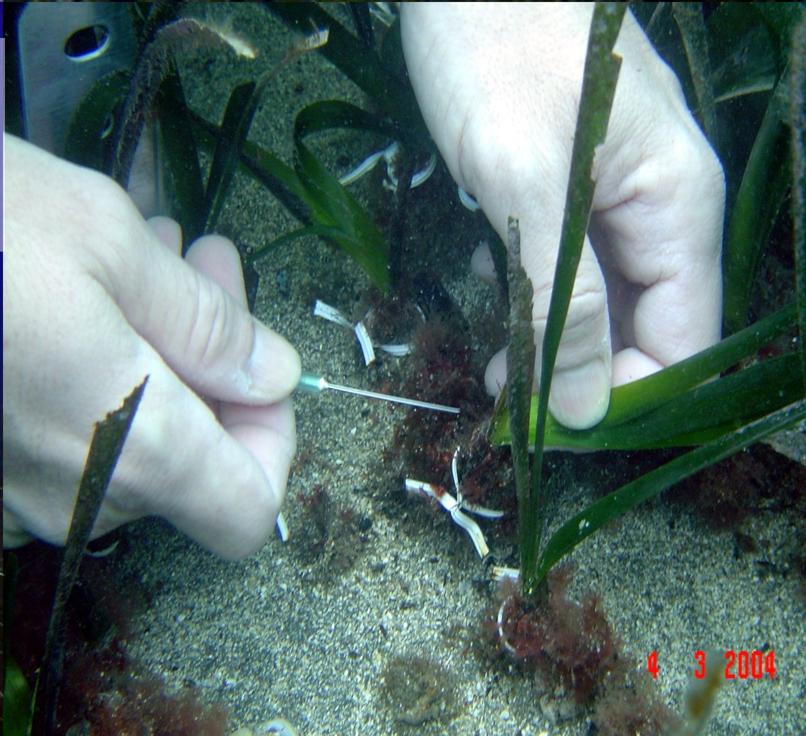
PALEO-ENVIR. Parameters

PALEO-BIOL. Parameters

Example of paleoreconstruction

Calibrating the proxy

Miguel Ángel Mateo Mínguez - Centro de Estudios
Avanzados de Blanes - CSIC



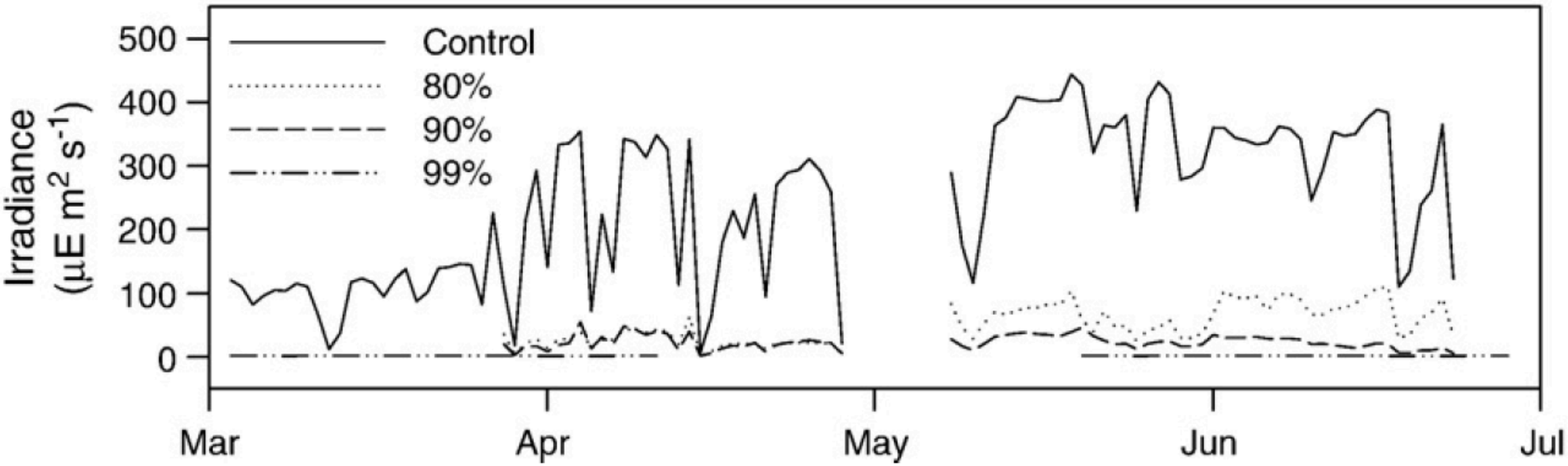
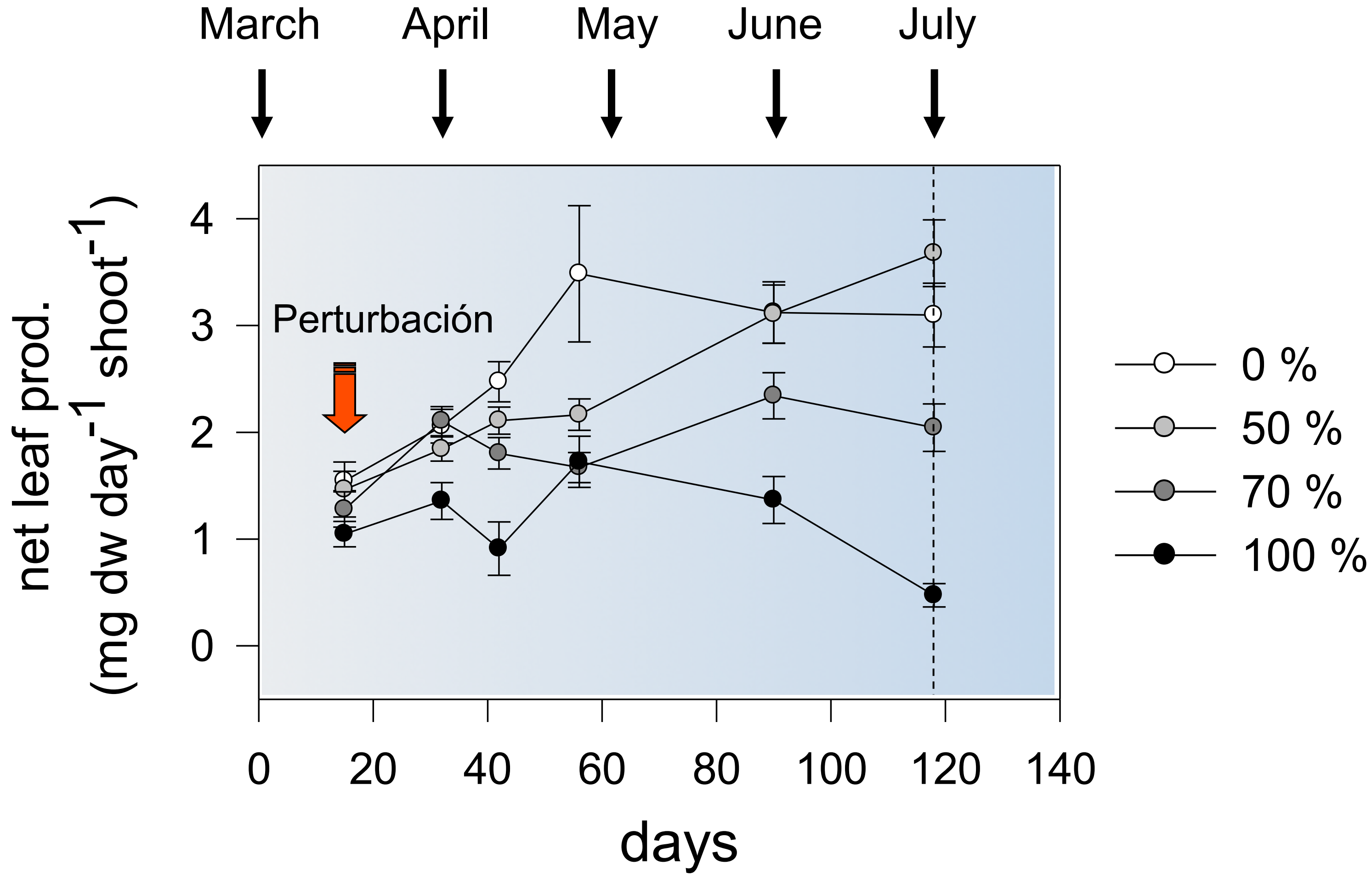
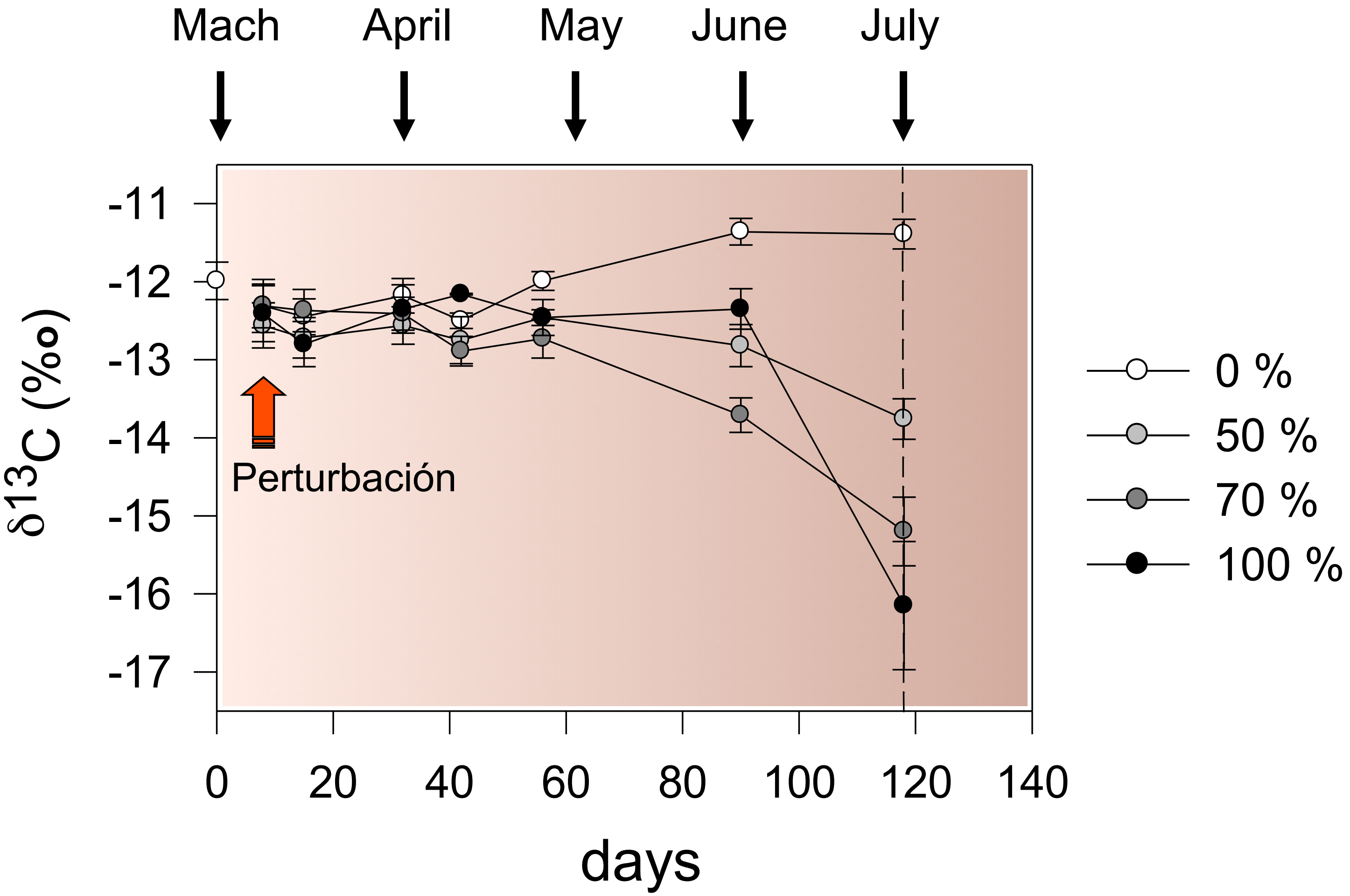
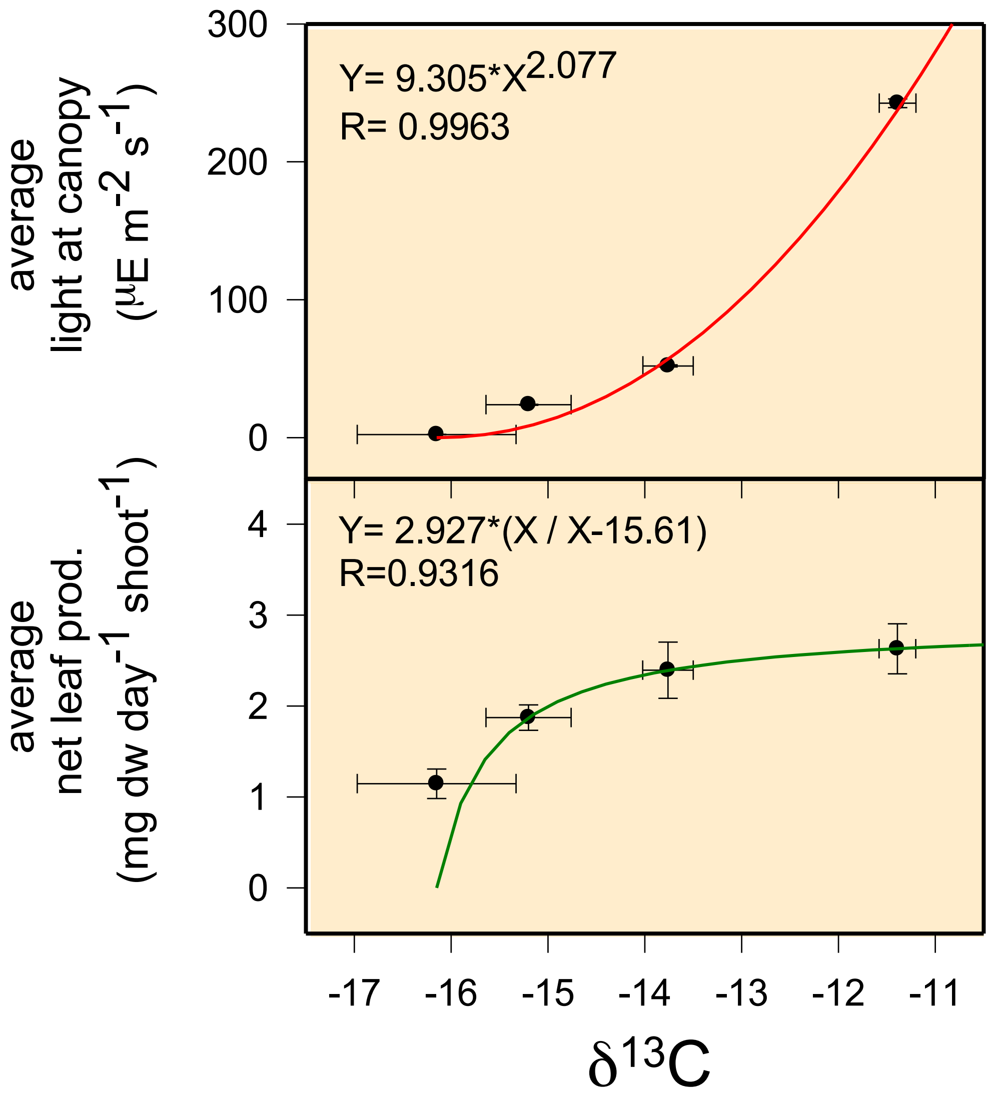


Fig. 4. Daily average irradiance recorded at the canopy under the four shading treatments.


March
April
May
June
July
Perturbación
net leaf prod.
(mg dw day^{-1} shoot^{-1})
4
3
2
1
0
0
20
40
60
80
100
120
140
days
0 %
50 %
70 %
100 %


Mach
April
May
June
July
-11
-12
-13
-14
-15
-16
-17
$\delta^{13}C$ (‰)
Perturbación
0
20
40
60
80
100
120
140
days
0 %
50 %
70 %
100 %

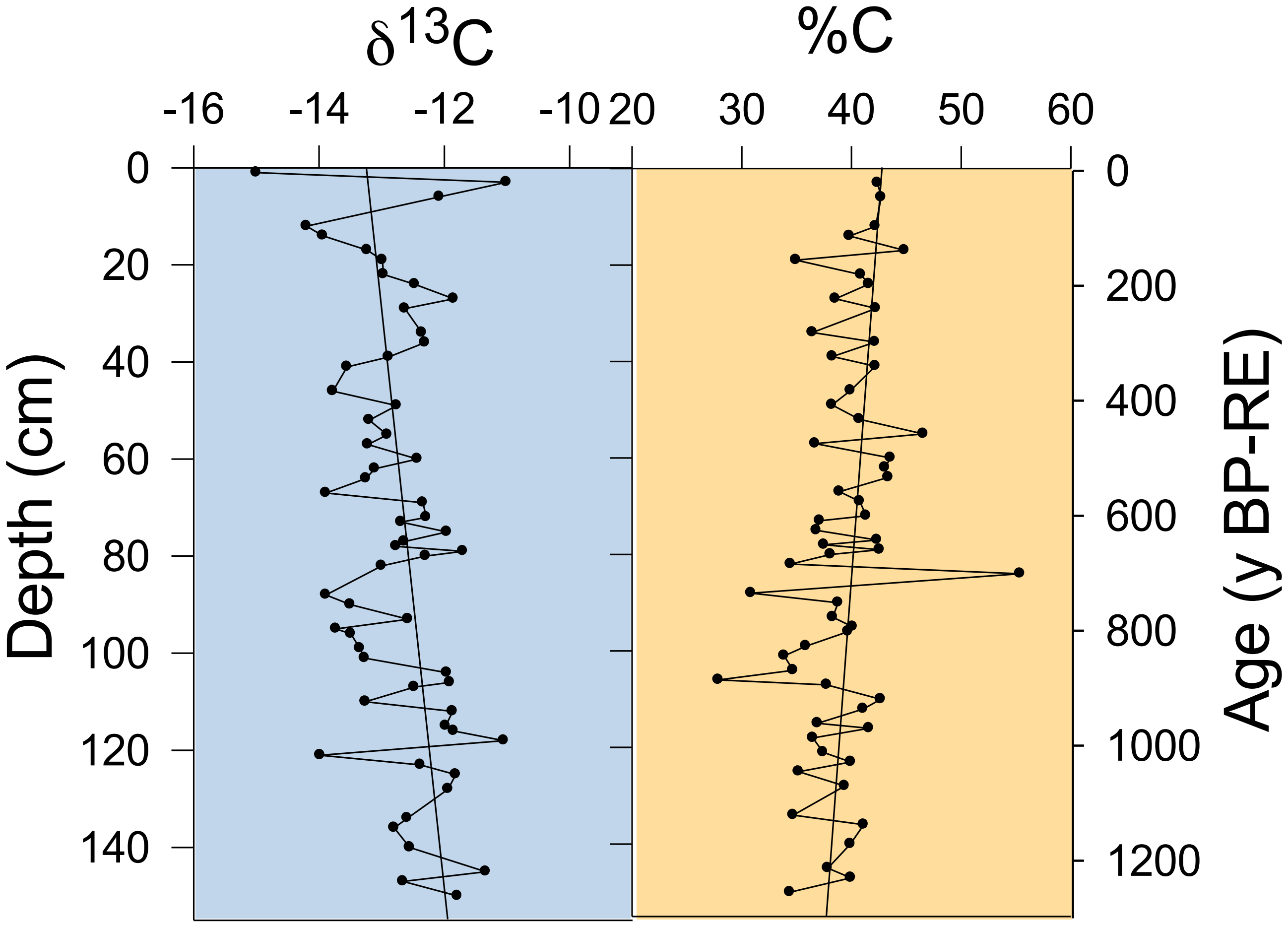


δ^{13}C

Proxy:

De alerta temprana

Paleo-ecológico



¿La huella del Cambio Climático?

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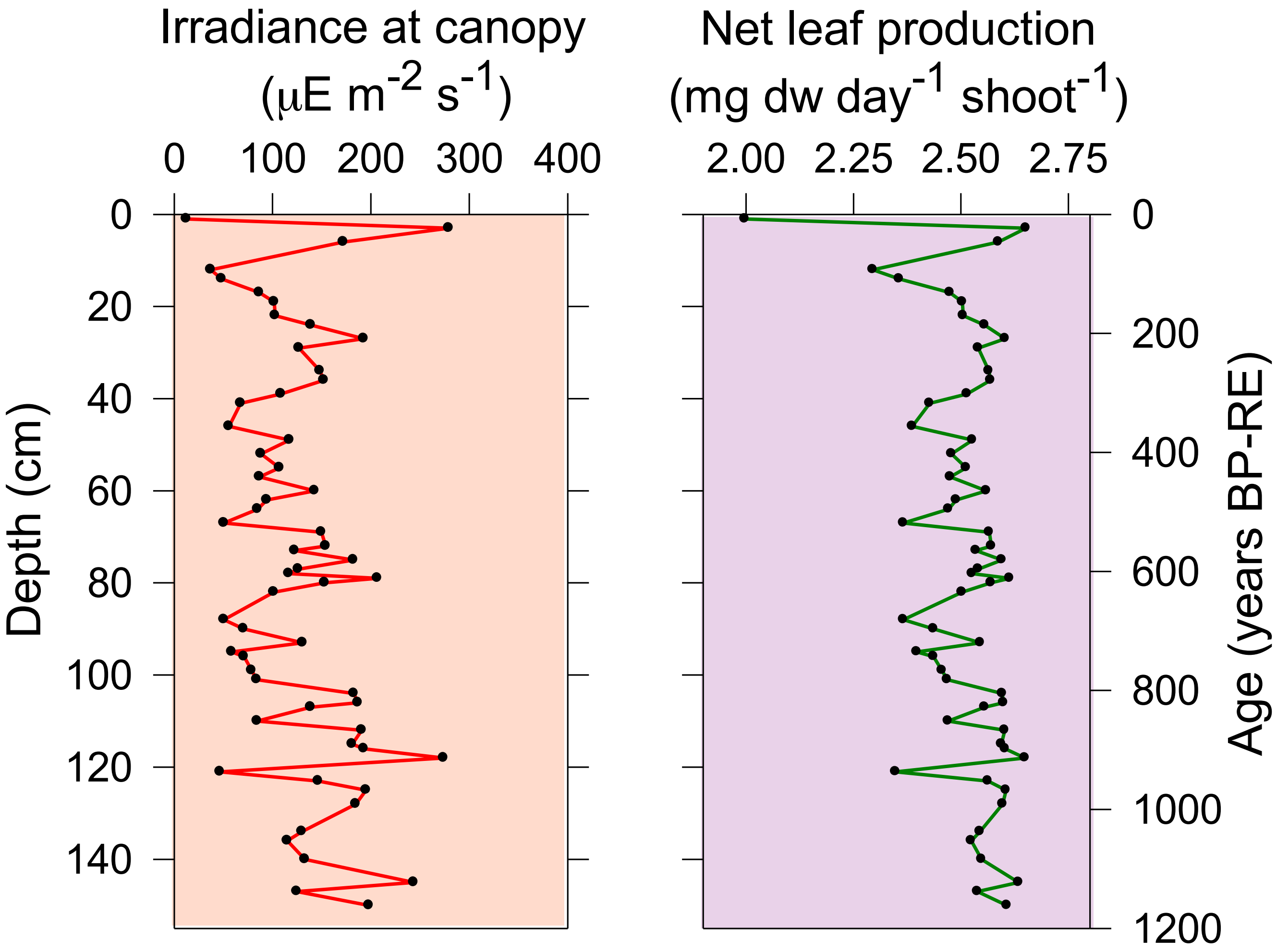

Estasis del Holoceno reciente

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