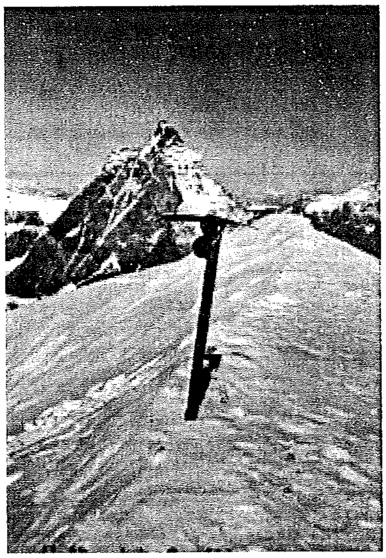
XXVII MOOR-EXKURSION
OF THE INSTITUTE OF PLANT SCIENCES, UNIVERSITY OF BERN

PENNINIC AND INSUBRIAN ALPS

6 – 14 September 2003

EXCURSION GUIDE



Organizers: Cesare Ravazzi, Willy Tinner, Amelia Aceti, Elisabetta Brugiapaglia, Francesco Carraro, Gabriele Carraro, Bruno Cerabolini, Roberta Ceriani, Marco Conedera, Walter Finsinger, Piero Guilizzoni, Petra Kaltenrieder, Stefania Lucchesi, Edoardo Martinetto, Roberta Pini, Per Sjögren, Verushka Valsecchi, Michael Wehrli, Mario Zanni

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Sunday, 7 September

Monday, 8 September

Tuesday. 9 September

Wednesday, 10 September

Thursday, 11 September

Friday, 12 September

Saturday, 13 September

ITINERARY

Saturday, 6 September:
Meeting point Bern, 18.00 h. Welcome party at the Institute of Plant Sciences
Overnight in Bern

Sunday, 7 September:
Bern - Grimsel (Mutternseewji) – Gletsch (Rhone Glacier) – Riederalp (Aletsch Glacier) – Simplon Pass
Overnight at Simplon Pass

Leaders: Willy Tinner, Brigitta Ammann, Adriana Carnelli, Erika Gobet, Andreas Grünig

Monday, 8 September:
Simplon Pass – La Tsermetta – Alpe d'Essertse (Gouillé Rion, Gouillé Loéré, Mire Grande Tsa) – Simplon Dorf Ecomuseum – Simplon Hospiz.
Overnight at Simplon Pass

Leaders: Petra Kaltenrieder, Andreas Grünig, Willy Tinner, Herbert E. Wright

Tuesday, 9 September:
Simplon Hospiz – Maschihüs – Nufenen Pass – Origlio – Muzzano – Locarno.
Overnight in Locarno

Leaders: Willy Tinner, Jean-Nicolas Haas , Michael Wehrli

Wednesday, 10 September:
Locarno – Arcegno (Balladrum, Segna, Piano) – Bellinzona -Locarno
Overnight in Locarno

Leaders: Verushka Valsecchi, Gabriele Carraro, Marco Conedera, Ennio Grisa, Willy Tinner

Thursday, 11 September:
Locarno – Re – Altoggio – Montecrestese – Pallanza – Mottalciata
Overnight in Mottalciata

Leaders: Cesare Ravazzi, Bruno Cerabolini, Roberta Ceriani, Piero Guilizzoni

Friday, 12 September:
Mottalciata – Cervo River – Gifflenga - Castelletto Cervo - Cossato - Candelo – Mottalciata
Overnight in Mottalciata

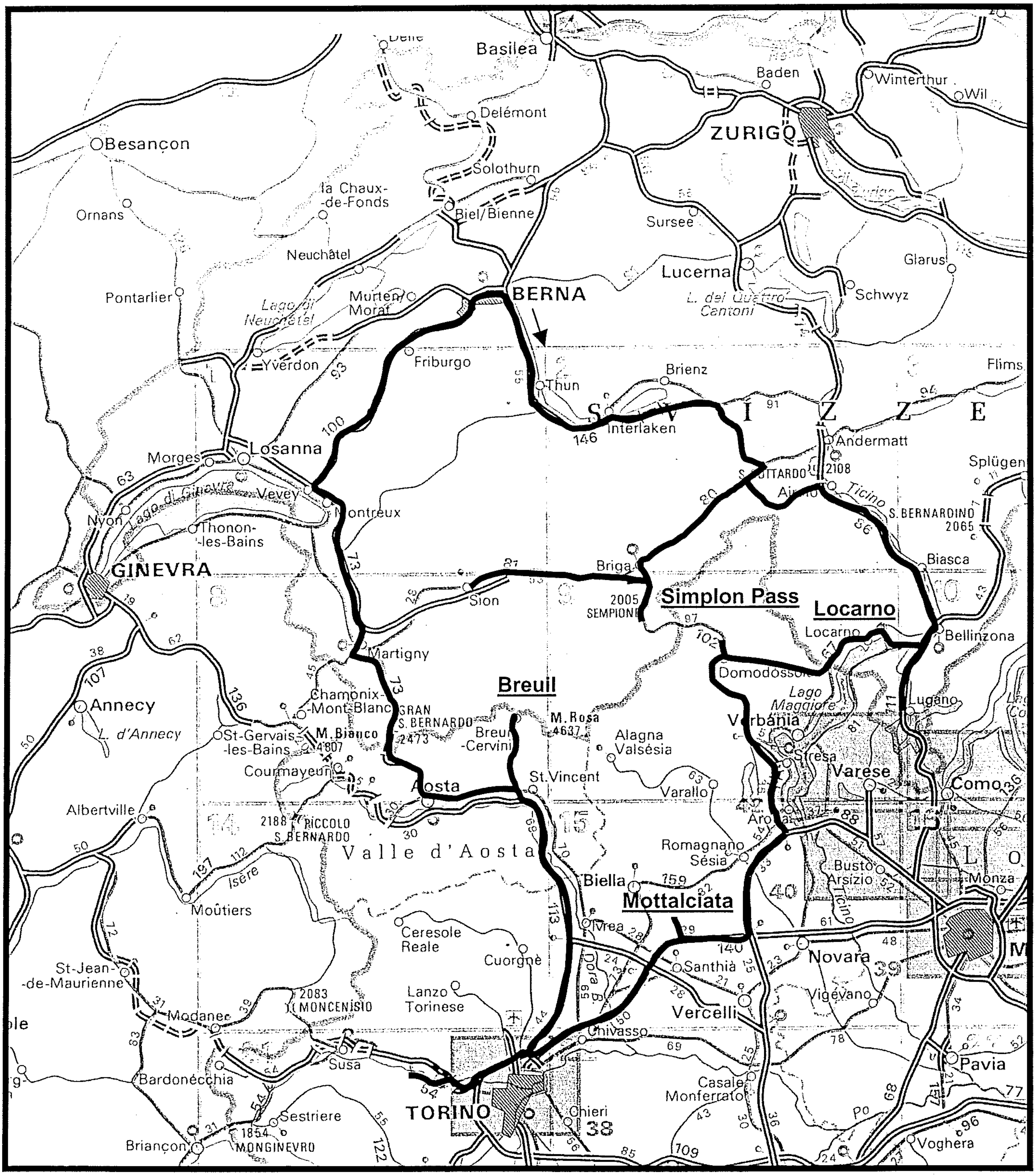
Leaders: Cesare Ravazzi, Bruno Cerabolini, Roberta Cerini, E. Martinetto, Giorgio Tanzi, Mario Zanni

Saturday, 13 September:
Mottalciata – Avigliana – Villa - Breuil
Overnight in Breuil

Leaders: Cesare Ravazzi, Amelia Aceti, Ronni Bessi, Christian Bigler, E. Brugiapaglia, Walter Finsinger

Sunday, 14 September. Return to Bern (at latest at about 14.00 h)

Overview Map, XXVII Moor-Exkursion



Addresses XXVII Moor-exkursion: Penninic and Insubrian Alps

1. Saturday, 6.9.03: Meeting point in Bern, Institute of Plant Sciences, Altenbergrain 21, CH 3013 Bern: 18.00 h. Overnight in Bern:

Hotel Marthahaus
Wyttenbachstr. 22a
CH - 3013 Bern, Switzerland
Tel. +41 31 332 41 35
Fax +41 31 333 33 86
info@marthahaus.ch

Meeting point for Sunday: 07.45 h Institute of Plant Sciences, Bern
2. Sunday, 7.9.03 – Monday 8.9.03: two overnights at Simplon-Pass:

Simplon Hospiz
CH - 3907 Simplon-Dorf, Switzerland
http://www.gsbernard.ch/simplon/
Tel. +41 27 979 13 22
Fax. +41 27 979 14 79
E-mail simplon@gsbernard.ch

3. Tuesday, 9.9.03- Wednesday 10.9.03 : two overnights in Locarno:

Hotel Geranio
Viale Verbano
Lungolago
CH - 6600 Muralto-Locarno, Switzerland
http://www.tiscover.ch/geranioaulac
Tel. +41 91 743 15 41
Fax. +41 91 743 79 94

4. Thursday, 11.9.03- Friday 12.9.03, two overnights in Mottalciata

Centro Turistico Mompolino srl
Regione Mompolino
I - 13874 Mottalciata (Biella), Italy
Tel. & Fax +39 0161 857667
E-mail: mompolino@libero.it

5. Saturday 13.9.03, Farewell party and overnight in Val d'Aosta, Cervinia

Hotel Bich
Frazione Evette n° 48
I - 11028 Valtournenche (Aosta), Italy
Tel. & Fax +39 0166 92148
e-mail: hotelbich@yahoo.it

6. Sunday, 14.9. Return to Bern (at about 14.00 h, for flights: please consider possible highway delays).

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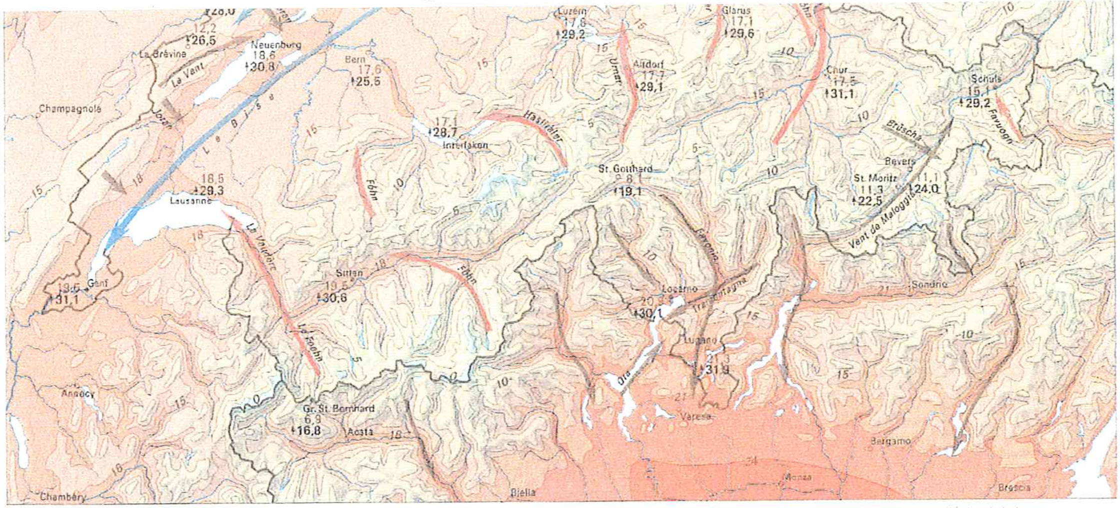
Climate in the western Alps



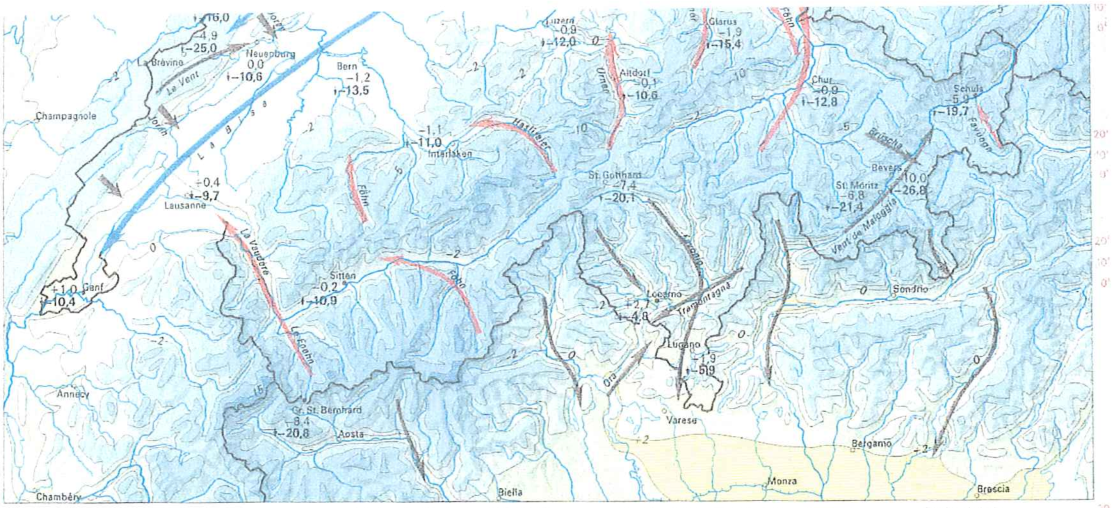
Mittlere Juli-Temperaturen
1:2000000

16,1 Monats-Mittelwerte (1901–1960)
†26,9 Mittlere Jahresmaxima im Zeitraum 1901–1960
• Station mit Klimadiagramm

0° +5° +10° +15° +18° +21° +24° C

Regionalwinde,
zeitweise auftretend
do., relativ kalt
do., relativ warm

Mean July temperatures



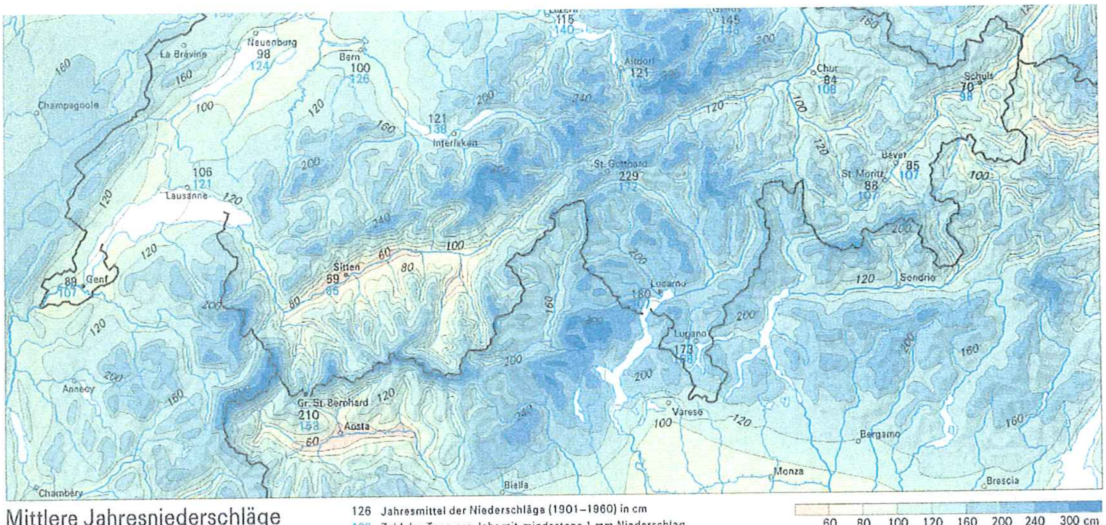
Mittlere Januar-Temperaturen
1:2000000

−2,1 Monats-Mittelwerte (1901–1960)
†−14,2 Mittlere Jahresminima im Zeitraum 1901–1960
• Station mit Klimadiagramm

−15° −10° −5° −2° 0° +2° C

Regionalwinde,
zeitweise auftretend
do., relativ kalt
do., relativ warm

Mean January temperatures



Mittlere Jahresniederschläge
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126 Jahresmittel der Niederschläge (1901–1960) in cm
129 Zahl der Tage pro Jahr mit mindestens 1 mm Niederschlag

60 80 100 120 160 200 240 300 cm

Mean annual precipitation

Source: Schweizer Weltatlas, 1994. EDK

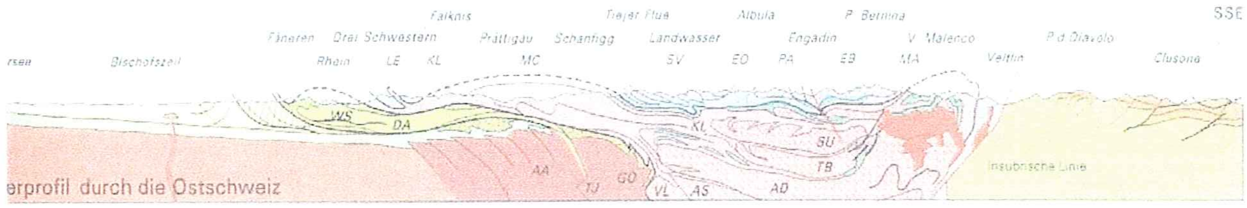
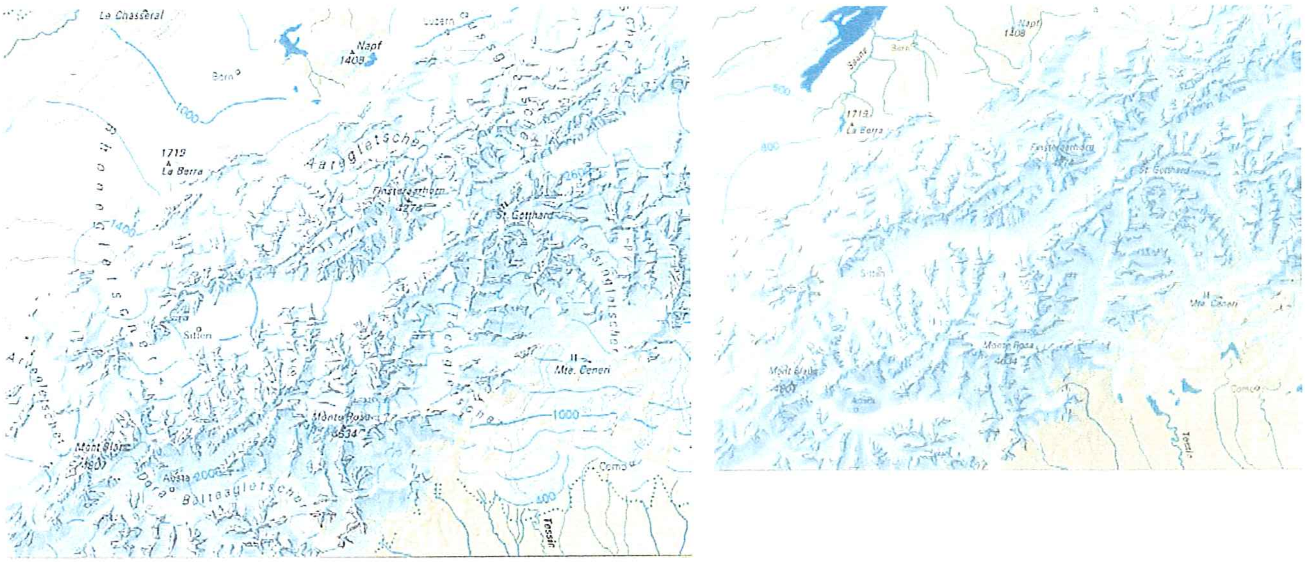


Fig. 2 – Geological section through Western and Central Alps f(NNW to SSE)



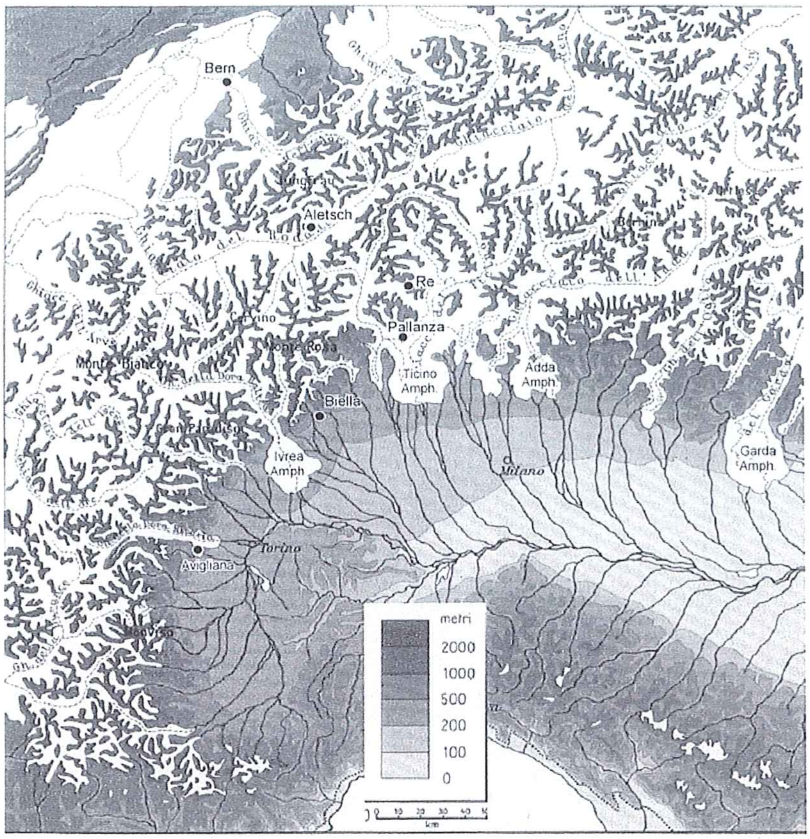
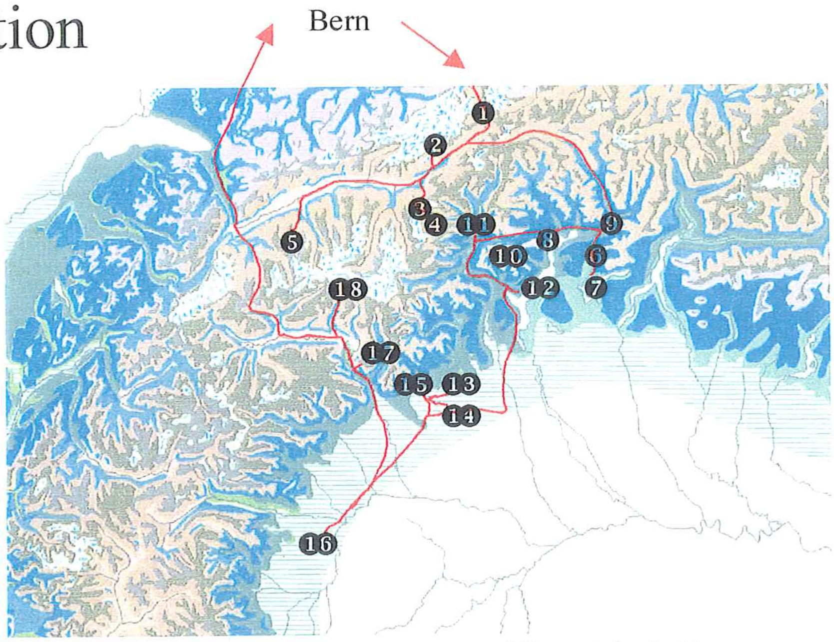


Fig. 3-4 (above): Reconstruction of the glacier extension about 20 Ka cal BP (Alpine Last Glacier maximum) and 17 Ka cal BP (during a stadial phase of the Late glacial). Please note that at the beginning of the Late glacial intestadial (about 14.5 Ka cal BP) the glaciers were well retired into the Alpine valleys (from the Swiss Atlas).

Fig. 5 (left): Map of the Maximum Quaternary Expansion of Glaciers (MEG) in western Alps and northern Apennines, showing the amphitheatres of Rivoli Torinese (including Avigliana), Ivrea, Ticino, Adda, Iseo and Garda.
In most amphitheatres, the MEG is dated to Middle Pleistocene. In the Ticino amphitheatre, 13 glaciations have been recently distingueshed (Bini, 1997).

Vegetation map



Forelands

- ⬜ Mediterranean vegetation
- ▤ Plain oak forest
- ⬜ Pannonic vegetation
- ▩ Submontane oak-beech forest

Collinean belt

- 🟩 Western type (*Quercus pubescens*)
- ▧ Eastern type (*Ostrya carpinifolia*)
- ▧ Central European t. (acidophilous oak for.)
- ▨ Suprapannonic type

Mountain belt

- 🟦 Outer beech forest
- 🟦 Inner fir and spruce forest
- ⬜ Inner Pine forest

Subalpine belt

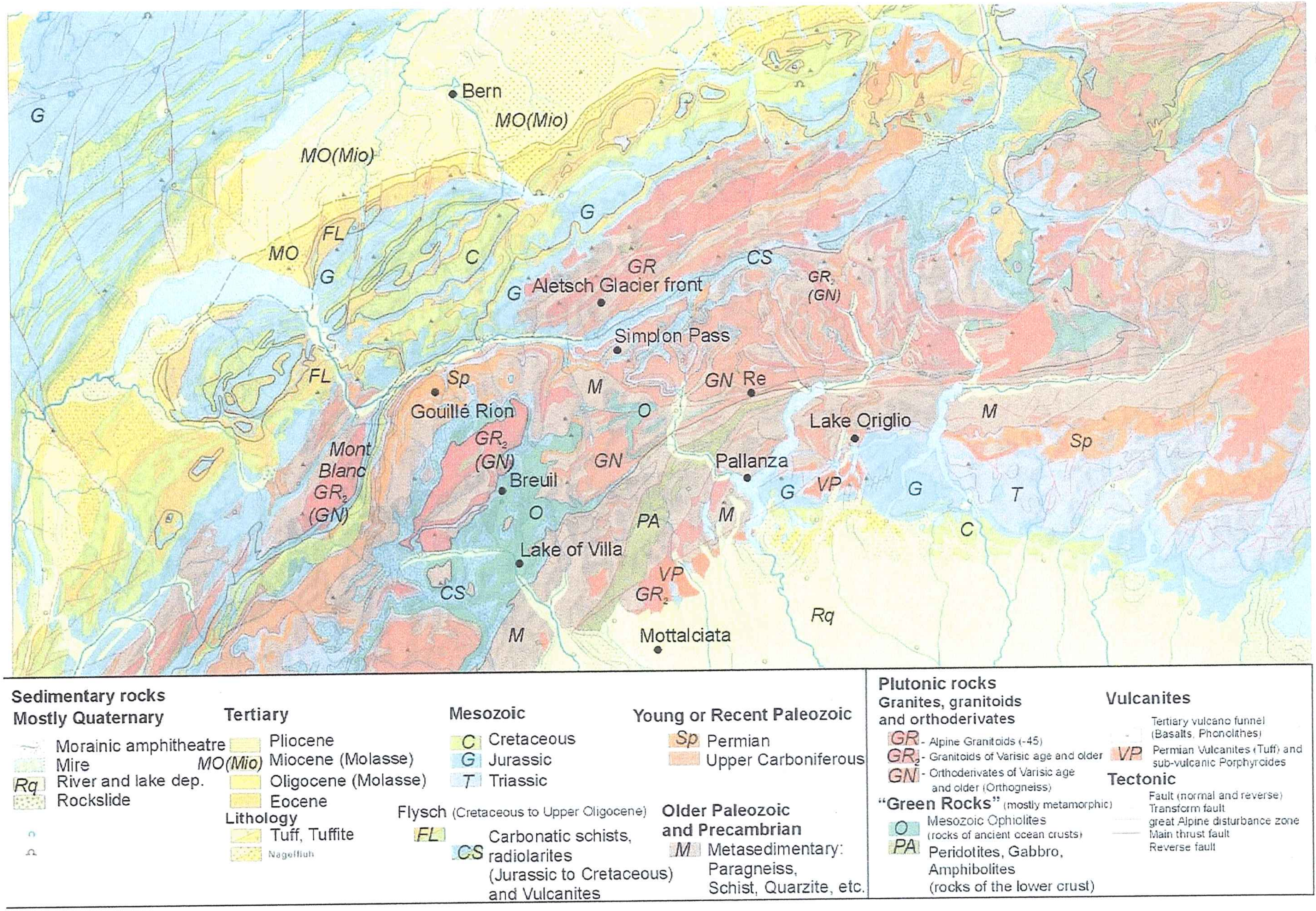
- ⬜ Outer type (mainly *Picea abies*)
- ⬜ Inner type (*Picea abies, Pinus cembra, Larix decidua*)

Alpine and nival belts

- ▧ On calcareous
- ▧ On siliceous rocks
- ⬚ Glaciers

1 = Mutternseewji, Gletsch
2 = Aletsch, Lengi Egga
3 = Simplon
4 = Simplon Dorf, Ecomuseum
5 = Gouillé Rion, Gouillé Loéré, Mire Grand Tsa
6 = Lago di Origlio
7 = Lago di Muzzano
8 = Mires Balladrum, Segna, Piano
9 = Bellinzona, WSL SdA
10 = Re
11 = Montecrestese
12 = Pallanza
13 = Candelo
14 = Cervo
15 = Mottalciata
16 = Laghi di Avigliana
17 = Lago Villa
18 = Breuil Cervinia

Source of map: Ozenda, P. 1985: Die Vegetation der Alpenkette im Rahmen der europäischen Gletscherwelt. G. Fischer, Stuttgart (modified)



Geological map of Western and Central Alps (original scale 1:1.500.000)

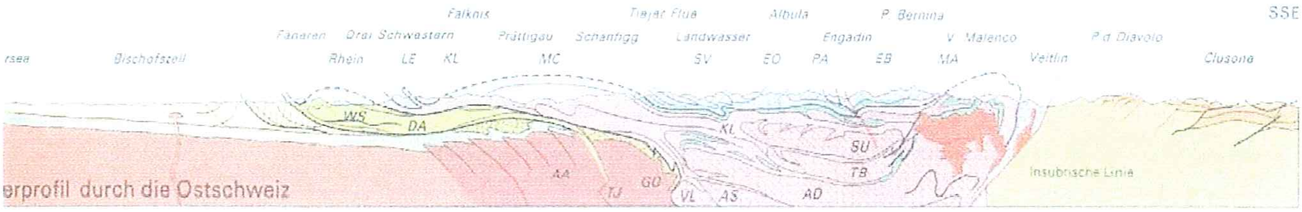
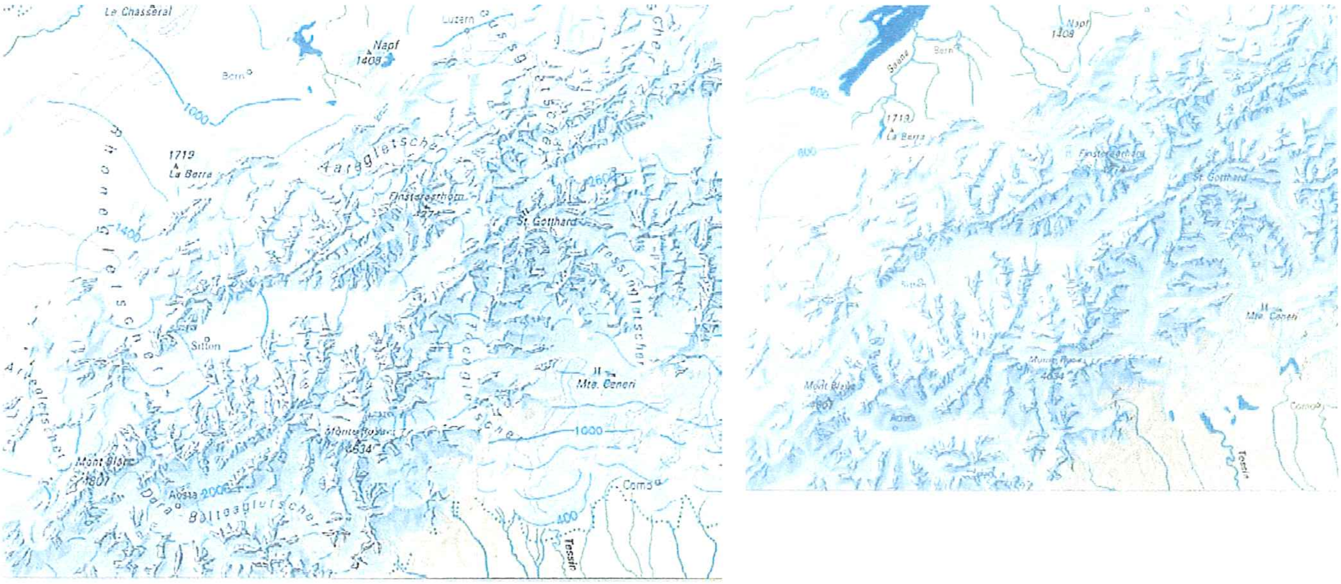
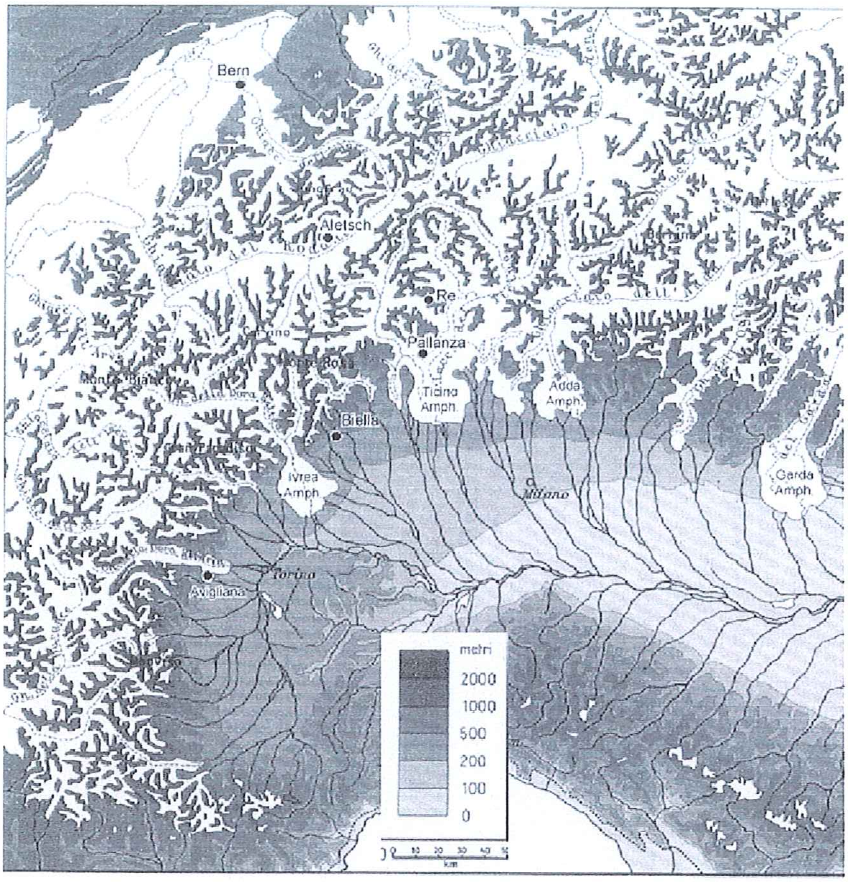


Fig. 2 – Geological section through Western and Central Alps f(NNW to SSE)





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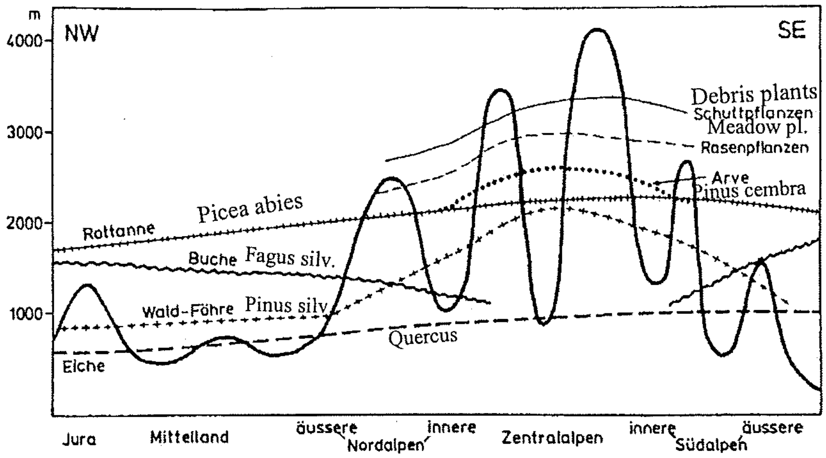
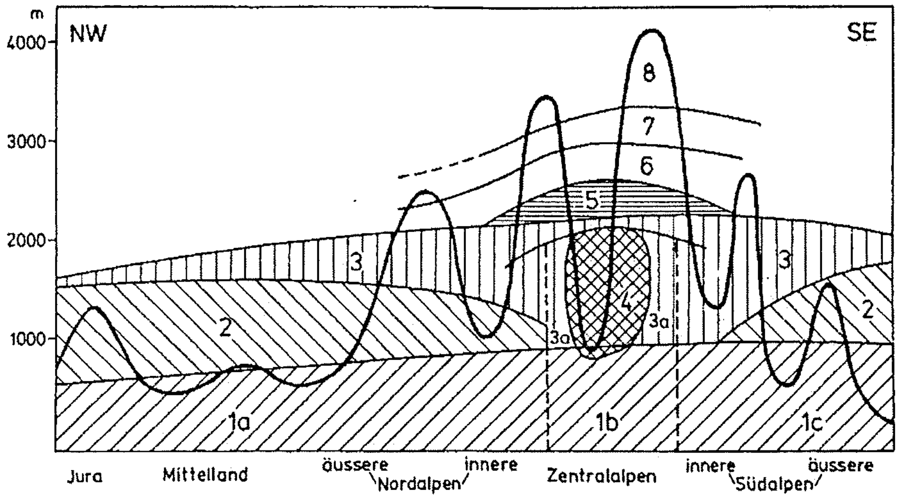


Altitudinal limits of important forest trees and high alpine plant groups



Vegetation belts across the Alps

1: **collinean belt** (oak-beech belt). 1a: North alpine formation with *Quercus robur*, *Q. petraea* and *Fagus silvatica*. 1b: Central Alps with *Q. pubescens*, without *Fagus*. 1 c Southern Alps with *Quercus pubescens* and *Fagus silvatica*.
2: **mountain belt** with *Fagus silvatica* and *Abies alba*.
3: **subalpine belt** with *Picea abies*. 3a Central Alps with *Picea abies* and *Pinus silvestris*.
4: **central-alpine mountain belt** with *Pinus silvestris*.
5: **suprasubalpine belt** with *Pinus cembra* and *Larix decidua*.
6: **alpine belt** with meadow plants
7: **subnival belt** with debris vegetation (usually low cushion plants)
8: **nival belt** without *Spermatophyta* with exception of favorable sites.

Source: Landolt E.1992; Unsere Alpenflora. Verlag Schweizer Alpen-Club

Ecological conditions and vegetation in the Alps

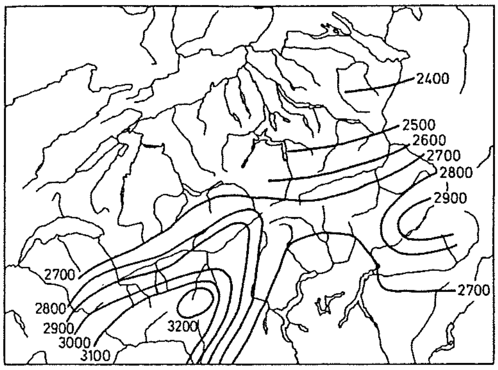


Abb. 14. Klimatische Schneegrenze in mü.M. (mittlere Grenze des bleibenden Schnees auf horizontalen Flächen) (nach JEGERLEHNER aus *3. k.*).

Climatic snowlimit in m a.s.l. (mean limit of enduring snow on horizontal surfaces

These altitudes probably correspond to the situation about 50-70 years ago. Modern observations show that the snowlimit has risen by 300-400 m

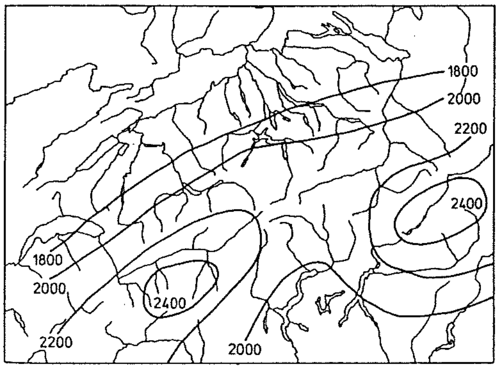


Abb. 15. Mittlere natürliche Waldgrenze in mü.M. (nach Angaben und Beobachtungen über höchststeigende Bäume und Baumgruppen).

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Mean natural timberline in m a.s.l. (following indications and observations of uppermost trees and tree groups)

The today's tree limit is about 100-120 m higher than mapped.

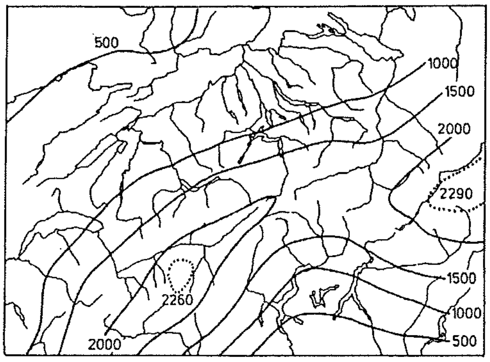


Abb. 12. Mittlere Höhen in mü.M. (berechnet für Quadrate von 64 km Seitenlänge) (nach LEHNER aus *3. b.*).

Mean altitudes in m a.s.l. (calculated for quadrangles of 64 km side length).

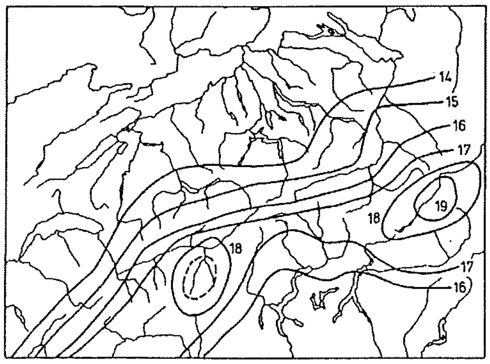


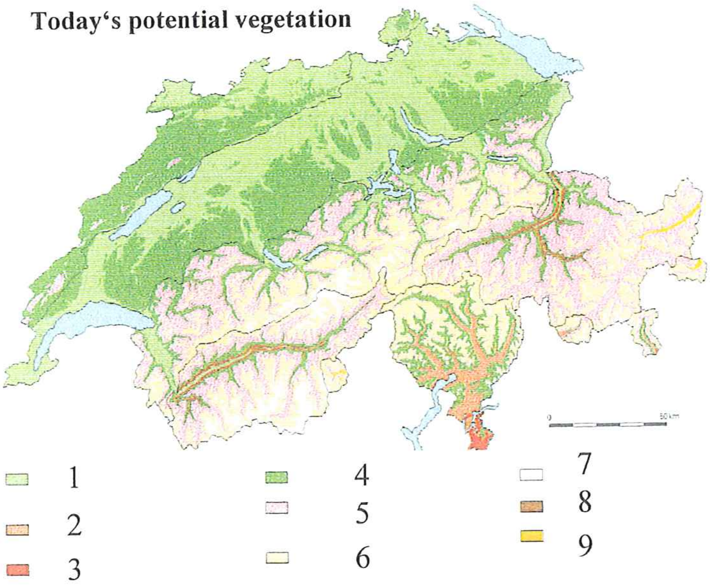
Abb. 13. Mittlere Julitemperaturen in °C um 13 Uhr in 1500 m Höhe (nach DE QUERVAIN aus *3. k.*).

42

Mean July temperatures in °C at 1.00 PM, 1500 m a.s.l..

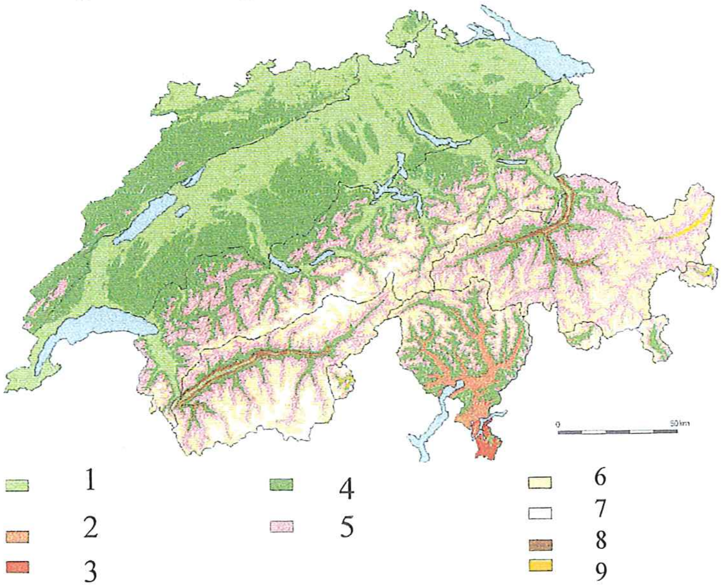
Source: Landolt E.1992; Unsere Alpenflora. Verlag Schweizer Alpen-Club

Today's potential vegetation



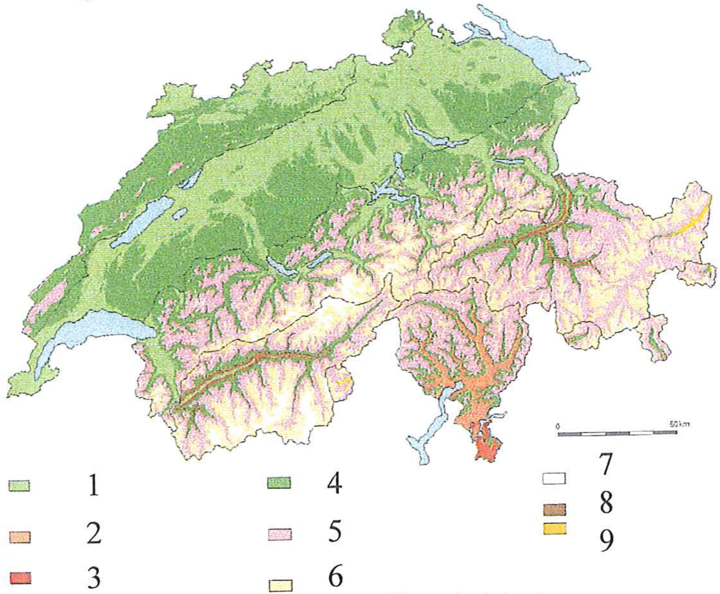
1: **Collinean belt: Northern Alps**: *Quercus-Tilia-Acer*-mixed deciduous forest, *Quercus-Carpinus* forest, *Fagus, Corylus, Quercus pubescens* (Jura, Valais), *Pinus silvestris*, riparian forests
2: **Collinean belt: Southern Alps**: *Quercus-Betula* forest, *Castanea sativa-Betula* forest, *Pinus silvestris*-heathlands, *Alnus*
3: *Ostrya carpinifolia, Fraxinus ornus, Tilia, Quercus petraea, Q. pubescens*
4: **Mountain belt**: *Fagus silvatica, Fagus-Abies* forest, *Abies-Picea* forest
5: **Subalpine belt**: *Picea* forest, *Pinus cembra-Larix decidua* forest (mainly central Alps), *Pinus mugo* ssp. *uncinata* forest, *Pinus mugo* ssp. *mugo*, *Alnus viridis*, tall herbs, heathlands
6: **Alpine belt**: meadows and debris communities, rock plants
7: **Nival belt**: Debris and rock vegetation, cryptogams, ice, snow
8: *Pinus silvestris, Quercus* dry forest, steppe and dry grasslands (Valais, middle Grisons).
9: *Pinus silvestris, Picea abies*, steppe grassland

Vegetation during the Subboreal (5000-2500 BP ^{14}C)



1: **Collinean belt: Northern Alps**: *Fagus* forest, reduced mixed *Quercus* forest, *Taxus, Buxus, Pinus silvestris, Abies alba, Betula, Alnus, Corylus, Carpinus*
2: **Collinean belt: Southern Alps**: *Quercus-Betula* forest, *Fagus silvatica, Carpinus betulus, Fraxinus excelsior*
3: *Carpinus betulus* and *Ostrya carpinifolia, Fraxinus ornus, Tilia, Quercus petraea, Q. pubescens*
4: **Mountain belt**: *Fagus silvatica-Abies alba* forest, *Abies alba forest*, mixed deciduous forest, *Taxus*, in part *Picea* forest, *Corylus, Alnus, Betula, Pinus*
5: **Subalpine belt**: *Picea* forest, *Betula, Pinus cembra-Larix decidua* forest (mainly central Alps), *Pinus silvestris, Pinus mugo* ssp. *uncinata* forest, *Alnus viridis, Juniperus*, heathlands
6: **Alpine belt**: meadows and debris communities, rock plants
7: **Nival belt**: Debris and rock vegetation, cryptogams, ice, snow
8: *Pinus silvestris*, steppe grassland, *Quercus pubescens.*
9: *Pinus silvestris, Picea abies*, steppe grassland

Vegetation at ca. 6000 BP ^{14}C (Atlantic)



Burga C.A. & Perret R., 1998: *Vegetation und Klima der Schweiz seit dem jüngeren Eiszeitalter*. Ott Verlag, Thun.

1: **Collinean belt: Northern Alps**: mixed *Quercus* forest (*Quercus, Ulmus, Tilia, Acer, Betula, Corylus, Alnus*), Abies alba, Quercus pubescens, *Buxus, Corylus, Alnus. Pinus silvestris*, riparian forest.
2: **Collinean belt: Southern Alps**: *Quercus-Betula* forest, *Betula* forest, *Pinus silvestris, Alnus, Fraxinus excelsior*, in part *Abies alba.*
3: *Quercus-Tilia-Acer* mixed deciduous forest with *Carpinus betulus, Ostrya carpinifolia* and *Quercus pubescens*
4: **Mountain belt**: *Abies alba* (rare in Jura), mixed deciduous forest with *Quercus, Ulmus, Tilia, Acer, Betula, Corylus, Alnus.* Beginning *Fagus silvatica* immigration in north eastern Switzerland.
5: **Subalpine belt**: *Picea* forest (east of Gotthard-Säntis), *Pinus mugo* ssp. *uncinata, Betula* in part, locally *Alnus viridis*, on top *Pinus cembra-Larix decidua* with heathlands (mainly central Alps)
6: **Alpine belt**: meadows and debris communities, rock plants
7: **Nival belt**: Cryptogams, ice, snow
8: *Pinus silvestris*, steppe grassland, *Quercus pubescens.*
9: *Pinus silvestris, Picea abies*, steppe grassland

Long-term Responses of Mountain Ecosystems to Environmental Changes: Resilience, Adjustment, and Vulnerability.

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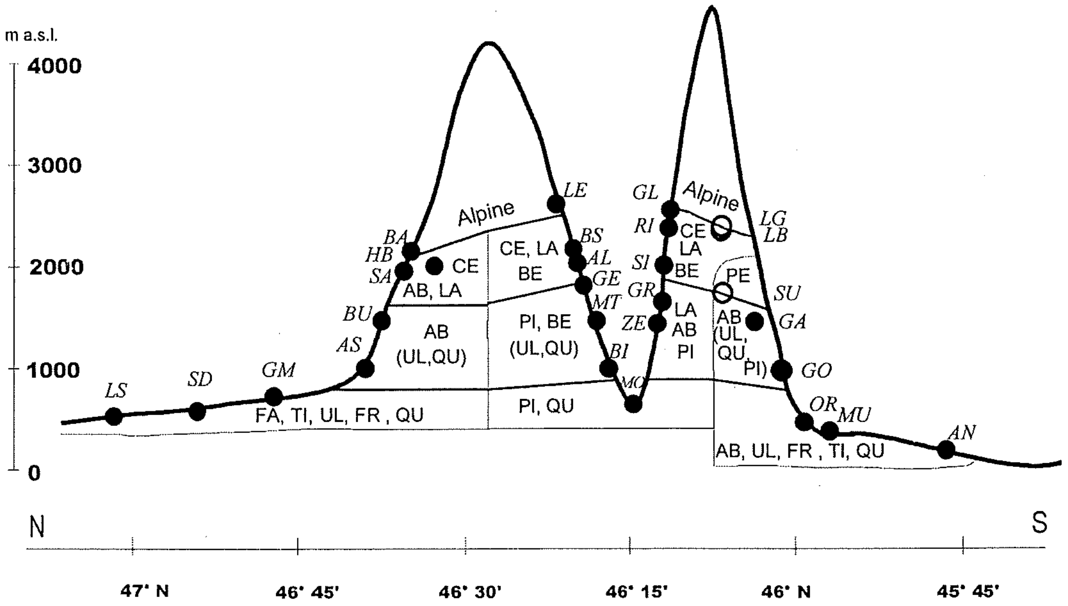
keywords: Alps, paleoecology, vegetation history, fire history, human impact, climate change

in press*:* *Global Change and Mountain Regions* (eds. H. Bugmann, U. Huber, M. Reasoner). Kluwer Academic Publishers, Dordrecht.

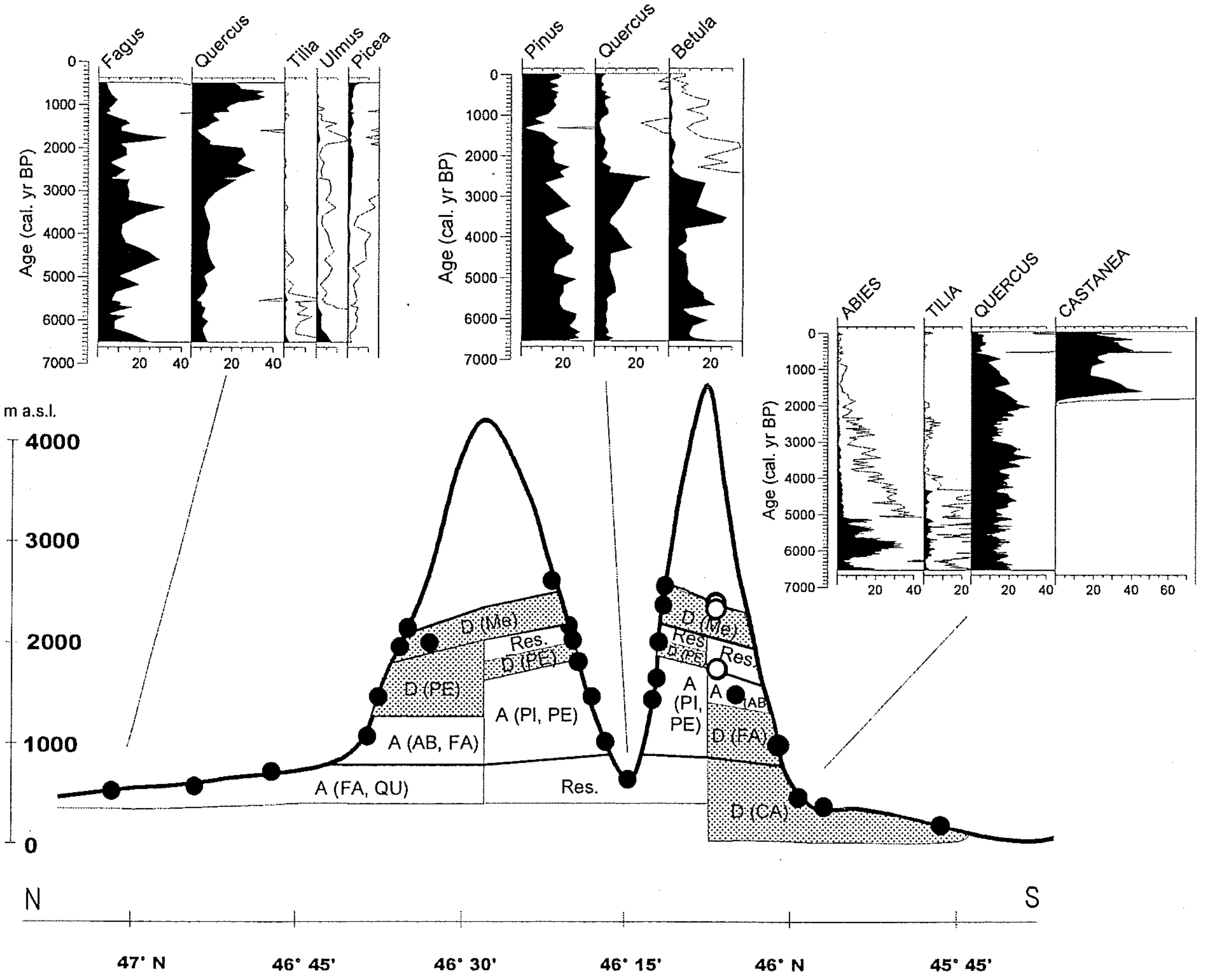
Caption to Fig. 1

Altitudinal transect through the western Alps. (a): Important forest trees at around 6500 cal. yr BP, when summer climate was about 1.5 ° C warmer than today. Less important tree species are in brackets (b): Modern forest distribution in regard to forest changes during the past 6500 yr. The summary pollen diagrams illustrate three modes of forest response to climate change and fire disturbance during the past 6500 yr: vegetational ajustments (Lobsigensee), resilience (Mont d'Orge), and vulnerability/displacement (Origlio). A = Adjustments, D = community displacements as a result of high vulnerability (gray shading), Res. = Resilient behaviour. The distinct change at ca. 2500 cal. BP at Mont d'Orge is explainable by a decrease in forested area, however the composition and structure of remaining forests hardly changed. Dominant present-day tree species are in brackets. Taxa and vegetation abbreviations: AB = *Abies alba*, BE = *Betula*, CA = *Castanea sativa*, CE = *Pinus cembra*, FR = *Fraxinus excelsior*, LA = *Larix*, Me = Meadows, PE = *Picea abies*, PI = *Pinus sylvestris*, QU = *Quercus*, TI = *Tilia*, UL = *Ulmus*. Abbreviations of study sites: AL = Aletschwald (Welten 1982), AN = Annone (Wick Olatunbosi 1996), AS = Aegelsee (Wegmüller and Lotter, 1990, BA = Bachalpsee (Wick et al. unpubl.), BI = Bitsch (Welten 1982), BS = Böhnigsee (Markgraf, 1969, BU = Untere Bunschleralp (Welten, 1982), GA = Gondo-Alpjen (Welten 1982), GE = Greicheralp (Welten 1982), GL = Gouillé Loéré (Tinner unpubl.), GM =Gänsemoos (Welten 1982), GO = Gola di Lago (Zoller and Kleiber 1971), GR = Grächensee (Welten 1982), MT = Montana (Welten 1982), HB = Höhenbiel (Küttel, 1990), LB = Lago Basso (Wick 1994), LE = Lengi Egga (Tinner unpubl.), LG = Lago Grande (Wick 1994), LS = Lobsigensee (Ammann et al. 1986), MO = Mont d'Orge (Welten 1982), MU = Muzzano (Gobet et al. 2000), OR = Origlio (Tinner et al. 1999), RI = Gouillé Rion (Tinner et al. 1996), SA = Sägistalsee (Wick et al. in press), SD= Lac de Seedorf (Richoz, 1998), SI = Simplon (Lang and Tobolski 1985), SU = Suossa (Zoller and Kleiber 1971), ZE = Zeneggen (Welten 1982). The latitudinal position is only approximate. Three sites in the southern Alps (open circles) are not part of the north-south transect. These locations are shown according to their position within different eco-regions.

a) Vegetation belts at ca. 6500 cal. yr BP (4550 BC), 1.2-1.6 ° C warmer than today



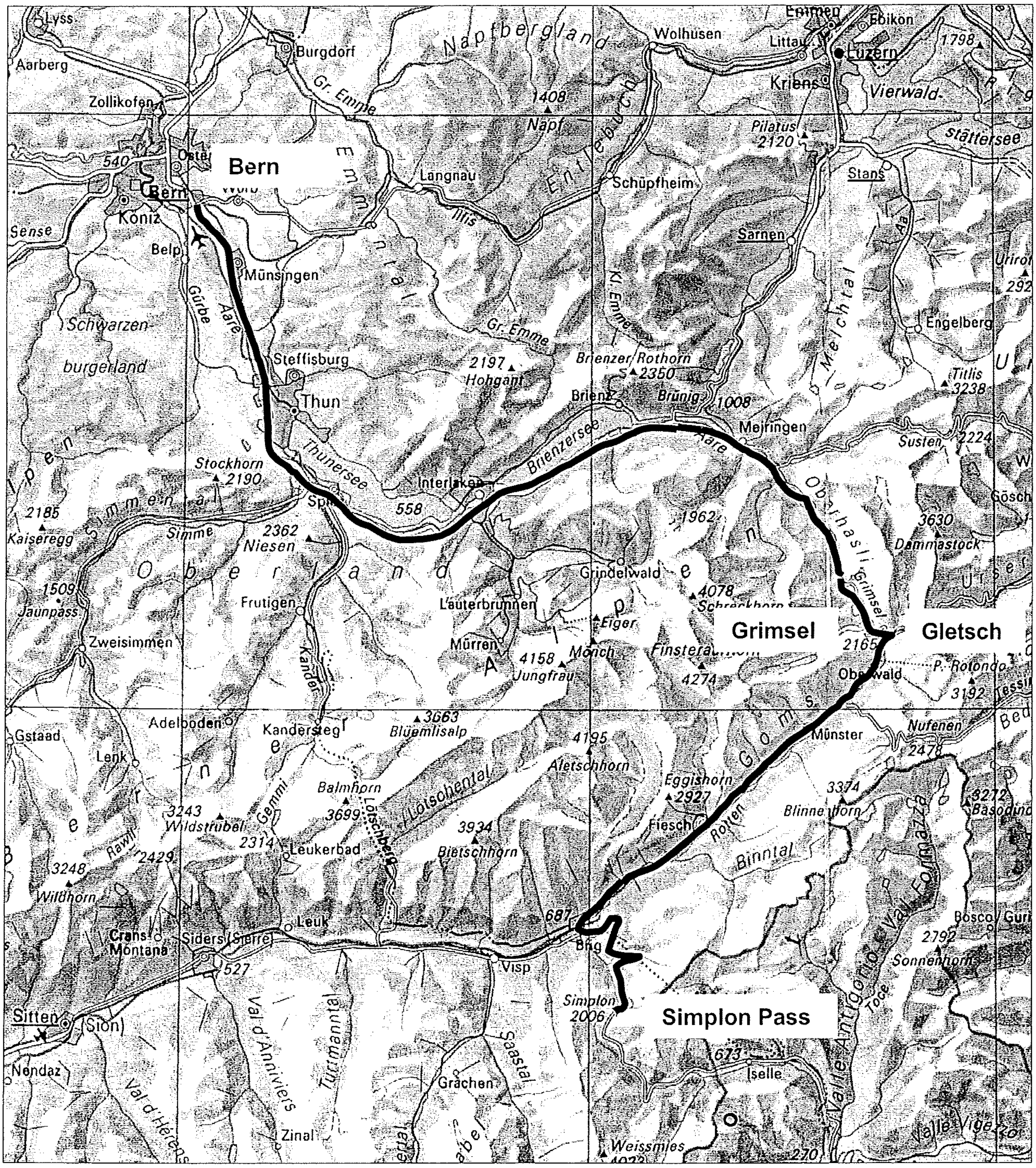
b) Resilience, adjustment, and vulnerability of forest vegetation during the past 6500 yr



Sunday, 7 September 2003

Grimsel, Gletsch, Riederalp

Sunday, 7 September



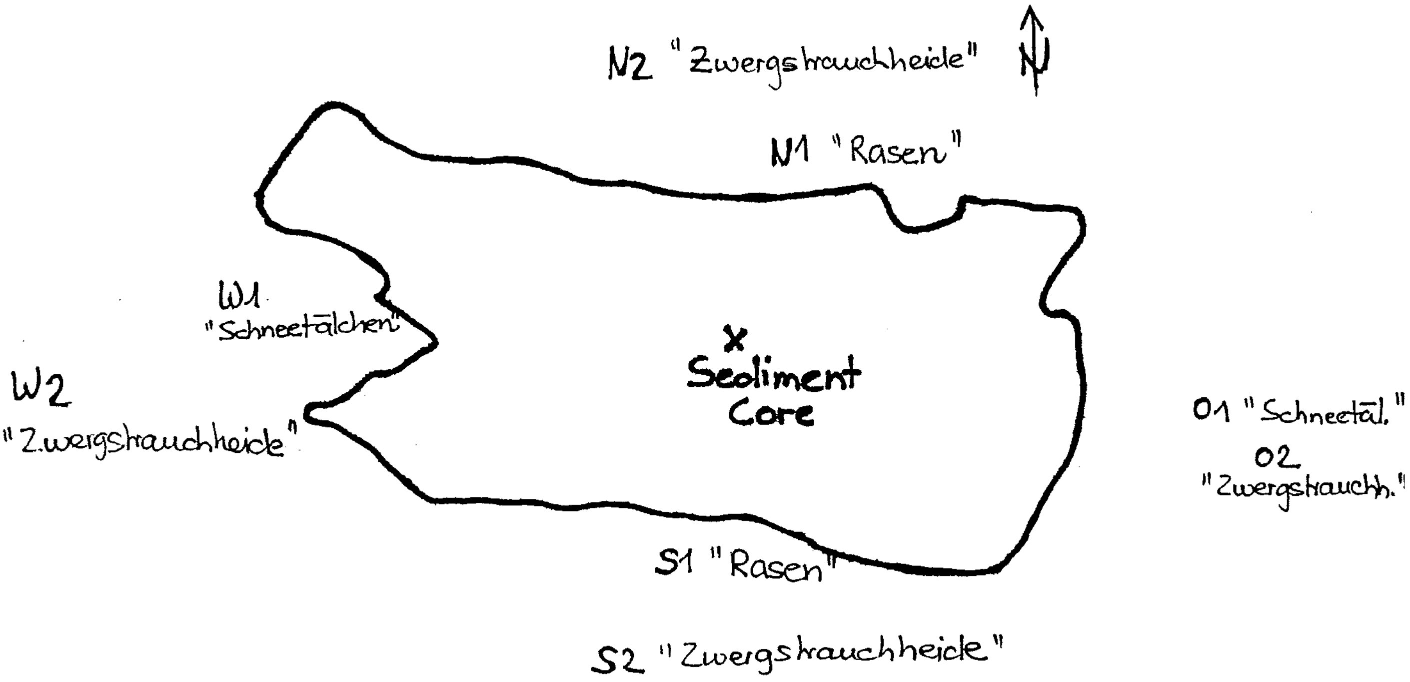
Mutternseewji

1 km south-southeast of Grimsel pass, 2151 m asl.
Mean annual temperature: 1.2 °C, July temperature: 8.9 °C
Mean annual precipitation: 2094 mm.

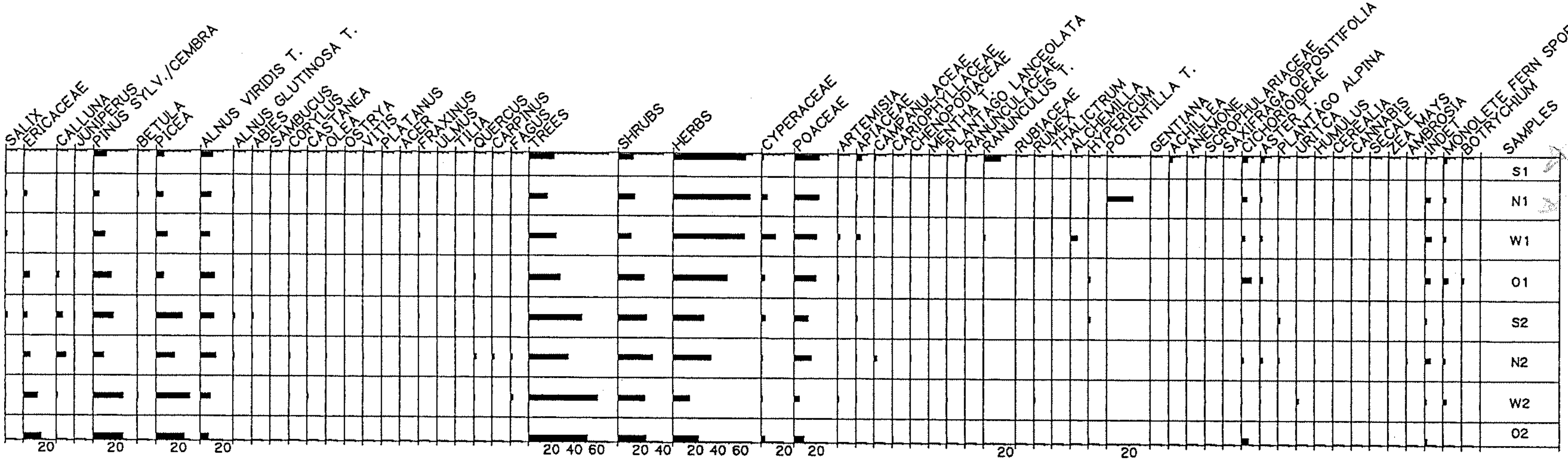
1. Moss surface pollen samples in 8 different places around the lake in 3 different plant communities: Alpine Rasen, Schneetälchen, Zwergstrauchheiden (see map)

2. Pollen percentages of the lake sediment core

3. Macro fossil concentrations of the same lake sediment core



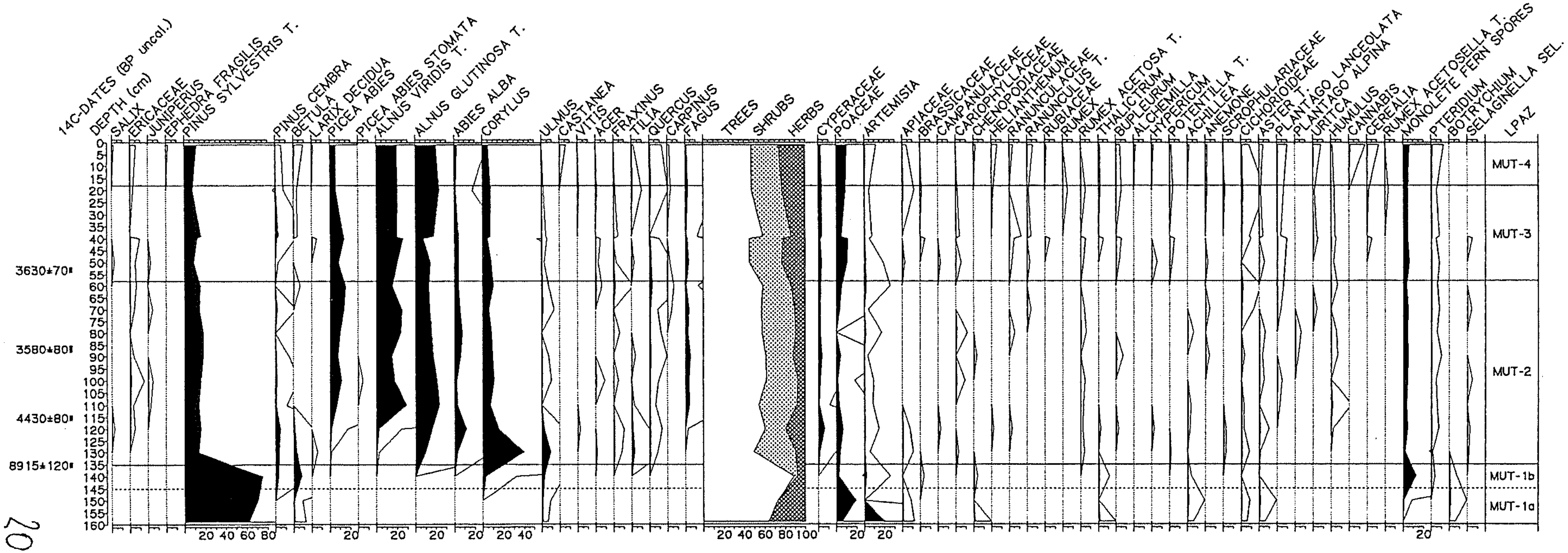
MUTTERNSEEWJI MOSS SURFACE POLLEN PERCENTAGES
ANALYSIS: E. GOBET, I. JANSEN



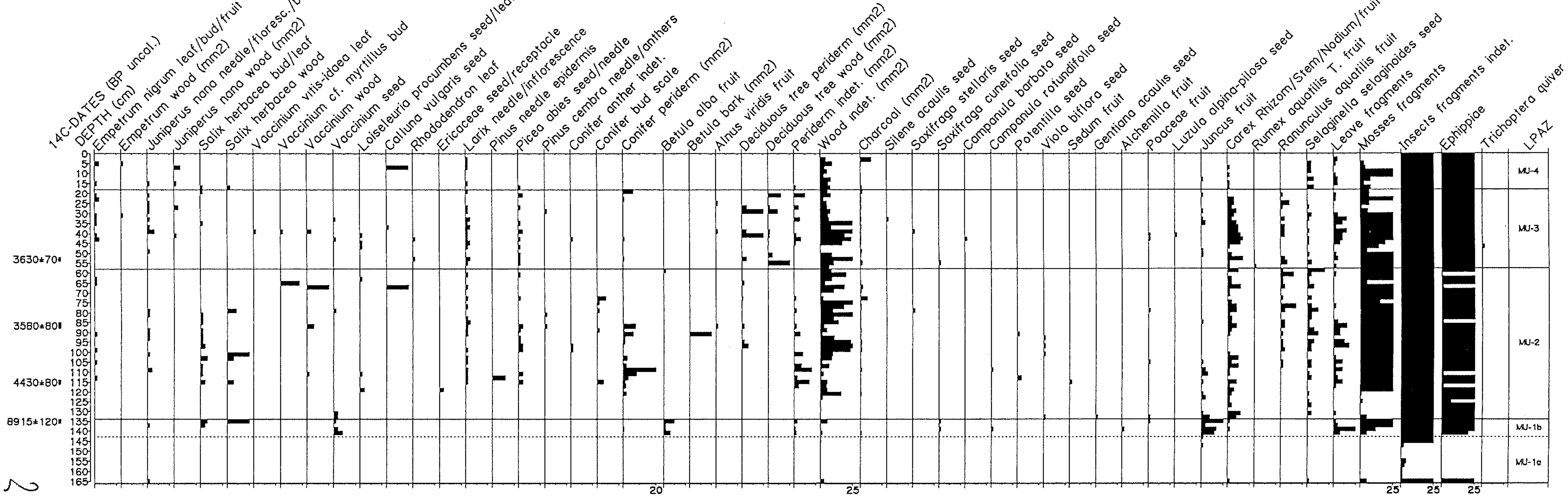
[illegible]
local bei probe!
Potentilla aurea.
meadows

dwarf shrubs
possibly collecting
from the air

MUTTERNSEEWJI POLLEN PERCENTAGES
ANALYSIS: E. GOBET



MUTTERNSEEWJI MACROFOSSILS
ANALYSIS: E. GOBET



The Rhone glacier - mire development in the glacier foreland

Andreas Grünig

Source of text and pictures: Cécile Schubiger-Bossard, 1994: After the glaciers – mire development in the Rhone Glacier foreland. In: A. Grünig (ed.) *Mires and Man*. WSL/FNP, Birmensdorf: 213-217.

3.12.5 Vegetation

Thanks to MERCANTON's paper (1916), "Vermessungen am Rhonegletscher 1874 bis 1915 AD" ["Survey of the Rhône glacier 1874 to 1915"] and the annual determination of the position of the glacial tongue (AELLEN 1979; Fig. 3.12.4), it has been possible to study the development of the plant population over a period of more than a hundred years in the area abandoned by the glacier. As a result of vegetation mapping (SCHUBIGER-BOSSARD 1988), no fewer than 15 plant associations have been found. This is more than 12% of the 120 associations recorded in the basic phytoecological mapping of Switzerland. The number of species reaches more than 13% of the total number of species to be found in Switzerland (382 phanerogams without cryptogams). MATTHEWS (1992, p. 222), in his comparison of glacier forelands, believes that the foreland of the Rhône glacier is the most floristically-rich in the world. Besides this variety, the Rhône glacier foreland is outstanding because of its mires with associations of Montio-Cardaminetalia and Adenostyletalia.

3.12.6 Specifications of the mires

Fens and transitional mires occur on impermeable soils. On the other hand, swamps and paludal forests occur in headwater areas. In the westernmost part of the excursion site (see Fig. 3.12.2, No. 2 and No. 3), a rich palette of acidic mires of the Caricetalia fuscae order (e.g. Caricetum fuscae) is found, including a range of poor sub-alpine silted habitats (*Carex rostrata* communities). East of this complex of acidic and transitional mires, on the south bank of the main glacial stream, Rotten, basic spring fens of the Tofieldietalia order (Saxifrago-Caricetum frigidae) exist. On the northern bank there is an exceptional spring fen on the old glacial spillways in front of a big glacial cave. In this mire, round-leaved sundew *(Drosera rotundifolia)* can be found on a thin horizon of black liverworts over sand. In the easternmost mire of Figure 3.12.2 the plant community is dominated by the two-coloured sedge *(Carex bicolor)*, and variegated horsetail *(Equisetum variegatum)* can be found. This belongs to the arctic-alpine alliance of Caricion juncifoliae. This alliance is endangered throughout the Alps because it needs very special conditions: a silted field with a cold glacial stream.

Swamps and mires of different ages can be found around the different moraine ramparts in the Vordere Gletschboden (Fig. 3.12.2). The wetlands have developed because of the compressed ground moraine and the low ledge at Gletsch which obstructs the flow of ground water from the area. These conditions, favourable for the development of wetlands, are improved by the moraine ramparts and an artificial dam.

Inside a great moraine, deposited by the glacier in 1856, a young swamp is developing. It consists of a mosaic of shallow hummocks and hollows. On the hummocks grow typical species of the Caricetum fuscae association: white sedge *(Carex curta)*, bog sedge *(Carex magellanica)*, thread rush *(Juncus filiformis)* and marsh violet *(Viola palustris)*. The soil profile consists of a muck-gley with a 15 cm (maximum 32 cm) thick layer of organic matter at the top soil. The hollows, characterized by black liverworts, are dominated by pioneer plants of wet sandy soils (*Cephalozia ambigua, Scapania spp., Odontoschisma elongatum* and few-flowered spike-rush *(Eleocharis quinqueflora)*). The muck layer is only 1.5 cm thick. After a period of only 120 years, a well-developed fen has established.

Outside the moraine rampart established in 1818, a mature Caricetum fuscae exists in hydrological contact with a wet transitional mire with dark bog moss *(Sphagnum teres)*. The former has a peat thickness of up to 50 cm and the latter a thickness of up to 100 cm. Its exact age is not yet known but lies between 174 and 390 years. After recent analyses of historical pictures of the Rhône glacier by ZUMBÜHL and HOLZHAUSER (1988), the dates attributed to the moraines by MERCANTON (1916) must be revised.

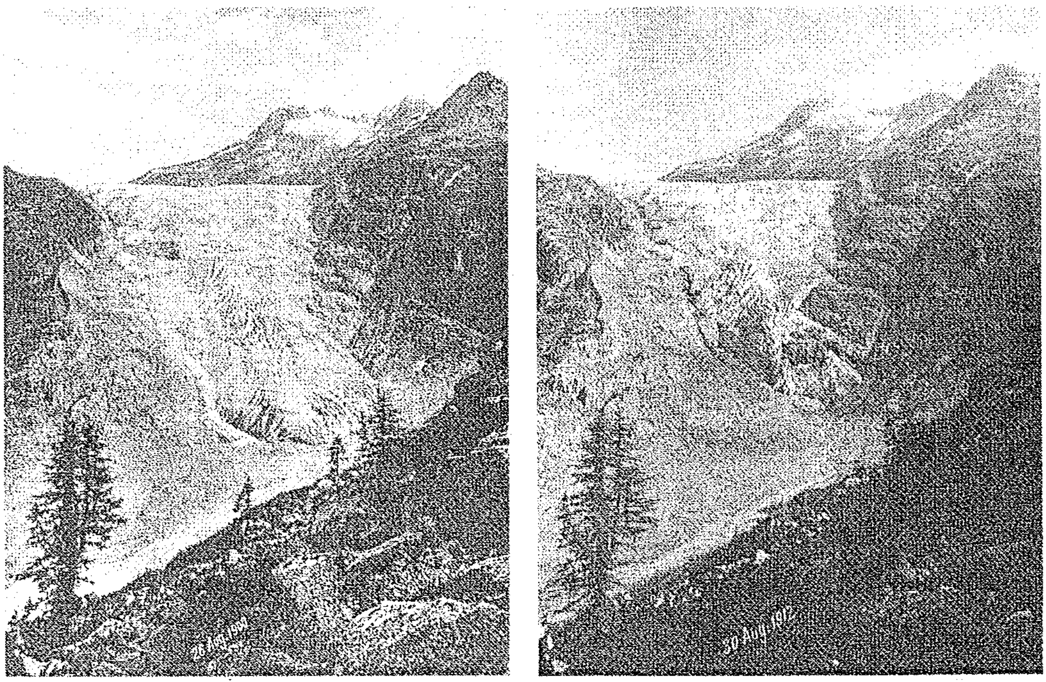


Fig. 3.12.1. Photos of the tongue of the Rhône glacier (and the Hotel Belvedere to the right of the glacier), taken in 1900 and 1912 respectively from the same vantage point by P.L. Mercanton to illustrate glacier oscillations. The pictures comprise a phase of rapid recession of the glacier's front position. Between 1912 and 1922, this was followed by a short period of glacial readvance (cf. Fig. 3.12.4). For further documentation refer to Aellen (1979) and Grove (1988).
Left: By 1900 the Rhône glacier's tongue extended out on the valley floor and a well-formed glacial cave gave way to the young Rhône River.
Right: By 1912 the tongue was hanging, showing symptoms of retreat, and the valley floor completely clear of ice.

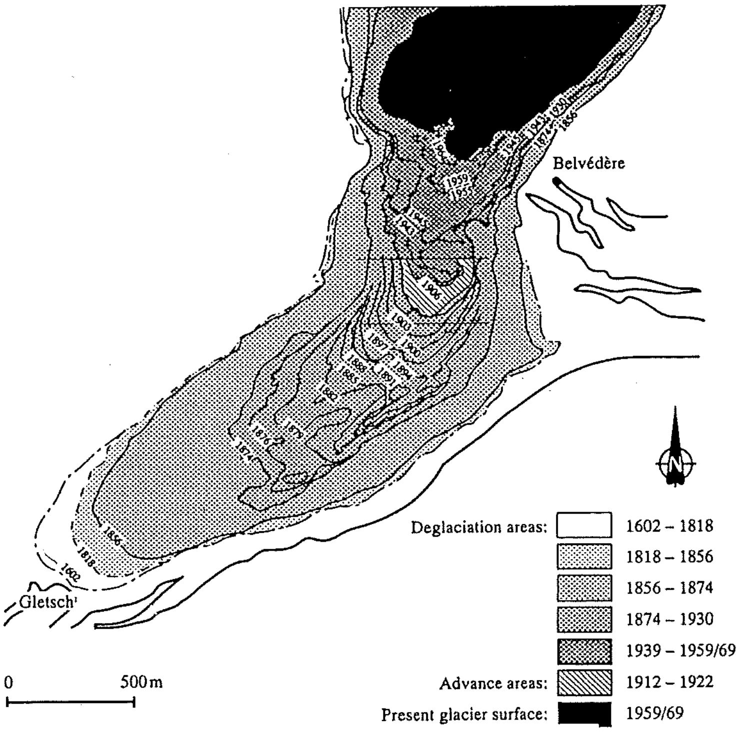


Fig. 3.12.4. Sketch of the different recessional stages and fluctuations of the Rhône glacier in the area of Gletsch from 1602 to 1977 (modified from Aellen 1979).

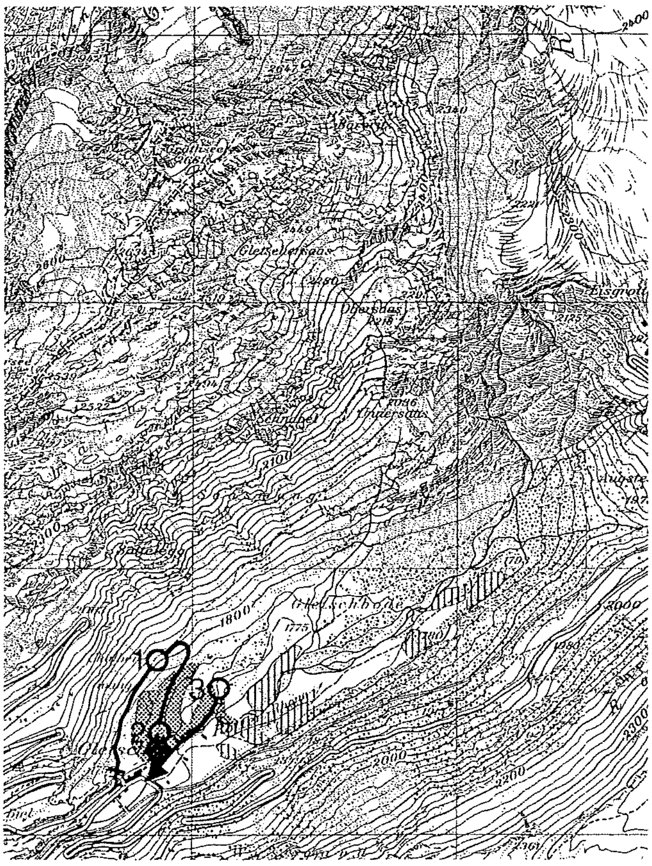


Fig. 3.12.2. Location of the transitional mires, fens and spring-fed mires which have developed since 1602 on the outwash plain of the Rhône glacier (modified from Schubiger-Bossard 1988).
1 Vantage points; 2 Moraine of the 1818 stade; 3 Mire approximately 120 years old; 4 Hotel Belvedere; 5 Trough wall above present glacier.
Scale of the map: 1 : 25,000; for key, see end-cover. Reproduced by courtesy of the Federal Office of Topography, Berne, 9 June 1992.

Pollen traps in Aletschwald

Seven years of annual pollen influx at the forest limit in the Swiss Alps studied by pollen traps: relations to vegetation and climate

W.O. van der Knaap*, Jacqueline F.N. van Leeuwen, Brigitta Ammann

Review of Palaeobotany and Palynology 117 (2001) 31–52

Annual pollen influx has been monitored in short transects across the altitudinal tree limit in four areas of the Swiss Alps with the use of modified Tauber traps placed at the ground surface. The study areas are Grindelwald (8 traps), Aletsch (8 traps), Simplon (5 traps), and Zermatt (5 traps). The vegetation around the traps is described. The results obtained are: (1) Peak years of pollen influx (one or two in seven years) follow years of high average air temperatures during June–November of the previous year for *Larix* and *Picea*, and less clearly for *Pinus* non-*cembra*, but not at all for *Pinus cembra* and *Alnus viridis*. (2) At the upper forest limit, the regional pollen influx of trees (trees absent within 100 m of the pollen trap) relates well to the average basal area of the same taxon within 10–15 km of the study areas for *Pinus cembra*, *Larix*, and *Betula*, but not for *Picea*, *Pinus* non-*cembra*, and *Alnus viridis*. (3) The example of Zermatt shows that pollen influx characterises the upper forest limit, if the latter is more or less intact. (4) Presence/absence of *Picea*, *Pinus cembra*, *Larix*, *Pinus* non-*cembra*, and *Alnus viridis* trees within 50–100 m of the traps is apparent in the pollen influx in peak years of pollen influx but not in other years, suggesting that forest-limit trees produce significant amounts of pollen only in some years. (5) Pollen influx averaged over the study period correlates well with the abundance of plants around the pollen traps for conifer trees (but not deciduous trees), *Calluna*, Gramineae, and Cyperaceae, and less clearly so Compositae Subfam. Cichorioideae and *Potentilla*-type. (6) Influx of extra-regional pollen derived from south of the Alps is highest in Simplon, which is open to southerly winds, slightly lower in Aletsch lying just north of Simplon, and lowest in Zermatt sheltered from the south by high mountains and Grindelwald lying north of the central Alps.

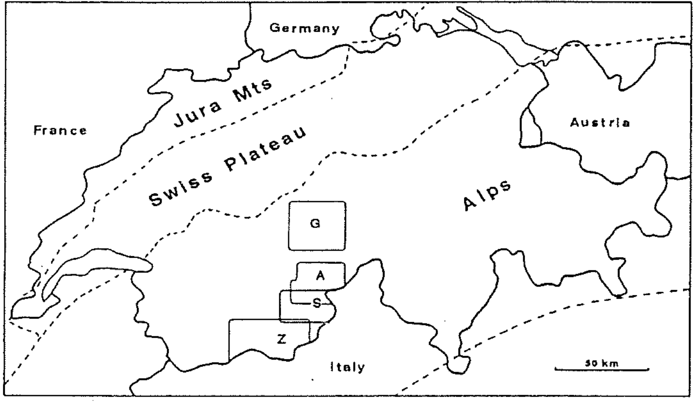
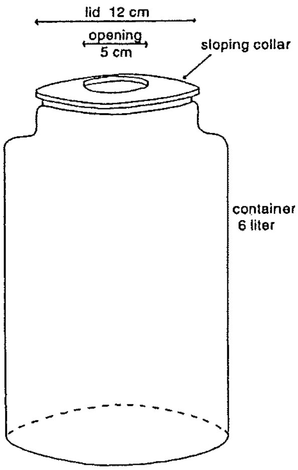


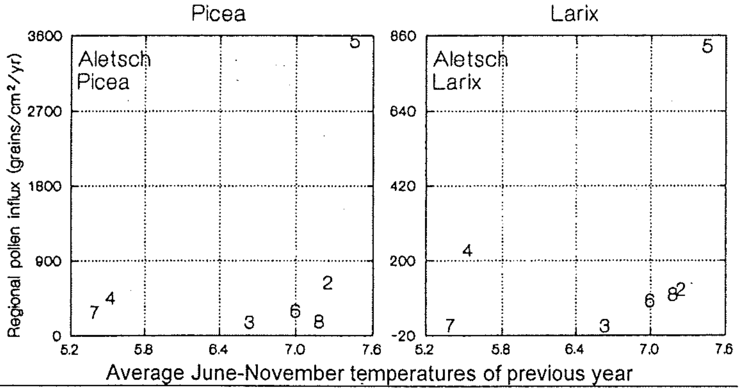
Fig. 1. Map of Switzerland indicating the four study areas (G = Grindelwald, A = Aletsch, S = Simplon, Z = Zermatt). The regions around the trap for which forest-inventory data were used are outlined.

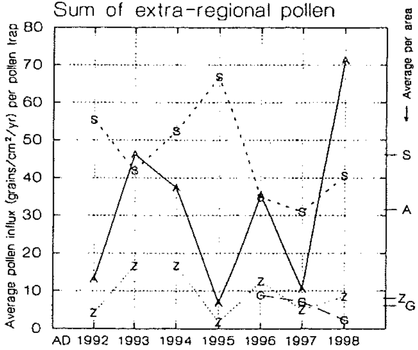
Modified Tauber Trap



Regional pollen influx / summer temperature of the previous year

No.	Pollen yr	Climate yr
2	1992	1991
3	1993	1992
4	1994	1993
5	1995	1994
6	1996	1995
7	1997	1996
8	1998	1997





Annual influx of extra-regional pollen

(derived from plants growing south of the Alps).

These are, in order of decreasing abundance: *Ostrya*-type, *Olea*, *Ambrosia*, *Fraxinus ornus*, *Cedrus*, *Eucalyptus*, *Ephedra distachya*-type, *Ephedra fragilis*-type, *Pistacia*, *Lygeum spartum*, *Cistus ladanifer*-type. Averages per study area are indicated on the far right. Study areas are:

Aletsch, **G**rindelwald, **S**implon, and **Z**ermatt.

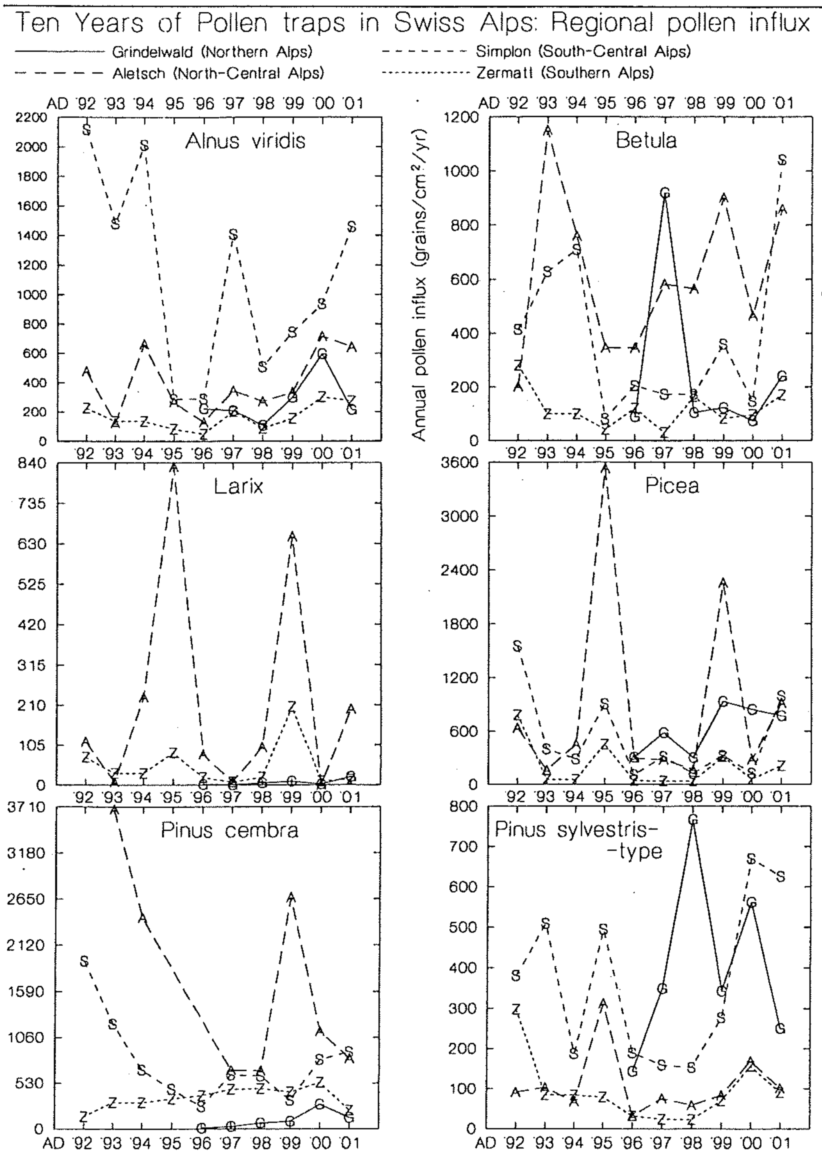
Regional pollen influx of trees per year

A **regional** pollen signal is assumed if the tree species does not grow within 100 m of the pollen trap.

Study areas are:
Aletsch
Grindelwald
Simplon
Zermatt.

These graphs cover 10 years (i.e. 3 years more than in the published paper).

Note the differences between years, and the differences and similarities between study areas.

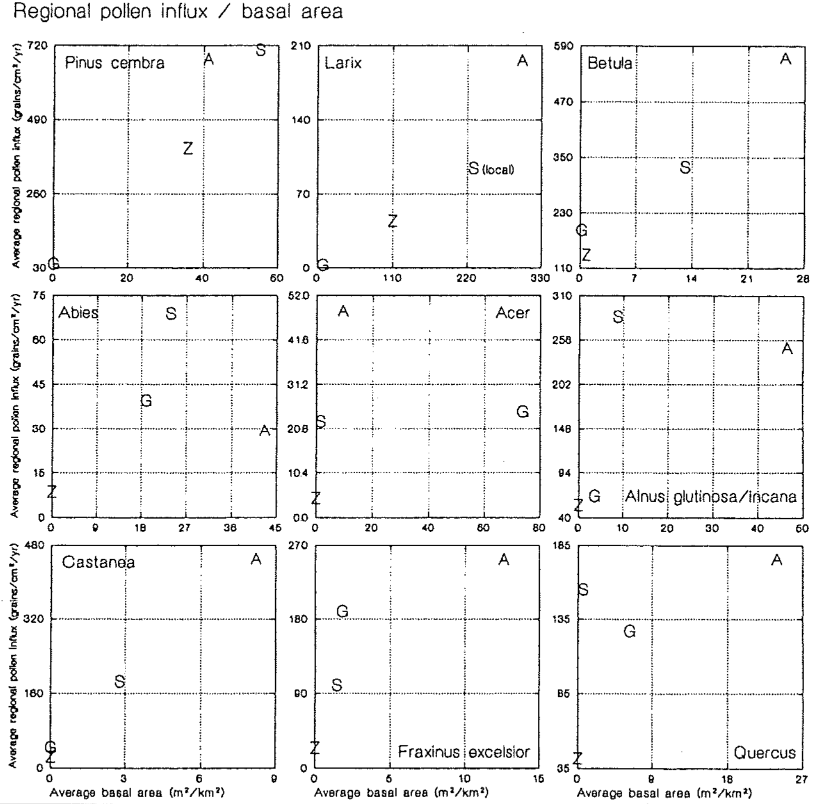


Regional pollen influx / tree abundance per study area

A **regional** pollen signal is assumed if the tree species does not grow within 100 m of the pollen trap.

Tree abundance is derived from the Swiss National Forest Inventory (LFI: Landes Forst Inventar) and is expressed as average basal area.

The **study areas** are outlined on the map (previous page).



The last 100 years in Aletschwald

Palynostratigraphy of the last centuries in Switzerland based on 23 lake and mire deposits: chronostratigraphic pollen markers, regional patterns, and local histories

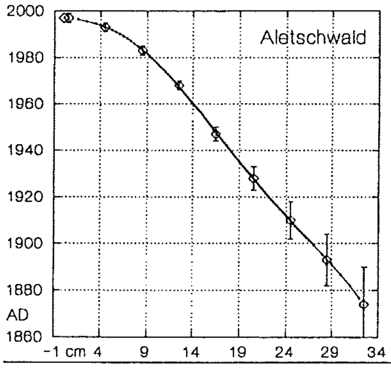
W.O. van der Knaap *, Jacqueline F.N. van Leeuwen, Andreas Fankhauser, Brigitta Ammann

Review of Palaeobotany and Palynology 108 (2000) 85–142

A total of 23 pollen diagrams [stored in the Alpine Palynological Data-Base (ALPADABA), Geobotanical Institute, Bern] cover the last 100 to over 1000 years. The sites include 15 lakes, seven mires, and one soil profile distributed in the Jura Mts (three sites), Swiss Plateau (two sites), northern Pre-Alps and Alps (six sites), central Alps (five sites), southern Alps (three sites), and southern Pre-Alps (four sites) in the western and southern part of Switzerland or just outside the national borders. The pollen diagrams have both a high taxonomic resolution and a high temporal resolution, with sampling distances of 0.5–3 cm, equivalent to 1 to 11 years for the last 100 years and 8 to 130 years for earlier periods.

The chronology is based on absolute dating (14 sites: ^{210}Pb 11 sites; ^{14}C six sites; varve counting two sites) or on biostratigraphic correlation among pollen diagrams. The latter relies mainly on trends in *Cannabis sativa*, *Ambrosia*, *Mercurialis annua*, and *Ostrya*-type pollen.

Individual pollen stratigraphies are discussed and sites are compared within each region. The principle of designating local, extra-local, and regional pollen signals and vegetation is exemplified by two pairs of sites lying close together. Trends in biostratigraphies shared by a major part of the pollen diagrams allow the following generalisations. Forest declined in phases since medieval times up to the late 19th century. *Abies* and *Fagus* declined consistently, whereas the behaviour of short-lived trees and trees of moist habitats differed among sites (*Alnus glutinosa*-type, *Alnus viridis*, *Betula*, *Corylus avellana*). In the present century, however, *Picea* and *Pinus* increased, followed by *Fraxinus excelsior* in the second half of this century. Grassland (traced by Gramineae and *Plantago lanceolata*-type pollen) increased, replacing much of the forest, and declined again in the second half of this century. Nitrate enrichment of the vegetation (traced by *Urtica*) took place in the first half of this century. These trends reflect the intensification of forest use and the expansion of grassland from medieval times up to the end of the last century, whereas subsequently parts of the grassland became used more intensively and the marginal parts were abandoned for forest regrowth. In most pollen diagrams human impact is the dominant factor in explaining inferred changes in vegetation, but climatic change plays a role at three sites.



Short peat section from Aletschwald

Peat section collected with a spade on 4 August 1997.
Swiss coordinates: 645.070/137.640.
Altitude 2017 m. Size of mire ca. 0.1 ha.
Dating is based on Lead isotopes (^{210}Pb).
Left: Depth-age model, based on fifth-order polynomial regression of ^{210}Pb dates against depth.
Research funded by the EU project FOREST (FOrest Response to Environmental Stress at Timberlines).

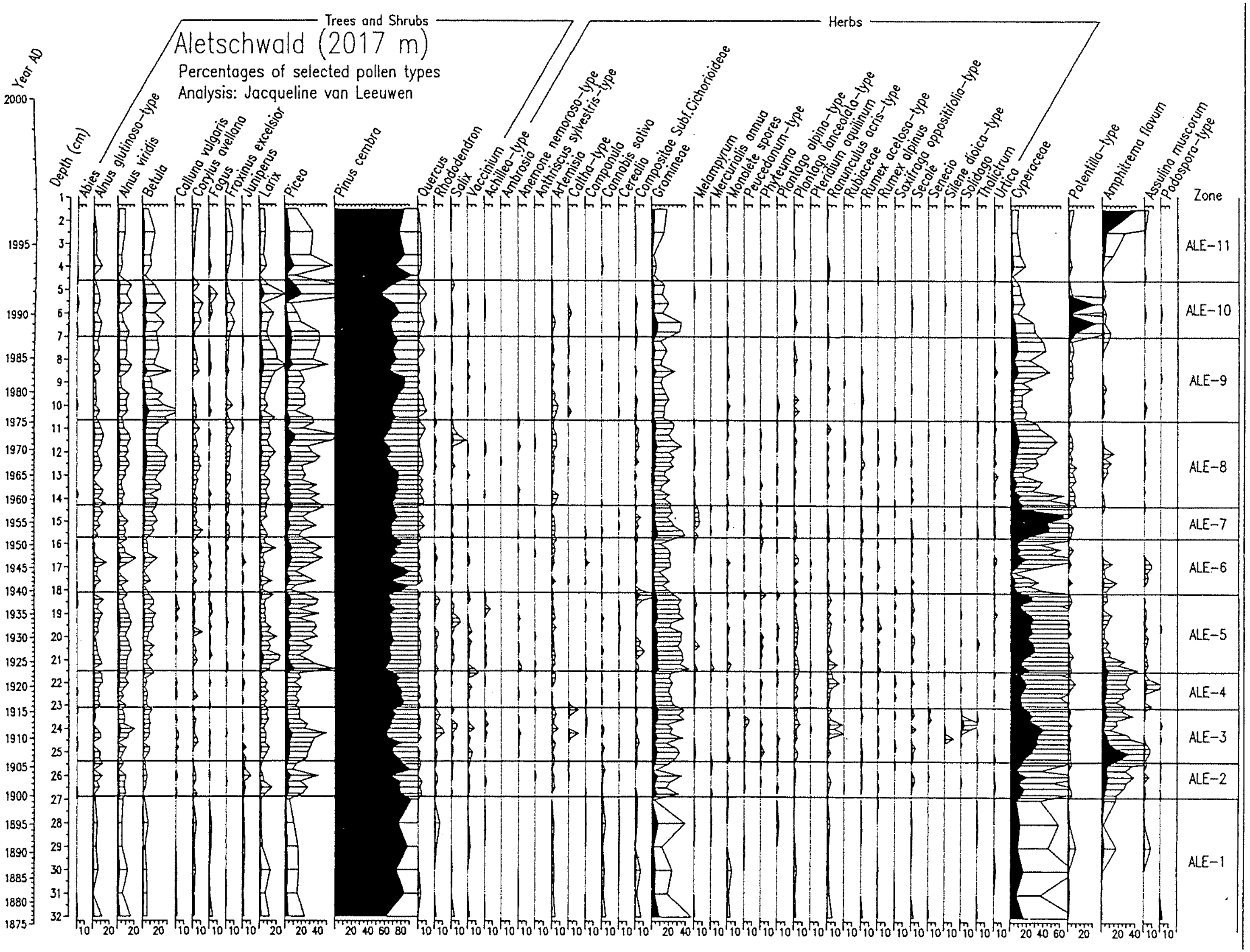
Aletschwald: the mire studied

The site is one of several small mires that measure up to ca. 100 m long and 50 m broad lying in depressions between an old lateral moraine of the Aletsch glacier and the mountain slope. The mire studied is about 20 × 50 m^2 and is separated by a low stony forested ridge from another mire cored by Welten (1982a) probably less than 50 m southwest of our sampling location. All mire vegetation in the nature reserve is heavily trampled and damaged today by game seeking refuge from hunting. Welten (1982a) mentions a number of species (observed in AD 1956) typical of bogs absent today (*Carex magellanica*, *Carex pauciflora*, *Eriophorum vaginatum*). Plants at the coring location today include *Carex rostrata* (Cyperaceae), *Molinia* and other Gramineae, *Potentilla erecta*, and *Vaccinium myrtillus*.

The bedrock is acid; forest undergrowth is dominated by ericaceous shrubs and grass and is relatively poor in species. Both forest and mire may have been richer in species before ca. AD 1975 (zone ALE-9), when many herbs disappeared from the pollen assemblage or declined. Over-use of the vegetation by game is the probable cause of this degradation. This idea is supported by the increase of *Caltha*, a plant growing today in trampled, nutrient-rich mire edges. This degradation contrasts with an earlier period of local grazing during zone ALE-3 (AD 1906–1916), suggested by a maximum of Cyperaceae and various grassland taxa and supported by spores of the coprophilous fungus *Podospora* (the latter already beginning in zone ALE-2; AD 1900–1906). There is in this period no sign of loss of biodiversity. The grazing regime may have been different, caused by domesticated animals rather than by hunted game.

Aletschwald

pollen diagram with annual resolution for the last hundred years



In press in "The Holocene"

Past uppermost tree limit in the Central European Alps (Switzerland) based on soil and soil charcoal

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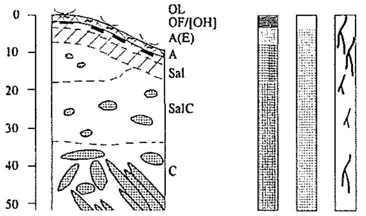
A **Abstract:** The uppermost limits of past treelines in the Alps are established using soil type and soil charcoal mass. In all the studied sites, a sharp decrease of soil charcoal mass is correlated with the upper altitudinal limit of PODZOSOLS. On the basis of this evidence, the uppermost tree limit reached 2500±100 m a.s.l. in the Valaisan Alps during the Holocene, i.e., it was 250±100 m higher than today's potential treeline. Consequently, the timberline would have reached 2400±100 m a.s.l.. From the strong decline of charcoals concentration in soils above 2500 m a.s.l., we infer that conifer species were rare or very rare above this altitude during the Holocene. Joined interpretation of charcoal, pollen, soil and macrofossil data suggest that alpine meadows with at most scattered conifers were present throughout the Holocene in the today's middle and upper alpine belt.

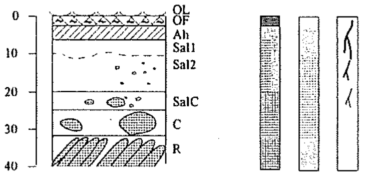
Figure 1 Belalp-Hofathorn transect. Soil sketches and logs of soil structure, texture and roots. In the tables are given sampling depth (cm); anthracomass per soil layer AM (mg of charcoal kg^{-1} soil); charcoals identifications and number of fragments recovered. (*) AM negligible (i.e. charcoal mass < 0.1 mg). Dated charcoals (black squares) were extracted in the layer 65-85 cm, graphic display is only indicative.

BA-HO4 2830 m a.s.l.; ALOSCRISOL



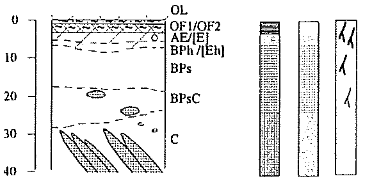
Depth (cm)	AM (mg kg^{1})	Conifers n.id	*Pinus cembra*	*Picea/Larix*
0-10	*			3
10-20	*	6	1	1
>25	*	2		
AM total	*			

BA-HO3 2665 m a.s.l.; ALOCRISOL



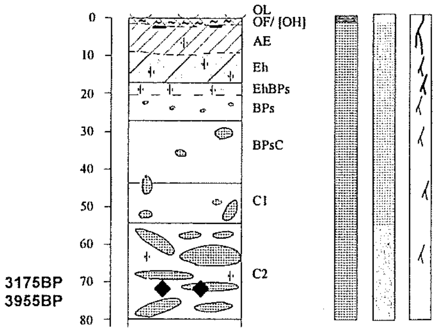
Depth (cm)	AM (mg kg^{-1})	Conifers n.id	*Pinus cembra*	*Picea/Larix*
0-10	*	2	1	5
10-35	0			
AM total	*			

BA-HO2 2570 m a.s.l.; PODZOSOL



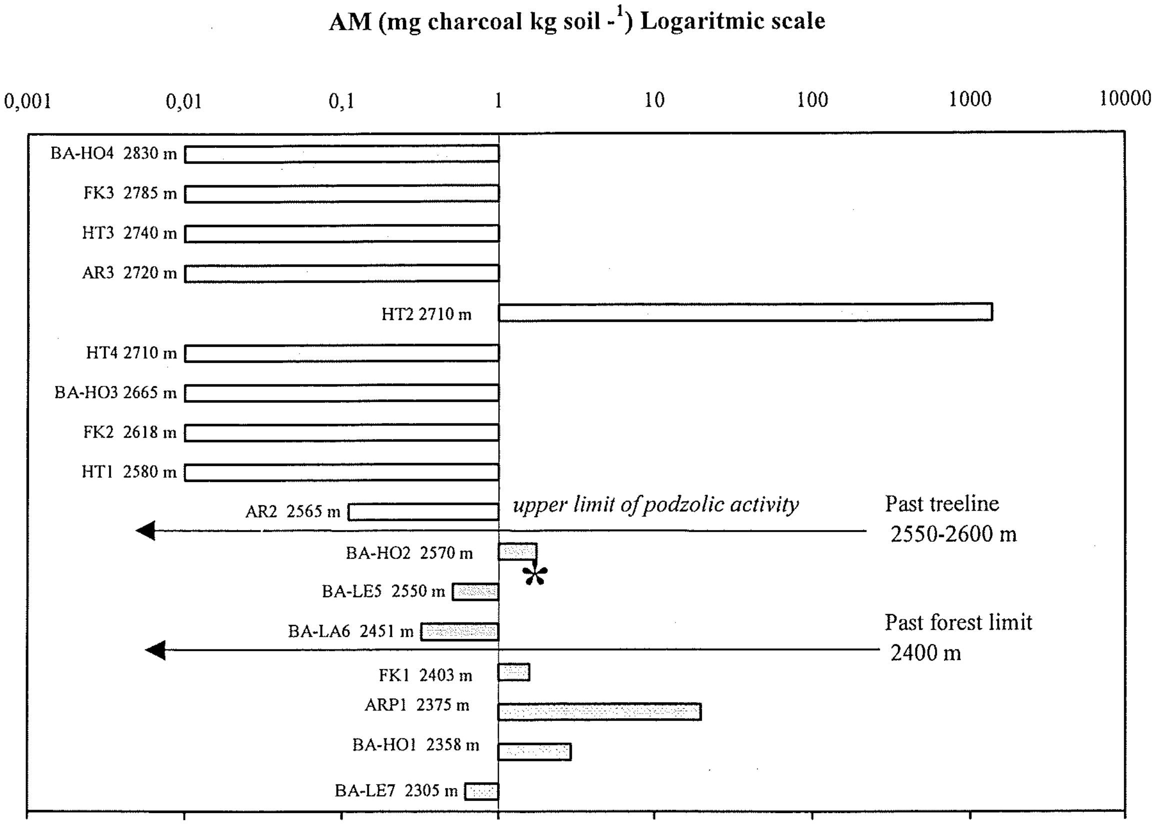
Depth (cm)	AM (mg kg^{-1})	Conifers n.id	*Pinus cembra*	*Picea/Larix*	n. id.
0-7	1.75	8	2	4	1
7-30	0				
30-40	0				
AM total	1.75				

BA-HO1 2358 m a.s.l.; PODZOSOL



Depth (cm)	AM (mg kg^{-1})	Conifers n.id.	*Pinus cembra*	*Picea/Larix*	n. id.
5-20	0.63	10	5	7	9
20- 45	0				
45 -65	0.08			2	
65- 85	2.18	7	1	9	
AM total	2.89				

Figure 2 Charcoal mass (AM, mg kg^{-1}) per soil profile with increasing elevation. The charcoal concentration drops significantly in correspondence of the upper limit of podzolic activity in soil (Wilcoxon ranked-sum test, two-tailed; p = 0.01). The AM decrease is significant with elevation (Kendall's rank correlation; p = 0.01). (*) = Altitude of the alpine mire Lengi Egga.



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Uppermost Limit, Extent, and Fluctuations of the Timberline and Treeline Ecocline in the Swiss Central Alps during the Past 11,500 Years

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Abstract

Pollen and macrofossils were analyzed at two sites above today's treeline (or tree limit) in the Swiss Central Alps (Gouillé Loéré, 2503 m a.s.l., and Lengi Egga, 2557 m a.s.l.) to test two contrasting hypotheses about the natural formation of timberline (the upper limit of closed forest) in the Alps. Our results revealed that *Pinus cembra–Larix decidua* forests near timberline were rather closed between 9000 and 2500 B.C. (9600–4000 ^{14}C yr BP), when timberline fluctuations occurred within a belt 100–150 m above today's tree limit. The treeline ecocline above timberline was characterized by the mixed occurrence of tree, shrub, dwarf-shrub, and herbaceous species, but it did not encompass more than 100–150 altitudinal meters. The uppermost limit reached by timberline and treeline during the Holocene was ca. 2420 and 2530 m, respectively, i.e., about 120 to 180 m higher than today. Between 3500 and 2500 B.C. (4700–4000 ^{14}C yr BP) timberline progressively sank by about 300 m, while treeline was lowered only ca. 100 m. This change led to an enlargement of the treeline-ecocline belt (by ca. 300 m) after 2500 B.C. (4000 ^{14}C yr BP). Above the treeline ecocline, natural meadows dominated by dwarf shrubs (e.g., *Salix herbacea*) and herbaceous species (e.g., *Helianthemum*, *Taraxacum*, *Potentilla*, *Leontodon* t., *Cerastium alpinum* t., *Cirsium spinosissimum*, *Silene exscapa* t., and *Saxifraga stellaris*) have been present since at least 11,000 cal yr ago. In these meadows tree and tall shrub species (>0.5 m) never played a major role. These results support the conventional hypothesis of a narrow ecocline with rather sharp upper timberline and treeline boundaries and imply that today's treeless alpine communities in the Alps are close to a natural stage. Pollen (percentages and influx), stomata, and charcoal data may be useful for determining whether or not a site was treeless. Nevertheless, a reliable and detailed record of past local vegetation near and above timberline is best achieved through the inclusion of macrofossil analysis.

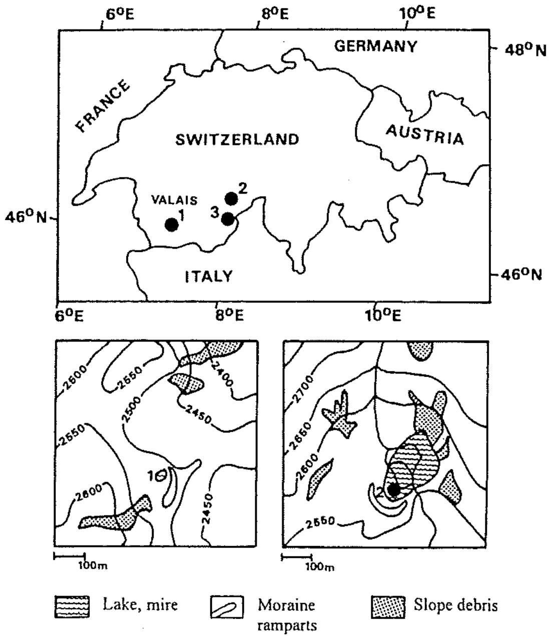


FIGURE 1. Map of the study sites in the Valais, Switzerland. 1 = Gouillé Loéré, 2 = Lengi Egga. Other already published sites with important pollen and macrofossil results: 1 = Gouillé Rion (Tinner et al., 1996), 3 = Simplon (Lang and Tobolski, 1985). Small map on the left: shows the topography around Gouillé Loéré, on the right: the topography around Lengi Egga.

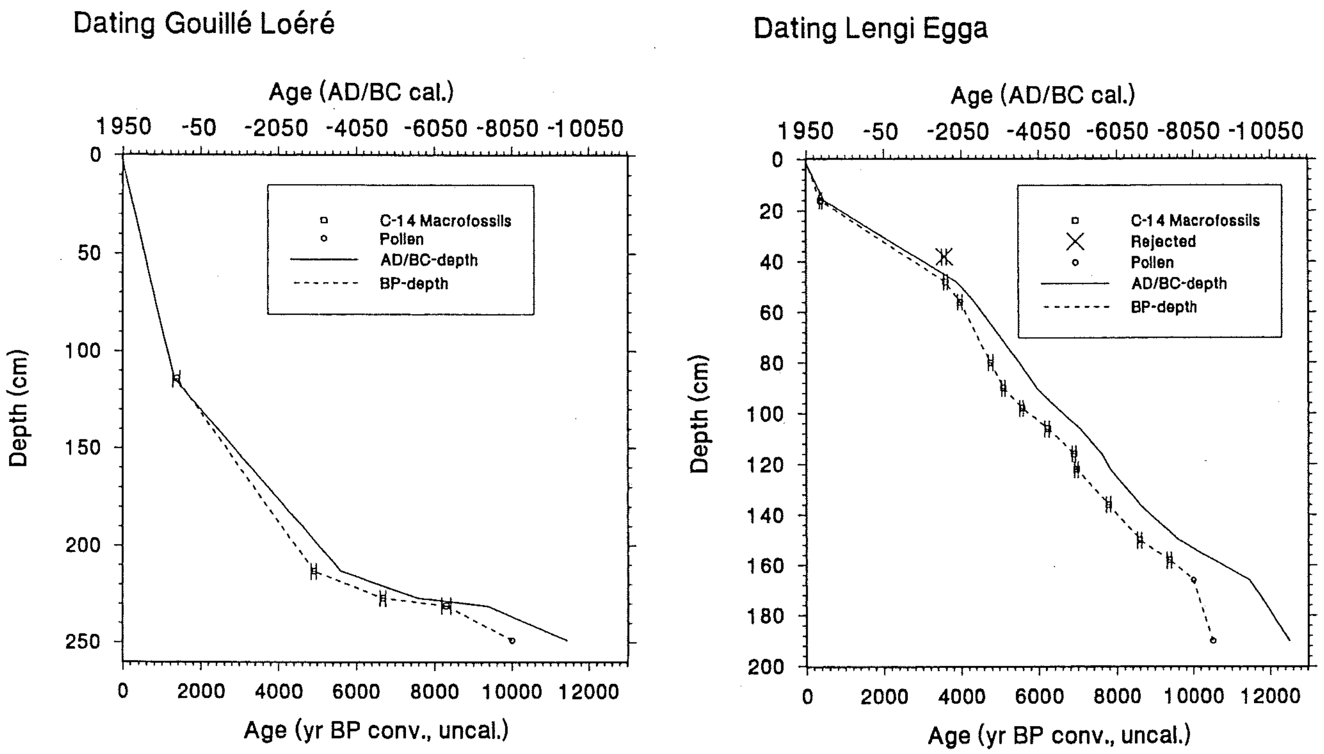


FIGURE 2. Radiocarbon dating of the sediments of Gouillé Loéré and Lengi Egga. The A.D./B.C. and the BP scales are interindependent (i.e., they cannot be linked together). The open squares indicate ^{14}C-AMS dates (terrestrial plant macrofossils), the black circles pollen-stratigraphical ages derived from comparison with radiocarbon-dated pollen diagrams of the region.

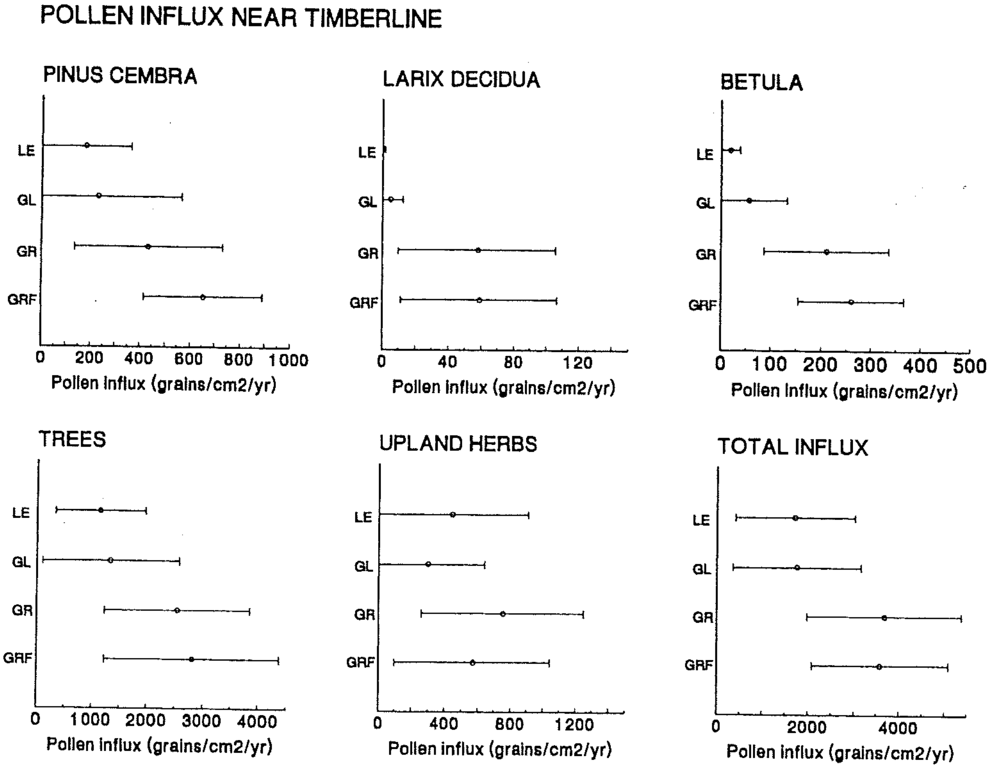


FIGURE 5. Pollen influx and mean and standard deviation of selected pollen types and groups along an altitudinal transect during the Holocene. At Gouillé Rion two different times are shown—the whole Holocene and the forested period, according to macrofossil findings (Tinner et al., 1996). GRF = Gouillé Rion forested period, GR = Gouillé Rion Holocene, GL = Gouillé Loéré Holocene, LE = Lengi Egga Holocene.

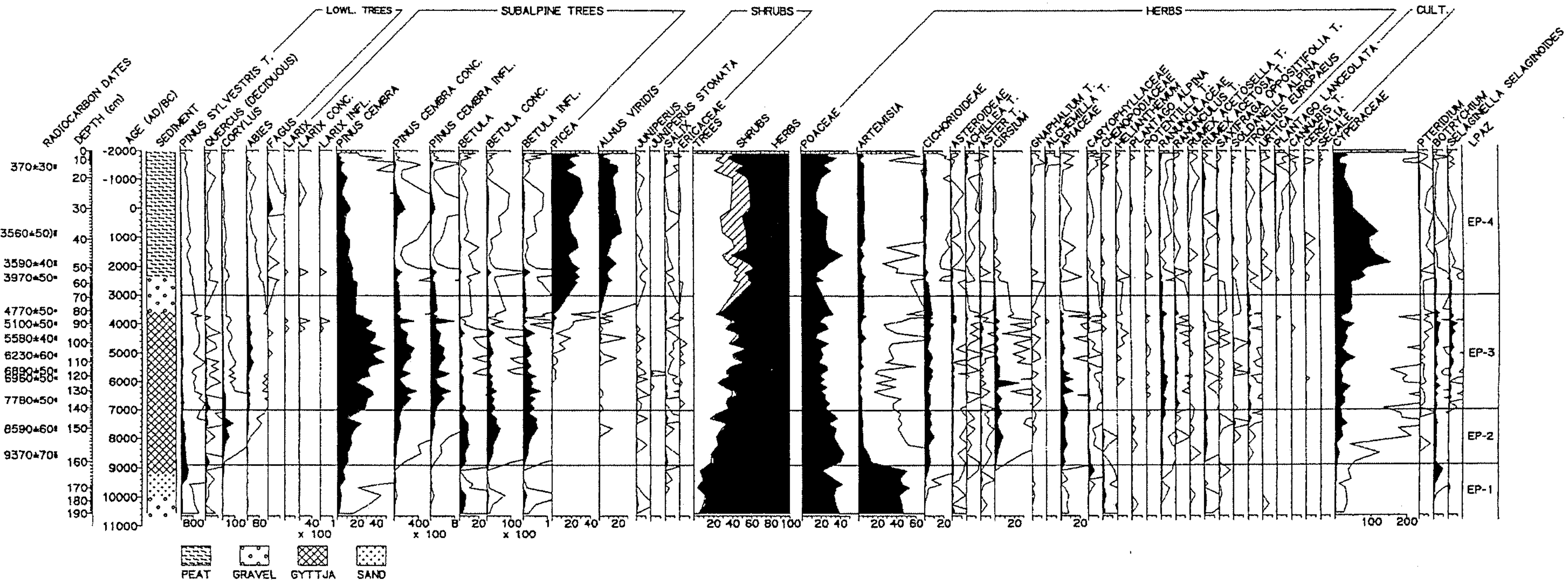


FIGURE 4. Pollen-percentage diagram (selected taxa) of Lengi Egga, Switzerland. Lowland plants, water plants, and ferns are excluded from pollen sum. Concentration (conc.) and influx (infl.) values are given for Betula, Larix, *and* Pinus cembra. *LPAZ = Local pollen assemblage zones. Cult. = cultural indicators. EP-1 to EP-4 = local pollen assemblage zones 1 to 4.*

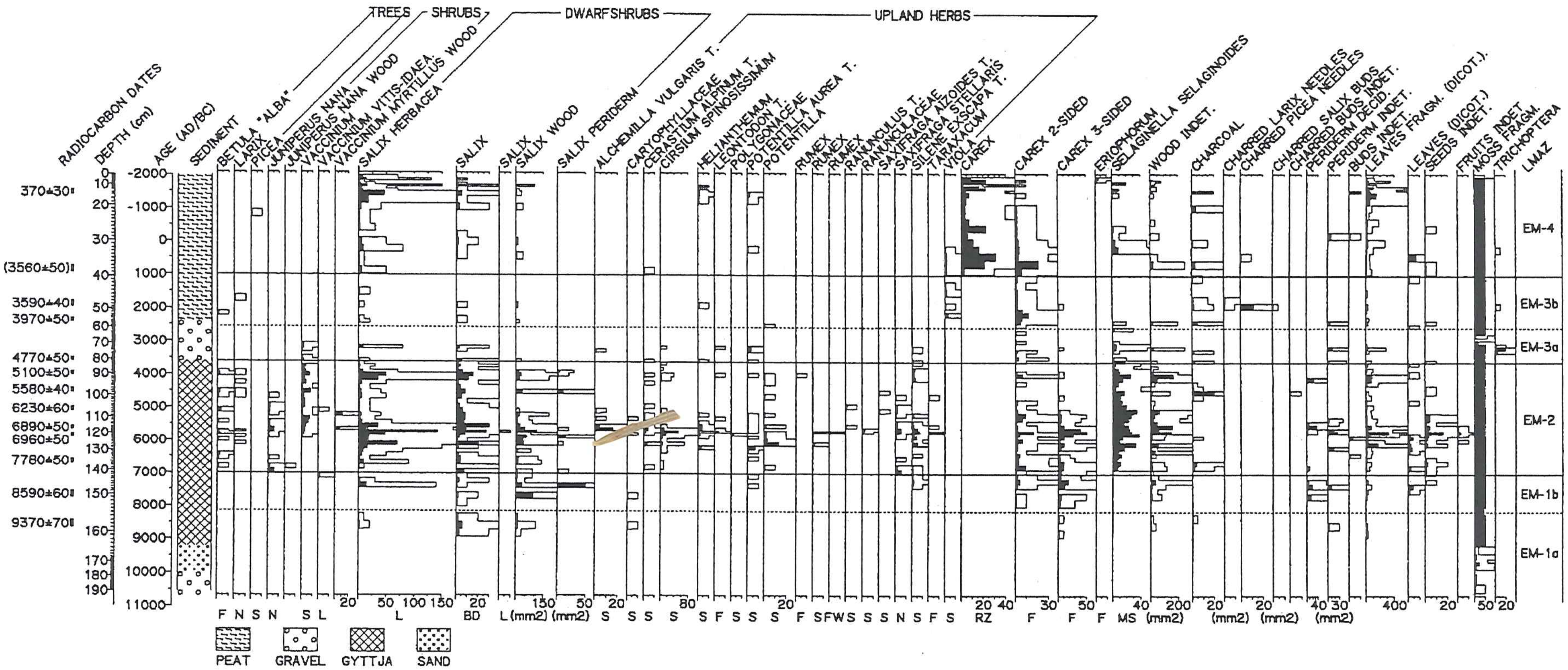


FIGURE 7. Plant-macrofossil concentrations at Lengi Egga (findings per 90 cm^3). LMAZ = Local macrofossil-assemblage zones. Dicot. = dicotyledon, BD = buds, BS = budscales, F = fruits, L= leaves, MS = macrospores, N = needles, RZ = rhizoms, S = seeds, EM-1a to EM-4 = local macrofossil-assemblage zones 1 to 4.

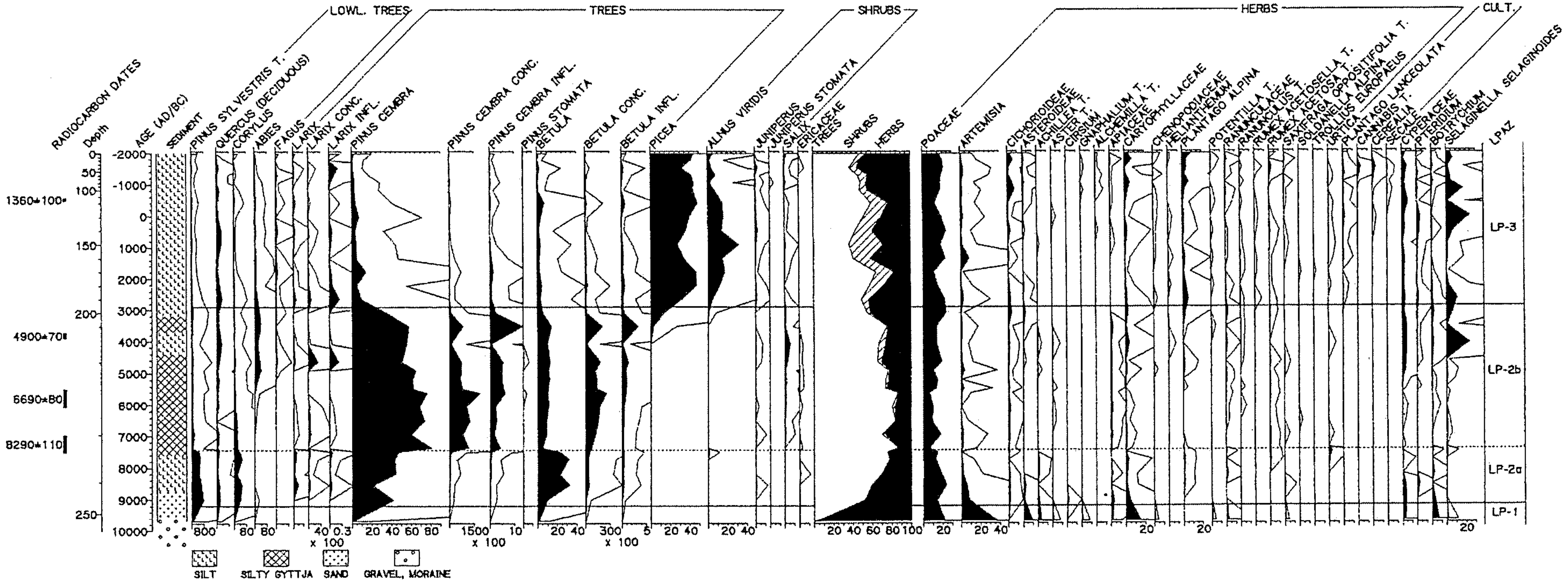


FIGURE 3. Pollen-percentage diagram (selected taxa) of Gouillé Loéré, Switzerland. Lowland plants, water plants, and ferns are excluded from pollen sum. Concentration (conc.) and influx (infl.) values are given for Betula, Larix, *and* Pinus cembra. *LPAZ = Local pollen assemblage zones. Cult. = cultural indicators. LP-1 to LP-3 = local pollen assemblage zones 1 to 3.*

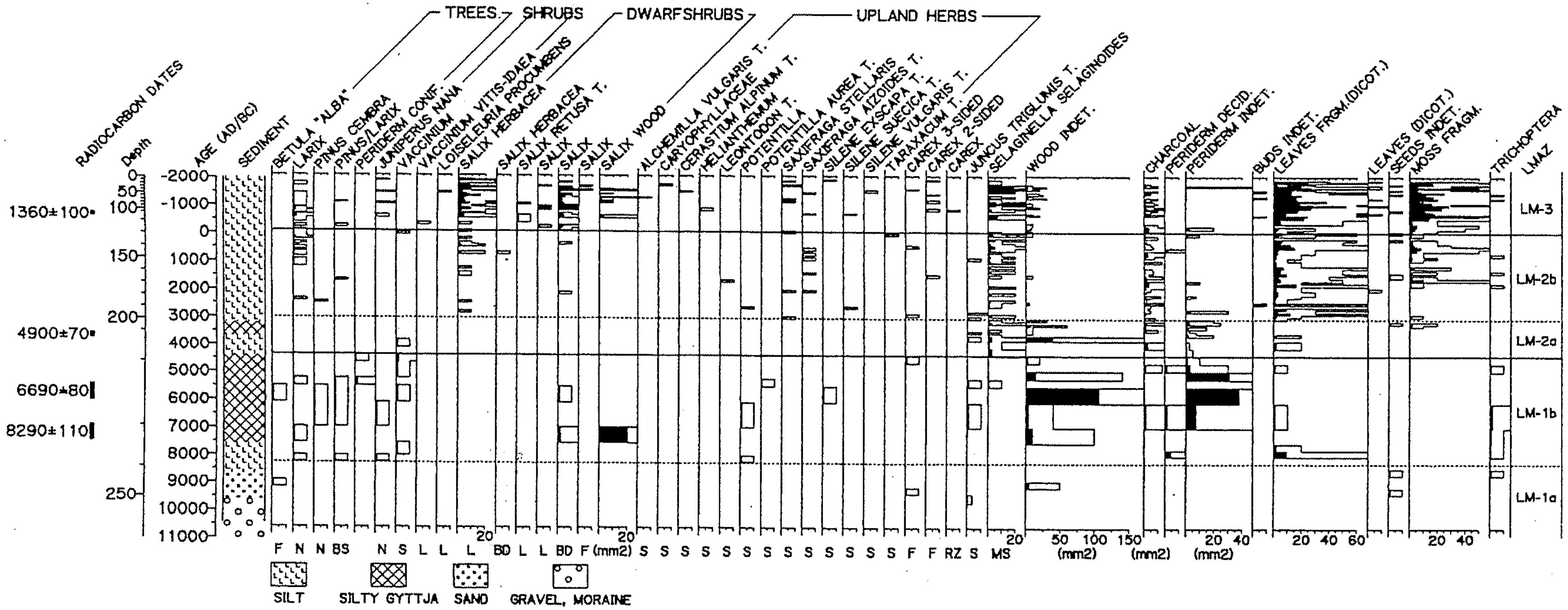


FIGURE 6. Plant-macrofossil concentrations at Gouillé Loéré (findings per 30 cm³). LMAZ = Local macrofossil-assemblage zones. Dicot. = dicotyledon, BD = buds, BS = budscales, F = fruits, L = leaves, MS = macrospores, N = needles, RZ = rhizomes, S = seeds, LM-1a to LM-3 = local macrofossil-assemblage zones 1 to 3.

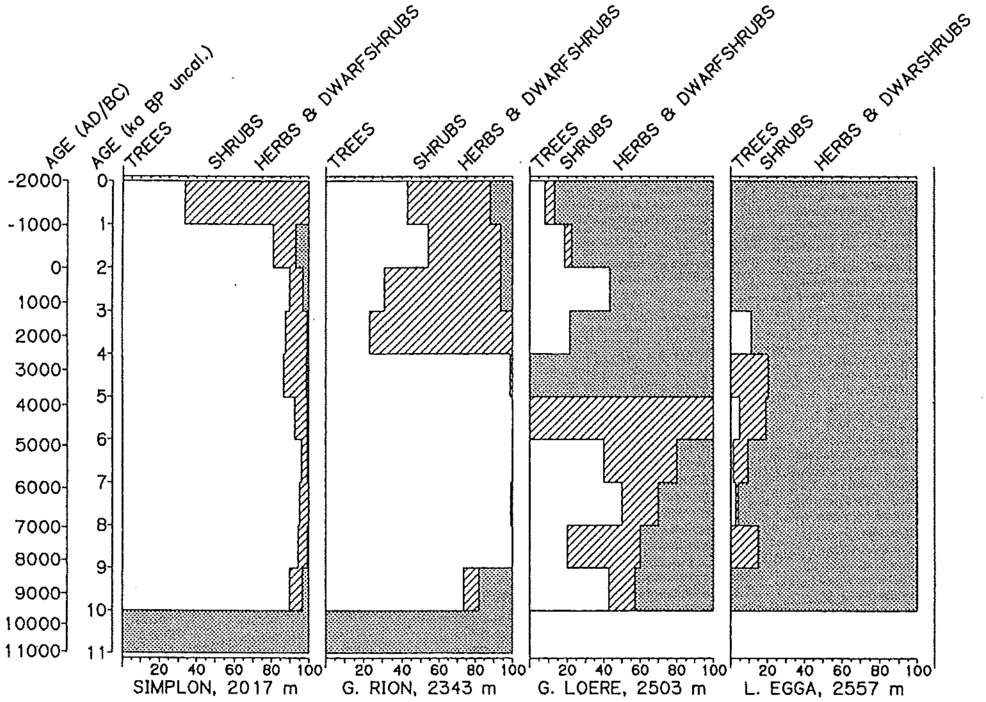


FIGURE 8. Macrofossil-percentage diagrams of four sites in the central Swiss Alps (Simplon: Lang and Tobolski [1985] modified; Gouillé Rion: Tinner et al. [1996] and Kaltenrieder [1999] modified; Gouillé Loéré and Lengi Egga: this study, Figures 6 and 7). Today's treeline is at about 2350 m a.s.l., i.e., near Gouillé Rion. Aquatic plants, Cyperaceae, and area measurements were excluded from macrofossil sum, and only taxa that could be unambiguously attributed to trees (indicating forests), shrubs (shrublands), and dwarf shrubs and upland herbs (alpine meadows) were considered for percentage calculation. The diagrams were subdivided in eleven 1000 radiocarbon-year steps.

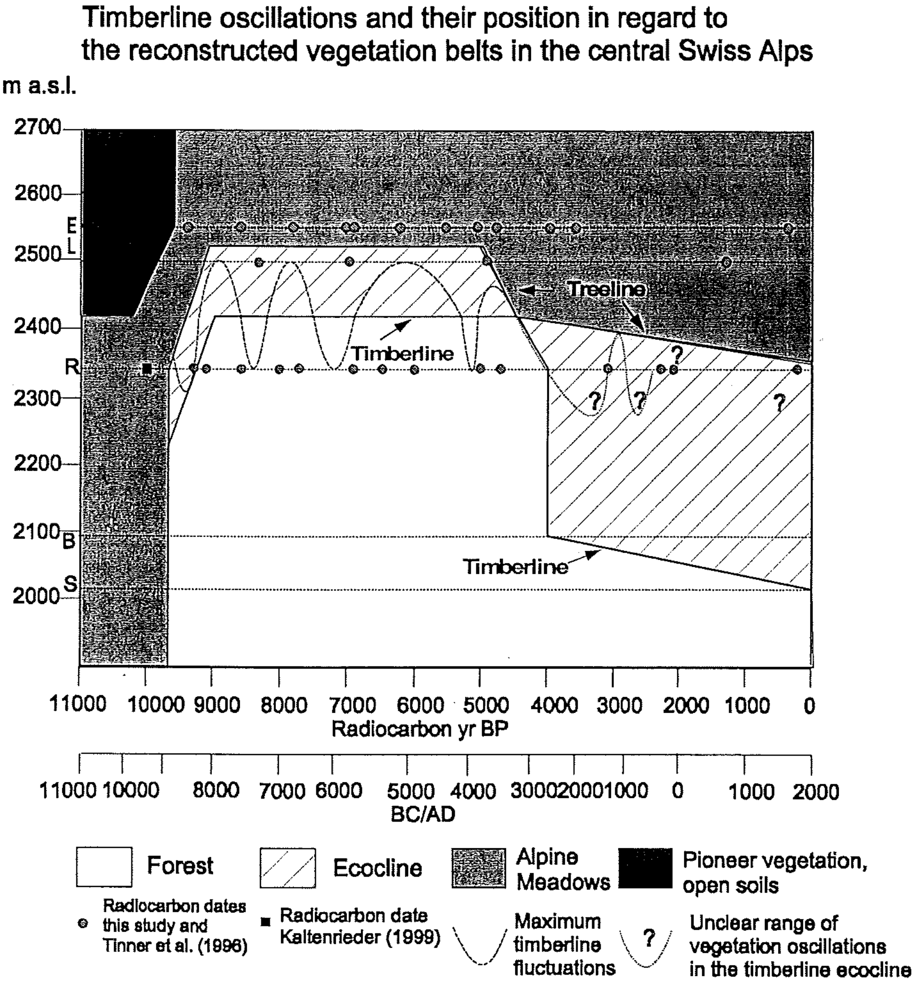
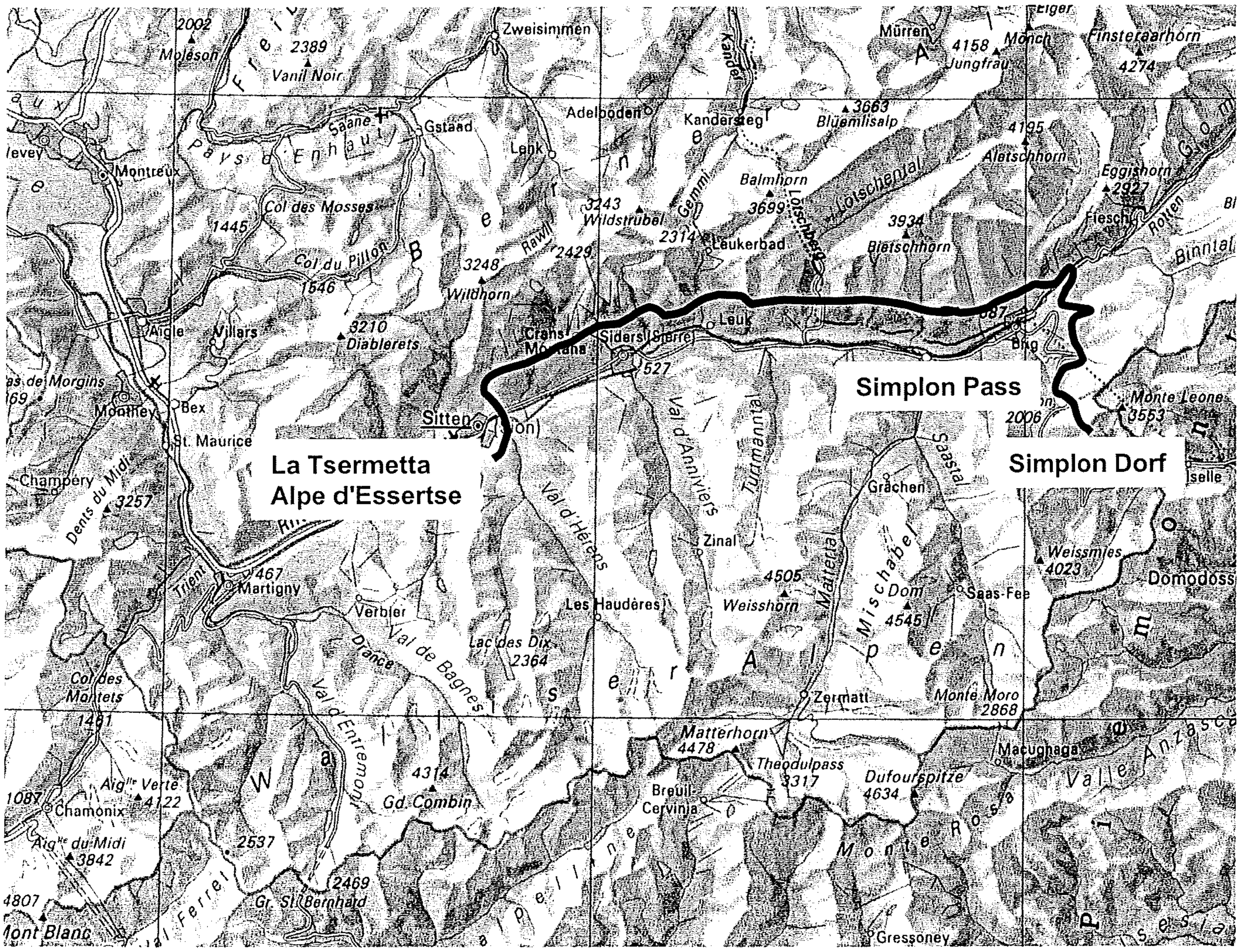


FIGURE 9. Diagram showing the altitudinal ranges of the main vegetational belts in the central Swiss Alps during the past 13,000 cal yr. The limits of the vegetational belts are placed between the sites recording the presence of the respective vegetation type as inferred by macrofossil analysis. The chronology relies on AMS-dating of terrestrial macrofossils at Gouillé Rion, Gouillé Loéré, and Lengi Egga, while at Simplon and Böhnigsee the original chronology published by the authors is supported by radiocarbon dating of gyttja samples (see van der Knaap and Ammann, 1997). For Böhnigsee no macrofossil data are available. Therefore stomata frequencies were used to reconstruct local vegetation (see Ammann and Wick, 1993). S = Simplon (Lang and Tobolski, 1985), B = Böhnigsee (Markgraf, 1969), R = Gouillé Rion (Tinner et al., 1996), L = Gouillé Loéré (this study), E = Lengi Egga (this study).

Monday, 8 September 2003

La Tsermetta, Alpe d’Essertse, Simplon Dorf

Monday, 8 September



Simplon-Hobschensee
The first macrofossil concentration diagram from a site near timberline in the Alps

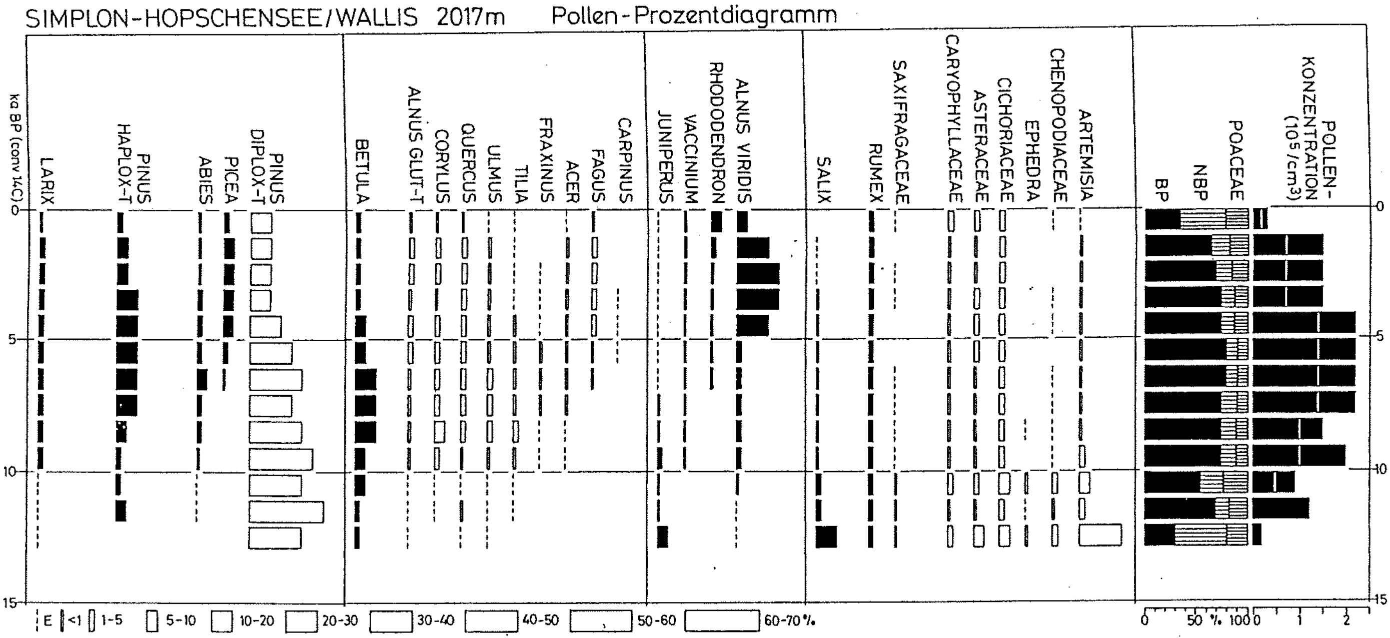
Source of text: Lang G. and Tobolski K., 1985: Hobschensee – Late Glacial and Holocene Environments of a Lake near Timberline. *Diss. Bot.* 87: 209-228. Source of figures: Lang G. 1994: *Quartäre Vegetationsgeschichte Europas*. G. Fischer, Jena, 462 pp.

The preliminary results of a palaeoecological study at Hobschensee (= Hobschusee) are presented. The lake is situated near the alpine timberline at an altitude of 2017 m a.s.l. in the Simplon pass area in the western central Alps (Wallis). The bedrock is crystalline, the vegetation in the surroundings consists today mainly of Juniperus-Ericaceae dwarf shrub with few scattered Larix trees.

Along a southwest-northeast transect the lake stratigraphy was studied by corings and two profiles were selected for palaeoecological investigations. The plant macrofossil analysis allows in combination with pollen percent and pollen concentration analysis (still under investigation) and in connection with two published pollendiagrams with radiocarbon dates (KÜTTEL 1979, WELTEN 1982) a detailed and reliable reconstruction of the environmental changes in that altitude during the last 13'000 years.

The pass area became ice free at the latest during the Bølling (13'000-12'000 B.P.) and was covered at first by alpine pioneer vegetation, later on by feldmark and snowbed communities (PAZ 1, MAZ 1a). In the Allerød (12'000-11'000 B.P.) the alpine vegetation cover was more closed and the timberline with birch was not far away (PAZ 2, MAZ 1b). In the Younger Dryas (11'000-10'000 B.P.) at first again alpine pioneer vegetation spread, indicating a remarkable climatic deterioration, followed by Salix snowbed vegetation (PAZ 3, MAZ 1c+1d).

During the Preboreal (10'000-9'000 B.P.) Juniperus-shrub spread, followed by Betula-Larix-forests (PAZ 4, MAZ 2 p.p.). In the Boreal (9'000-8'000 B.P.) and Atlantic (8'000-5'000 B.P.) the whole pass area was occupied by Larix-Pinus cembra forests (PAZ 5+6 p.p., MAZ 2 p.p.). During the Subboreal (5'000-2'500 B.P.) the forest cover was reduced and partly replaced by Alnus viridis-shrub (PAZ 6 p.p.+7 p.p., MAZ 2 p.p.+3), likely due to climatic deterioration. Finally in the Subatlantic (2'500 B.P.-present) the forest and shrub vegetation was more replaced by dwarf shrub and alpine meadows, mostly under human activity (PAZ 7 p.p.+8, MAZ 4+5).



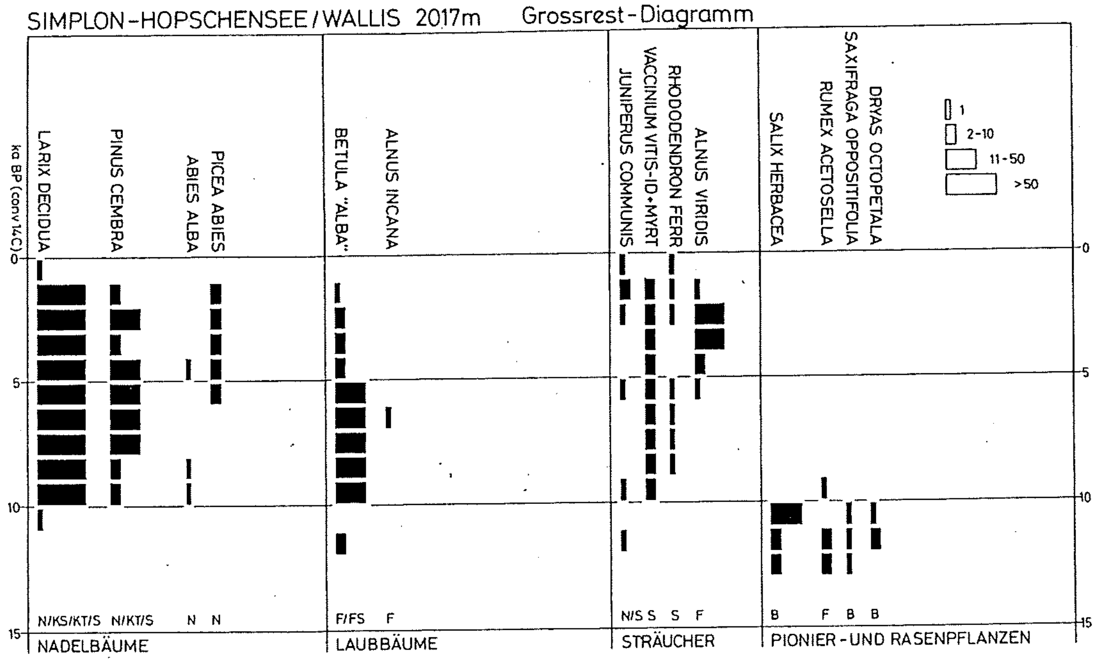


Abb. 4.3.4.-6. Pollen- und Großrestdiagramm aus dem Bereich der alpinen Waldgrenze in den Schweizer Zentralalpen: Simplon-Hopschensee (2017 m). Pollendiagramm (oben) nach KÜTTEL (1979), WELTEN (1982; mit 9 ^{14}C-Daten) und LANG (n.publ.), vereinfacht und als Histogramm mit geschätzten Mittelwerten für Perioden von jeweils 1000 Radiokarbonjahren dargestellt. Schwarz: Lokal vorhandene Pollentaxa (Großrestfunde). Weiß: Pollenfernflug (keine Großrestnachweise). Das Pollendiagramm enthält alle nachgewiesenen Gehölztaxa, jedoch nur eine Auswahl der Zwergsträucher und Kräuter und keine Sumpf- und Wasserpflanzen. Großrestdiagramm (unten) nach LANG & TOBOLSKI (1985), aus zwei Profilen kombiniert und vereinfacht als Histogramm dargestellt. B: Blattreste. F: Früchte. FS: Fruchtschuppen. KS: Knospenschuppen. KT: Kurztriebe. N: Nadeln. S: Samen.

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Treeline Fluctuations Recorded for 12,500 Years by Soil Profiles, Pollen, and Plant Macrofossils in the Central Swiss Alps

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Abstract

Past treelines can rarely be recorded by pollen percentages alone, but pollen concentration, pollen influx, and plant macrofossils (including stomata of conifers) are more reliable indicators. In addition, ancient forest soils above today's treeline may trace the maximum upper expansion of the forest since the last glaciation. Charcoal in such soil profiles may be radiocarbon dated. Our example from the Central Swiss Alps at the Alpe d'Essertse consists of a plant-macrofossil diagram and pollen diagrams of the pond Gouillé Rion at 2343 m a.s.l. and a sequence of soil profiles from 1780 m to 2600 m a.s.l. The area around the pond was forested with *Larix decidua* and *Pinus cembra* between 9500 and 3600 BP. After 4700 BP the forest became more open and *Juniperus nana* and *Alnus viridis* expanded (together with *Picea abies* in the subalpine forest). Between 1700 and 900 BP the *Juniperus nana* and *Alnus viridis* scrubs declined while meadows and pastures took over, so that the pond Gouillé Rion was definitively above timberline. The highest Holocene treeline was at 2400 to 2450 m a.s.l. (i.e. 50 to 100 m higher than the uppermost single specimen of *Pinus cembra* today) between 9000 and 4700 BP, but it is not yet dated in more detail. The highest charcoal of *Pinus cembra* at 2380 m a.s.l. has a radiocarbon date of 6010 ± 70 BP. Around 6900 BP a strong climatic deterioration caused an opening of timberline forest. First indicators of anthropogenic influence occurred at 4700 BP, when the forest limit started to move down. The lowering of timberline after 4700 BP was probably due to combined effects of human and climatic impact.

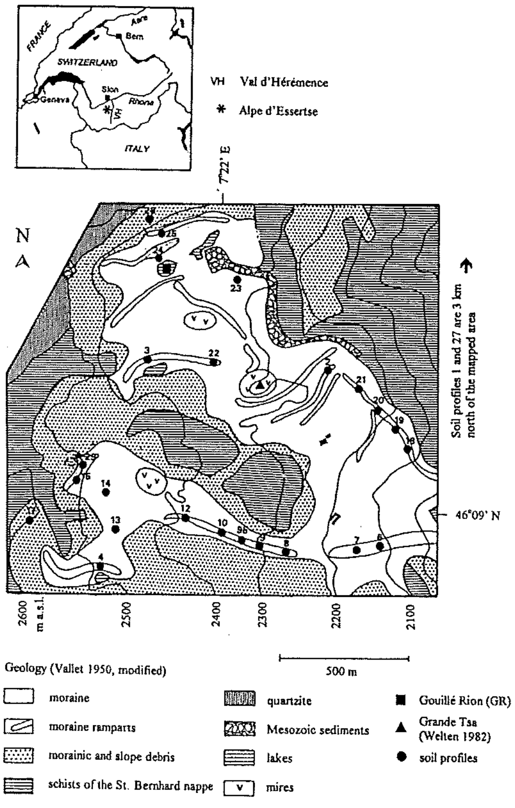


FIGURE 1. Topography and geology of Alpe d'Essertse, Swiss Alps.

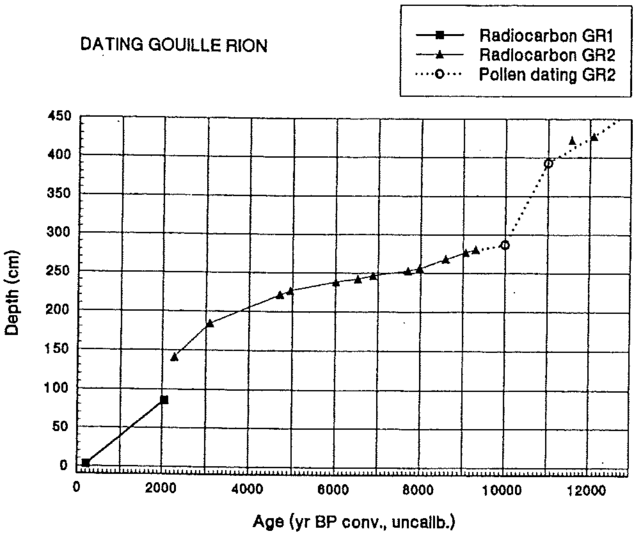


FIGURE 2. Radiocarbon and pollen dating of the sediments of Gouillé Rion.

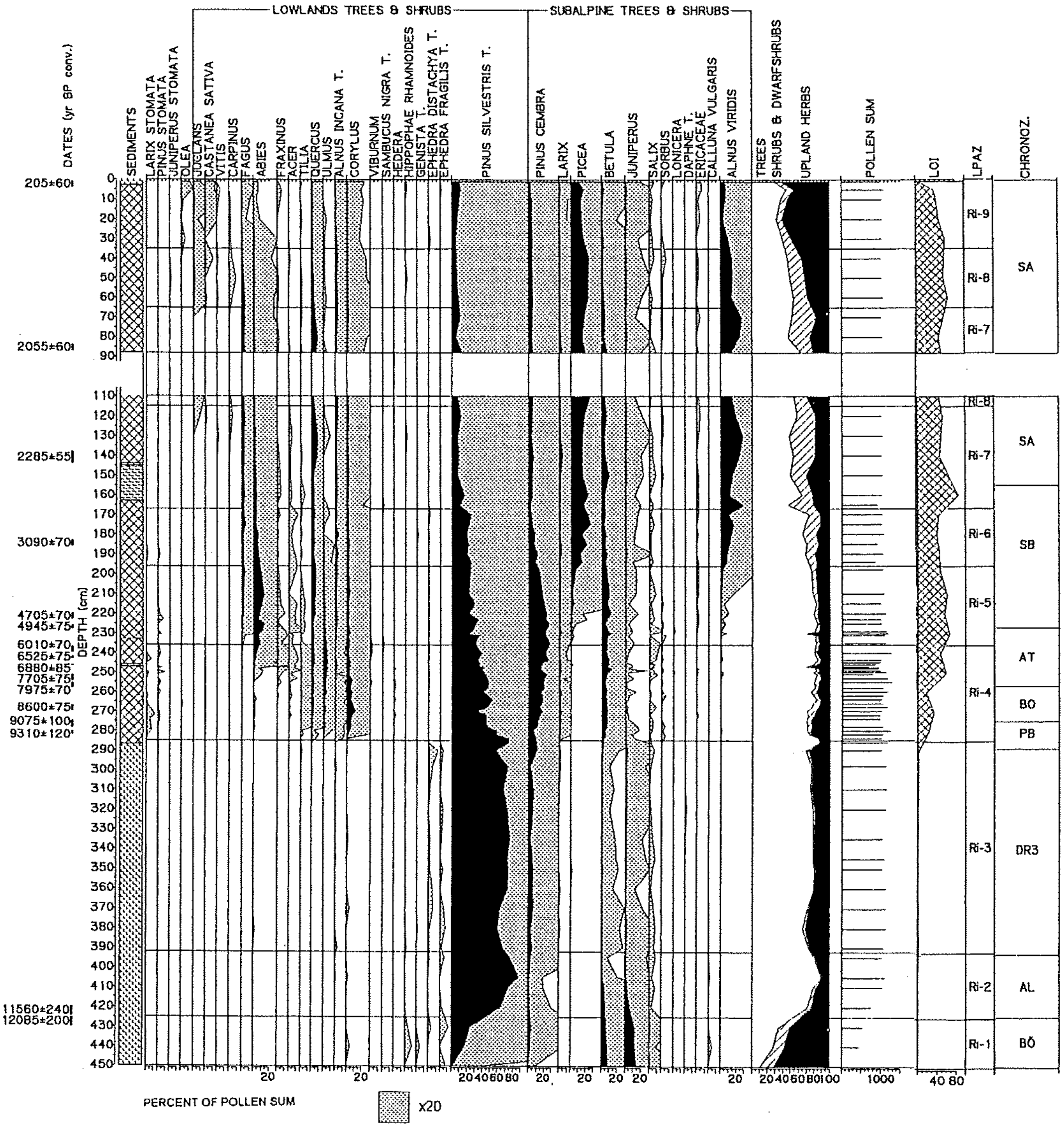


FIGURE 4. Percent arboreal pollen diagram of Gouillé Rion. GR 1 = 0–90 cm depth, GR 2 = 110–450 cm depth, LOI = loss on ignition, LPAZ = local pollen assemblage zones, CHRONOZ = chronozones according to Welten (1982).

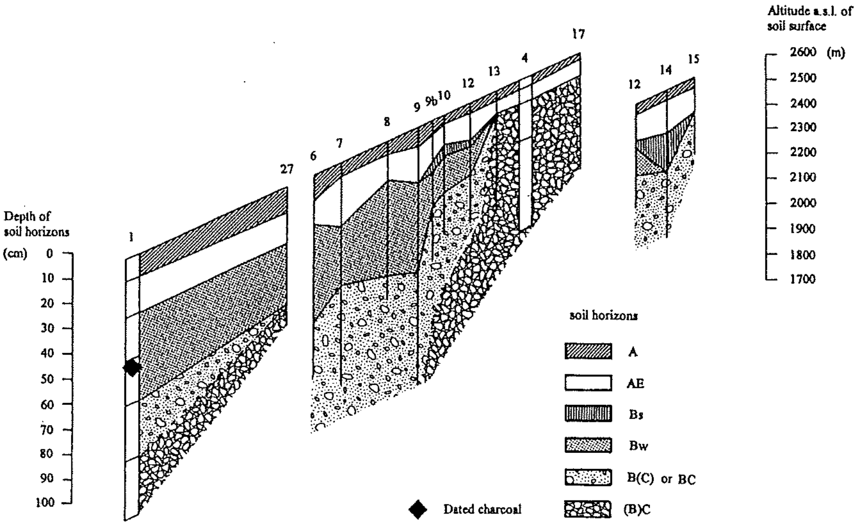


FIGURE 7. Southern transect of Alpe d'Essertse. Soil horizons and altitude a.s.l. shown with reference to the soil surface. The numbers of soil profiles are indicated above the soil surface. On the right (profiles 12–15) is the northern branch of the transect. Between 2400 and 2500 m a.s.l., Bw and Bs horizons are replaced by (B)C horizons.

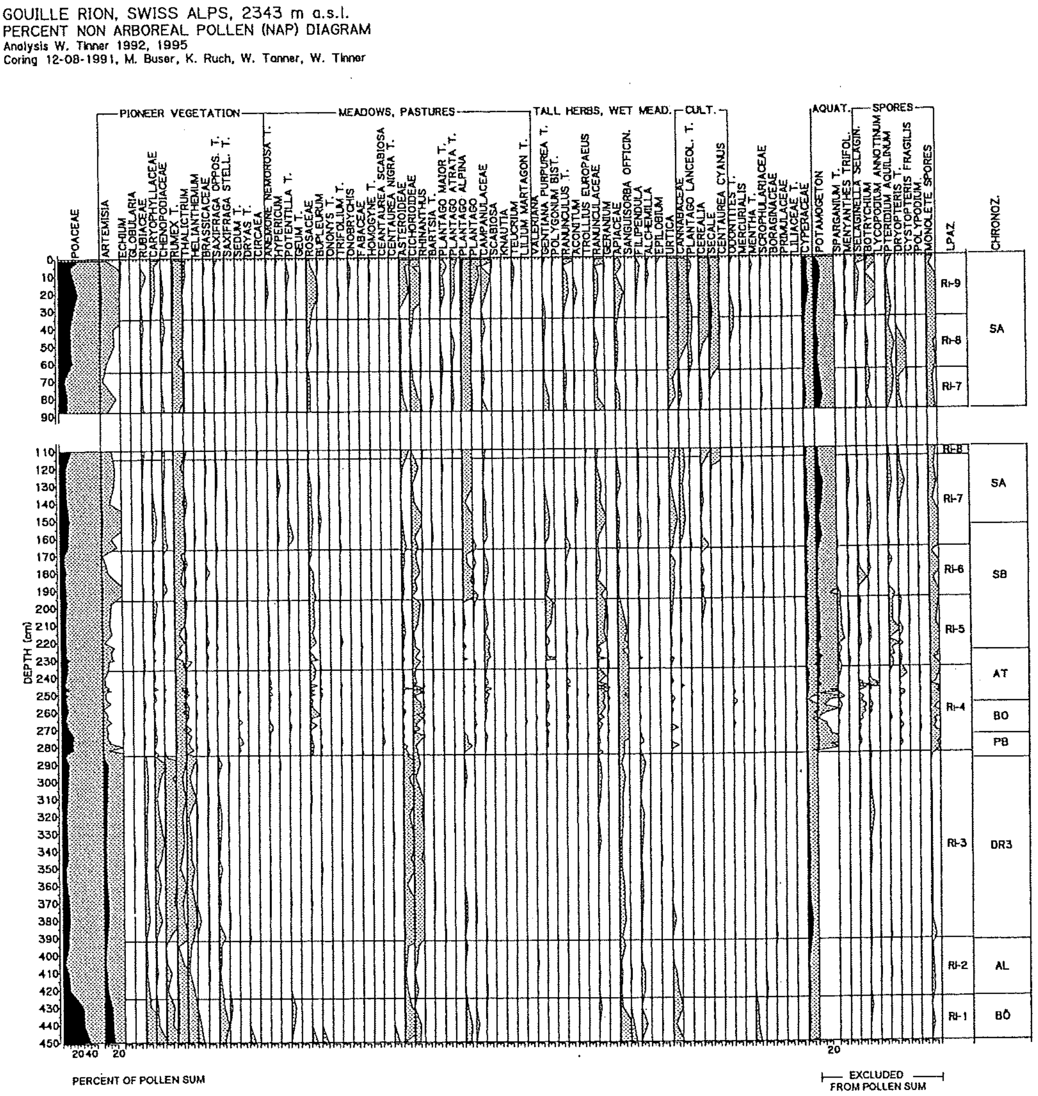


FIGURE 5. Percent nonarboreal pollen diagram of Gouillé Rion. GR 1 = 0–90 cm depth, GR 2 = 110–450 com depth, LPAZ = local pollen assemblage zones, CHRONOZ = chronozones according to Welten (1982).

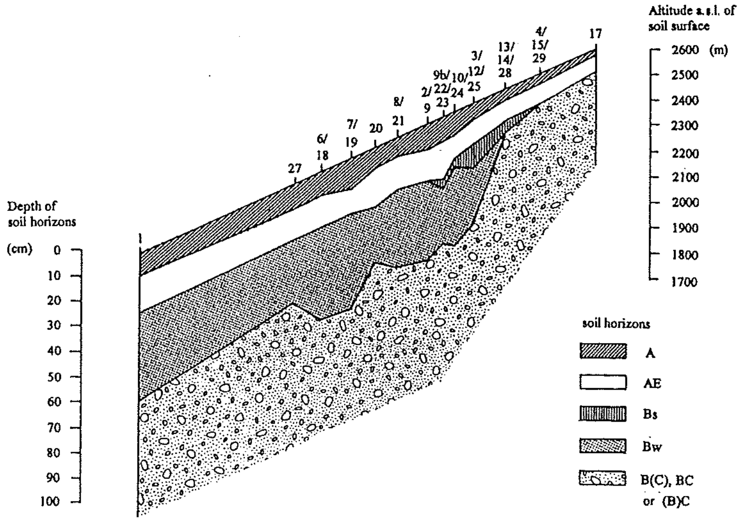
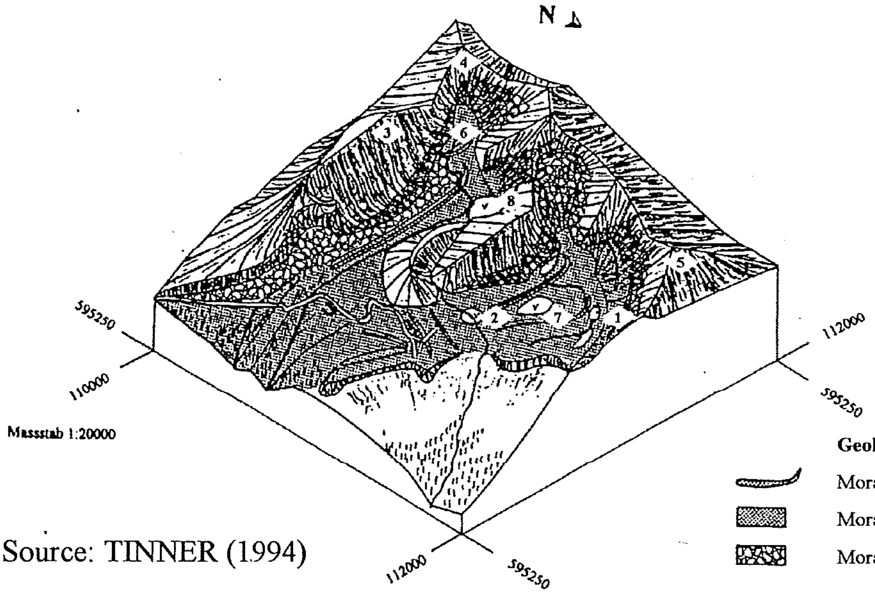


FIGURE 9. Summary view of northern and southern transects. Soil horizons and altitude a.s.l. are calculated for soil groups of similar altitude as arithmetic means. Between 2400 and 2500 m a.s.l., Bw and Bs horizons are replaced by (B)C horizons.

Holocene vegetation history and upper treeline fluctuations at Gouillé Rion (2343 m a.s.l. VS, Switzerland)

Petra Kaltenrieder, Brigitta Ammann, Willy Tinner; unpubl.

Due to problems of pollen production and long-distance pollen dispersal are characteristic of many wind-pollinated trees, it is of major importance to evaluate pollen-inferred timberline reconstructions by plant macrofossils. Using macrofossil analysis with a high temporal resolution (every 0.5 cm sediment depth, 15-25 yr) and a precise chronology, we reconstruct the local vegetation history, especially reforestation dynamics and timberline fluctuations. Comparison of our results with former macrofossil data tests the reproducibility of macrofossil studies.



Mountains, lakes, mires:

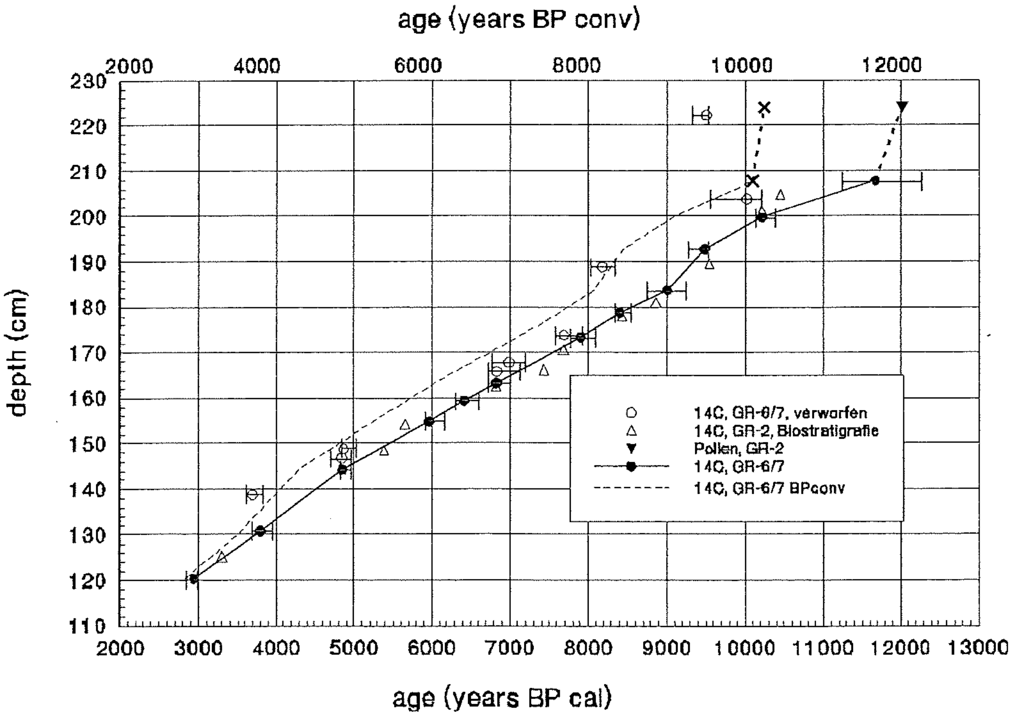
1	Gouillé Rion
2	mire Grand-Tsa (Welten)
3	Moncet
4	Greppon Blanc
5	Mont Rouge
6	Gouillé Verte
7	"Terrassenhochmoor"
8	"Geschichtetes Anmoor"

Geology:

Moraine ramparts
▨ Moraine material
▨ Morainic and slope debris

Source: TINNER (1994)

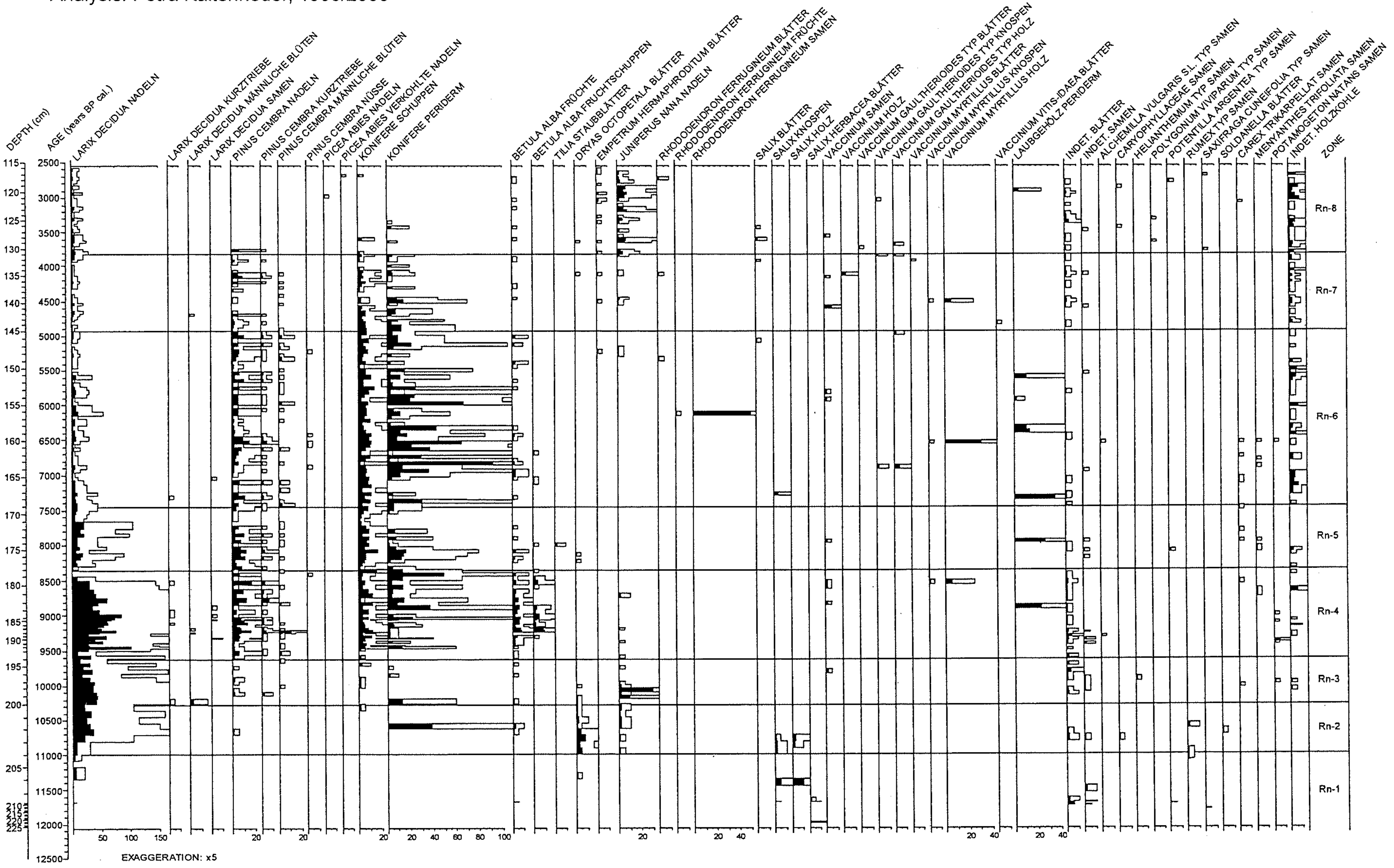
DATING GOUILLE RION



GOUILLE RION (2343m asl.)

PLANT MACROFOSSIL CONCENTRATION DIAGRAM: SELECTED TAXA

Analysis: Petra Kaltenrieder, 1999/2000



Vergleichende Biostratigrafie des Gouillé Rion 1996 (Pollen und pfl. Makroreste) und 1999/2000 (pfl. Makroreste)

Gouillé Rion 1999/2000 (GR-6/7)			**Gouillé Rion aus TINNER et al. (1996) (GR-2)**		
Zone	**Vegetationstyp**	**^{14}C Alter in J. BP cal.**	**Zone**	**Vegetationstyp**	**^{14}C Alter in J. BP cal.**
LMAZ 1	alpine Rasen, Pioniervegetation	12'100-11'000	PAZ Ri-3 MZ Rn-2	alpine Rasen, Pioniervegetation	12'950-11'050
LMAZ 2	offene Lärchenbestände mit *Salix, D.octopetala* und wenig *J. nana*	11'000-10'300	PAZ Ri-4 MZ Rn-3	offene Lärchenbestände mit *D. octopetala* und *J. nana*	11'050-6'650
LMAZ 3	offene Lärchenbestände mit einzelnen Arven und *J. nana*	10'300-9'650		Wald mit Lärchen und zunehmender Arven-Dominanz sowie *Betula alba*	
LMAZ 4	Lärchen-Arvenwald mit *Betula alba*	9'650-8'350			
LMAZ 5	Lärchen-Arvenwald	8'350-7'450			
LMAZ 6	Arvenwald mit einzelnen Lärchen	7'450-4'950	PAZ Ri-5 MZ Rn-4	Arvenwald mit einzelnen Lär.	6'650-3'900
LMAZ 7	offene Arvenbestände mit einzelnen Lärchen	4'950-3'800		rückgängiger Arvenwald mit einzelnen Lär.	
LMAZ 8	Zwergwacholderheiden mit einzelnen Lärchen	3'800-2'550	PAZ Ri-6 MZ Rn-5	Zwergwacholderheiden mit Grünerlengebüschen und einzelnen Lär.	3'900-2'830

The patterned fen of La Grand Tsa at 2330 m in the Swiss Alps

H.E. Wright, Ivanka Stefanova, Jacqueline F.N. van Leeuwen, Brigitta Ammann

Peatlands occur where drainage is impeded and where plant growth is vigorous enough for accumulation to exceed decomposition. Peatland surfaces may contain mounds as a result of local presence of trees or shrubs that provide woody biomass that decomposes less readily than graminoids and mosses. Between the mounds are low spots in which water can accumulate and inhibit growth of vascular plants. The patterns formed by mounds and hollows may become linear if a gentle slope exists, and the long axes of the hollows are invariably parallel to the contours of the slope. The intricate winding pattern of pools in the string fens (aapamoors) of boreal Finland is an extreme example, but the domal form of raised bogs provides enough slopes for the development of an arcuate pattern of pools. The miniature fen of La Grand Tsa in the Swiss Alps has a pattern of three parallel linear pools with orientation that fits the model so well represented in boreal forests.

Any distinctive pattern in the landscape begs for an explanation. Research on the pools on the patterned fens of southeastern Labrador and on the raised bog of Hammarmossen in central Sweden (Foster et al. 1983) led to an hypothesis that can be applied to La Grand Tsa. The development of linear pools involves the following steps/

1 When enough peat accumulates on a gently sloping substrate to lead to the formation of irregularities on the surface, water collects in the low spots during snow melt to form small pools.
2 When a pool fills above the level of a low segment on the downslope rim, it will drain to the next lower pool and not enlarge. But when the lowest part of the rim is on the contour, the pool will drain laterally to the next pool, producing a larger linear pool parallel to the contour
3 Plant growth in the pool is inhibited in the standing water, whereas on the relatively dry adjacent ridge shrubs and even trees increase the height, and the pool thereby becomes deeper.
4 Dissolved oxygen in the water, enhanced by the products of algal photosynthesis, results in decomposition of the peat on the floor of the pool, and the adjacent ridge may be locally undermined. The pool thus becomes deeper and larger. Masses of decomposed peat may rise to the surface as a result of the methane and carbon dioxide produced by decomposition. Such masses release gas when poked with a stick. Some masses may still be attached to the floor by a root like an umbilical cord.
5 With a larger water surface and deeper water, algal growth results in accumulation of detritus (gyttja), thus burying the decomposed peat.
6 The pool may ultimately fill with gyttja, the surface of which then can support growth of mosses and sedges, and the cycle may start again.

In the oriented pools investigated on a fen in southeastern Labrador, the sequence terminated with step 4, and the peat on the floor of the pool was completely removed by decomposition to the mineral substratum, with only pieces of refractory wood remaining (Foster et al. 1983). The arcuate pools studied on flanks of the raised bog

Hammarmossen in central Sweden were well developed, and the entire sequence was represented. Radiocarbon dating of the basal peat an a transect of pools showed that the bog grew from the center outward (Foster and Wright 1990). The early stages of development from dry hollows to linear pools can be witnessed near the modern bog margin, and the full sequence can be observed in the older and deeper pools toward the center. In the latter area paired radiocarbon dates from the top of the decomposed peat and the base of the overlying gyttja at four different sites indicated hiatuses of 250, 430, 640, and 1430 years (Foster et al. 1988). An hiatus represents the amount of peat removed by decomposition before burial by gyttja. After the hiatus in these four cases gyttja accumulation started at 2390, 3779, 1300, and 2500 years ago, respectively.

In the patterned mini-fen of La Grand Tsa cores were obtained from a pool and from the adjacent peat ridge. The 3-m core from the ridge actually contained gyttja as the basal 30 cm of sediment, so a lake first filled the depression before peat developed over the entire area. In the pool core, the basal peat was overlain by 28 cm of decomposed peat to a depth of 20 cm below the water surface. After a 2-cm transition, 16 cm of gyttja continued to the top of the core., Radiocarbon dates just below and above the transition were 3720 and 3080 yr BP, indicating that 700 yr of peat was removed by decomposition before being buried by pool gyttja.

To provide further evidence that the hiatus was a result of removal of the peat by complete decomposition, pollen profiles were prepared for the ridge core and the pool core. The ridge core presumably provided an uninterrupted stratigraphic sequence of peat.accumulation. (A gap between 70 and 100 cm was the result of incomplete recovery in the top 1-m core segment.) The pollen profiles of the two cores can be matched up to 70-cm depth in the ridge core and to 24 cm in the pool core, as marked by the steep rise of *Picea* to about 30 %, along with increase of *Alnus viridis, Larix,* and *Fagus,* and the decrease of *Pinus* and *Abies*. The succeeding 70 cm of peat in the ridge core up to the sharp rise in *Pinus* at about 16 cm is missing from the pool core. The missing 70 cm pf peat in the pool core represents about 700 years of complete decomposition of the pool peat before it was buried by gyttja, as measured by the two radiocarbon dates just below and just above the base of the gyttja.

The above reconstruction must be considered speculative until radiocarbon dates on the ridge core can evaluate the correlations of the pollen sequence in the two cores.

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Foster, D.R., Wright, H.E., Jr., Thelaus, M., amd King, G.A., 1988. Bog development and landform dynamics in central Sweden and southeastern Labrador, Canada. Journal of Ecology 76, 1164-1185.

Foster, D.R., and Wright, H.E., Jr., 1990. Role of ecosystem development and climate change in bog formation in central Sweden. Ecology 71, 450-463.

Figure captions

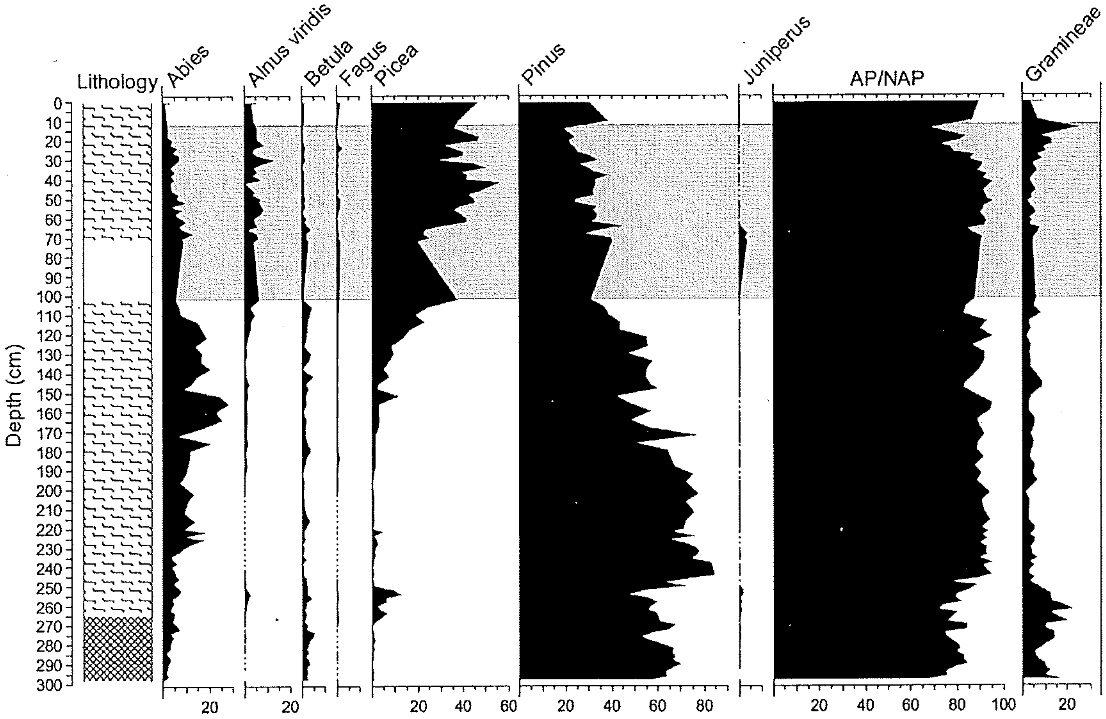
1. Pollen diagram for the core from the peat ridge. The shaded part shows the 70-cm section that was removed in the pool by peat decompositon before burial by gyttja
2. Pollen diagram for the pool core. The shaded section, bounded by two radiocarbon dates 700 years apart, marks the transtional contact between decomposed peat below and gyttja above. The peat that was decomposed and removed is shown in Figure 1. Note that the forms of the *Picea* and *Pinus* profiles below the shaded sections of both figure 1 and 2 can be correlated. The correlation above the shaded sections is less convincing, but note the difference in the vertical scale in the two figures.

tsa-main (3212x2340x256 tiff)

Tourbiere de La Grande Tsa

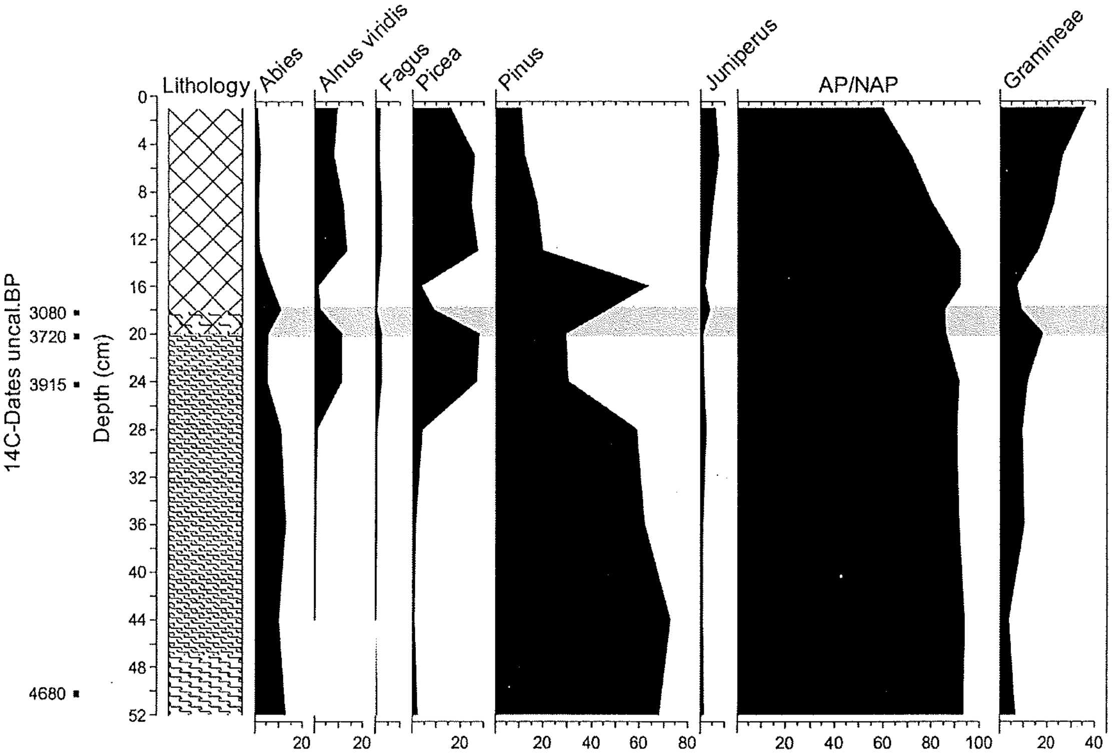
Master core

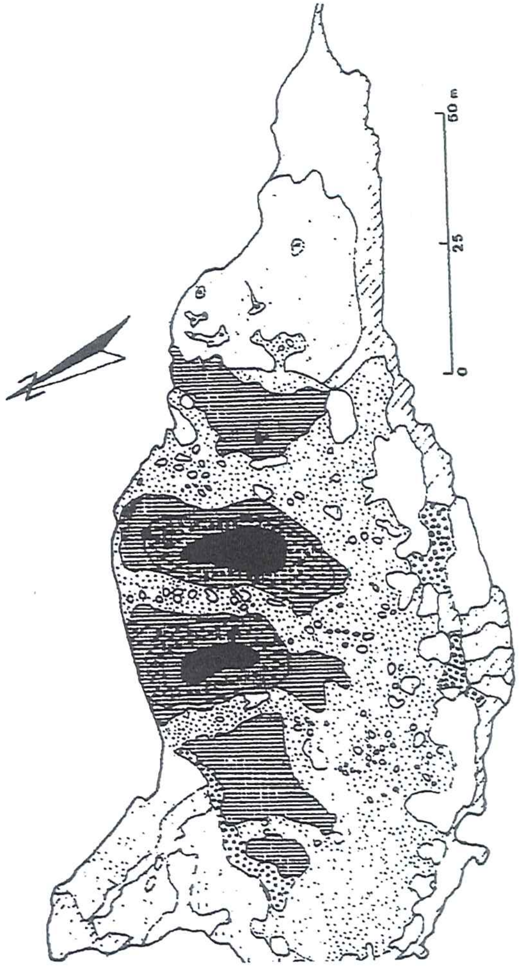
Pollen percentages of selected taxa



tsa-pool (3058x2340x256 tiff)

Tourbiere de La Grande Tsa
Pool III
Pollen precentages of selected taxa





Roh & Rey 1989

■ Plan d'eau libre	□ *Sphagnetum fusci*
⁘ *Caricetum rostratae*	☷ *Caricetum fuscae trichophoretosu*
▥ *Caricetum limosae*	⁘ *Trichophoretum caespitosi alpinum*
▧ *Caricetum fuscae*	* Tourbe dénudée

Was it climate or land cover change?
A model-based reconstruction of forest dynamics in the Valais

Abstract of the presentation by H. Bugmann & C. Heiri

Based on a new Holocene temperature reconstruction (Heiri 2001), a first attempt of reconstructing forest dynamics along an elevational transect in the Valais was made using ForClim, a semi-mechanistic forest gap model (cf. Bugmann & Pfister 2000). Weather data for today's climate was interpolated along a virtual transect between two grid points of the Swiss National Forest Inventory that are close to those sites at which long-term records of pollen and macrofossil data are available (Simplon 2017 m a.s.l., Gouillé Rion 2343 m a.s.l, crossing the current tree line position).

A test run with the model under current climate showed the importance of estimating the water balance variables as precise as possible. Changes in soil properties lead to a flip-flop behavior of the system between a forest dominated by Swiss stone pine (*Pinus cembra*) and a forest dominated by Norway spruce (*Picea abies*). Similar results can be obtained by slightly varying the average amount of precipitation, or by changing precipitation variability. Unfortunately, due to the lack of a good reconstruction of precipitation across the last 12000 years, the amount and variability of precipitation were assumed to be constant in the simulation.

The results of the simulation across the Holocene at 2350 m.a.s.l. showed, unlike the pollen data, no continuous forest cover. Along the simulated virtual transect the tree line position was found to vary between 2150 and 2400 m.a.s.l., whereas the analysis of fossil findings suggests a smaller range of 150 m. The deviation between simulation and paleoecological findings may be caused by the fact that the model-based reconstruction used the unsmoothed temperature reconstruction data, which may not be entirely reliable.

We conclude that our first attempt of reconstructing tree line dynamics during the Holocene in the Valais is faced with some major uncertainties: (1) the accuracy of the Holocene climate scenario, mainly the precipitation scenario; (2) the lack of knowledge of soil development across the Holocene; and (3) the accuracy of the model projections themselves (location of the flip-flop of the system in climate space).

The next steps of the project will be to analyse and improve the input variables for the current climate, to launch simulation studies at all sites with available pollen data, and to look into the question of finding a way to include Holocene precipitation and soil development scenarios in future simulation experiments.

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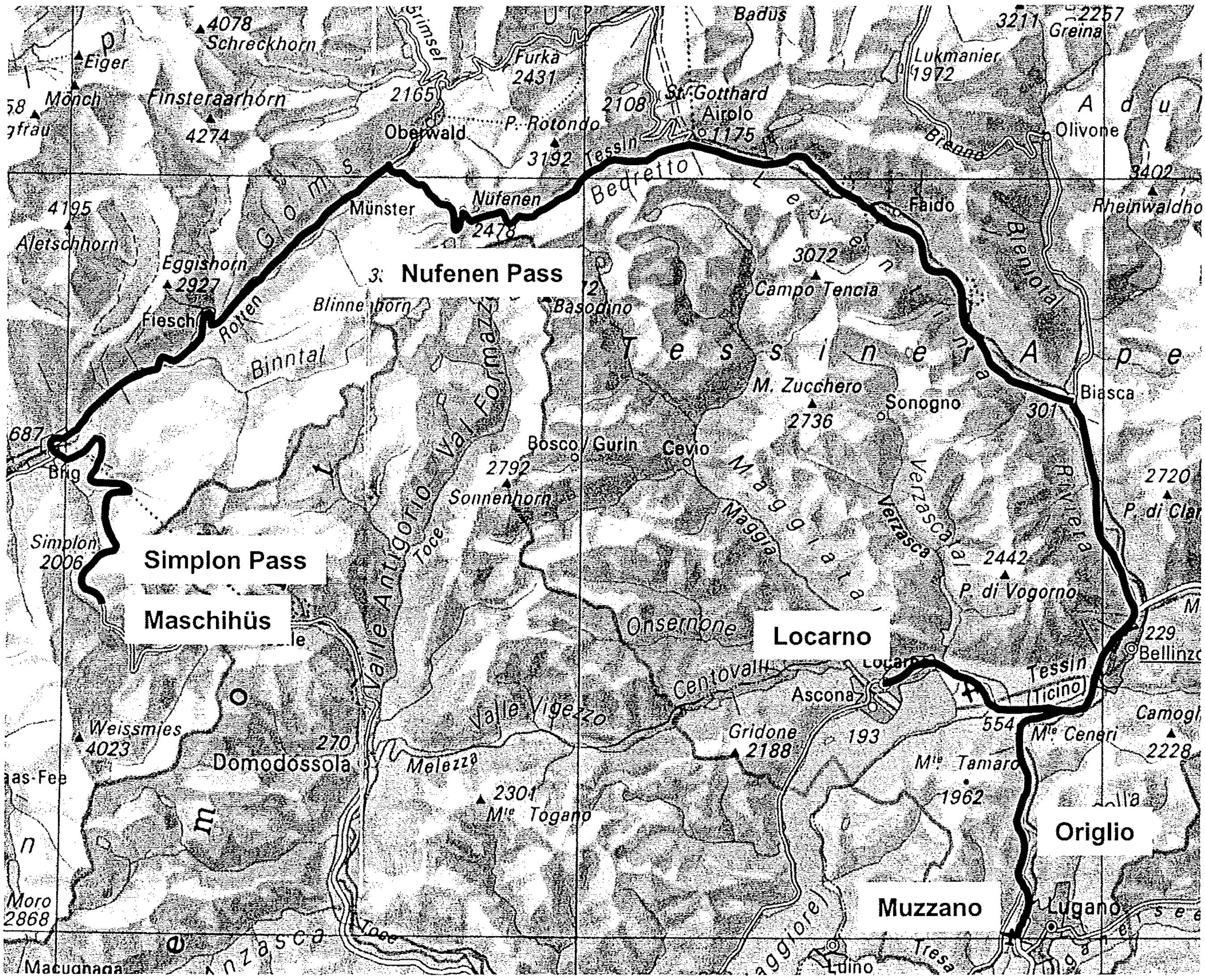
Tuesday, 9 September 2003

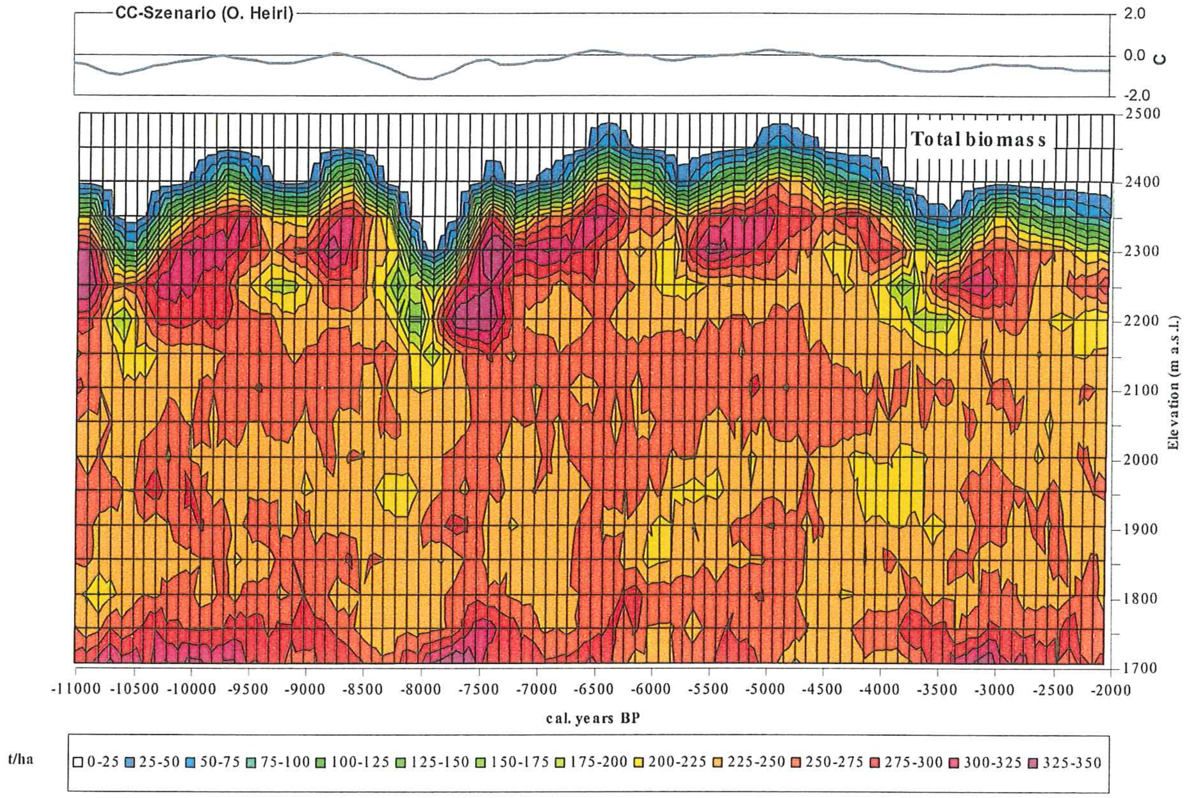
Maschihüs, Nufenen Pass, Origlio, Muzzano

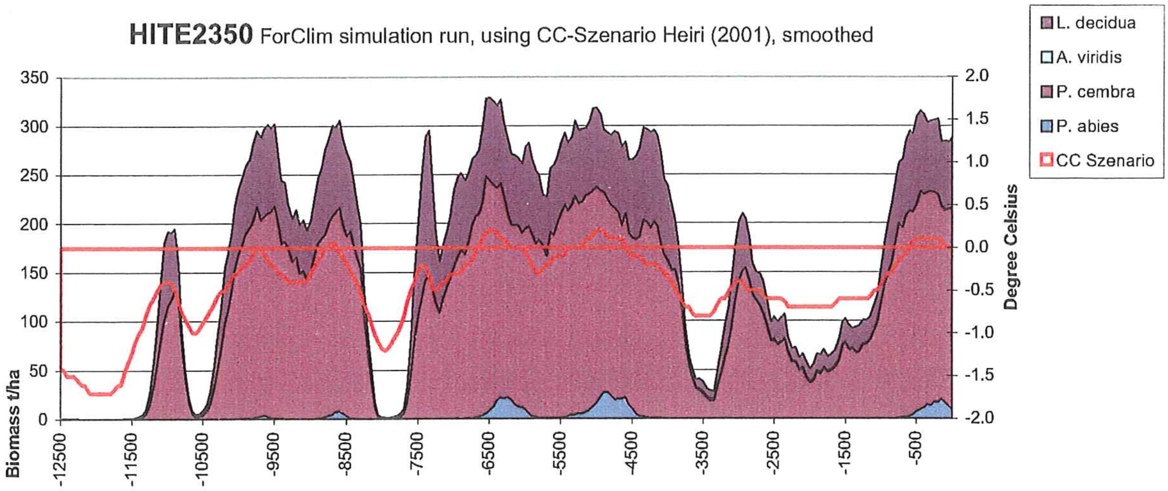
Tuesday, 9 September

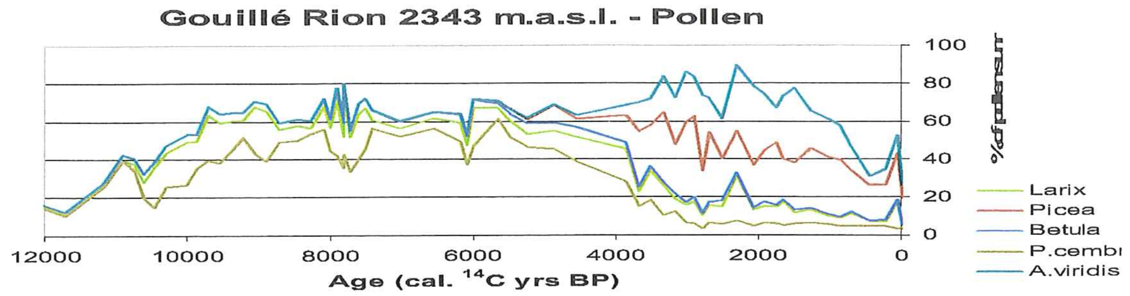


Results: virtual altitudinal transect

based on smoothed temp. reconstruction (Heiri, 2001)







Timberline Paleoecology in the Alps

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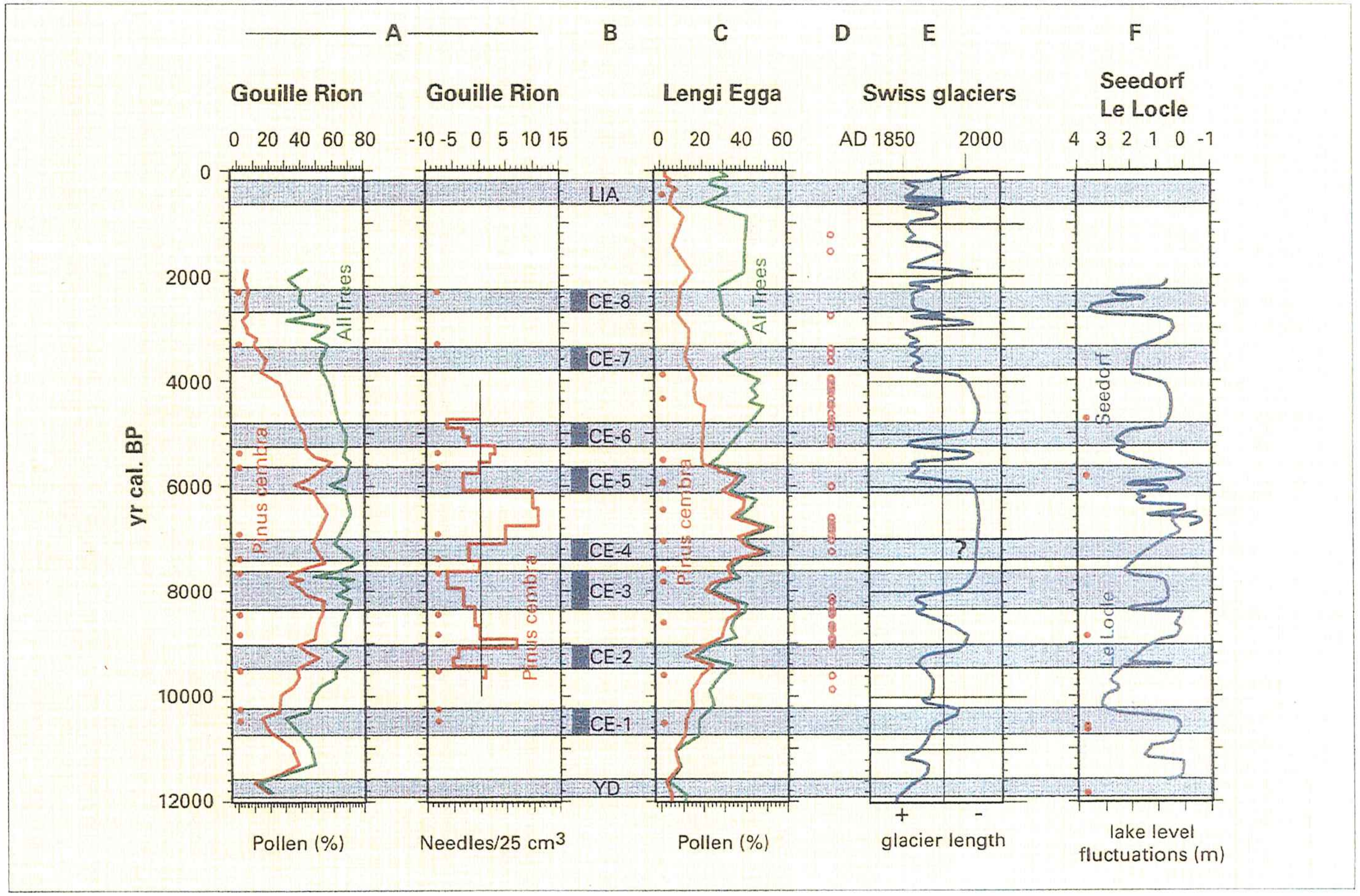

*Fig. 1. Comparison between timberline vegetation, glaciers, and lake level fluctuations during the past 12,000 cal. yr BP. **A**: Pollen percentages (Pinus cembra, sum of trees) and macrofossil concentrations (Pinus cembra needles) at Gouillé Rion (Swiss Alps) (Tinner et al., 1996; Tinner and Wick, 1997). The pollen sum includes only subalpine and alpine taxa. **B**: Central European cold-humid phases (Haas et al., 1998). **C**: Pollen percentages (Pinus cembra, sum of trees) at Lengi Egga (Swiss Alps) (Tinner, unpublished). The pollen sum includes only subalpine and alpine taxa. **D**: Chronological position of radiocarbon dates of wood and organic debris collected in front of Alpine glaciers (Hormes et al., 2001). **E**: Estimated length variation of Swiss glaciers (Maisch et al., 1999). **F**: Lake level fluctuations in meters at Seedorf and Le Locle (Switzerland) (Magny and Richoz, 1998; Magny and Schoellammer, 1999). The dots in A, C, and F show the chronological position of radiocarbon dates used for the depth-age models.*

SCHWARZENSTEIN-BOG IN THE ALPINE ZILLER VALLEY (TYROL, AUSTRIA): A KEY SITE FOR THE PALYNOLOGICAL DETECTION OF MAJOR AVALANCHE EVENTS IN MOUNTAINOUS AREAS

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INTRODUCTION

Avalanches made out of snow and ice belong to the most destructive natural hazards in High Mountain regions worldwide. Up to very recently only historical accounts existed for such catastrophes, which can deeply affect humans, their settlements, as well as their overall economy. Within our new, interdisciplinary research project '**HOLA** – Evidence and Analysis of Holocene Avalanche Events' (http://fbva.forvie.ac.at/800/hola.html) running from 2002-2005 and initiated by the 'Austrian Federal Office and Research Centre for Forests' we are now able to extend our knowledge about prehistorically important avalanches in the Alps far back in time.

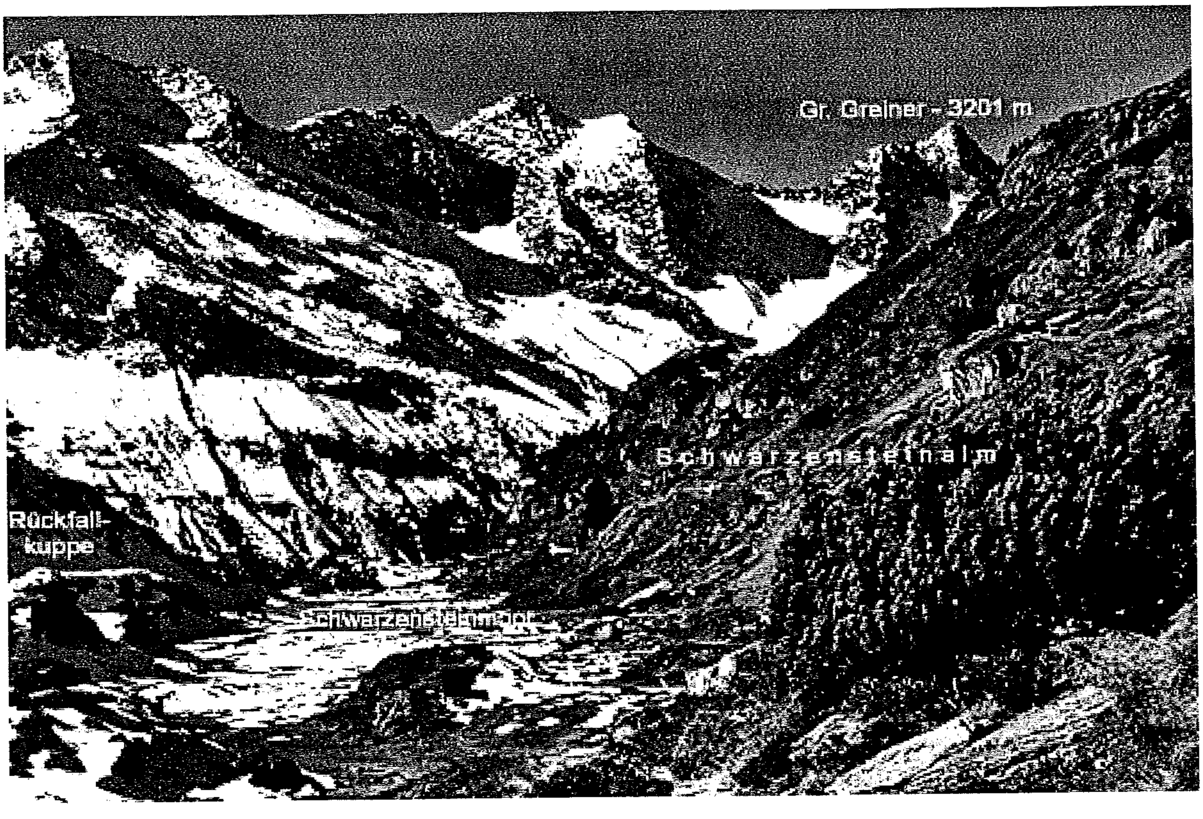

Fig. 1: View of Schwarzenstein-Bog in Tyrol Austria (Photo: P. Pindur).

The dendrochronological investigation on several dozens of up to 400 years-old *Pinus cembra* tree stems found within the peaty body of Schwarzenstein-Bog in the high alpine area of the 'Oberer Zemmgrund' in the Zillertaler Alps in Tyrol, Austria (2150 m a.s.l.; N 47°01'45'', E 11°49’00’’; Fig. 1 & 2) offers now the possibility of dating, interpretation and modelling of major avalanche events for the last 6000 years.

Grundlage:
SW - Luftbild Nr. D13566 (nicht entzerrt)
Waldbestandsaufnahme von Tirol, 19. Aug. 1954
Luftbildscan: 2000 dpi
Bundesamt für Eich- und Vermessungswesen, Wien
Bearbeitung: Peter Pindur 2001

Fig. 2: Aerial Overview of Schwarzenstein-Bog with the coring location marked.

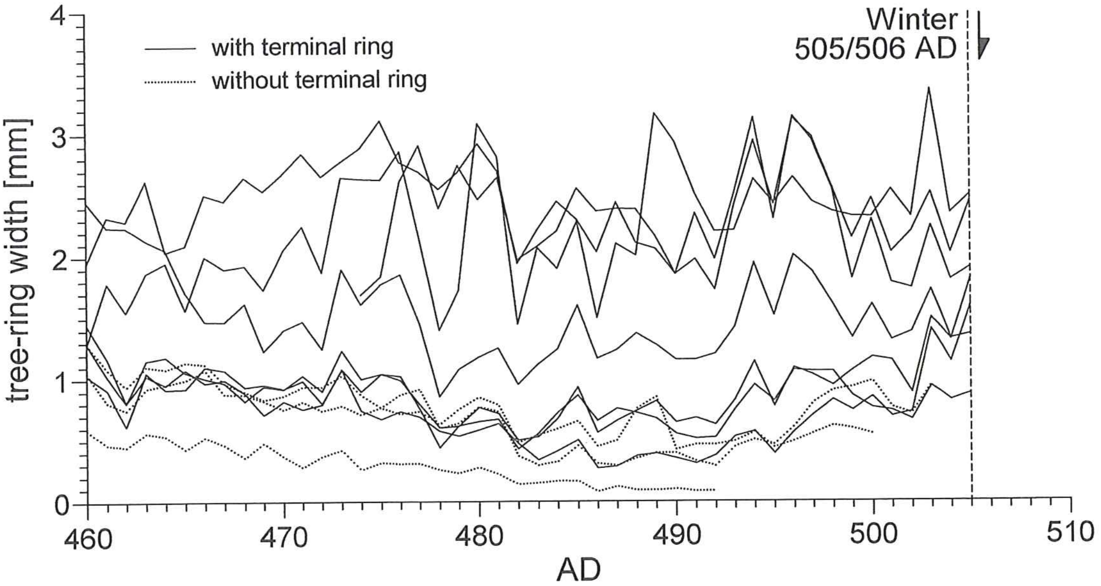

Fig. 3. Tree-ring series of subfossil trees killed by the avalanche event in winter 505/506 AD.

Calendar dates for such avalanche events at Schwarzenstein-Bog (Pindur, 2001; Nicolussi et al., in prep.) were done by using a new 7000-year long Alpine tree-ring chronology (Nicolussi & Schießling, 2002). Typical avalanche logs show fully developed and wide terminal rings, indicating a sudden, synchronous death of the trees during winter (Fig. 3). According to the dendrochronological dating of tree-stem series five major avalanche disasters existed in the winter of 3834/3833 BC, 2787/2786 BC, 2774/2773 BC, 168/167 BC, and 505/506 AD. Another may be less pronounced avalanche event occurred in the winter of 4055/4054 BC (Luzian & Pindur 2000; Pindur 2001; Pindur *et al.* 2001). To our knowledge, this is the first time that prehistorical avalanches were year-dated with such precision for alpine areas. We have therefore excellent possibilities for the detection and calibration of such avalanche events in the according pollen profiles from Schwarzenstein-Bog, which furthermore will potentially lead to the possibility of recognising major, prehistorical avalanche events at other localities in the European Alps and elsewhere (Northern Europe, North America, Asia).

MATERIALS AND METHODS

First pollenanalytical investigations are running since June 2003 and the first preliminary results are presented here (Fig. 3). The 280 cm long sedge- and moss-peat stratigraphy covers about 9500 years of pretty regular deposition and was taken in autumn 2002 from the bog part 'E' hidden behind a small ridge, unaffected from major avalanches today. Sample preparation was done according to standard techniques (Seiwald 1980; Stockmarr 1971), but without using HF. Palynological analyses were performed for pollen, for fern and bryophyte spores, as well as for all kinds of extrafossils, and by counting at least 1000 pollen per sample depth. Two radiocarbon datings give an already acceptable time control and allow (together with pollen indicators for specific time periods (such as *Castanea sativa*, *Juglans regia* and *Secale cereale* for the Roman Times) to construct a preliminary, time-linear pollen profile. This is also done in order to compare year-dated avalanche events with vegetation changes and possible plant succession stages (Fig. 3).

RESULTS

The 9500-year Holocene vegetation development follows the general trends known for this part of the Tyrolean Alps (Hüttemann & Bortenschlager 1987; Weirich & Bortenschlager 1980). Pollen from Pine, Cembran Pine, Spruce and Green Alder dominate the local tree cover at altitudes above 1500 metres. Pollen from typical 'Krummholz' plant societies, as well as herbs form high alpine pioneer and meadow plant species are also well represented throughout the pollen record. The appearance and constant presence of anthropogenic indicators since about 5800 years is remarkable for this relatively remote area. The regular presence of several species of e.g. *Plantago, Rumex, Oxyria, Artemisia*, Urticaceae, and *Pteridium aquilinum* points to a very likely early use of the area for livestock grazing. Such an anthropogenic use of near-timberline zones is also known from other valleys in Tyrol for this mid- to late Neolithic time period, and also fits the presence of the Iceman along the main Alpine Ridge around 5300 years ago (Bortenschlager 2000). Interestingly enough this first grazing period at Schwarzenstein-Bog is preceded and paralleled by a massive rise of the algae *Botryococcus* cf. *pila*. The massive presence of this unicellular green algae living today in (wet) bogs, (acid) swamps, moors and (ephemeral) lakes (often dominated by *Sphagnum* in the littoral) may thus represent a time period where the in-wash of nutrients due to grazing activities around the bog may have favoured the growth of this algae. Another possibility could be that a decline in the water table of the bog due to climatic change (i.e. drier summers) resulted in an in-wash of humic degradation products (local *Sphagnum* growth is present at the edges of the bog area), which then would have supplied enough nitrogen for the growth of *Botryococcus* (Dulhunty 1944). This interpretation would therefore be comparable to the findings of Holocene *Botryococcus* blooming in some lowland lakes of Denmark (Odgaard 1994). For further interpretation the exact determination and/or confirmation of the *Botryococcus* species involved will be necessary even if this might be taxonomically difficult (Komarek & Marvan 1992; Jankovska & Komarek 2000). However, the nearly synchronous appearance of pollen indicators standing for anthropogenic and livestock activities is intriguing, as well as the first appearance of two avalanche events at the same time period. This leads to our new working hypothesis that massive avalanche events may have been favoured by the action of man and livestock during the Neolithic Period through the slow but pronounced opening of the forested area above 2150 m a.s.l.

Two other major avalanche events also occurred during the late-Neolithic Period around 2780 BC within 12 years, which corresponds well with today's experience that major avalanche events may follow each other within a few years because of the very slow reforestation of avalanche tracks. Thereafter, no avalanches are recorded for the Bronze Age, and the pollen values of *Pinus cembra* remain very low, which could mean that the Cembran Pine was not present above our study site at that time. This is sustained by the continuing presence of anthropogenic indicators, but has to be checked by a macrofossil study planned for the upcoming second project phase. During the Late Bronze Age and Iron Age the *Botryococcus* cf. *pila* values drop dramatically. This decline in importance is also visible within influx-values (not shown here) and may be due to a general climatic deterioration recorded all over Europe at that time (Van Geel et al. 1998). On the other hand this massive reduction of *Botryococcus* cf. *pila* ending during the Iron Age is paralleled by a rise in freshwater Dinoflagellates and by constant rise in the importance of charcoal particles. This may therefore also represent a shift in the management of these high alpine areas by using fire as agent for keeping the grazing landscape open. Further detailed pollen analyses will eventually provide additional evidences in order to disentangle human and climatic impact at such altitudes.

Two additional major avalanche events are recorded just before and just after the Roman Period starting 15 BC in Tyrol. The presence of pollen from *Castanea sativa*, *Juglans regia* and *Secale cereale* for this part of the diagram confirms well the presence of Roman agriculture in the nearby lowlands, and additionally gives a good time marker and control for our time model. In addition, the general pollen reductions visible for the NAP (Herb-) total, as well as in the charcoal particles may represent a reduction in grazing pressure above 2000 m a.s.l. at those times.

DISCUSSION & CONCLUSIONS

All in all we are not yet able to assess the direct influence of major avalanches on the local, prehistorical vegetation. Continuous sediment sampling and pollen counting will eventually help to resolve this question by help of pollen influx-data together with radiocarbon wiggle-matching dating planned. However, even if the palynological results are preliminary only, it is striking that the major, dendrochronologically dated avalanche events did occur during times of known and pollenanalytically recorded human activities (i.e. grazing) in these high Alpine areas. As such massive avalanches are only possible with huge masses of snow at the starting point of the avalanches (in the case of Schwarzenstein-Bog this is at ca. 2600 m a.s.l.) this events give insight to the winter precipitation and climate for above mentioned years where these avalanches occurred. This will inevitably help to refine the already available SAMOS-simulation model for the massive flow-avalanches at Schwarzenstein-Bog in order to better understand the snow quantities necessary, as well as the return times of such climatic events.

ACKNOWLEDGEMENTS

Financial support for the palynological studies at Schwarzenstein-Bog comes from the 'Austrian Federal Office and Research Centre for Forests'. Many thanks also go to the Austrian Academy of Sciences for providing the first radiocarbon datings.

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The Holocene 8,1 (1998) pp. 31–42

Pollen and charcoal in lake sediments compared with historically documented forest fires in southern Switzerland since AD 1920

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Abstract: Charcoal in unlaminated sediments dated by ^{210}Pb was analysed by the pollen-slide and thin-section methods. The results were compared with the number and area of forest fires on different spatial scales in the area around Lago di Origlio as listed in the wildfire database of southern Switzerland since AD 1920. The influx of the number of charcoal particles $> 75\ \mu m^2$ in pollen slides correlates well with the number of annual forest fires recorded within a distance of 20–50 km from the coring site. Hence a size-class distinction or an area measurement by image analysis may not be absolutely necessary for the reconstruction of regional fire history. A regression equation was computed and tested against an independent data set. Its use makes it possible to estimate the charcoal area influx (or concentration) from the particle number influx (or concentration). Local fires within a radius of 2 km around the coring site correlate well with the area influx of charcoal particles estimated by the thin-section method measuring the area of charcoal particles larger than $20\,000\ \mu m^2$ or longer than $50\ \mu m$. Pollen percentages and influx values suggest that intensive agriculture and *Castanea sativa* cultivation were reduced 30–40 years ago, followed by an increase of forest area and a development to more natural woodlands. The traditional *Castanea sativa* cultivation was characterized by a complete use of the biomass produced, so abandonment of chestnut led to an increasing accumulation of dead biomass, thereby raising the fire risk. On the other hand, the pollen record of the regional vegetation does not show any clear response to the increase of fire frequency during the last three decades in this area.

Key words: Charcoal analysis, forest fires, fire history, pollen analysis, vegetation change, lake sediments, thin sections, pollen slides, Switzerland.

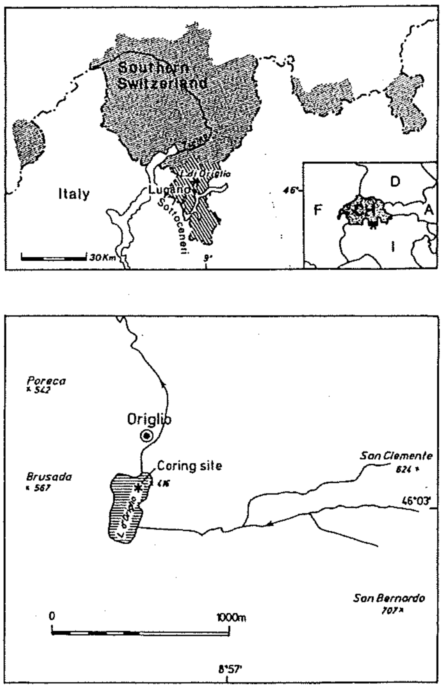

Figure 1 Map of southern Switzerland, showing the location of the study site 5 km north of Lugano in Canton Ticino. The Sottoceneri is hatched.

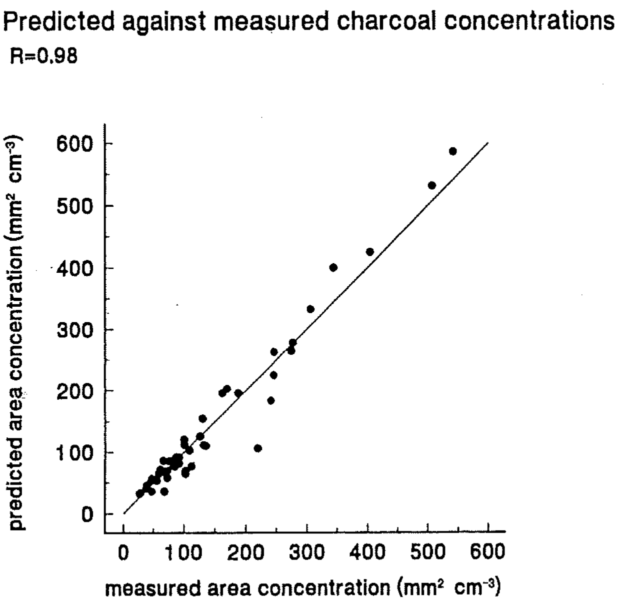

Figure 4 Scatterplot of predicted against measured charcoal concentrations. This independent test data set consists of the Holocene charcoal concentrations (area and number) measured in pollen slides from Lago di Origlio. The predicted charcoal concentrations are based on the linear regression of ln-transformed variables.

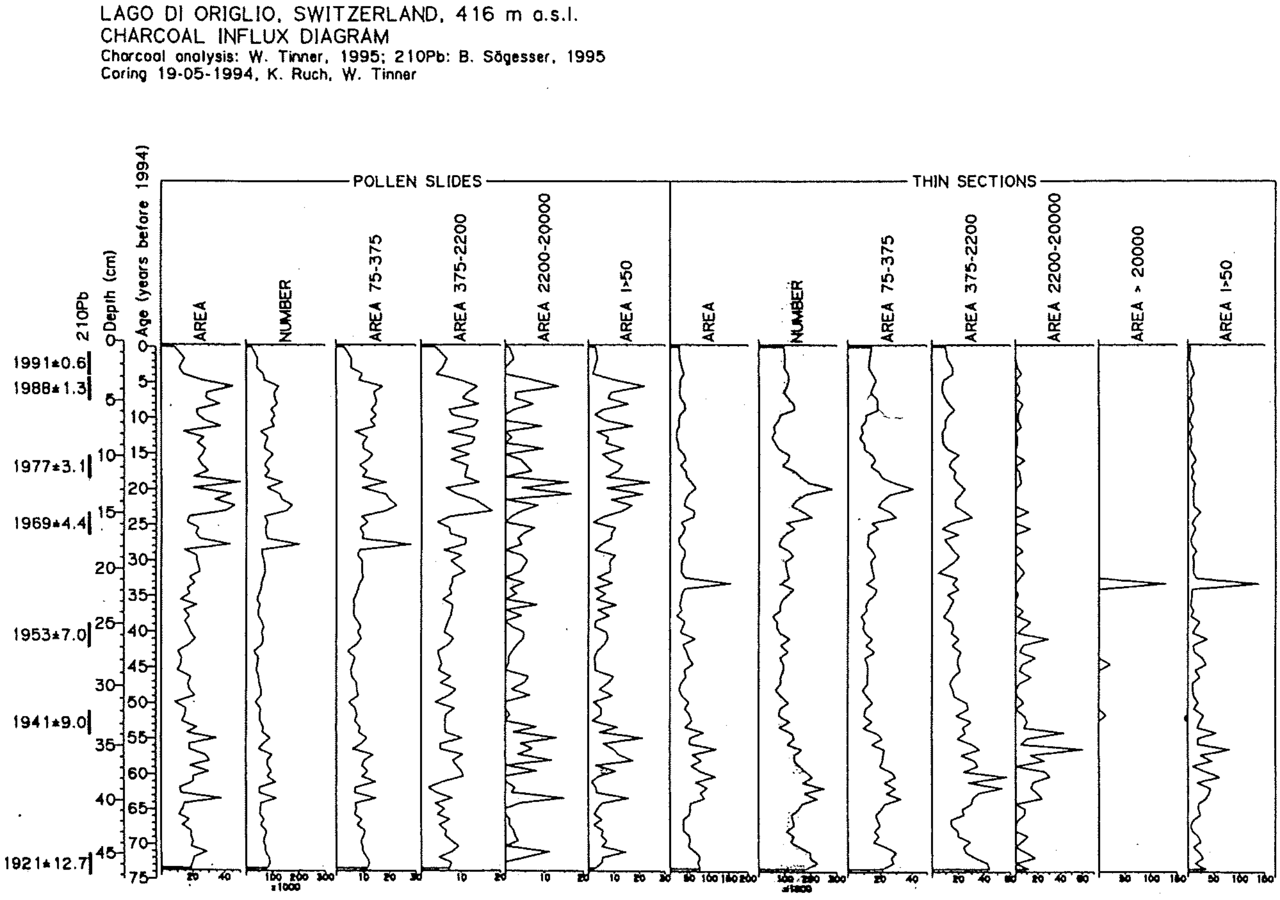

Figure 2 Charcoal influx diagram of Lago di Origlio estimated by pollen slides and thin sections. The units used for charcoal area influx are mm^2 cm^{-2} yr^{-1} and for charcoal number influx particles cm^{-2} yr^{-1}.

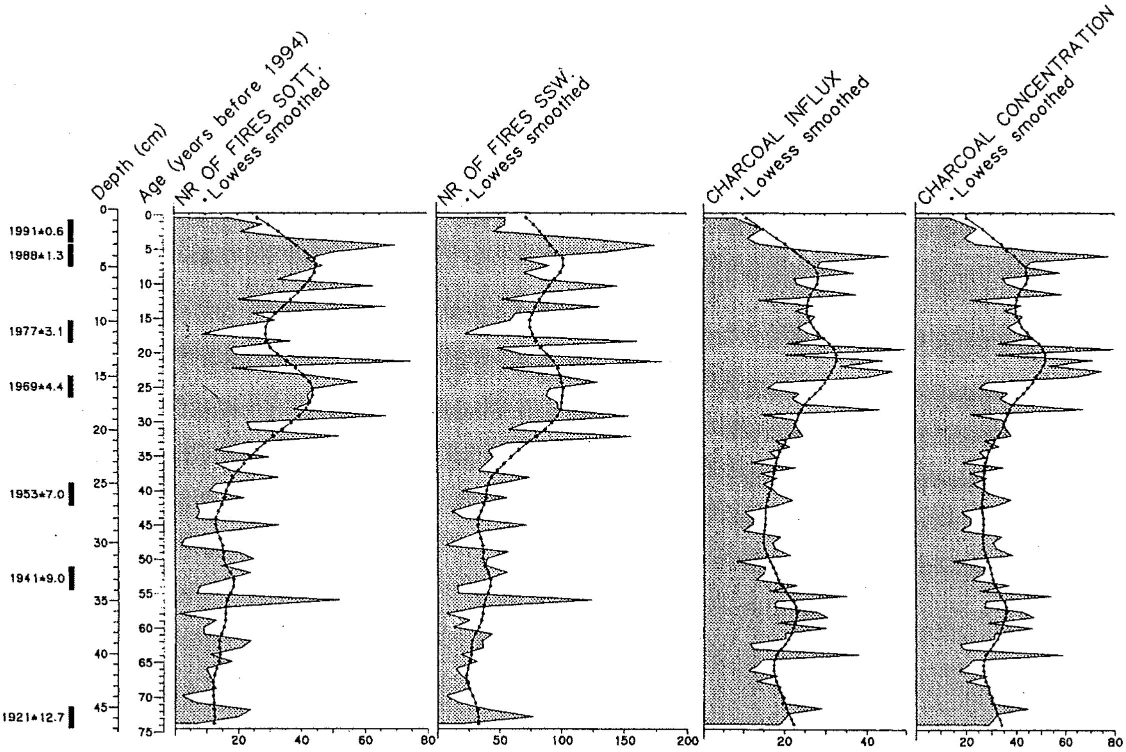

Figure 5 Diagram showing the number of forest fires in Sottoceneri and southern Switzerland since AD 1920 in comparison with charcoal influx (mm² cm⁻² yr⁻¹) and concentration (mm² cm⁻³) of particles > 75 μm² from pollen slides of Lago di Origlio. SOTT. = Sottoceneri, SSW. = southern Switzerland.

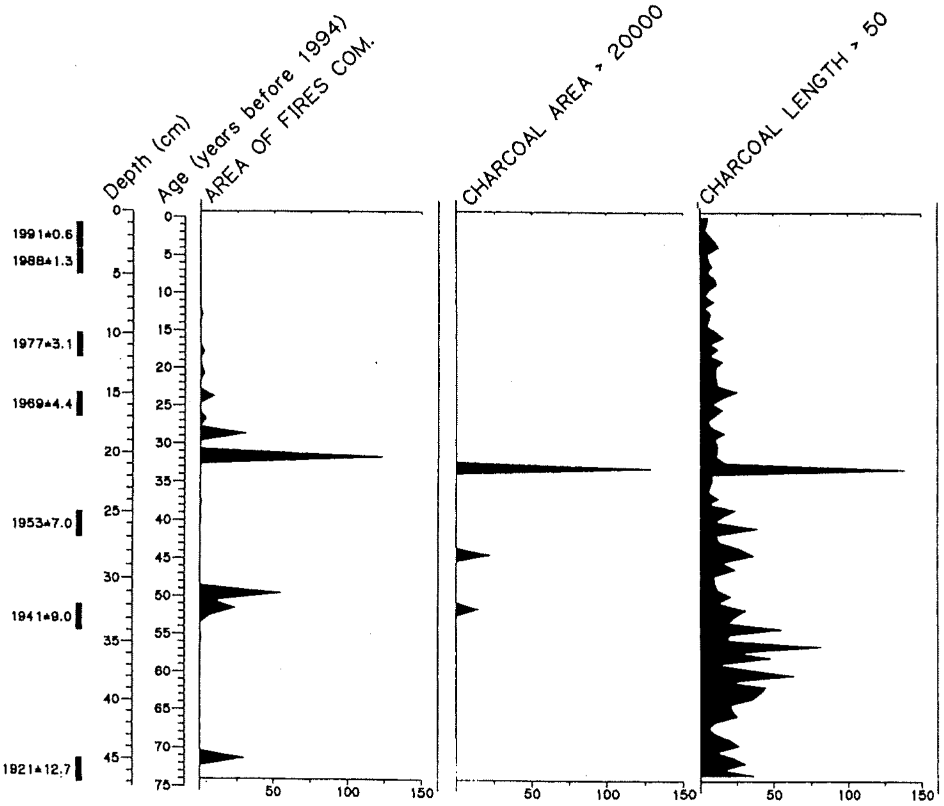

Figure 6 Diagram showing the burned area (hectares) in the lake catchment since AD 1920, in comparison with charcoal influx (mm² cm⁻² yr⁻¹) of particles larger than 20 000 μm² and of particles longer than 50 μm from thin sections of Lago di Origlio.

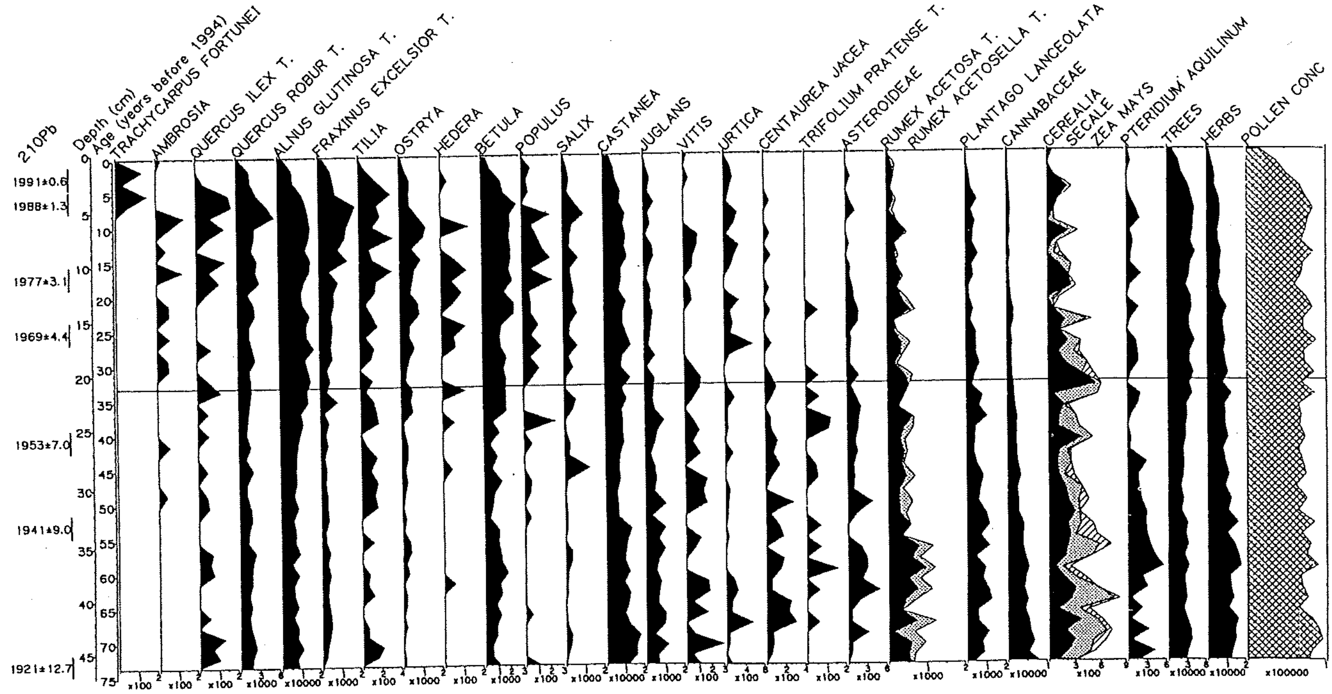

Figure 8 Diagram showing pollen influx (pollen cm^{-2} yr^{-1}) of selected pollen types and the total pollen concentration (last curve on the right, pollen grains cm^{-3}) of Lago di Origlio.

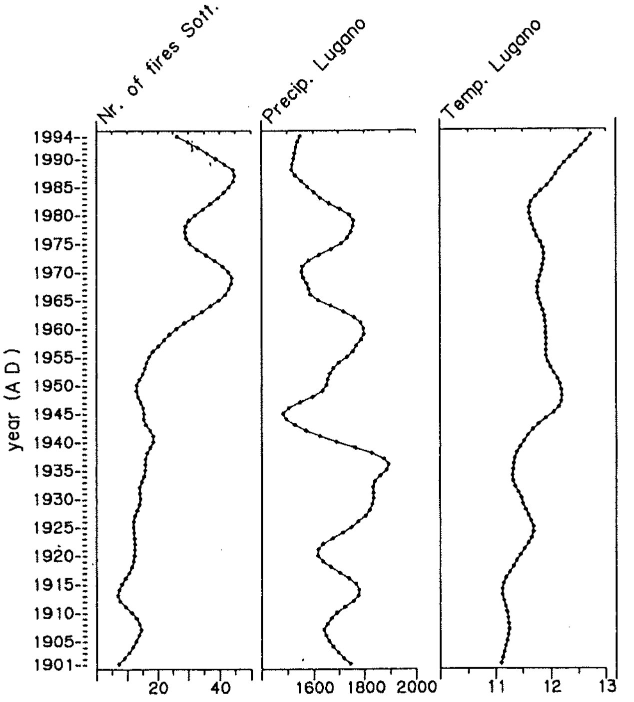

Figure 9 Number of forest fires in Sottoceneri compared with annual precipitation (mm) and temperature (°C) of Lugano (southern Switzerland) since 1901. All values are lowess smoothed. Source of climate data: Swiss Meteorological Institute, Observatory of Locarno-Monti.

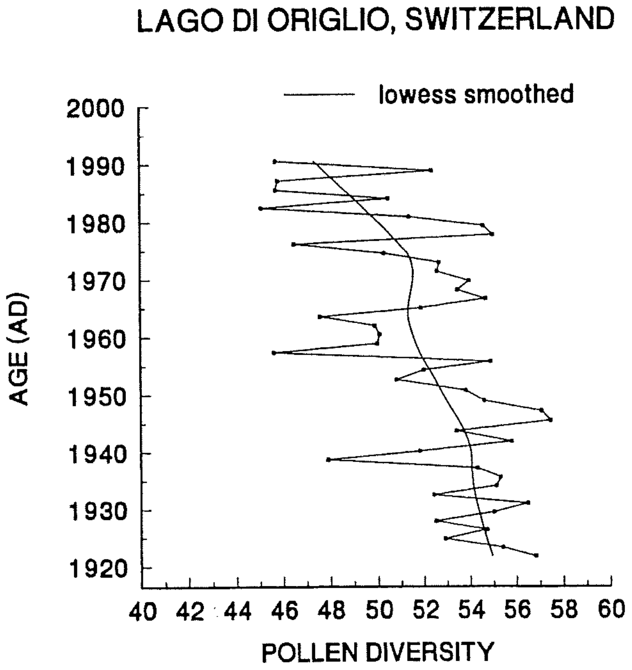

Figure 10 Diagram showing changes in pollen diversity since AD 1920 at Lago di Origlio.

The Holocene 13,4 (2003) pp. 499–505

Size parameters, size-class distribution and area-number relationship of microscopic charcoal: relevance for fire reconstruction

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Abstract: Charcoal analysis was conducted on sediment cores from three lakes to assess the relationship between the area and number of charcoal particles. Three charcoal-size parameters (maximum breadth, maximum length and area) were measured on sediment samples representing various vegetation types, including shrub tundra, boreal forest and temperate forest. These parameters and charcoal size-class distributions do not differ statistically between two sites where the same preparation technique (glycerine pollen slides) was used, but they differ for the same core when different techniques were applied. Results suggest that differences in charcoal size and size-class distribution are mainly caused by different preparation techniques and are not related to vegetation-type variation. At all three sites, the area and number concentrations of charcoal particles are highly correlated in standard pollen slides; 82–83% of the variability of the charcoal-area concentration can be explained by the particle-number concentration. Comparisons between predicted and measured area concentrations show that regression equations linking charcoal number and area concentrations can be used across sites as long as the same pollen-preparation technique is used. Thus it is concluded that it is unnecessary to measure charcoal areas in standard pollen slides – a time-consuming and tedious process.

Key words: Charcoal analysis, microscopic charcoal, pollen slides, thin sections, fire history.

Table 4 Statistical comparison of measured and predicted charcoal area concentrations

Model used	Mean MAC	Mean diff.	Sd.d. diff.	R	P (R = 0)	W.S.R.	P (mn = 0)
OP→GY	32.32	2.18	16.49	0.87	0.0001	−26	0.4693
OP→WI	27.72	−9.74	10.58	0.89	0.0001	−81	0.0004
WI→GY	32.32	10.83	18.64	0.87	0.0001	88	0.0087
GY→WI	27.72	−12.51	18.46	0.87	0.0001	−78	0.0008
WI→OP	34.93	10.77	7.51	0.87	0.0001	2028	0.0001
GY→OP	34.93	1.08	8.88	0.86	0.0001	571	0.0208

OP→GY = Grizzly area concentrations (mm^2 cm^{-3}) predicted by the Origlio equation.
Mean MAC = the mean of measured charcoal area concentrations (mm^2 cm^{-3}).
Mean diff. = the mean of the differences (mm^2 cm^{-3}) between pairs of measured and predicted charcoal area concentrations.
Sd.d. diff. = standard deviation (mm^2 cm^{-3}) of the differences between pairs of measured and predicted charcoal area concentrations.
P (R = 0): P values for the null hypothesis that the Pearson correlation coefficients are not different from zero.
W.S.R. = Wilcoxon Signed Rank.
P (mn = 0): P values for the null hypothesis that the difference between the means of predicted and measured charcoal area concentrations is not different from zero.

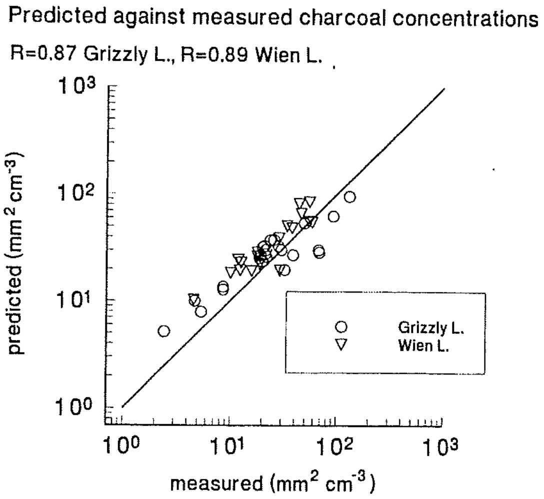

Figure 5 Predicted versus measured charcoal concentrations for Grizzly Lake and Wien Lake. The predicted charcoal concentrations were calculated by applying the linear regression of ln-transformed variables from Lago di Origlio to the number concentration data from Grizzly Lake and Wien Lake.

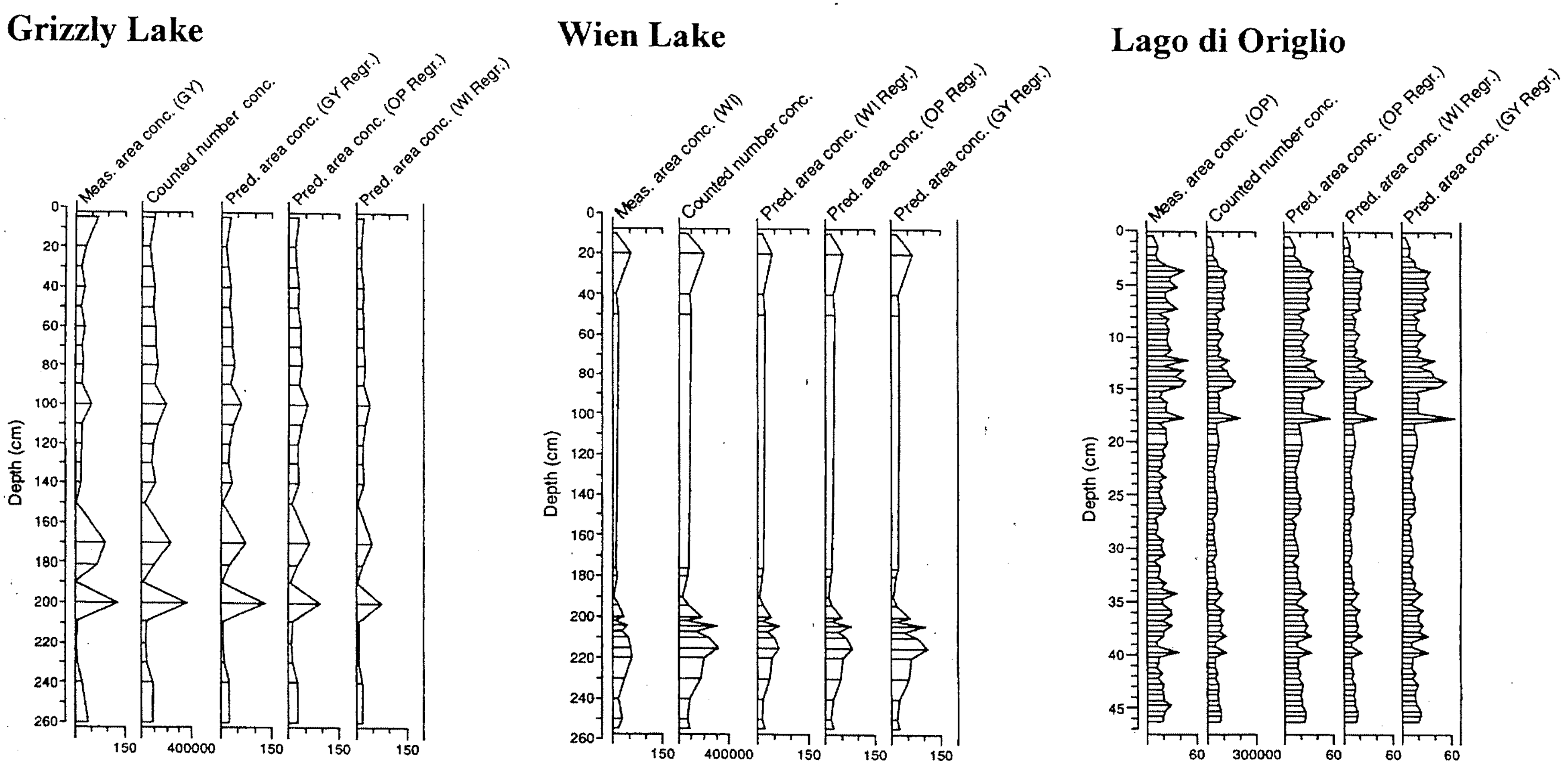

Figure 4 Charcoal concentration diagrams for Grizzly Lake, Wien Lake and Lago di Origlio. Charcoal area concentrations (mm^2 cm^{-3}) measured by image analysis are compared with number concentrations (number cm^{-3}) and with number-predicted area concentrations (mm^2 cm^{-3}). Number-predicted area concentrations were computed using the regression equations of Grizzly Lake, Lago di Origlio and Wien Lake.

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Long-term forest fire ecology and dynamics in southern Switzerland

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Summary

1 Pollen and charcoal analysis at two lakes in southern Switzerland revealed that fire has had a prominent role in changing the woodland composition of this area for more than 7000 years.
2 The sediment of Lago di Origlio for the period between 5100 and 3100 BC cal. was sampled continuously with a time interval of about 10 years. Peaks of charcoal particles were significantly correlated with repeated declines in pollen of *Abies*, *Hedera*, *Tilia*, *Ulmus*, *Fraxinus excelsior* t., *Fagus* and *Vitis* and with increases in *Alnus glutinosa* t., shrubs (e.g. *Corylus*, *Salix* and *Sambucus nigra* t.) and several herbaceous species. The final disappearance of the lowland *Abies alba* stands at around 3150 BC cal. may be an example of a fire-caused local extinction of a fire-intolerant species.
3 Forest fires tended to diminish pollen diversity. The charcoal peaks were preceded by pollen types indicating human activity. Charcoal minima occurred during periods of cold humid climate, when fire susceptibility would be reduced.
4 An increase of forest fires at about 2100 BC cal. severely reduced the remaining fire-sensitive plants: the mixed-oak forest was replaced by a fire-tolerant alder–oak forest. The very strong increase of charcoal influx, and the marked presence of anthropogenic indicators, point to principally anthropogenic causes.
5 We suggest that without anthropogenic disturbances *Abies alba* would still form lowland forests together with various deciduous broadleaved tree taxa.

Keywords: Abies alba, charcoal analysis, fire history, pollen analysis, southern Alps, vegetation history

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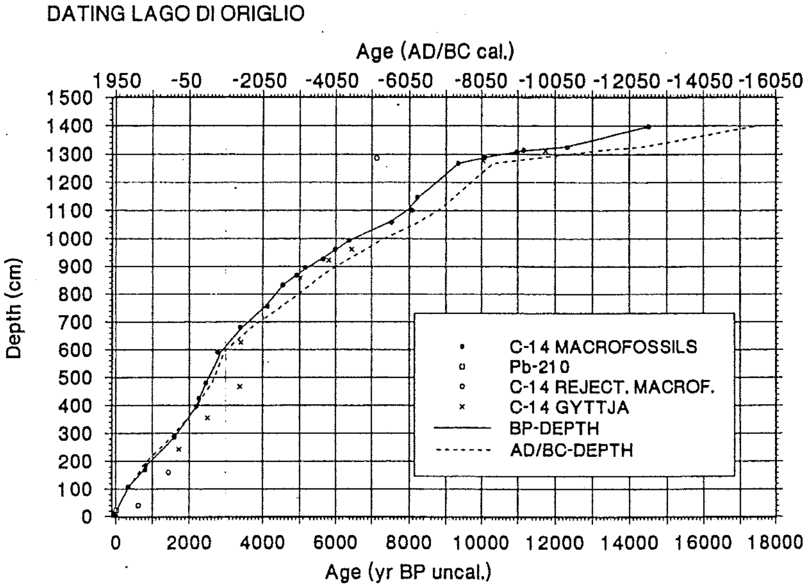


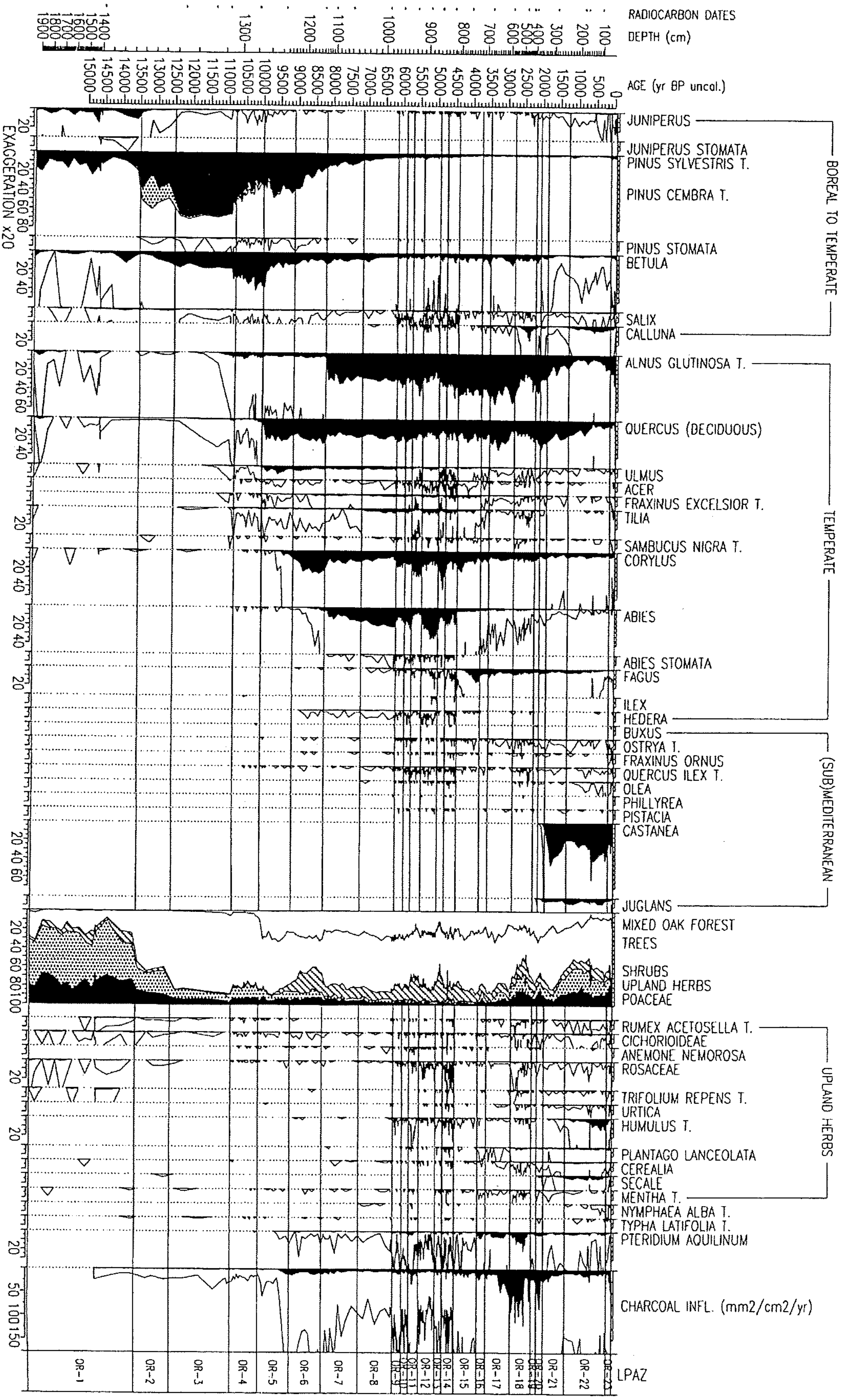


Fig. 3 Percentage pollen diagram (selected taxa) of Lago di Origlio (416 m a.s.l.), southern Switzerland. The Cannabaceae, the water plants, and the ferns are excluded from pollen sum. LPAZ, OR = local pollen assemblage zones of Lago di Origlio.

Table 1 The vegetation history of Lago di Origlio

Age BC/AD cal.	Age BP uncal.	LPAZ	Vegetation type	Important taxa (decreasing relevance)	Thermophilous plants
1994–200 AD	Present–1800	OR 21–23	Chestnut forests and farm lands	*Castanea sativa*, *Quercus* (deciduous), *Alnus glutinosa*, herbs, cultivated plants, neophytes	+ + +
200 AD–2150BC	1800–3750	OR 16–20	Oak–alder forests and farm lands	*Alnus glutinosa*, *Quercus* (deciduous), *Pteridium aquilinum*, *Betula*, *Calluna vulgaris*, herbs, cultivated plants	+ + (+)
2150–3000BC	3750–4400	OR 15	Late Insubrian forests	*Alnus glutinosa*, *Fagus sylvatica*, *Tilia*, *Quercus* (deciduous), *Fraxinus excelsior*, *Ulmus*, *Corylus avellana*	+ + (+)
3000–5000 BC	4400–6100	OR 9–14	Disturbed Insubrian forests	*Abies alba*, *Tilia*, *Fraxinus excelsior*, *Ulmus*, *and Hedera helix* were regularly replaced by *Corylus avellana*, *Alnus* glutinosa and in part *Betula*	+ + +
5000–7200 BC	6100–8200	OR 7–8	Insubrian forests	*Abies alba*, *Tilia*, *Alnus glutinosa*, *Quercus* (deciduous), *Fraxinus excelsior*, *Ulmus*, *Corylus avellana*, *Hedera helix*	+ + (+)
7200–9200? BC	8200–10 000	OR 5–6	Temperate continental forests and shrublands	*Pinus sylvestris*, *Quercus (deciduous)*, *Corylus avellana*, *Ulmus*, *Betula*,*Fraxinus excelsior*, *Tilia*	+ +
9200?–12 700? BC	10 000–12 500	OR 3–4	Late Glacial forests	*Pinus sylvestris*, *Betula*	+
12 700?–14 200? BC	12 500–13 500	OR 2	Open Late Glacial forests	*Pinus cembra*, *Betula*, *P. sylvestris*	
14 200?–17 500?BC	13 500–16 500?	OR 1	Late Glacial tundra steppes	*Artemisia*, Poaceae and other herbs. Since 14 700 BP *Juniperus* is locally present	

LPAZ = Local pollen assemblage zones; OR = Origlio.
+ = Thermophilous plants were present but not dominant, mixed oak forest ⩽ 5%.
+ + = Thermophilous plants were dominant.
+ + (+) = Thermophilous plants were dominant, submediterranean and mediterranean were occasionally present.
+ + + = Thermophilous plants were dominant, submediterranean and mediterranean plants were regularly present.

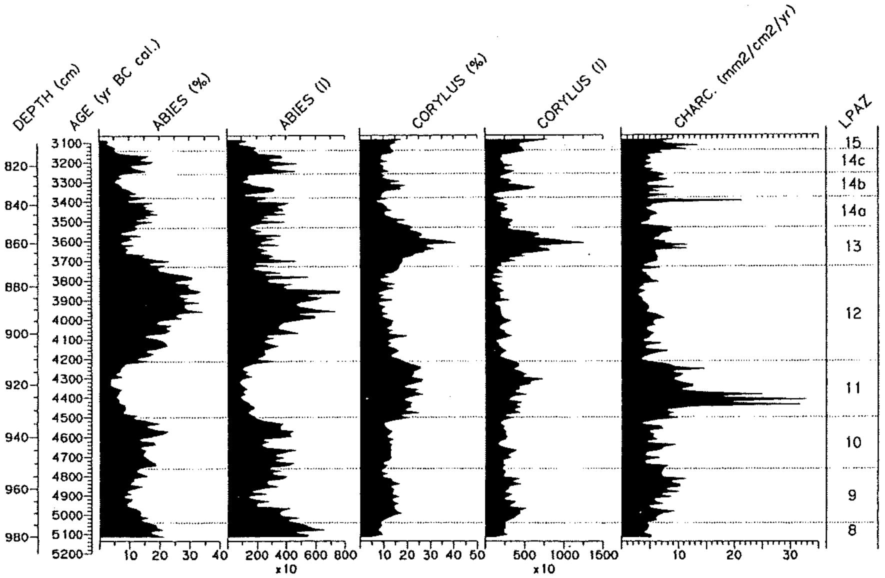


Fig. 5 Pollen percentage and influx diagram of *Abies* and *Corylus*, and charcoal influx diagram for Lago di Origlio (5100–3100 BC cal.).

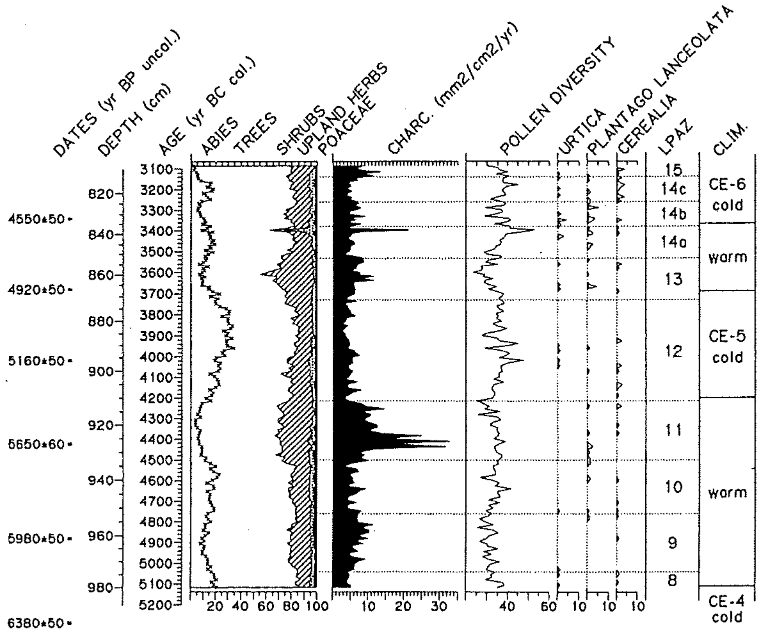
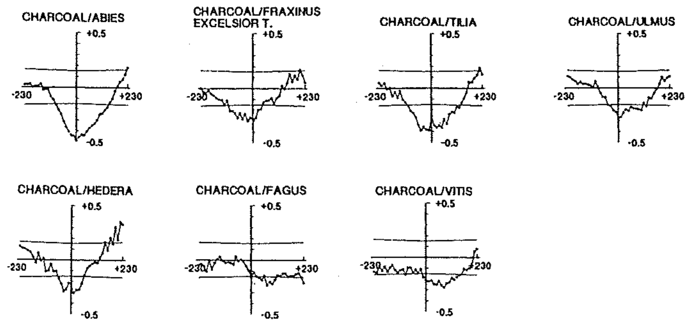
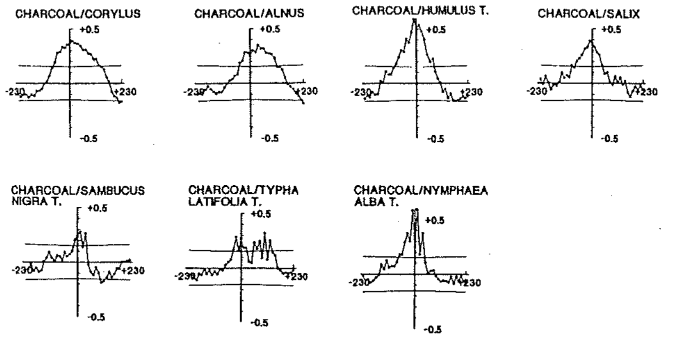


Fig. 9 Pollen percentage diagram, pollen diversity, anthropogenic indicators and charcoal influx for Lago di Origlio (5100–3100 BC cal.). CE = central European cold phases following Haas *et al.* (1998).

(a) Decreasing types



(b) Increasing types



(c) Opportunists

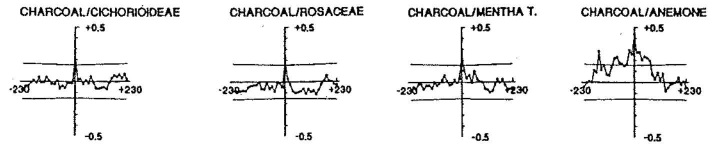
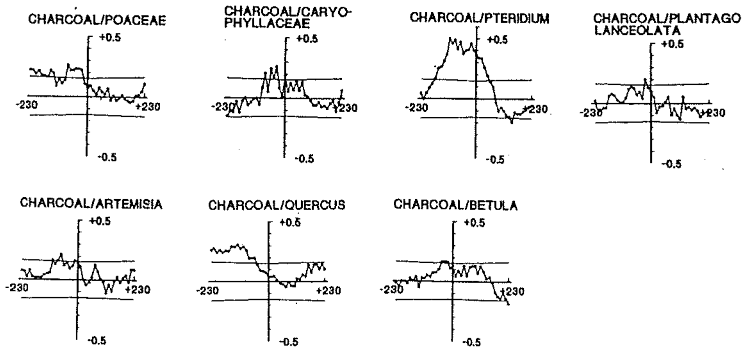
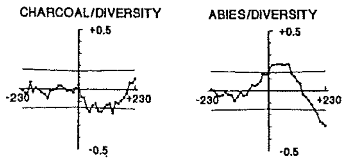


Fig. 6. (a), (b) and (c)

(d) Precursors



(e) Diversity



(f) Summary

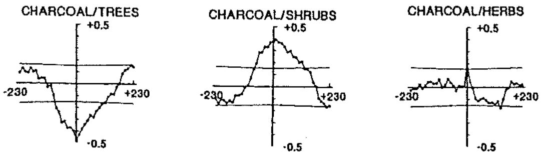


Fig. 6 Correlograms of charcoal influx, pollen percentages and diversity from Lago di Origlio (5100–3100 BC cal.). Horizontal axis shows lag in years (one lag = 11.6 years). Vertical axis shows correlation coefficient; those outside the lines are significant at $P = 0.05$.

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The use of mineral magnetism in the reconstruction of fire history: a case study from Lago di Origlio, Swiss Alps

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Abstract

The use of magnetic measurements in the detection of fire signals has been neglected since the work of Rummery et al. (1979), yet considerable developments have been made in the interpretation of magnetic measurements over the last 16 years. This paper presents a study of the fire history of Lago di Origlio in the southern Swiss Alps. The study utilises the technique of mineral magnetism alongside the stratigraphic pollen, spore and charcoal records. Correlation between the various proxy records indicates that a magnetic 'fire' record is present within the sediments for the last 4 ka. The magnetic fire record has a distinct mineralogical and magnetic grain size signature that can be recognised against the background sedimentary signal. The results suggest that magnetic measurements may be usefully employed in the reconstruction of fire history. Their application is rapid and non-destructive and the results may provide additional information in relation to the links between catchment fire events and the sedimentary record. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: charcoal analysis; fire history; mineral magnetism; pollen analysis; Southern Alps

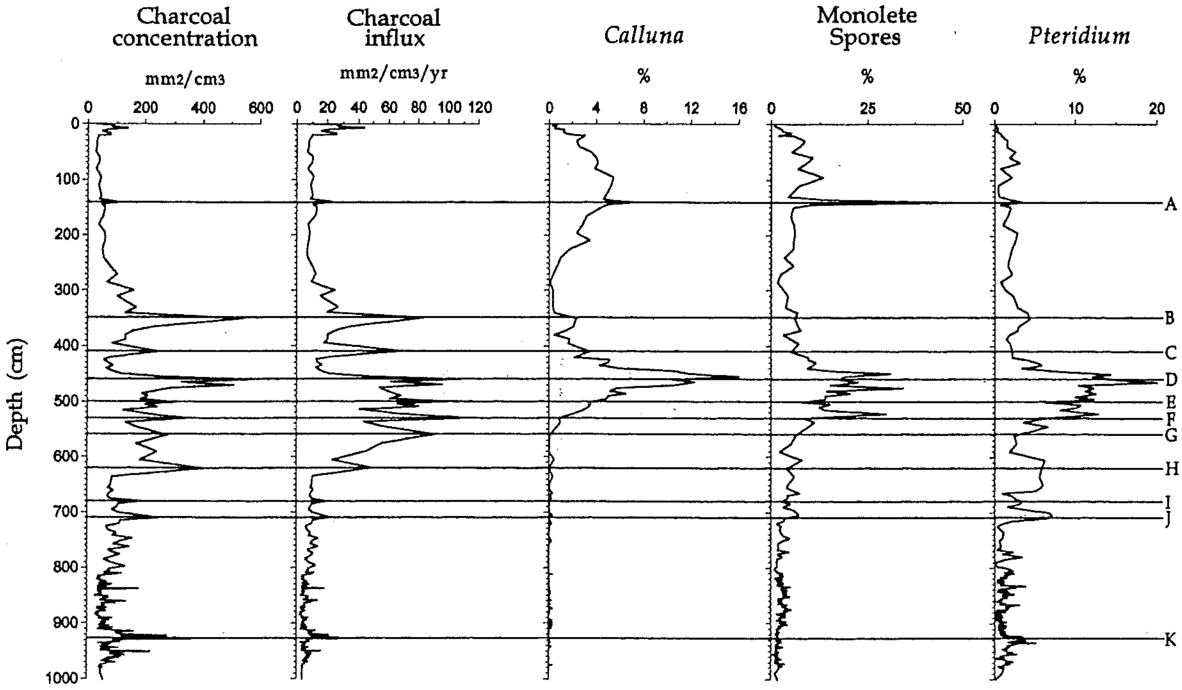

Fig. 2. Charcoal concentration and influx and *Calluna*, Monolete and *Pteridium* percentage fire indicators for Lago di Origlio, Switzerland. 11 horizons (A to K) are identified, representing the increased incidence of fires.

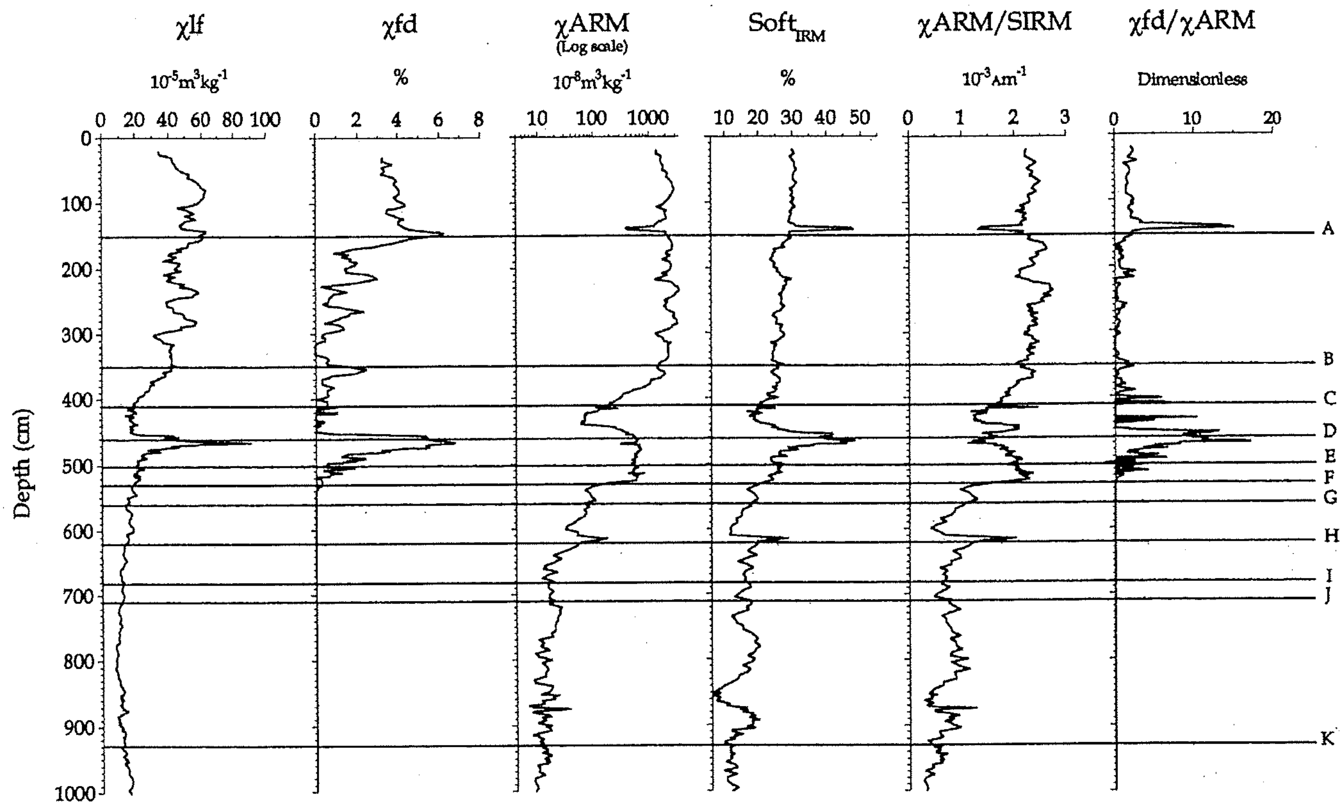

Fig. 3. Magnetic profiles for Lago di Origlio, Switzerland. The 11 horizons of high fire activity identified from the charcoal, pollen and spore record are shown with respect to the magnetic record. The χ_{fd}/χARM quotient does not extend below 530 cm as no χ_{fd} measurements could be obtained below this depth.

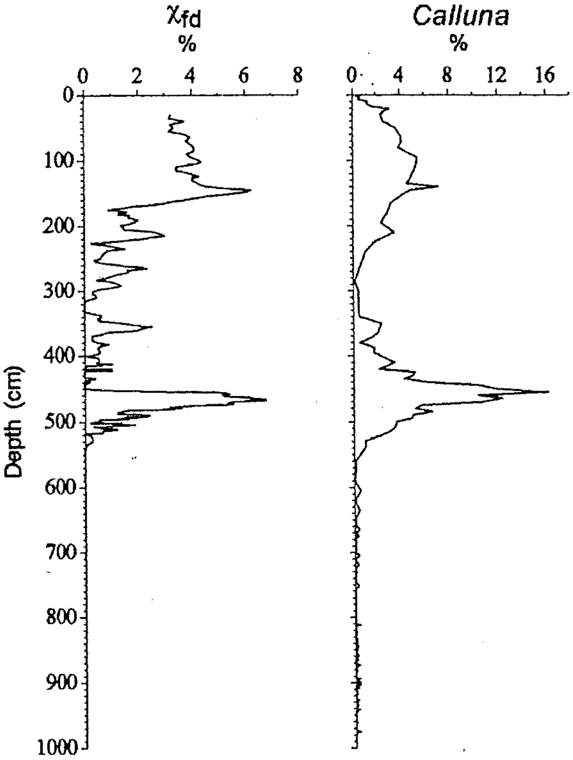

Fig. 4. The χ_{fd} and *Calluna* pollen percentage profiles for Lago di Origlio, Switzerland. Close correspondence between the profiles indicates the similar overland flow pathways for the two parameters.

The Holocene 10,5 (2000) pp. 565–574

A palaeoecological attempt to classify fire sensitivity of trees in the southern Alps

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Abstract: Using pollen percentages and charcoal influx to reconstruct the Holocene vegetation and fire history, we differentiate six possible responses of plants to fire of medium and high frequency: fire-intolerant, fire-damaged, fire-sensitive, fire-indifferent, fire-enhanced and fire-adapted. The fire sensitivity of 17 pollen types, representing 20 woody species in the southern Alps, is validated by comparison with today's ecological studies of plant chronosequences. A surprising coincidence of species reaction to fire of medium frequency is characteristic for completely different vegetation types, such as woodlands dominated by *Abies alba* (7000 years ago) and *Castanea sativa* (today). The temporal persistence of post-fire behaviour of plant taxa up to thousands of years suggests a generally valid species-related fire sensitivity that may be influenced only in part by changing external conditions. A non-analogous behaviour of woody taxa after fire is documented for high fire frequencies. Divergent behaviour patterns of plant taxa in response to medium and high fire frequencies (e.g., increases and decreases of *Alnus glutinosa*) also indicate that post-fire plant reactions may change with increasing fire frequency.

Key words: Charcoal analysis, pollen analysis, long-term fire ecology, post-fire vegetation dynamics, southern Alps.

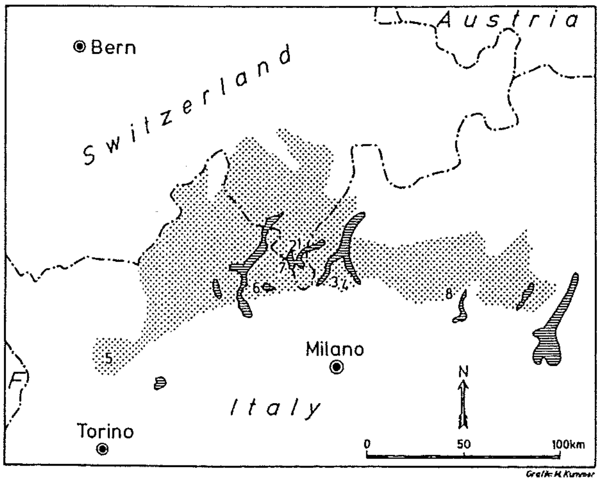

Figure 1 The Insubrian region as defined by annual precipitation values > 1500 mm (dotted area). Inside this region, the Insubrian lowland vegetation is restricted to altitudes between 100 and 900 m a.s.l. Numbers 1 to 8 represent important modern palaeoecological study sites. Charcoal and pollen data are available for sites 1–4 and 8, and pollen data for sites 5–7. (1) Lago di Origlio; (2) Lago di Muzzano; (3) Lago del Segrino (Gobet *et al.*, unpublished data); (4) Lago di Annone (Wick Olatunbosi, 1996); (5) Lago di Alice (Schneider, 1978); (6) Lago di Biandronno (Schneider, 1978); (7) Lago di Ganna (Schneider and Tobolski, 1985); (8) Lago di Gaiano (Gehrig, 1997).

Table 1 Reference studies used for validation of the fire-sensitivity values

Study	Vegetation type	Geological substrate	Aspect	Number of relevés
Zuber (1979)	Chestnut forests	Siliceous	South	190
Delarze *et al.* (1992)	Chestnut forests	Siliceous	South	264
Hofmann *et al.* (1998)	Mixed broadleaved forests	Calcareous	South	53
	Beech forests	Calcareous	South	25
			North	33
	Chestnut forests	Siliceous	North	67

Table 2 Definition of fire-frequency levels

Fire-frequency level	Charcoal influx ($mm^2\ cm^{-2}\ yr^{-1}$)	Twentieth-century analogue (number of fires 440 $km^{-2}\ yr^{-1}$; Tinner *et al.*, 1998)
low	< 10	< 5
medium	$> 10 < 40$	$> 5 < 50$
high	> 40	> 50

Table 3 Definition of fire-sensitivity classes

Fire-sensitivity class	Definition of fire-sensitivity classes	Representatives in Figures 2 and 3
1	Fire-intolerant: fire rapidly leads to local extinction. Usually no regeneration.	*Abies**
2	Fire-damaged: fire slowly leads to local extinction.	*Ulmus**
3	Fire-sensitive: fire leads to considerable decreases, usually no local extinction.	*Fagus**, **
4	Fire-indifferent: fire frequency usually does not influence presence.	*Quercus**
5	Fire-enhanced: fire favours abundance.	*Corylus*, *Alnus*, *Castanea**
6	Fire-adapted: high abundance largely depends on fire.	*Pteridium*, *Calluna***

* = Medium fire frequencies (see Table 2).
** = High fire frequencies.

Table 4 Tentative assignments of fire-sensitivity values derived from the palaeobotanical results of Lago di Origlio and Lago di Muzzano

Pollen type	Palaeoecologically derived fire sensitivity (Table 3)		Comparison with ecological studies* (only for medium fire frequencies)	
	Medium fire frequency	High fire frequency	Species concerned	Agreement
Abies	1	1	*Abies alba*	+
Acer	2	2	*Acer campestre*	+
			Acer pseudoplatanus	++
Alnus glutinosa t.	5	3	*Alnus glutinosa*	+
Betula	5	3–4	*Betula pendula*	++
Calluna	4–5	6	*Calluna vulgaris*	+
Castanea	5	?	*Castanea sativa*	++
Corylus	5	3–4	*Corylus avellana*	–
Fagus	3	3	*Fagus sylvatica*	++
Fraxinus excelsior t.	2	2	*Fraxinus excelsior*	++
Hedera	1	1	*Hedera helix*	++
Ilex	1	1	*Ilex aquifolium*	++
Quercus (deciduous)	4	3	*Quercus pubescens*	+/–
			Quercus petraea	+/–
Salix	5	3	*Salix caprea*	+
Sambucus nigra t.	5	5	*Sambucus nigra*	?
Tilia	2	2	*Tilia cordata*	++
			Tilia platyphyllos	+
Ulmus	2	2	*Ulmus glabra*	+
Vitis	2	2?	*Vitis sylvestris*	?
Monolete fern spores	5	6	?	?
Pteridium aquilinum	6	6	*Pteridium aquilinum*	++
Most upland herbs (e.g., Poaceae, Asteraceae, Rosaceae, *Anemone nemorosa*, *Humulus* t., *Potentilla* t., *Trifolium repens* t., etc)	5	5	A multitude of species	++

* E.g., Zuber (1979), Delarze *et al.* (1992), Hofmann *et al.* (1998).
– Disagreement in ecological literature.
\+ Agreement in one source.
++ Agreement in more than one source.
? Data not available.

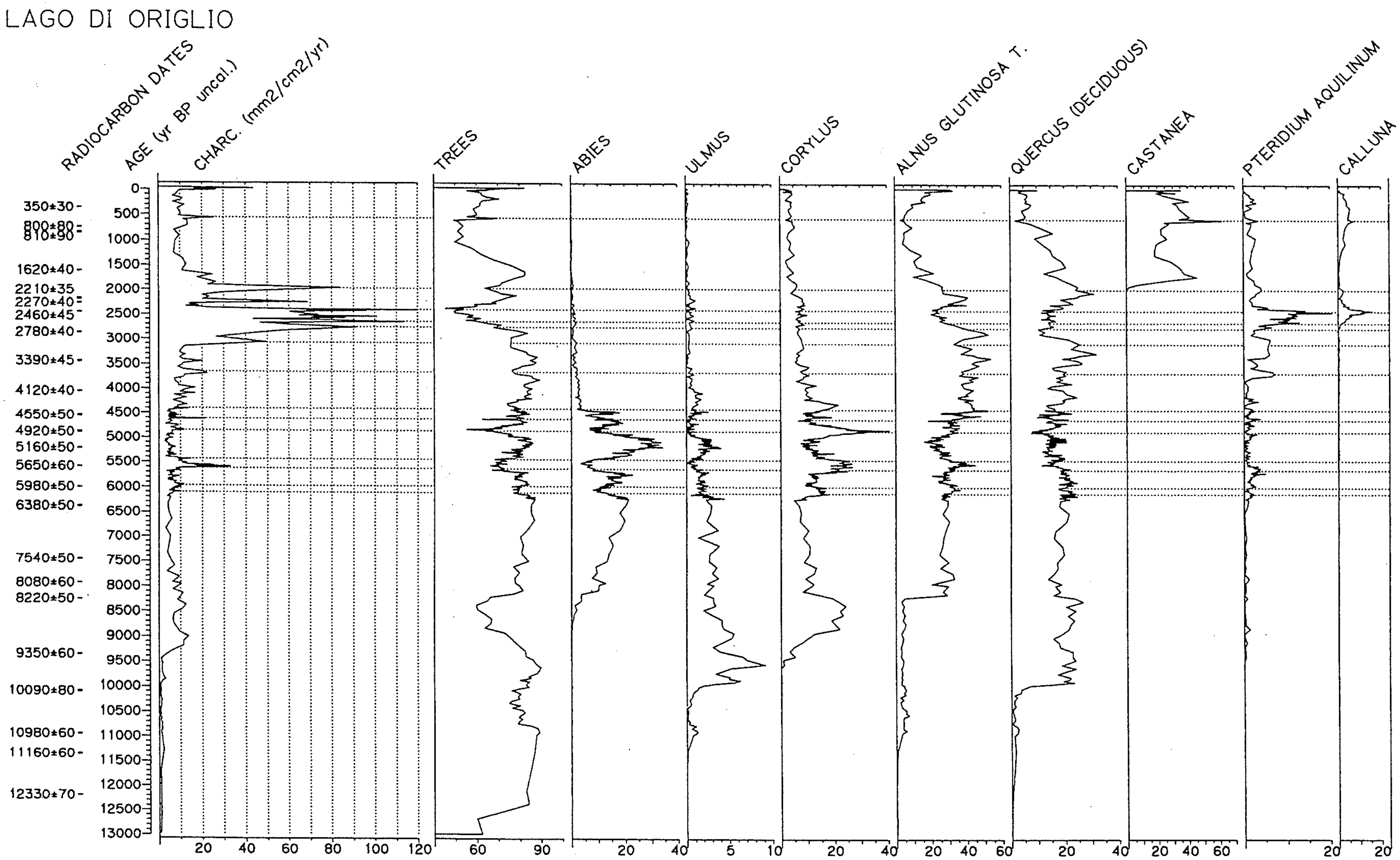

Figure 2 Pollen-percentage and charcoal-influx diagram from Lago di Origlio. Selected pollen types belonging to different fire-sensitivity categories (Tables 3 and 4).

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Effects of climate, fire, and humans on forest dynamics: forest simulations compared to the palaeological record

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Abstract

In order to find out which factors influenced the forest dynamics in northern Italy during the Holocene, a palaeoecological approach involving pollen analysis was combined with ecosystem modelling. The dynamic and distribution based forest model DisCForm was run with different input scenarios for climate, species immigration, fire, and human impact and the similarity of the simulations with the original pollen record was assessed. From the comparisons of the model output and the pollen core, it appears that immigration was most important in the first part of the Holocene, and that fire and human activity had a major influence in the second half. Species not well represented in the simulation outputs are species with a higher abundance in the past than today (*Corylus*), with their habitat in riparian forests (*Alnus*) or with a strong response to human impact (*Castanea*). © 2002 Elsevier Science B.V. All rights reserved.

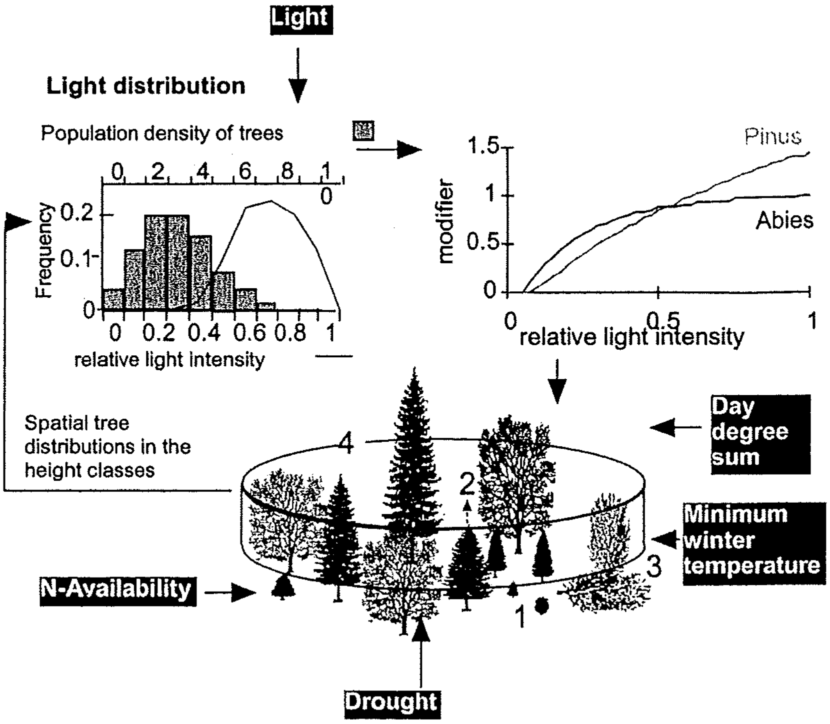
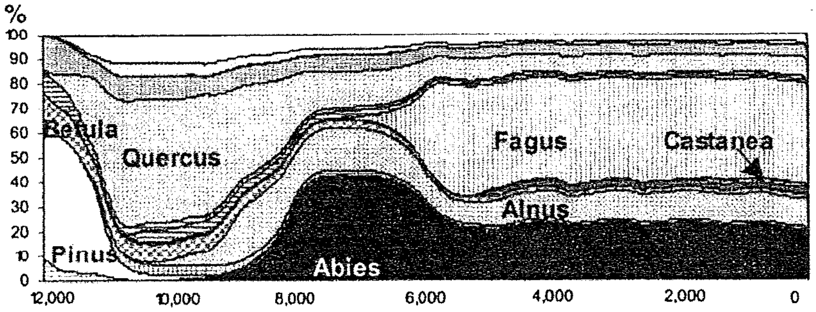
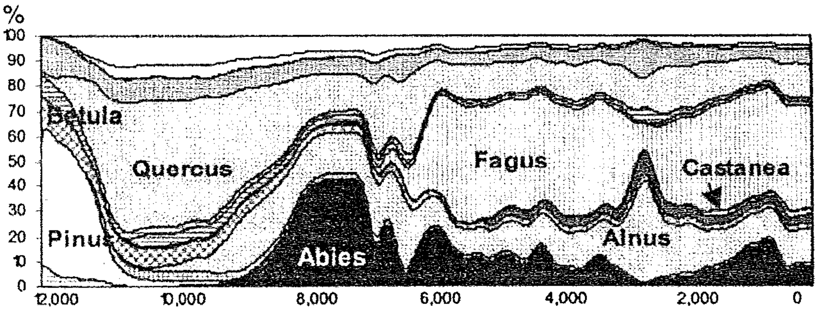


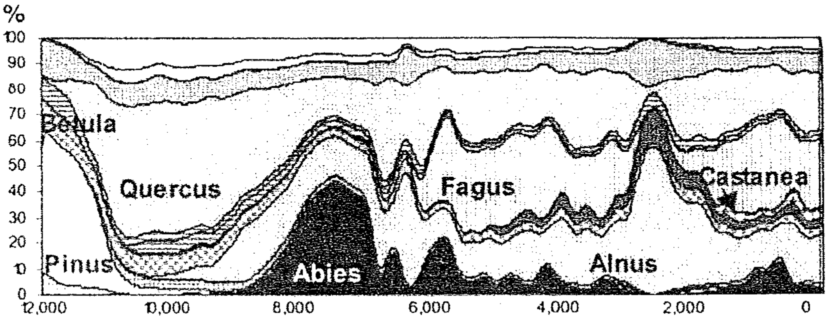
Fig. 2. Distribution-based forest model DisCForM: DisCForM simulates the species specific establishment (1), growth (2) and death (3) of trees in discrete height classes (4), depending on drought, day degree sum, mimimum winter temperature, N-availability and light intensity.



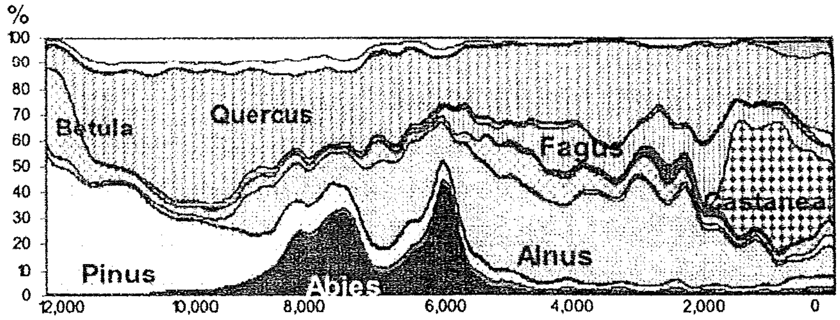
e.) climate scenario (var. temp., var. precip.) with immigration



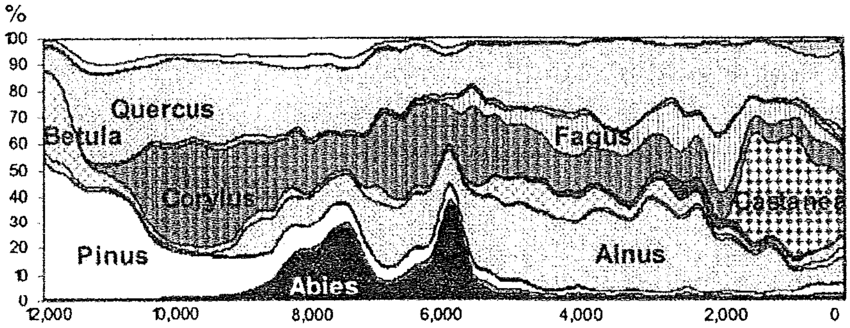
f.) e with fire



h.) g with very hot fire



b.) original pollen diagram without *Corylus*



a.) original pollen diagram with *Corylus*

Lago di Muzzano 1/4

GARY LARSON: DIE ANDERE SEITE

Entomologisches Rodeo.

«Der Bund», August 19th 2003

Fischsterben im Tessin

Hunderte von toten Fischen im **Lago di Muzzano**

Aus dem Lago di Muzzano oberhalb von Lugano sind gestern Hunderte von toten Fischen geborgen worden. Verursacht wurde das Fischsterben durch Algen. Wegen deren Zersetzungsprozess blieb den Fischen kaum noch Sauerstoff zum Atmen übrig.

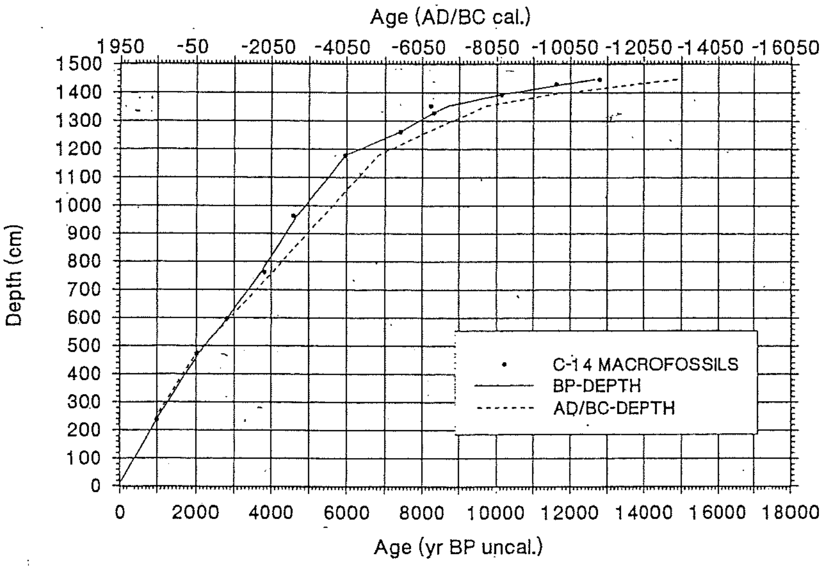
Einige hundert Fische, vorab Karpfen, konnten in letzter Minute gerettet und in den nahen Luganersee transportiert werden. «Die Lage war dramatisch, aber 1994 war es viel schlimmer», sagte Davide Conconi von der Pro Natura. Damals seien 35 Tonnen toter Fische aus dem Lago di Muzzano geholt worden. Gemäss Conconi hat sich die Situation im Verlaufe des Montags wieder verbessert. Es werde jedoch noch einige Tage dauern, bis der maximal vier Meter tiefe See von den Algen gesäubert sei. Die Hitze der vergangenen Tage habe deren Wachstum beschleunigt.

Verendete Fische am Ufer des Lago di Muzzano. KEY

Erholung im Rhein

Im Rhein zwischen Untersee und Schaffhausen hat das Fischsterben seinen Höhepunkt überschritten. In den vergangenen Wochen hatten Berufs- und Hobbyfischer weit über 20 000 tote Äschen aus dem Hochrhein gefischt und entsorgt. Wie viele der erwachsenen Edelfische die zu hohe Wassertemperatur nicht überlebt haben, ist noch unklar. Nach dem Temperaturrückgang der letzten Tage hat sich das Wasser des Rheins von 27 auf 25 Grad abgekühlt. Für die Kälte liebenden Äschen ist eine Wassertemperatur von über 25 Grad tödlich. (sda)

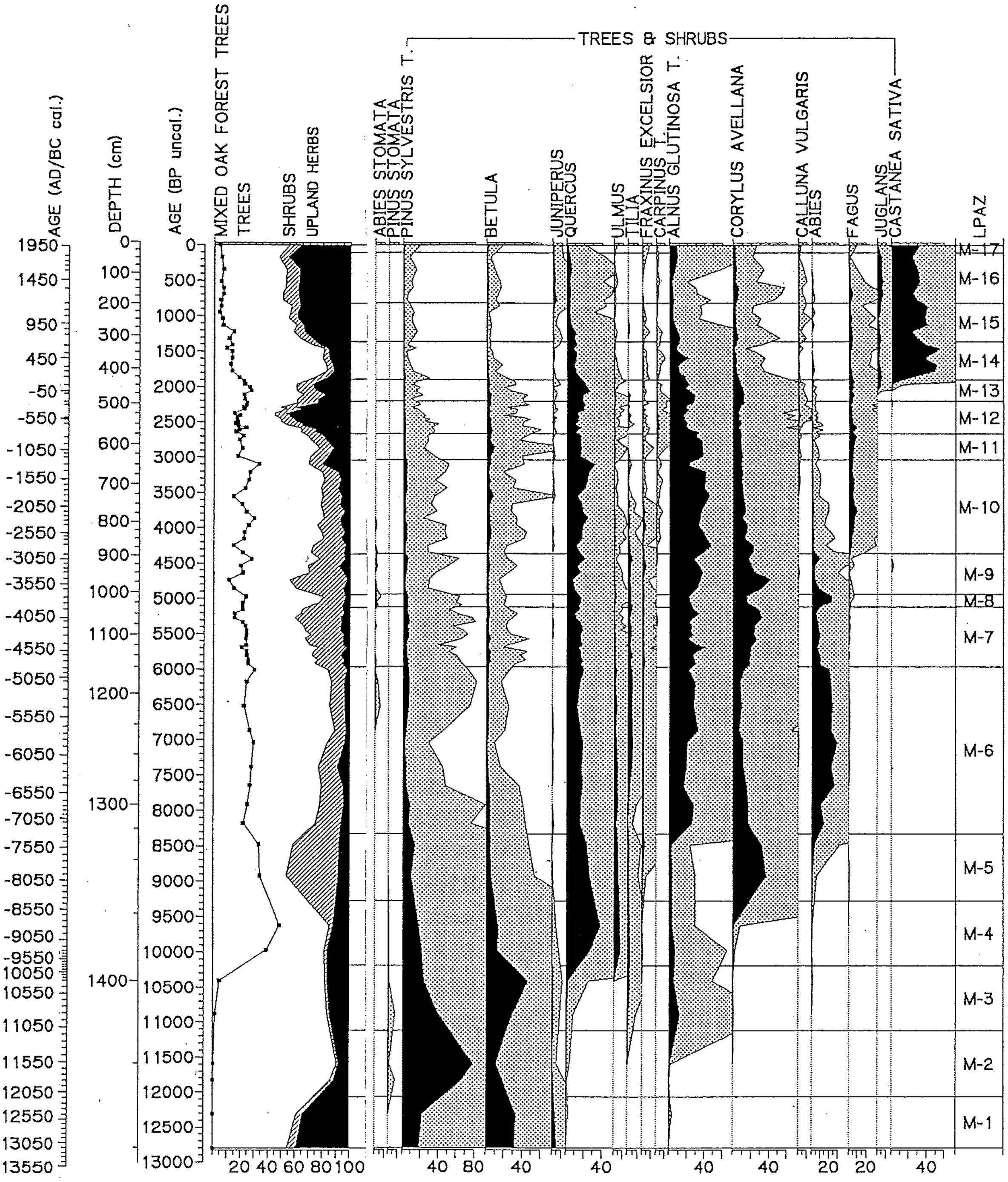
DATING LAGO DI MUZZANO



(Source: Tinner et al. 1999)

Abstract. Vegetation history for the study region is reconstructed on the basis of pollen, charcoal and AMS ^{14}C investigations of lake sediments from Lago del Segrino (calcareous bedrock) and Lago di Muzzano (siliceous bedrock). Late-glacial forests were characterised by *Betula* and *Pinus sylvestris.* At the beginning of the Holocene they were replaced by temperate continental forest and shrub communities. A special type of temperate lowland forest, with *Abies alba* as the most important tree, was present in the period 8300 to 4500 B.P. Subsequently, *Fagus, Quercus* and *Alnus glutinosa* were the main forest components and *A. alba* ceased to be of importance. *Castanea sativa* and *Juglans regia* were probably introduced after forest clearance by fire during the first century A.D. On soils derived from siliceous bedrock, *C. sativa* was already dominant at ca. A.D. 200 (A.D. dates are in calendar years). In limestone areas, however, *C. sativa* failed to achieve a dominant role. After the introduction of *C. sativa*, the main trees were initially oak *(Quercus* spp.) and later the walnut *(Juglans regia). Ostrya carpinifolia* became the dominant tree around Lago del Segrino only in the last 100-200 years though it had spread into the area at ca. 5000 cal. B.C. This recent expansion of *Ostrya* is confirmed at other sites and appears to be controlled by human disturbances involving especially clearance. It is argued that these forests should not be regarded as climax communities. It is suggested that under undisturbed succession they would develop into mixed deciduous forests consisting of *Fraxinus excelsior, Tilia, Ulmus, Quercus* and *Acer.*

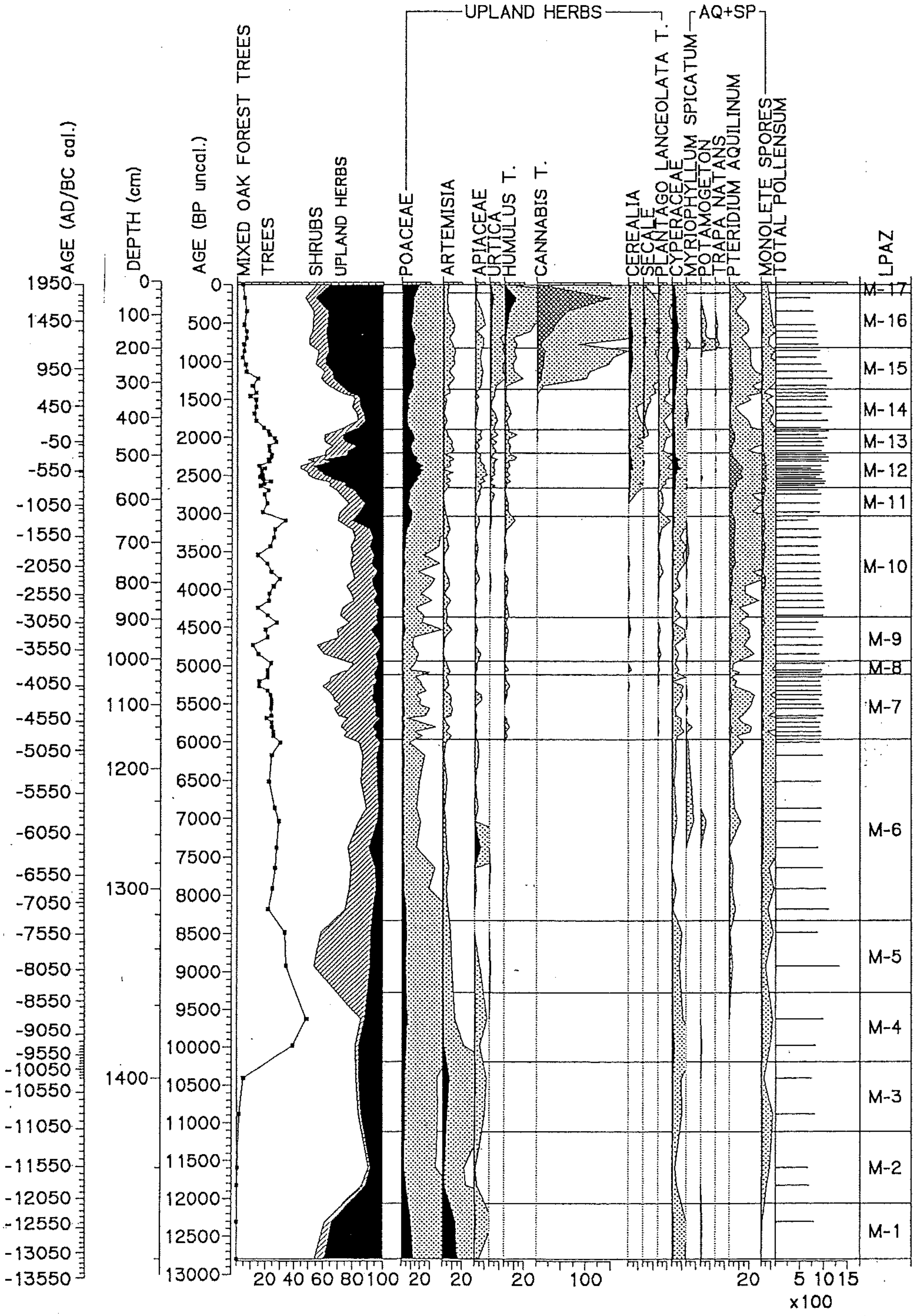
(Source: Gobet et al. 2000)



Percentage arboreal pollen (AP) diagram from Lago di Muzzano (selected taxa). Exaggeration x10 is indicated by stippling.

Analysts: Priska Hubschmid and Michael Wehrli, 1997.

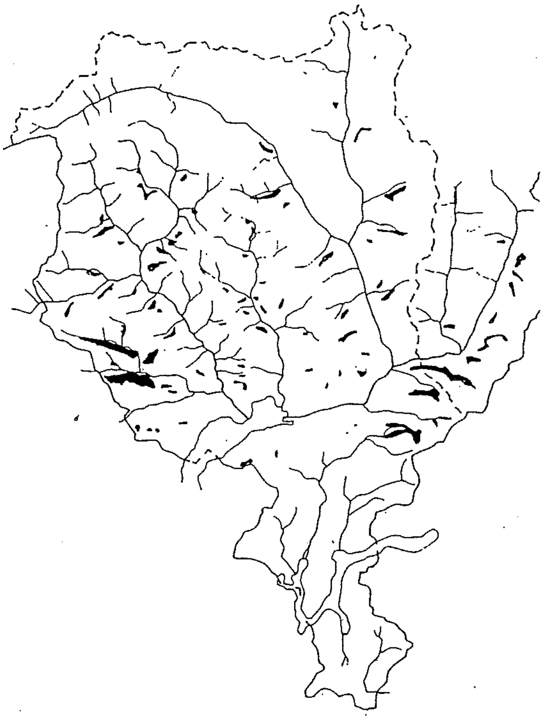
(Source: Gobet et al. 2000, modified selection)



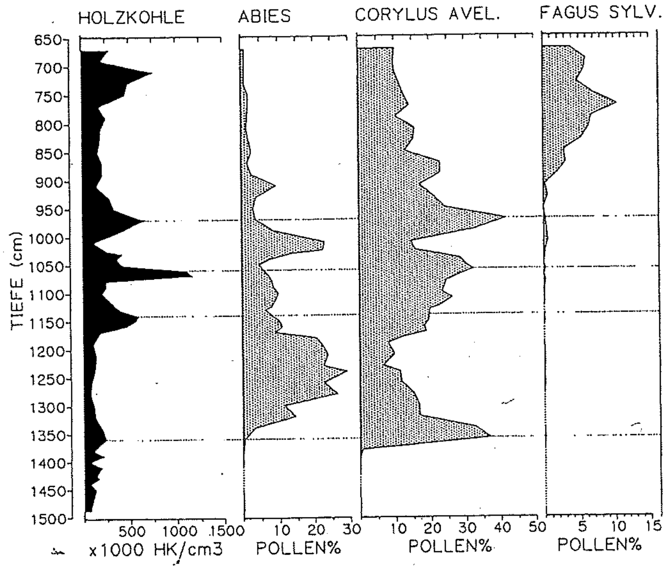
Percentage non-arboreal pollen (NAP) diagram from Lago di Muzzano (selected taxa). Exaggeration x10 is indicated by stippling. *Cannabis*-type and the group *AQ* (aquatics) and *SP* (spores) are excluded from the pollen sum.

Analysts: Priska Hubschmid and Michael Wehrli, 1997.

(Source: Gobet et al. 2000, modified selection)



Map of the present Abies alba-occurrence in Ticino and Val Mesolcina
(Source: Ceschi 1985, cited by Aurachi et al. 1986)



Charcoal / *Abies* / *Corylus* / *Fagus* diagram
(Source: Wehrli 1997)

```
LAG    CORR     SE -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
                   +----+----+----+----+----+----+----+----+----+----+
-10   -.088   .204                (       xx|         )
 -9   -.236   .200                (    xxxxx|         )
 -8   -.306   .196                 ( xxxxxxx|        )
 -7   -.245   .192                 (  xxxxxx|        )
 -6   -.014   .189                 (        |        )
 -5    .100   .186                 (        |xx      )
 -4   -.060   .183                 (       x|        )
 -3   -.241   .180                  ( xxxxxx|       )
 -2   -.415   .177               xx (xxxxxxx|       )
 -1   -.463   .174              xxx (xxxxxxx|       )
  0   -.454   .171              xxx (xxxxxxx|       )
  1   -.339   .174                  (xxxxxxx|       )
  2   -.138   .177                  (    xxx|       )
  3   -.031   .180                  (       |       )
  4    .010   .183                 (        |        )
  5   -.046   .186                 (       x|        )
  6   -.058   .189                 (       x|        )
  7    .000   .192                 (        |        )
  8    .105   .196                 (        |xx      )
  9    .109   .200                (         |xx       )
 10    .043  -.204                (         |x        )
```

Cross correlation diagram of charcoal vs. *Abies*, 1360-890 cm (8900-4350 years BP uncalibrated).
(Source: Wehrli 1997)

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PERGAMON

Quaternary Science Reviews 22 (2003) 1447–1460

QSR

Climatic change and contemporaneous land-use phases north and south of the Alps 2300 BC to 800 AD

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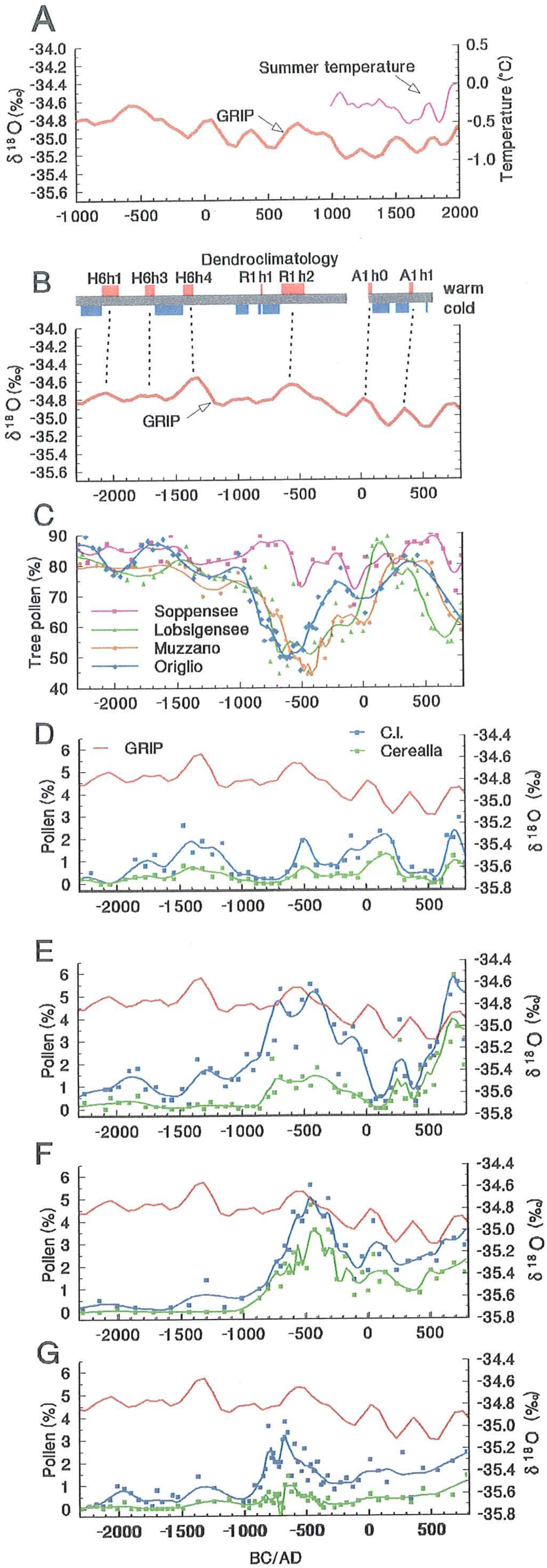
Abstract

Fluctuations in the $\Delta^{14}C$ curve and subsequent gaps of archaeological findings at 800–650 and 400–100 BC in western and central Europe may indicate major climate-driven land-abandonment phases. To address this hypothesis radiocarbon-dated sediments from four lakes in Switzerland were studied palynologically. Pollen analysis indicates contemporaneous phases of forest clearances and of intensified land-use at 1450–1250 BC, 650–450 BC, 50 BC–100 AD and around 700 AD. These land-use expansions coincided with periods of warm climate as recorded by the Alpine dendroclimatic and Greenland oxygen isotope records. Our results suggest that harvest yields would have increased synchronously over wide areas of central and southern Europe during periods of warm and dry climate. Combined interpretation of palaeoecological and archaeological findings suggests that higher food production led to increased human populations. Positive long-term trends in pollen values of Cerealia and *Plantago lanceolata* indicate that technical innovations during the Bronze and Iron Age (e.g. metal ploughs, scythes, hay production, fertilising methods) gradually increased agricultural productivity. The successful adoption of yield-increasing advances cannot be explained by climatic determinism alone. Combined with archaeological evidence, our results suggest that despite considerable cycles of spatial and demographic reorganisation (repeated land abandonments and expansions, as well as large-scale migrations and population decreases), human societies were able to shift to lower subsistence levels without dramatic ruptures in material culture. However, our data imply that human societies were not able to compensate rapidly for harvest failures when climate deteriorated. Agriculture in marginal areas was abandoned, and spontaneous reforestations took place on abandoned land south and north of the Alps. Only when the climate changed again to drier and warmer conditions did a new wide-spread phase of forest clearances and field extensions occur, allowing the reoccupation of previously abandoned areas. Spatial distribution of cereal cultivation and growth requirements of Cerealia species suggest that increases in precipitation were far more decisive in driving crop failures over central and southern Europe than temperature decreases.



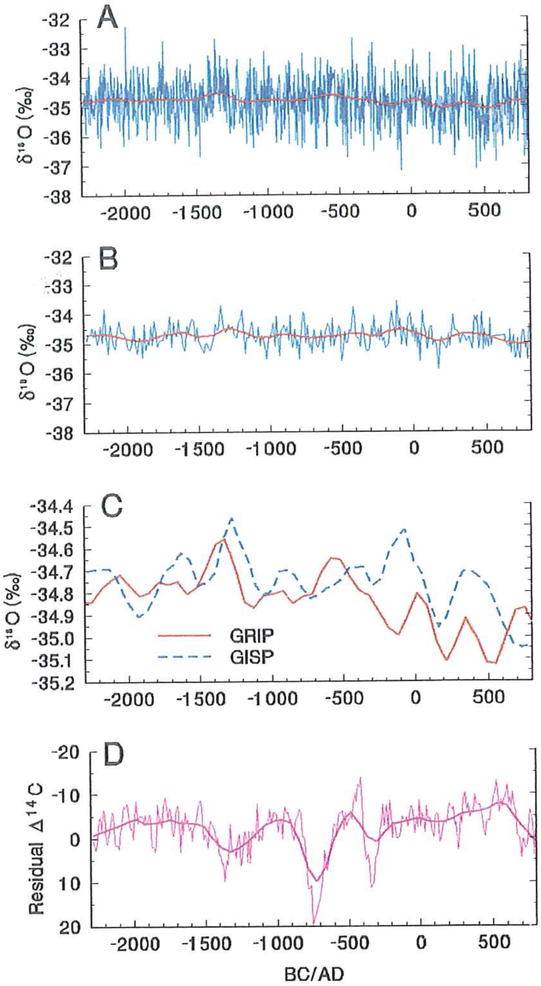


Fig. 4. Comparison of Holocene climate proxies for the period 2300 BC–800 AD (all LOWESS curves with span=10%). (A) GRIP (European Greenland ice-core project) stable oxygen isotope record (Dansgaard et al., 1993), the line indicates LOWESS-smoothing. (B) GISP2 (US Greenland ice Sheet Project 2) stable oxygen isotope record (Grootes et al., 1993), the line indicates LOWESS-smoothing. (C) Comparison between LOWESS-smoothed GRIP and GISP2 oxygen isotope values. (D) Variation of residual $\Delta^{14}C$ (Stuiver and Braziunas, 1991), the heavy line indicates LOWESS smoothing.

Fig. 5. Holocene climatic proxies and lowland pollen records located north and south of the Alps. For better comparison of common trends all data were LOWESS-smoothed (tension 10%). The scatterplots show the original pollen percentage values. The lines indicate LOWESS smoothing. Chronologies for pollen records were assessed by radiocarbon dating (see Table 1) and correlated with Greenland oxygen isotope records according to their absolute ages. (A) Comparison between GRIP stable oxygen isotope records (Dansgaard et al., 1993) and northern-hemisphere summer temperature reconstructions (Jones et al., 1998). (B) Comparison between dendroclimatological records from the Alps and GRIP stable isotope records. The abbreviations denominate warm phases in the Alps according to Bircher (1986). For comparison ^{14}C BP yr ages were calibrated to BC/AD ages. A1h0 is a pronounced warm phase (1940–1890 ^{14}C yr BP; see Bircher, 1986) which is unnamed in the original studies. For abbreviations of cold phases see Bircher (1986). (C) Tree pollen percentages at Soppensee, Lobsigensee, Lago di Muzzano and Lago di Origlio. (D) Comparison between the GRIP stable isotope record and pollen records of Soppensee. (E) Comparison between the GRIP stable isotope record and pollen records of Lobsigensee. (F) Comparison between the GRIP stable isotope record and pollen records of Lago di Muzzano. G: Comparison between the GRIP stable isotope record and pollen records of Lago di Origlio. (D–G) The green LOWESS curve indicates the Cerealia pollen percentages and the blue LOWESS curve the percentage sum of Cerealia and *Plantago lanceolata* (=cultural indicators, CI).

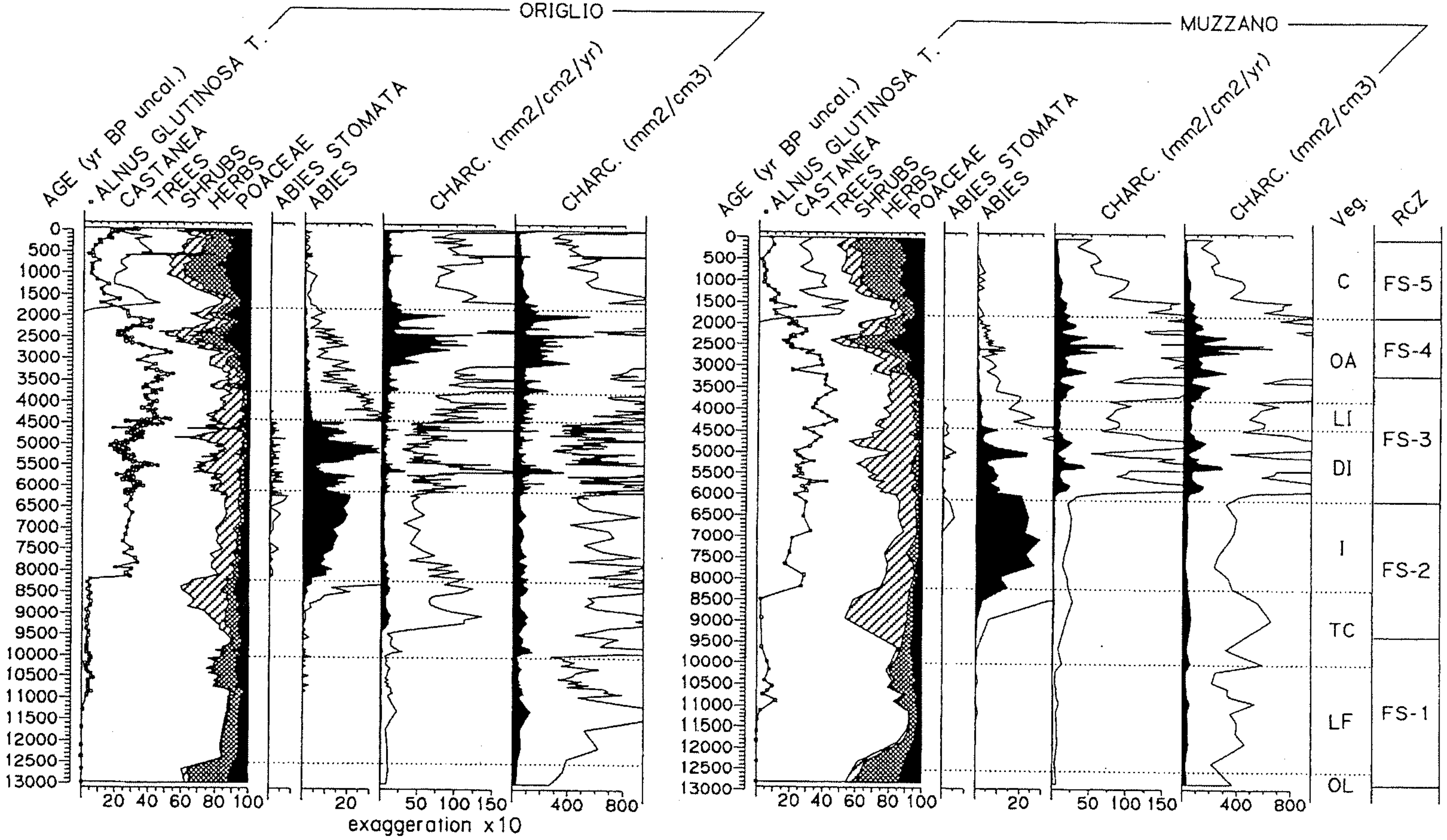
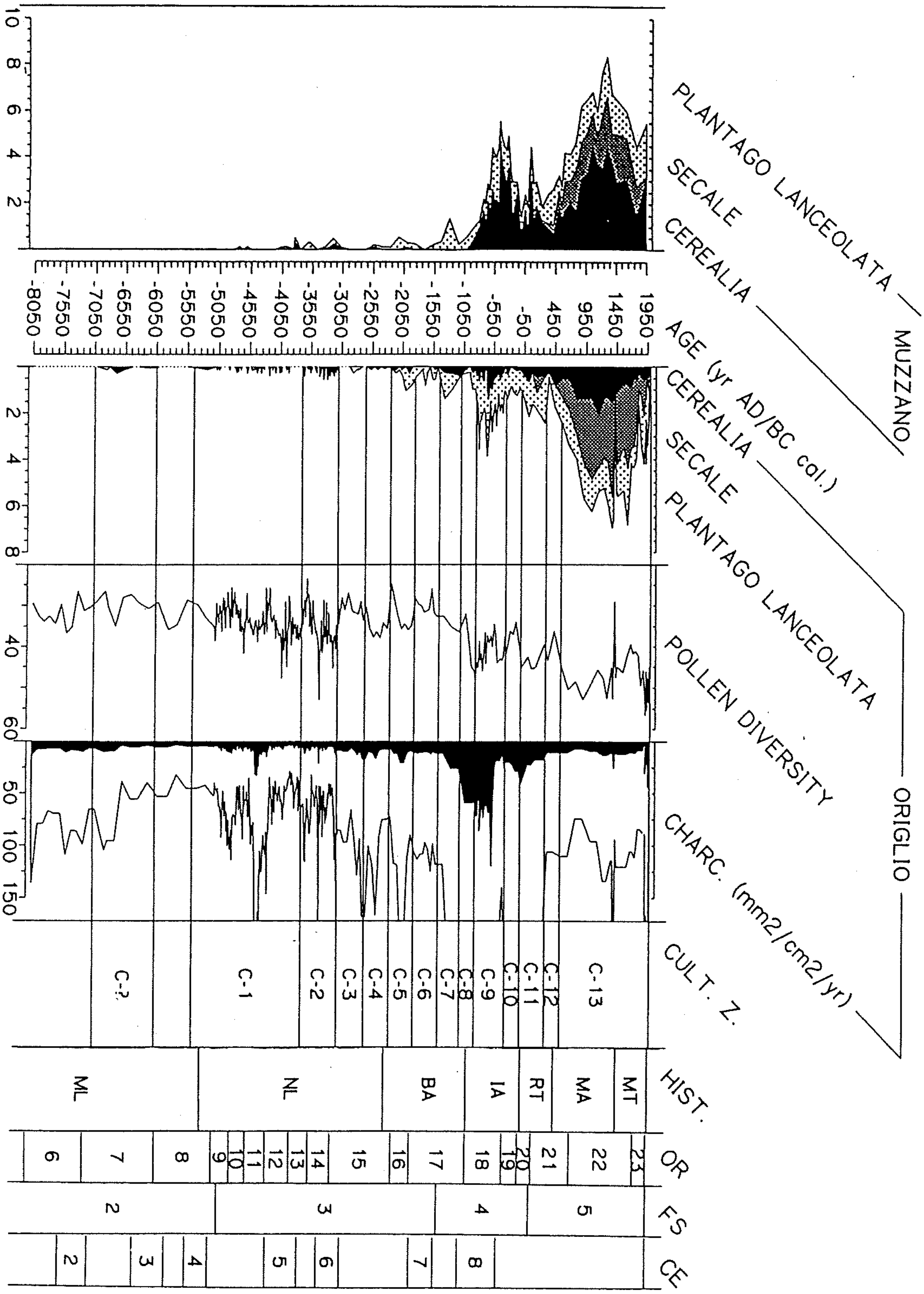


Fig. 4 Pollen percentage diagrams and charcoal influx (mm^2 cm^{-2} year^{-1}) and concentration (mm^2 cm^{-3}) diagrams for Lago di Origlio and Lago di Muzzano. Veg. = Vegetation type according to Table 1. C = Chestnut forests and farmlands; OA = oak–alder forests and farm lands; LI = late Insubrian forests; DI = disturbed Insubrian forests; I = Insubrian forests; TC = temperate continental forests and shrublands; LF = Late Glacial forests; OL = open Late Glacial forests. RCZ, FS = Regional charcoal zones of southern Switzerland.

Tinner et al. 1999, J. Ecol.: 273-289



Culture indicators at Lago di Muzzano and Lago di Origlio. CULT.Z. = Cultural zones, HIST. = historical and prehistorical periods: ML = Mesolithic, NL = Neolithic, BA = Bronze Age, IA = Iron Age, RT = Roman Time, MA = Middle Ages, MT =Modern Time. OR = Local pollen assemblage zones of Lago di Origlio, FS = Regional charcoal zones of southern Switzerland, CE = Central European cold/wet phases following Haas et al. (1998).

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