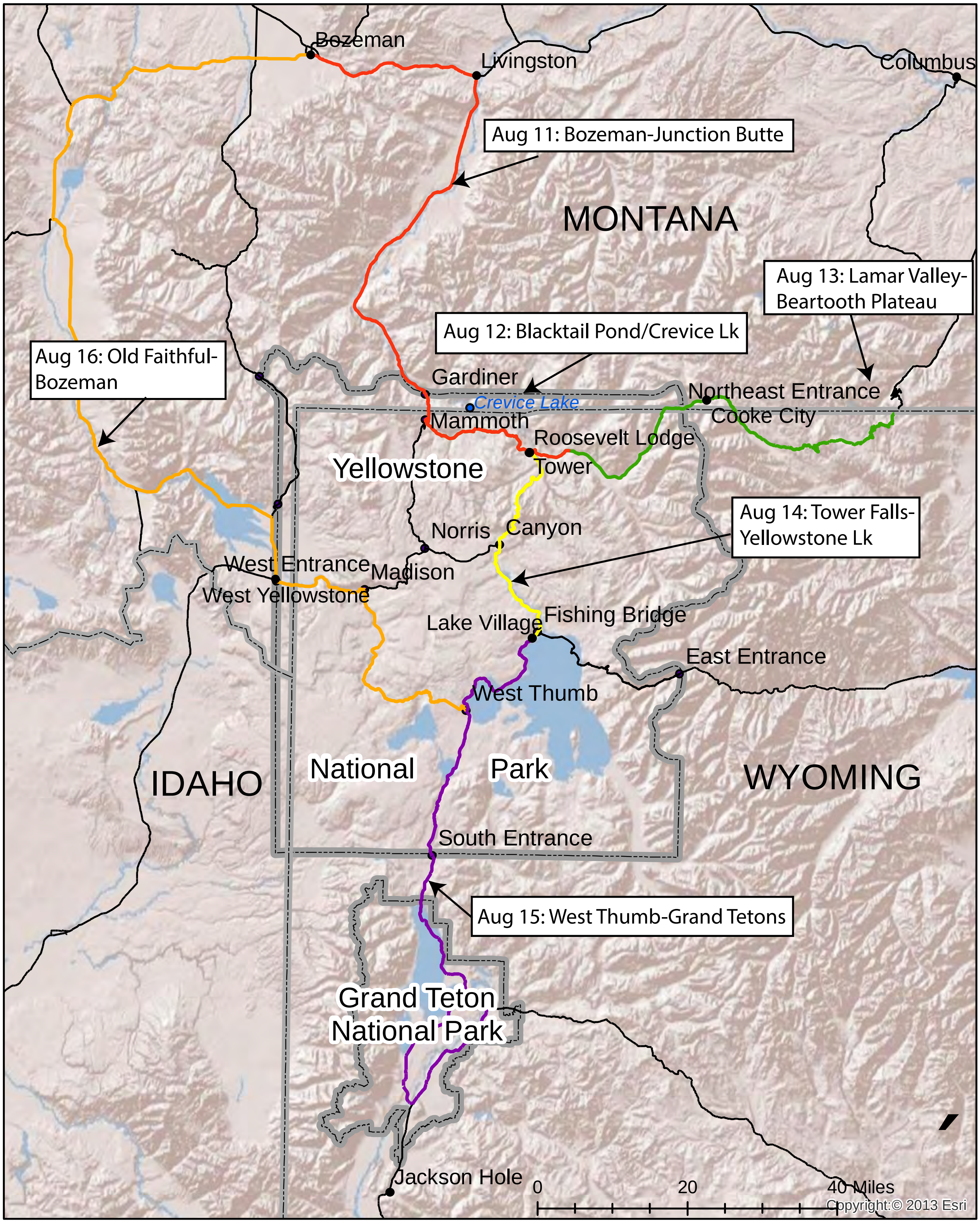
XXXVII International Moor Excursion
Greater Yellowstone Ecosystem: Its History and Ecology



Greater Yellowstone Moor Excursion: Tentative Schedule & Information		
Date	**Activity**	**Information**
August 10	Arrival and Welcome (Leaders: Whitlock, Krause)	
	Check-in: City Center Inn	City Center Inn, 507 W. Main St., Bozeman Cab from airport, approximately $25 (USD) Cathy's cell: 406-570-1483 Teresa's cell: 406-220-9301
6:30 pm	Welcome and light dinner	Weaver Room, Emerson Cultural Center 111 S Grand St. (few blocks east of motel), Bozeman
8:00 pm	Excursion introduction	The week ahead
August 11	Glacial history of northern Yellowstone (Leaders: Pierce, Whitlock, Licciardi, Krause)	
8:00 am	Check-out & Depart	Departure at 8:00 a.m. Please be prompt.
8:00 am	Paradise Valley of the Yellowstone	Livingston to Mammoth
12:30 pm	Lunch: Mammoth Hot Springs	
2:00 pm	Northern Yellowstone glacial history	Mammoth to Junction Butte
4:30 pm	Check in: Mammoth Hotel	Hike the Terraces before dinner
7:00 pm	Dinner: K-Bar	
August 12	Vegetation and fire history of northern Yellowstone (Leaders: Whitlock, Krause)	
8:00 am	Lunch making	Make your own lunches.
8:30 am	Depart	Departure at 8:30 a.m. Please be prompt.
9:00 am	Blacktail Pond paleoecology	
10:00 am – 4:00 pm	Crevice Lake paleoecology (a 13 km roundtrip moderate hike) Lunch: Crevice Lake	Wear sturdy hiking shoes and carry water bottles, hat, raingear, sunscreen, insect repellent.
Evening	Dinner: Mammoth Hotel	No reservations, charge dinner to your room.
7:00 pm	Optional trip: Norris Hot Springs	This is a 2-hour trip, we'll see who's interested.
August 13	Beartooth Plateau: Alpine history and archeology (Leaders: Pederson, Lee)	
8:00 am	Check out & Depart	Departure at 8:00 a.m. Please be prompt.
8:00-10:30 am	Drive through Lamar Valley	Wildlife viewing opportunities.
10:30-11:30 am	Beartooth overlook/tree-ring research	
12:00-1:30 pm	Lunch: Beartooth Lake	
1:30-4:00 pm	Ice-patch archeology	Short hike in alpine zone.
6:00 pm	Dinner: Soda Butte Lodge Cooke City	
8:00 pm	Check-in: Roosevelt Lodge	
August 14	Tower to Yellowstone Lake (Leaders: Renkin, Hale, Whitlock, Gresswell)	
8:30	Check-out & Depart	Departure at 8:30 a.m. Please be prompt.
9:00-10:00 am	Tower Falls	
10:00-11:30 am	Yellowstone fire ecology	Meet Roy Renkin; drive over Dunraven Pass.
12:30-3:00 pm	Lunch, Grand Canyon of the Yellowstone	Lunch at Uncle Tom's Trailhead; hikes in various directions.
4:00 pm	Yellowstone Lake prehistory	
5:00 pm	Check-in: Lake Hotel cabins	
5:45 pm onwards	Dinner: On your own: Lake Hotel Dining Hall/ Lake Lodge Grill	Group reservations at Lake Hotel Dining Hall: 5:45, 6:15, and 6:30 pm. Alternatively: Lake Lodge Grill (less expensive, cafeteria).

August 15	Grand Teton National Park (Lead: Licciardi, Whitlock)	
8:30 pm	Depart	Departure at 8:30 a.m. Please be prompt.
9:00 pm	West Thumb Geyser Basin	
11:30 am	AMK Ranch, Archeology in Jackson Hole	
12:00 pm	Lunch: AMK Ranch	
2:00 pm	Jenny Lake and vicinity: paleobeavers and Pleistocene glaciers	3-4 km easy hike.
4:00 pm	Return trip with photo stops	
7:30 pm	Dinner: Grant Village	Group reservations at Grant Village Dining Room: 7:30 and 7:45.
9:00 pm	Return to Lake Hotel	
August 16	Old Faithful to Bozeman (Lead: Whitlock)	
9:00 am	Check-out & Departure	Departure at 9:00 a.m. Please be prompt.
10:00 am	Duck Lake charcoal studies	
11:00 am	Old Faithful Geyser Basin Lunch: Old Faithful	
2:00 pm	Midway Geyser Basin	
3:30 pm	Madison Junction postfire recovery	
5:30 pm	Check in: City Center Inn	
7:00 pm	Farewell Dinner: I-Ho’s Korean Grill (2.4 km from City Center Inn)	Bus will pick you up, City Center Inn at 6:50 p.m. I-Ho’s Korean Grill: 1216 W. Lincoln Street, Bozeman

A few notes:

- Breakfasts are on your own: restaurants/coffee options start at 6:30 a.m.
- Your registration covers dinners and lunches (except for Aug 14 when you are on you own). The group will be making sandwiches for lunch. Vegetarian and gluten-free options will be available.
- Alcohol is not covered, but in Montana, bars are always close by and we’ll bring some beer and wine for group sharing.
- Weather can be variable (30°C in the day; 0°C at night), with thunderstorms possible on any day. Layers of clothing are a great solution and bring good walking shoes, a water bottle, sun hat and rain gear.
- Cell phones do not work in the park - there is no signal at all in most places.
- Let us know if you have any questions or concerns.

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Participant List

Name	Affiliation	E-mail Address
Ariana White	University of Oregon	awhite5@uoregon.edu
Basil Davis	École Polytechnique Fédérale de Lausanne	basil.davis@epfl.ch
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Donna Hawthorne	Trinity College Dublin	hawthord@tcd.ie

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Trip Leaders

Cathy Whitlock
Montana State University
Montana Institute on Ecosystems (IoE)

Cathy Whitlock is a professor in Earth Sciences and Director of the Montana Institute on Ecosystems at Montana State University. Her research focuses on the vegetation, climate, and fire history of the western U.S. and southern hemisphere, and she and her students have worked on the environmental history of the Greater Yellowstone Ecosystem since 1986.

Ken Pierce
US Geological Survey (USGS)

Ken Pierce is a geologist emeritus with the USGS Northern Rocky Mountain Science Center. His research is in the field of Quaternary Geology and Geomorphology, focusing on natural landscapes and the geologic processes responsible for their formation. Ken Pierce is the recipient of the Distinguished Career Award of the Quaternary Geology and Geomorphology Division of the Geological Society of America.

Teresa Krause
Montana State University

Teresa Krause is wrapping up her PhD dissertation research with Cathy Whitlock. Her work investigates the controls of ecosystem development during rapid environmental change, considering Yellowstone in the late-glacial and early Holocene periods. Her research interests are focused in paleoecology. She also has strong interests in teaching and education.

Greg Pederson
US Geological Survey (USGS)

Greg Pederson is a research ecologist with the USGS Northern Rocky Mountain Science Center. His research focuses primarily on climate variability and its role in driving biological and physical components of mountainous ecosystems of western North America. His recent studies have addressed the susceptibility of natural resources within national parks and protected areas to climate variability and change.

Craig Lee
University of Colorado
Institute of Arctic and Alpine Research (INSTAAR)

Craig Lee is a research scientist at INSTAAR in Boulder, Colorado. He studies human ecology and landscape archaeology of alpine and high latitude environments with an emphasis on sharing the process and results with numerous audiences, including the professional scientific community, Native American communities, and the interested public.

Bob Gresswell
US Geological Survey (USGS)

Bob Gresswell is a research biologist with the USGS Northern Rocky Mountain Science Center, and has been studying and working on Yellowstone Lake for more than 30 years. His research focuses on the habitat relationships and life-history organization of cutthroat trout, as well as on the suppression of invasive lake trout in Yellowstone Lake.

Joe Licciardi
University of New Hampshire

Joe Licciardi is an associate professor in the Department of Earth Sciences at the University of New Hampshire. His past and current research integrates fieldwork, laboratory techniques, and modeling studies in order to resolve key issues in Quaternary geology, with a unifying theme of understanding mechanisms of climate change.

Roy Renkin
National Park Service
Vegetation Program Leader
Yellowstone Center for Resources

Roy Renkin has decades of experience with the National Park Service. He is the vegetation management specialist and the Park's expert on fire ecology and post-1988 fire recovery.

Elaine Hale
National Park Service

Elaine Hale is an archaeologist with Yellowstone National Park and has studied the prehistory of Yellowstone Lake.

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Reading List

General

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August 11: Bozeman to Junction Butte

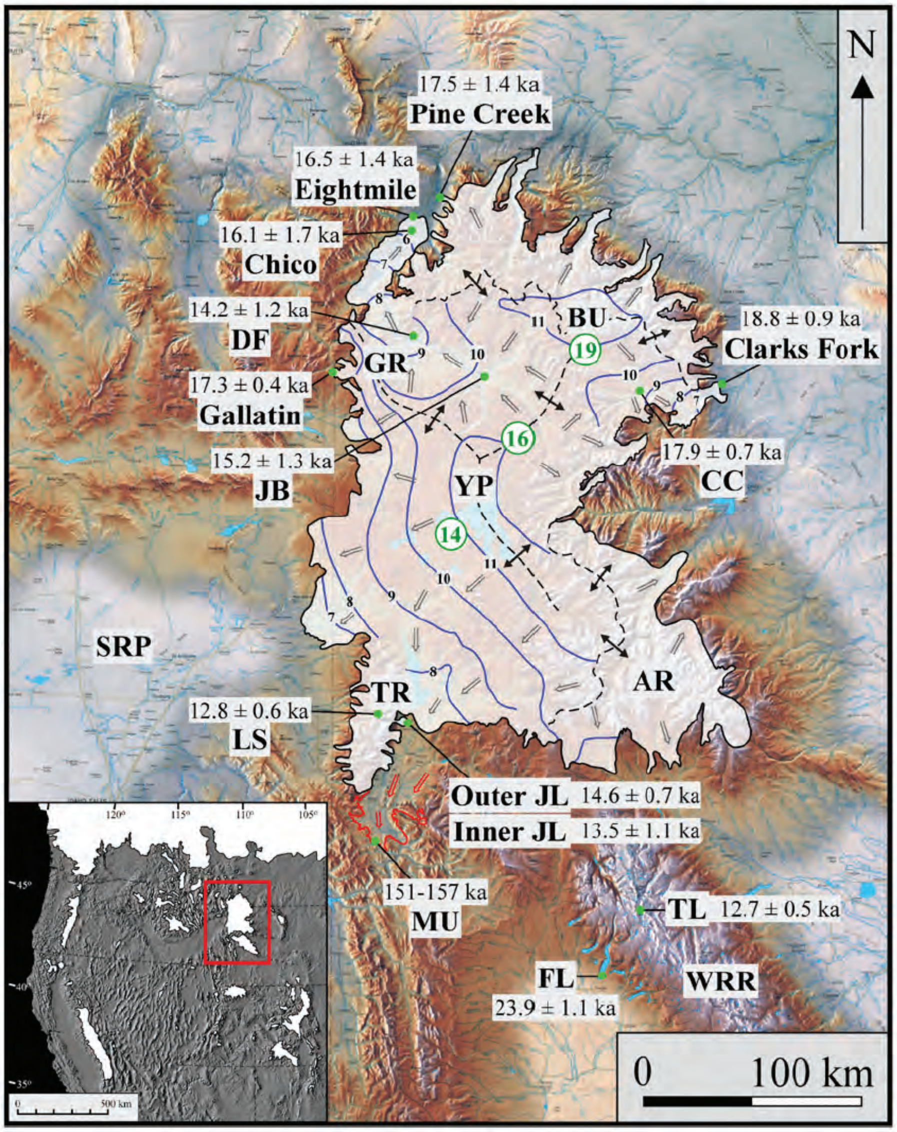


Fig. 1. Summary of ^{10}Be moraine ages around the greater Yellowstone glacial system. Blue lines depict maximum Pinedale ice surface elevation contours in thousands of feet. Red line indicates Bull Lake (Munger) ice limit in Jackson Hole. Pleistocene ice cover outside the greater Yellowstone glacial system (e.g., in the Wind River Range) is omitted on main map for clarity. Encircled green numbers are ages (in ka) that schematically depict the southwest migration of the center of gravity of the Yellowstone glacial system through time (see Section 9). Glacier outlines in locator map of the western US from Pierce (2004). AR, Absaroka Range; BU, Beartooth Uplift; CC, Crandall Creek; DF, Deckard Flats; FL, Fremont Lake; GR, Gallatin Range; JB, Junction Butte; JL, Jenny Lake; LS, Lake Solitude; MU, Munger ice limit; SRP, Snake River Plain; TL, Titcomb Lakes; TR, Teton Range; WRR, Wind River Range; YP, Yellowstone Plateau. Shaded relief base map here and in Figs. 3–7 used with permission from Yellowstone Ecological Research Center.

from Licciardi and Pierce, 2008

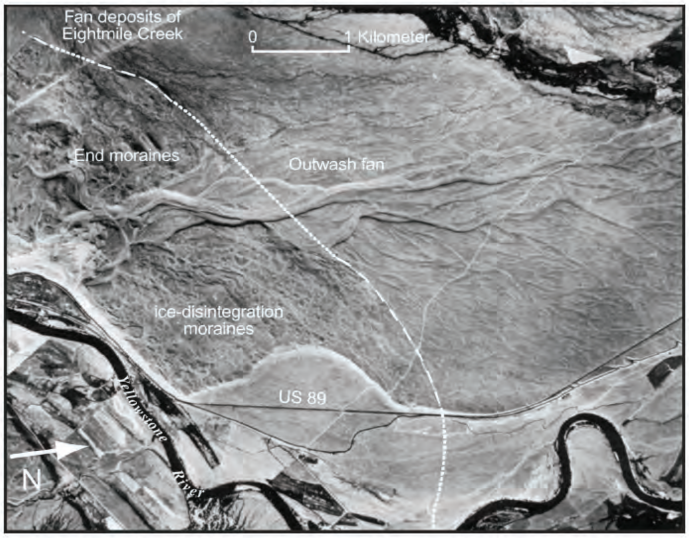


Figure 3. Pinedale end moraines and outwash fan of the northern Yellowstone outlet glacier, showing preservation of detailed braided channel pattern (from Pierce, 1979, Fig.16). The head of the fan is 200 ft above the Yellowstone River whereas it converges with the river level about 15 miles to the north (right).

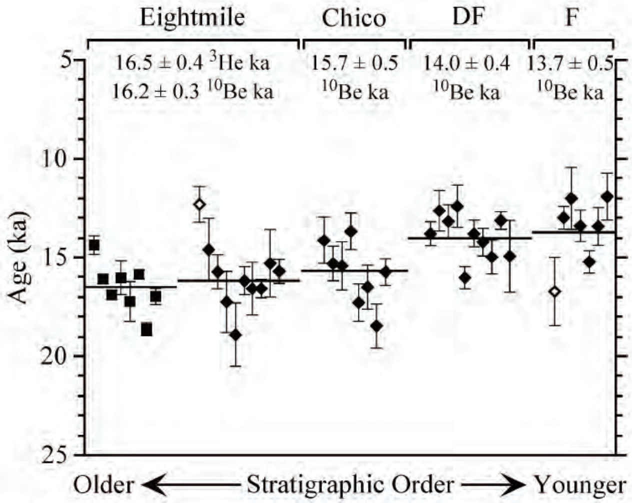
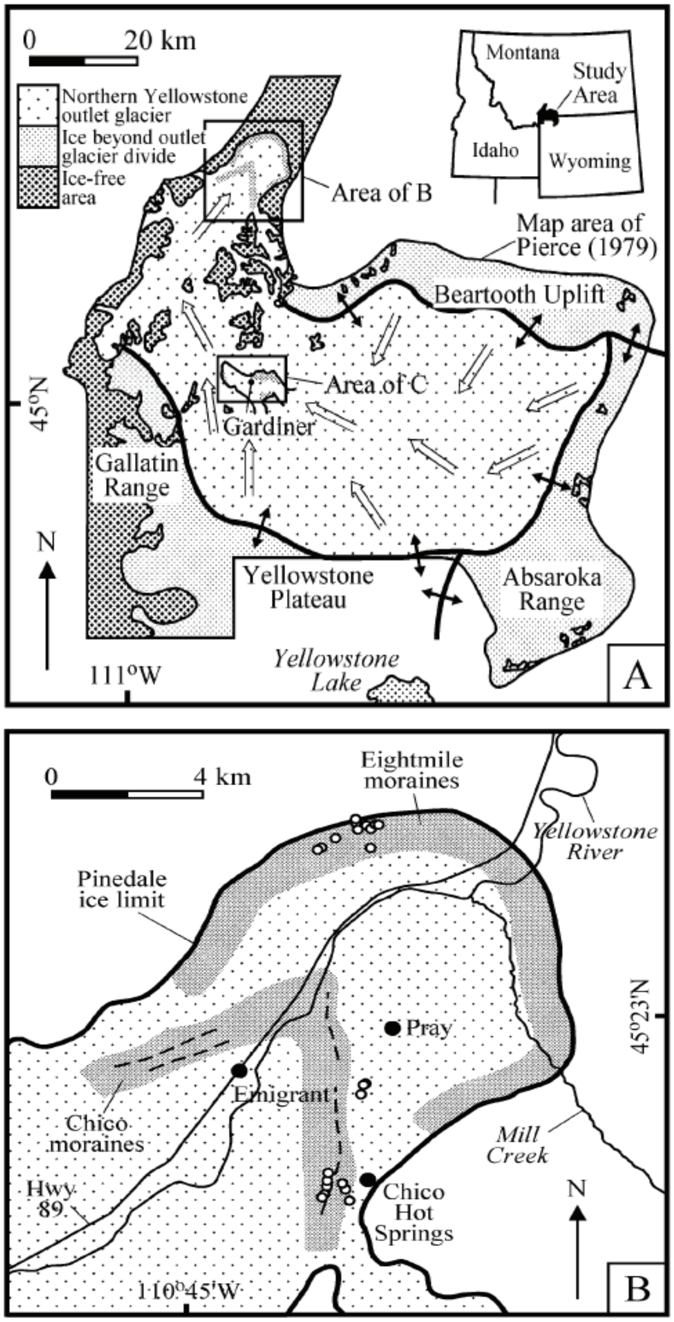
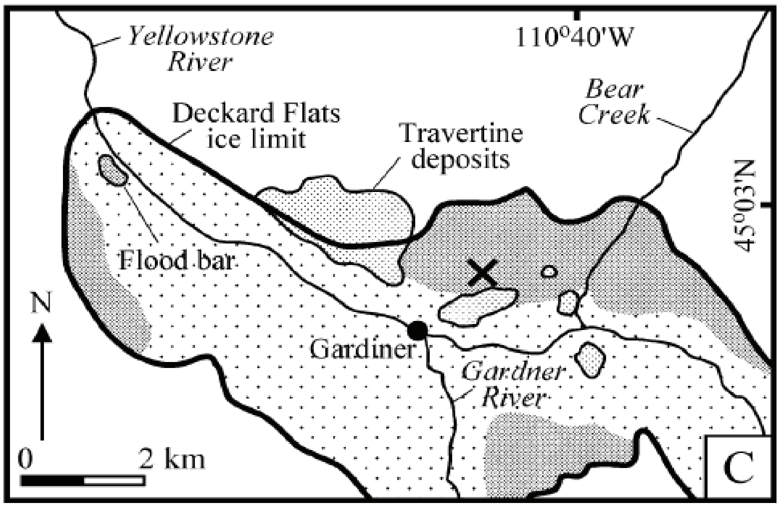


Figure 5. Cosmogenic ages of Yellowstone moraines and flood deposits, plotted in stratigraphic order from oldest (left side of graph) to youngest (right side) (from Licciardi et al., 2001). Solid squares are ^{3}He ages, and solid diamonds are ^{10}Be ages. Error bars on each age represent 1σ analytical uncertainty only, and do not include errors due to production rate, scaling, and other uncertainties. Horizontal lines and quoted ages indicate weighted means of each landform. Open diamonds indicate two outliers not included in weighted means. DF – Deckard Flats moraines; F – late–glacial flood deposits.

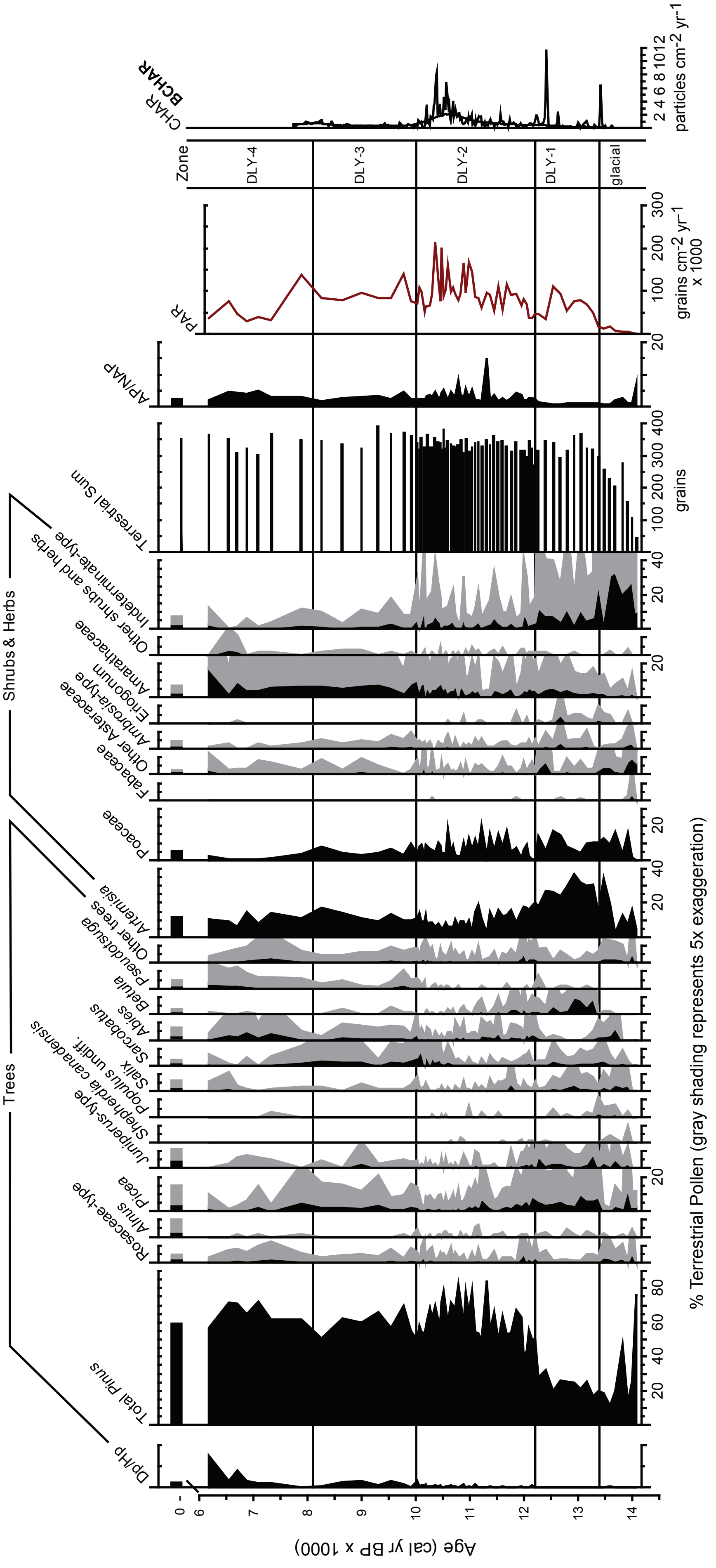




from Pierce et al., 2003

August 11 Cont'd

Dailey Lake, MT Pollen and Charcoal Record



% Terrestrial Pollen (gray shading represents 5x exaggeration)

Dp/Hp = Diploxylon-type *Pinus*/Haploxylon-type *Pinus*

August 12: Blacktail Pond/Crevice Lake

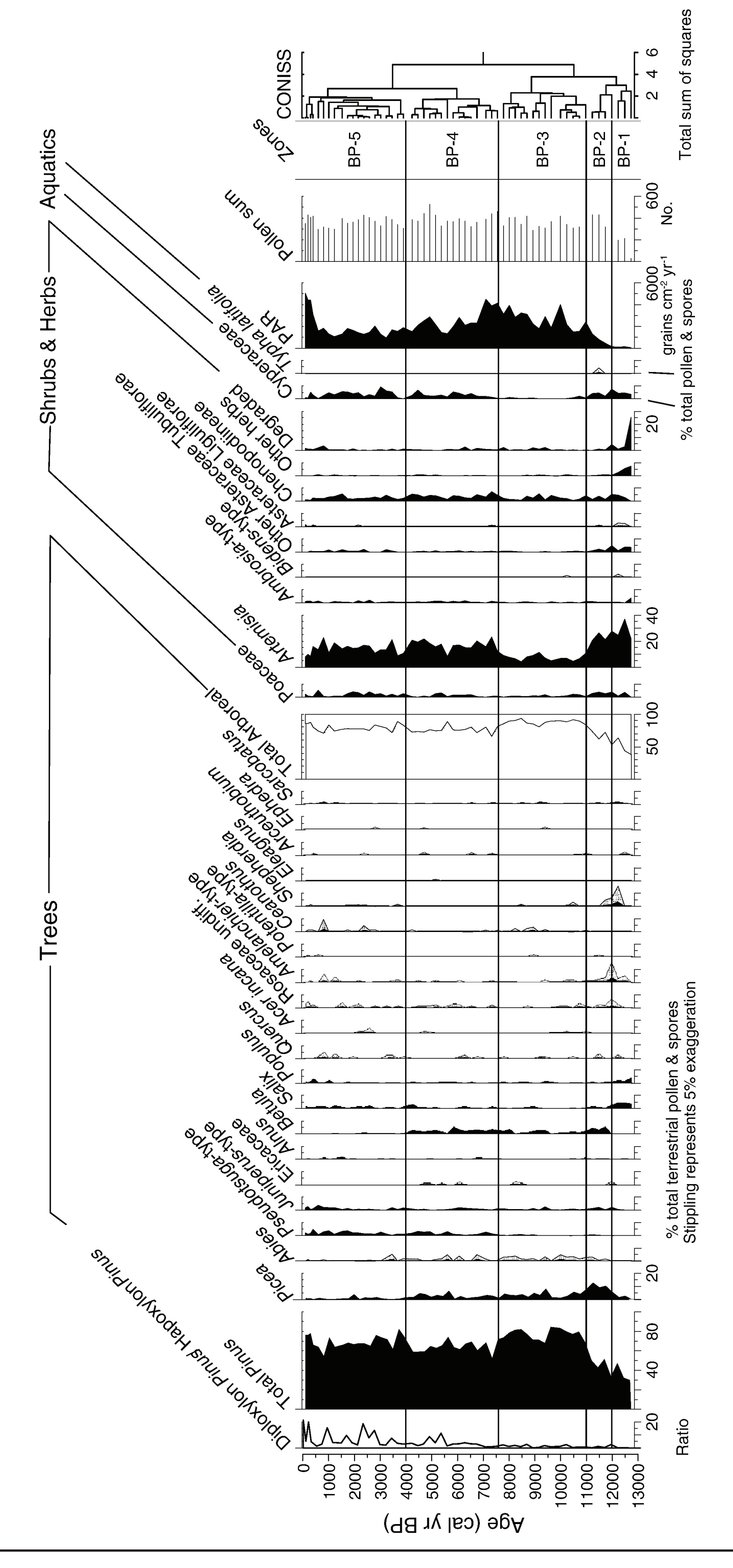


Fig. 4. Pollen percentages for selected taxa and total pollen accumulation rate (PAR) from Blacktail Pond.

from Huerta et al., 2008

August 12 Cont'd

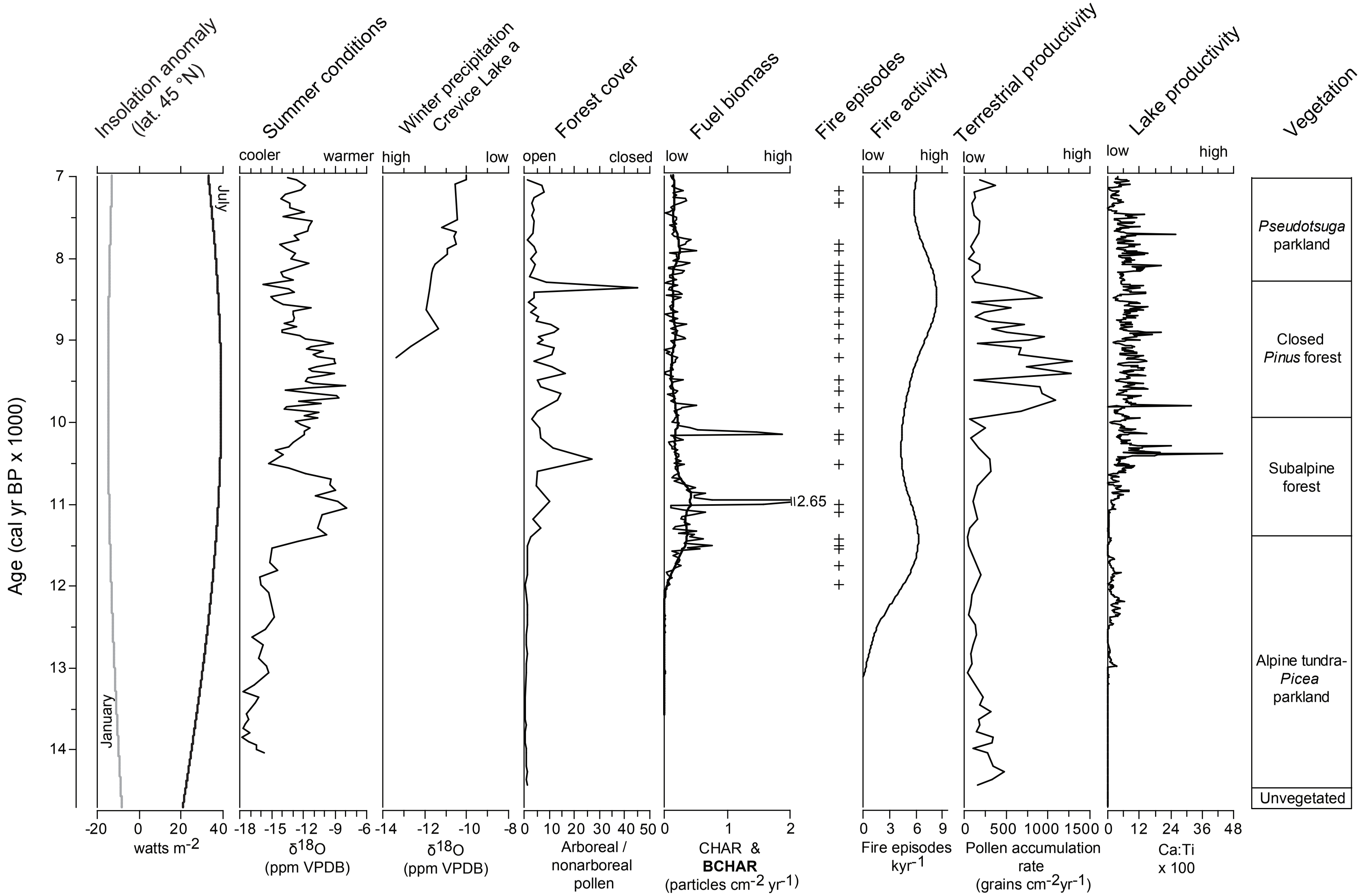


Figure 5. Summary of environmental proxy at Blacktail Pond during the late-glacial/early Holocene transition plotted against January and July insolation anomalies.

a Whitlock et al. (2012)

from Krause and Whitlock, 2013

August 12 Cont’d

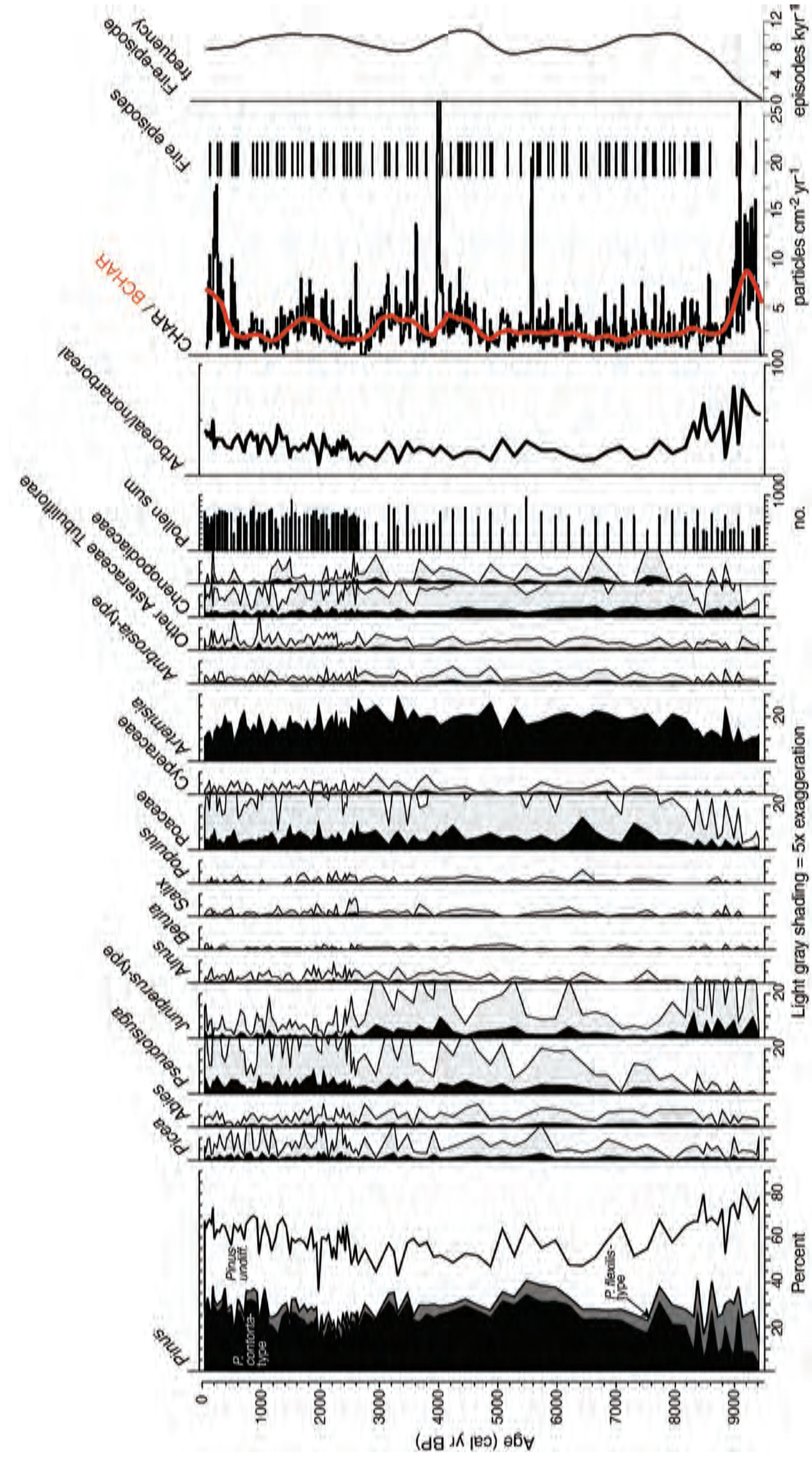


Fig. 5. Percentages of selected pollen taxa, arboreal/nonarboreal pollen, total charcoal accumulation rates (CHAR) and moving CHAR average (BCHAR), fire episodes, and fire-episode frequency in core CV01 from Crevice Lake.

from Whitlock et al., 2012

August 12 Cont'd

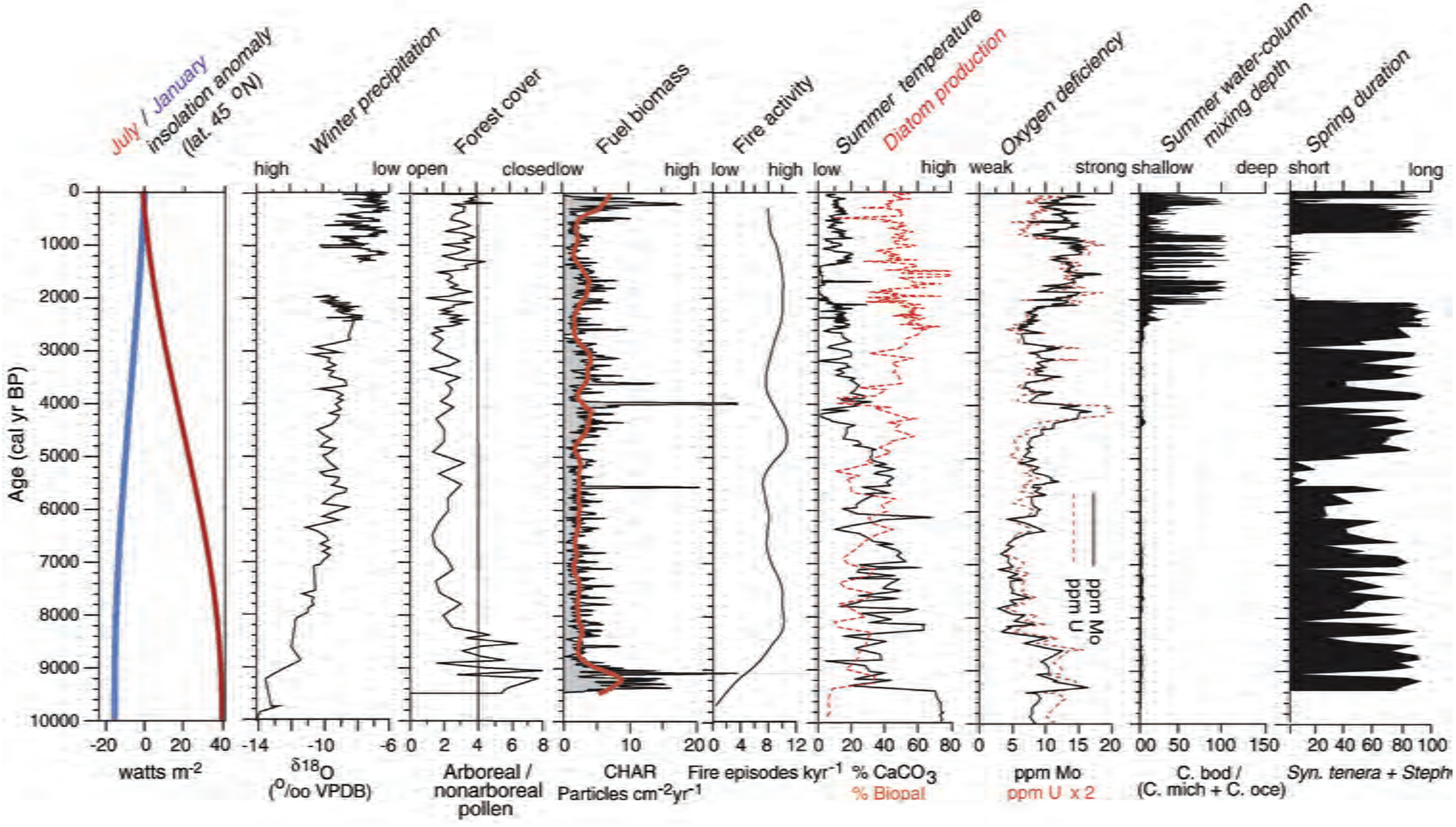


Fig. 6. Summary of the environmental proxy at Crevice Lake over the last 9400 cal yr BP plotted against July and January insolation anomalies.

from Whitlock et al., 2012

August 12 Cont'd

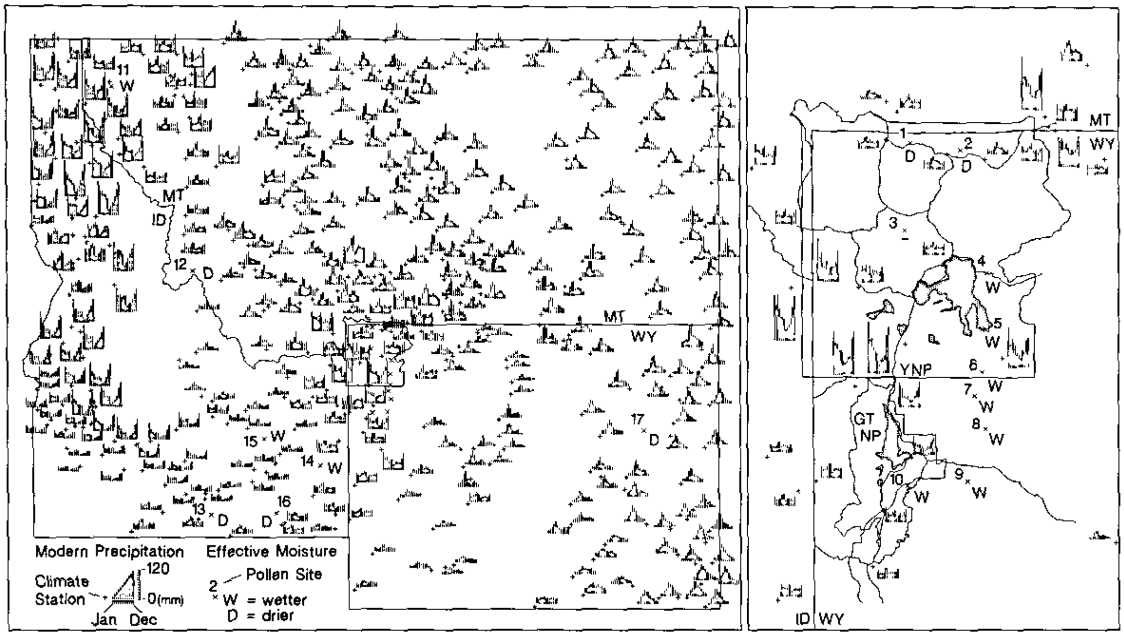


FIG. 4. (Left) Map showing annual distribution of precipitation at climate stations in Idaho, Wyoming, and Montana (World WeatherDisc Associates, n.d.); location of fossil sites; and inferred effective moisture changes from 9000 to 6000 yr B.P. (Right) Map of the same information in the vicinity of Yellowstone National Park (YNP) and Grand Teton National Park (GTNP). Fossil sites are listed in Table 1.

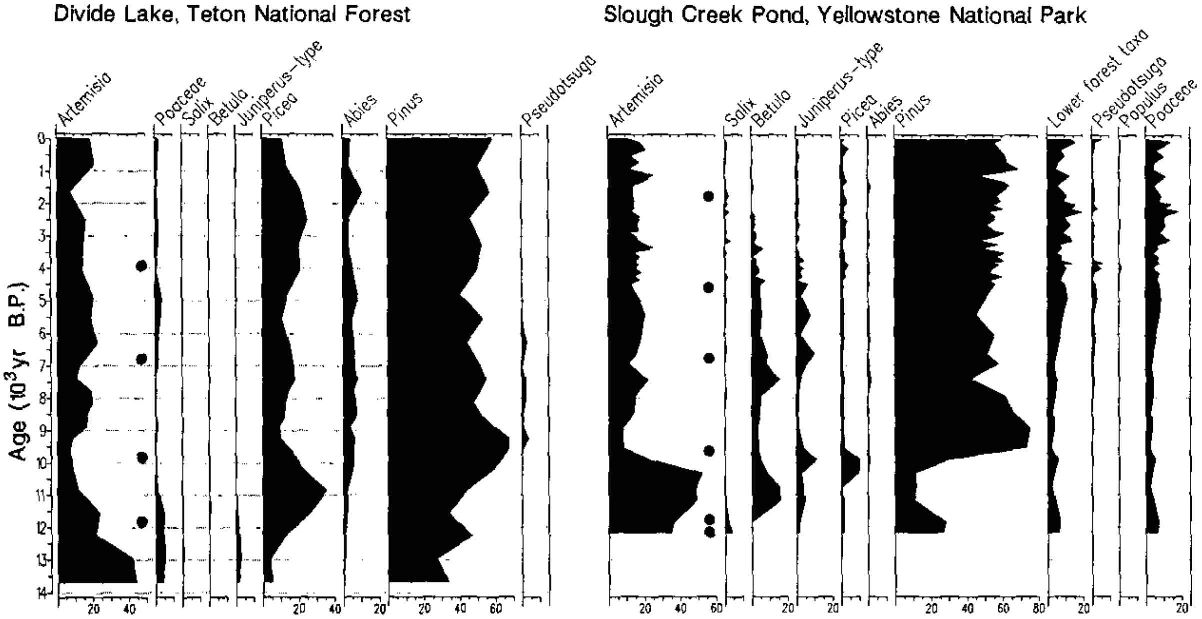


FIG. 2. Pollen percentage diagrams of selected taxa at Divide Lake and Slough Creek Pond in the Yellowstone/Grand Teton region. Circles indicate the stratigraphic position of radiocarbon dates and tephra layers.

from Whitlock and Bartlein, 1993

August 12 Cont’d

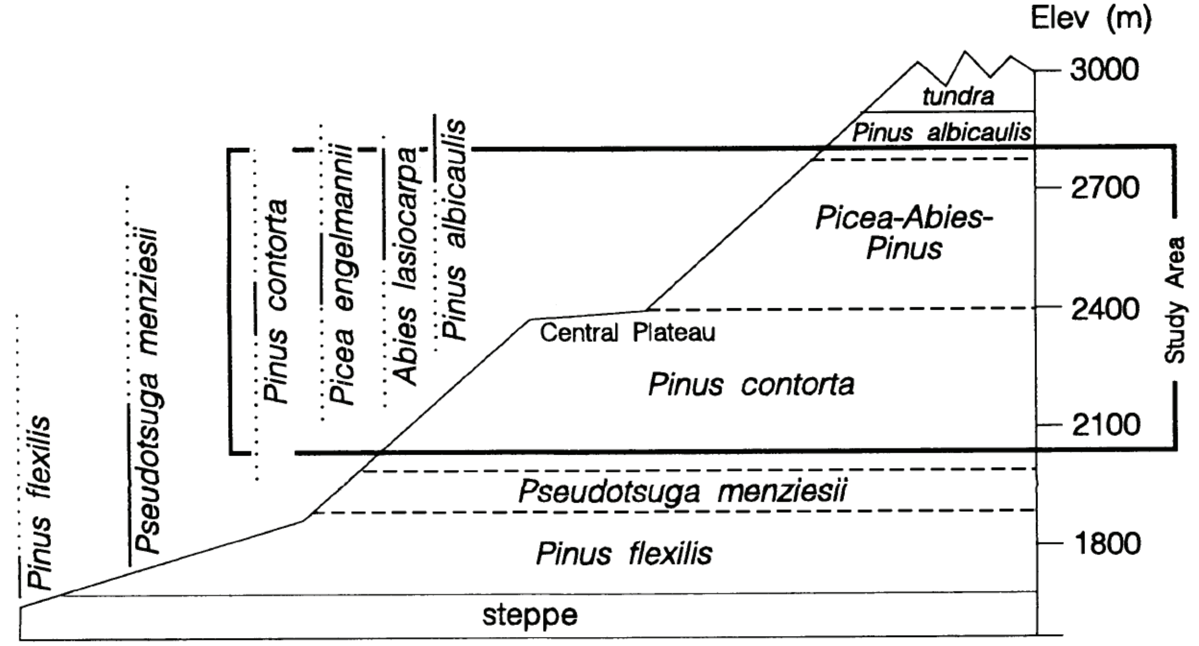


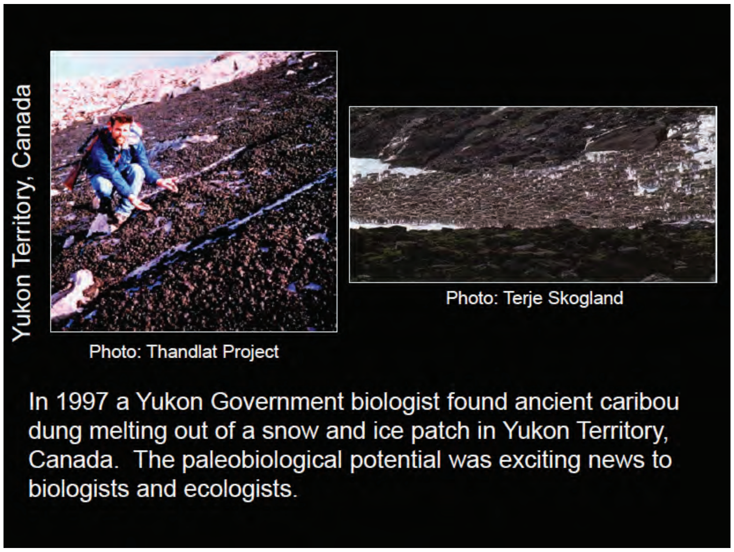
FIG. 2. Vegetation zones of the study area. Solid vertical lines show the altitudinal range where the species is important; dotted vertical lines indicate where the species is present (modified from Baker 1986).

from Whitlock, 1993

Otzi "The Ice Man" marked the first well-publicized recovery of archaeological material in association with Alpine snow and ice.

Ötztal Alps, Austria

In 1991, the discovery was not recognized as a part of a global phenomena.



Yukon Territory, Canada

Photo: Thandlat Project

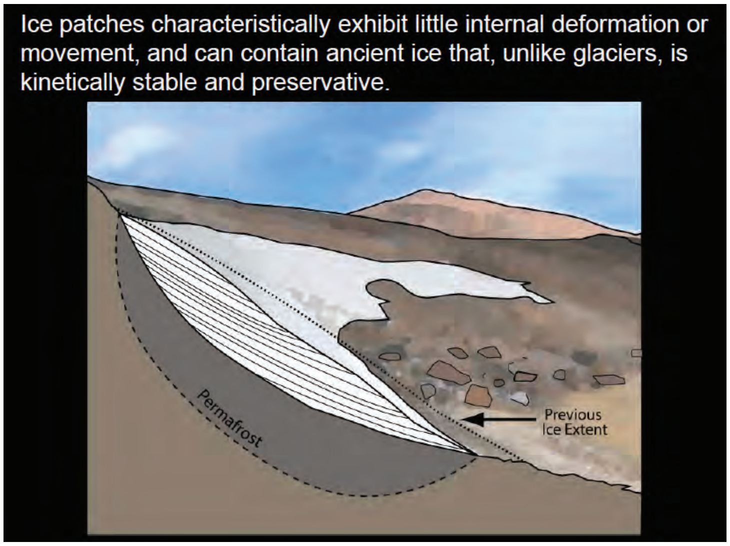
Photo: Terje Skogland

In 1997 a Yukon Government biologist found ancient caribou dung melting out of a snow and ice patch in Yukon Territory, Canada. The paleobiological potential was exciting news to biologists and ecologists.

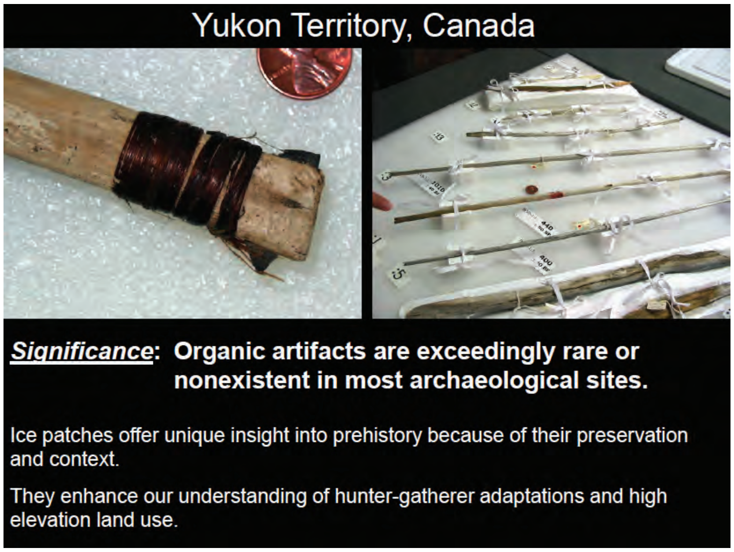
What are the drivers?

Insect predation, thermal regulation and late-season forage.

Photos: Tom Andrews



Ice patches characteristically exhibit little internal deformation or movement, and can contain ancient ice that, unlike glaciers, is kinetically stable and preservative.

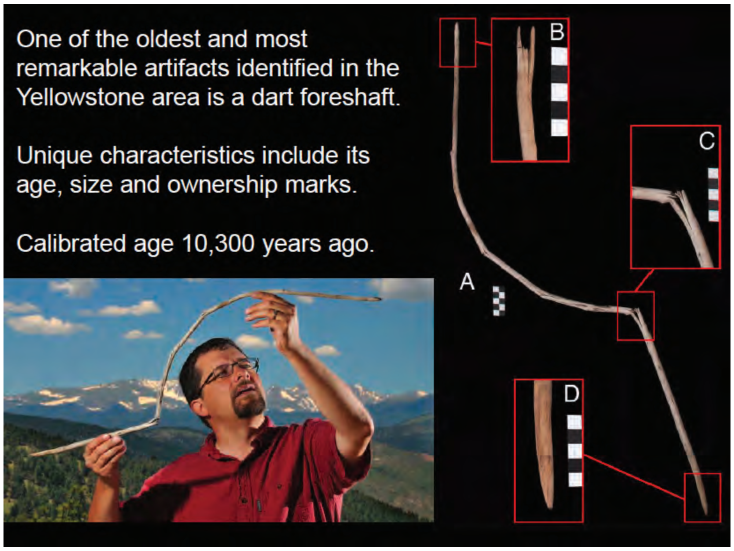


Yukon Territory, Canada

***Significance*: Organic artifacts are exceedingly rare or nonexistent in most archaeological sites.**

Ice patches offer unique insight into prehistory because of their preservation and context.

They enhance our understanding of hunter-gatherer adaptations and high elevation land use.

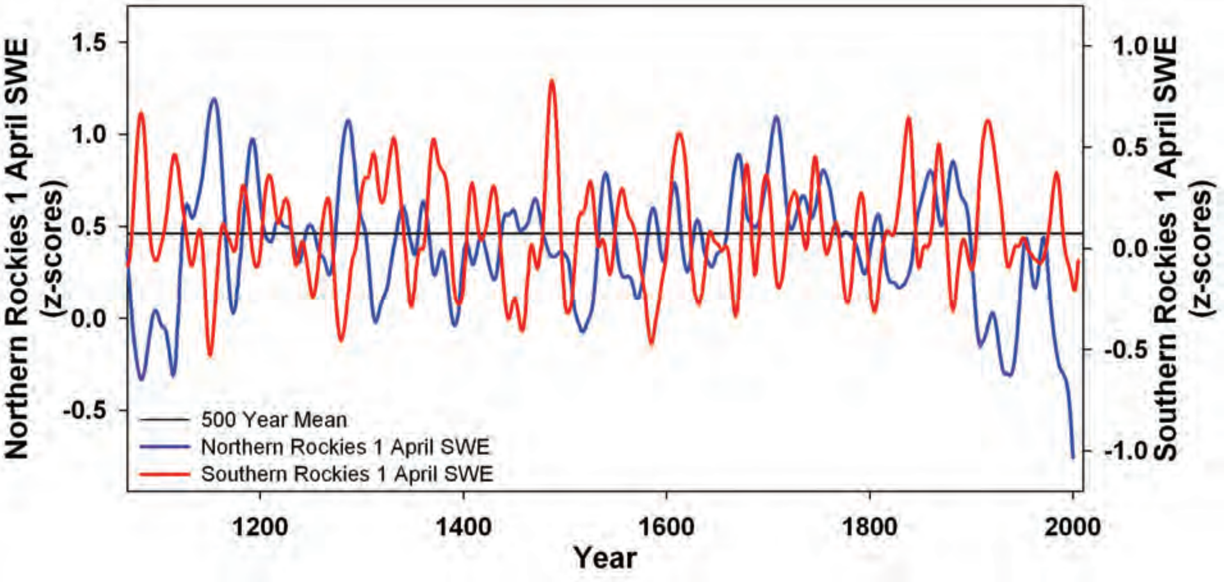


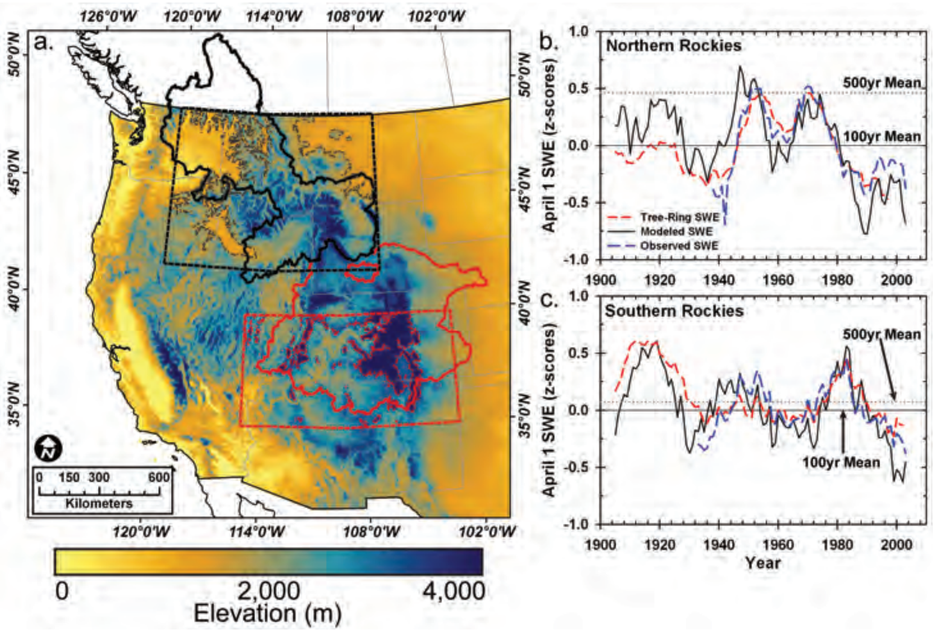
One of the oldest and most remarkable artifacts identified in the Yellowstone area is a dart foreshaft.

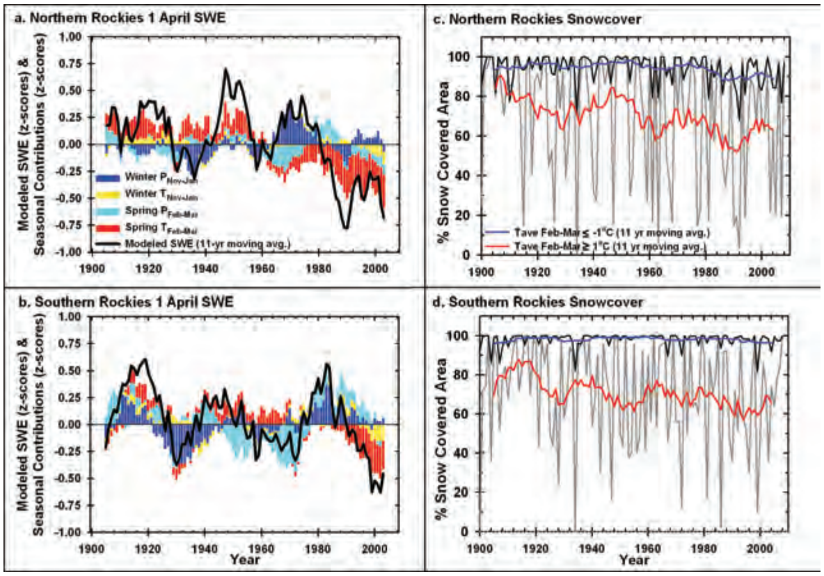
Unique characteristics include its age, size and ownership marks.

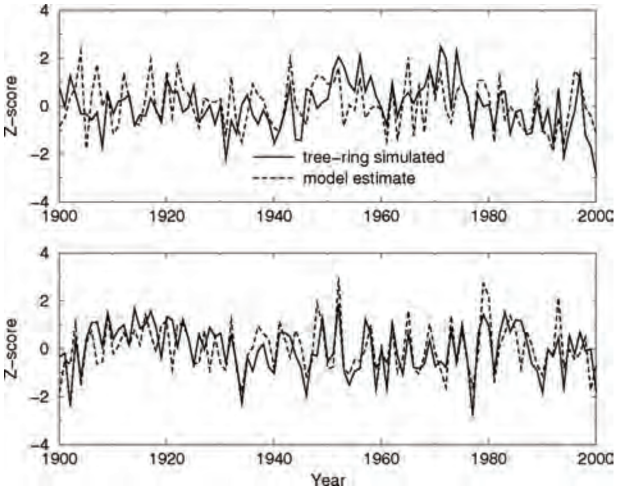
Calibrated age 10,300 years ago.

August 13 Cont'd









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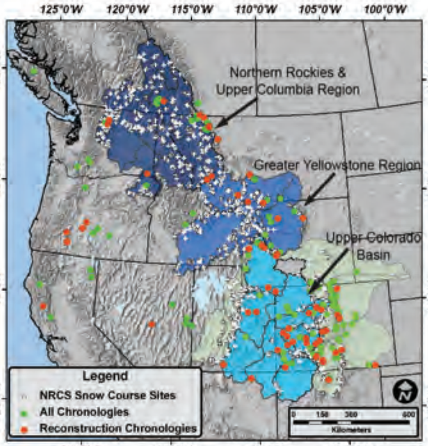

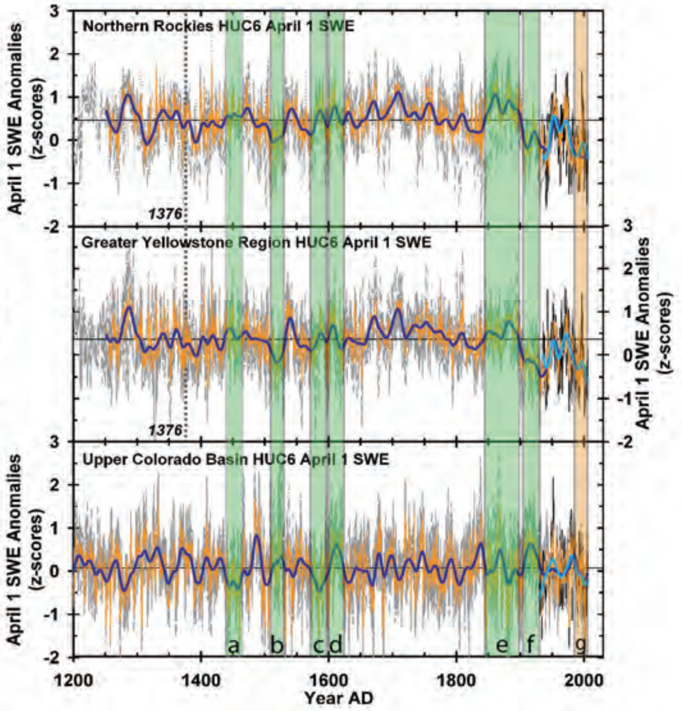

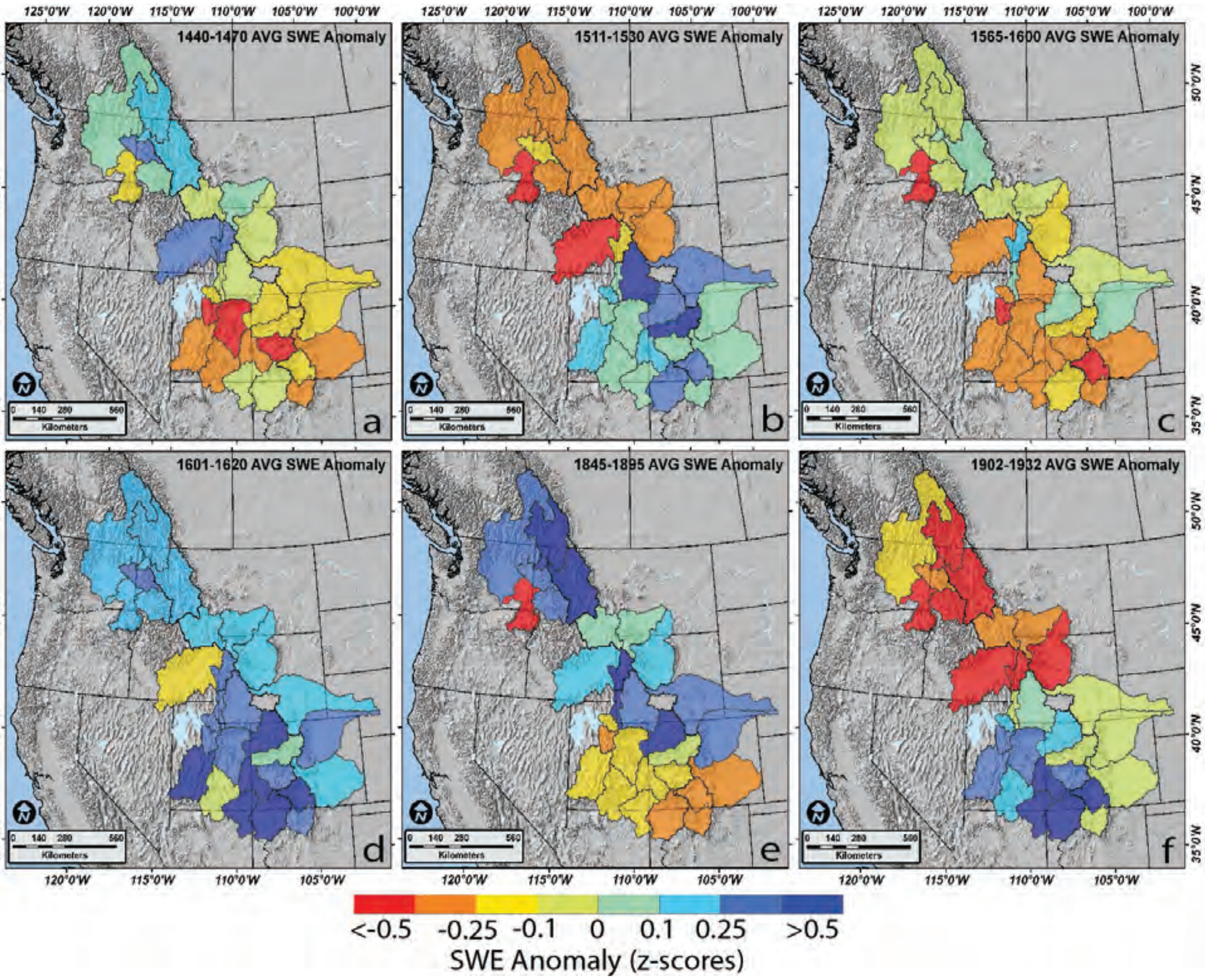

from Pederson et al., 2011

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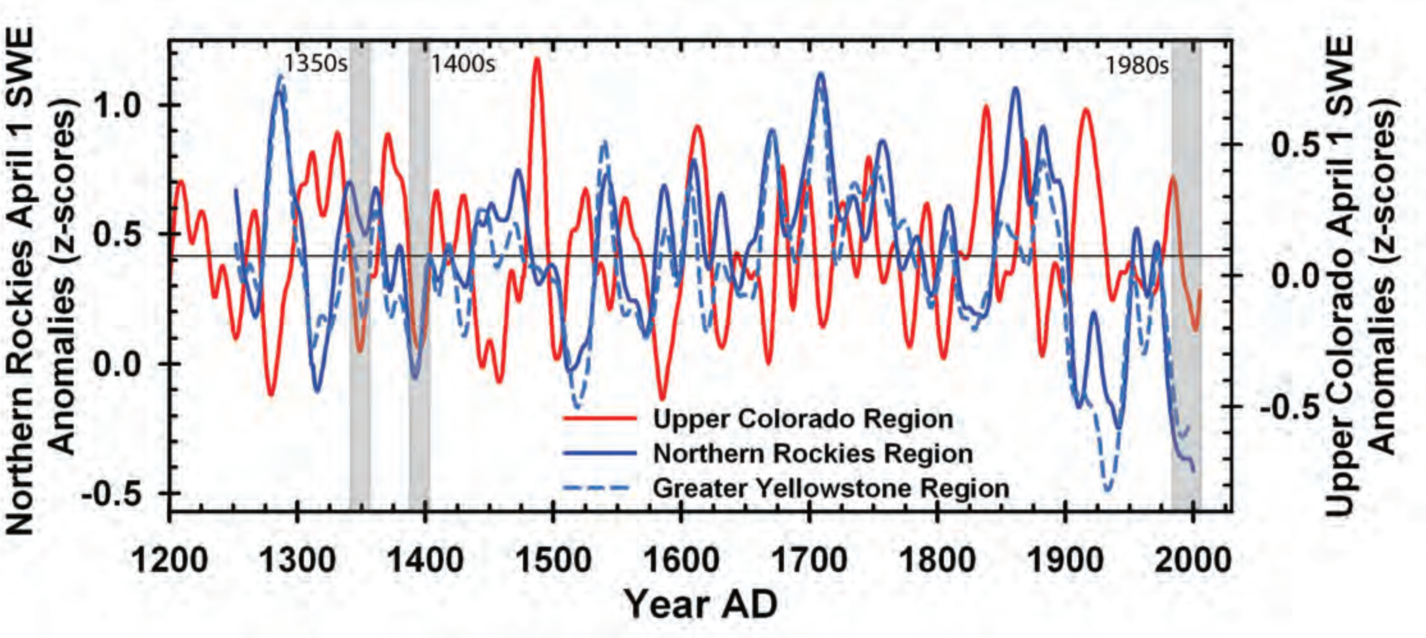

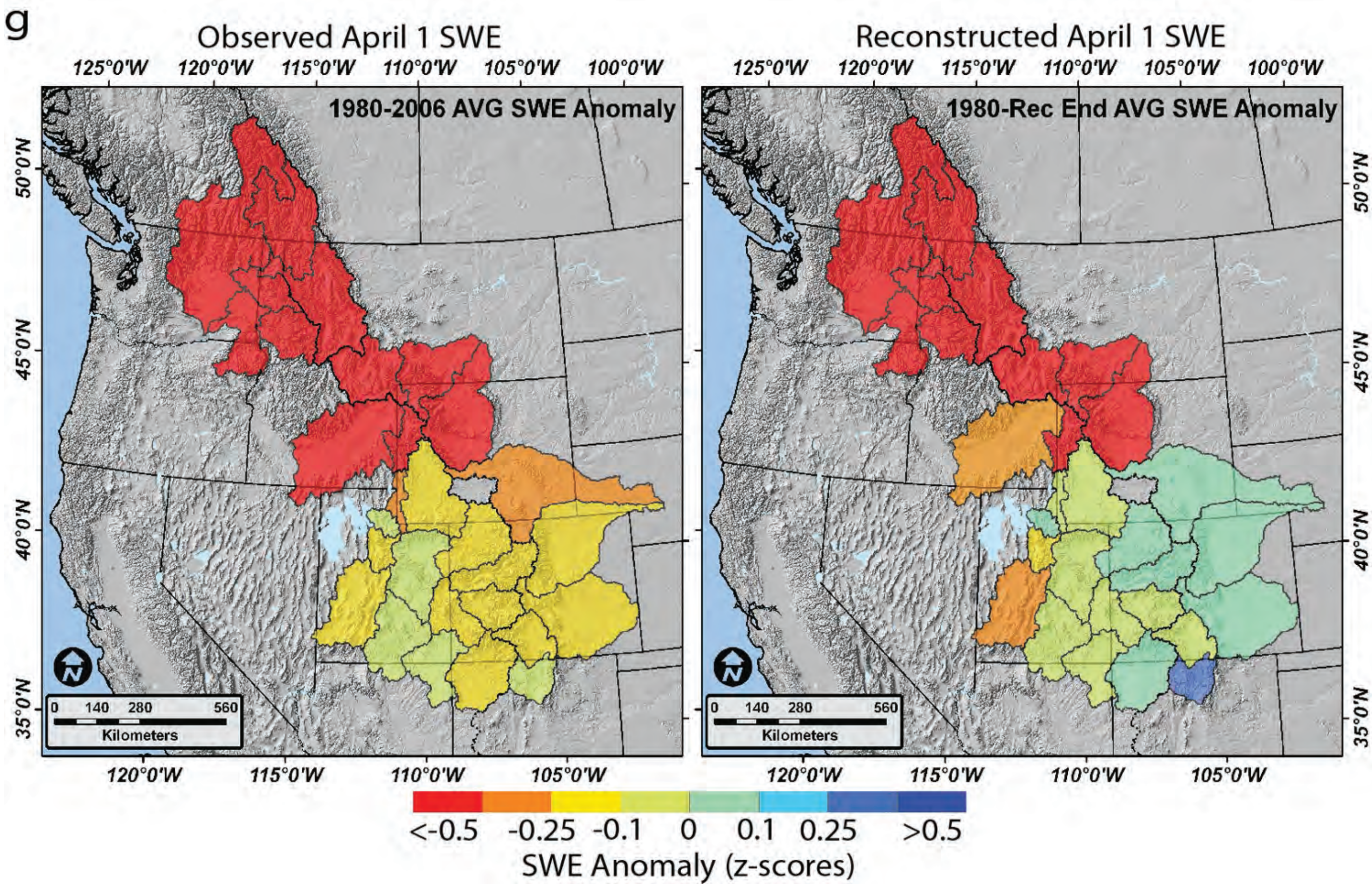

from Pederson et al., 2011

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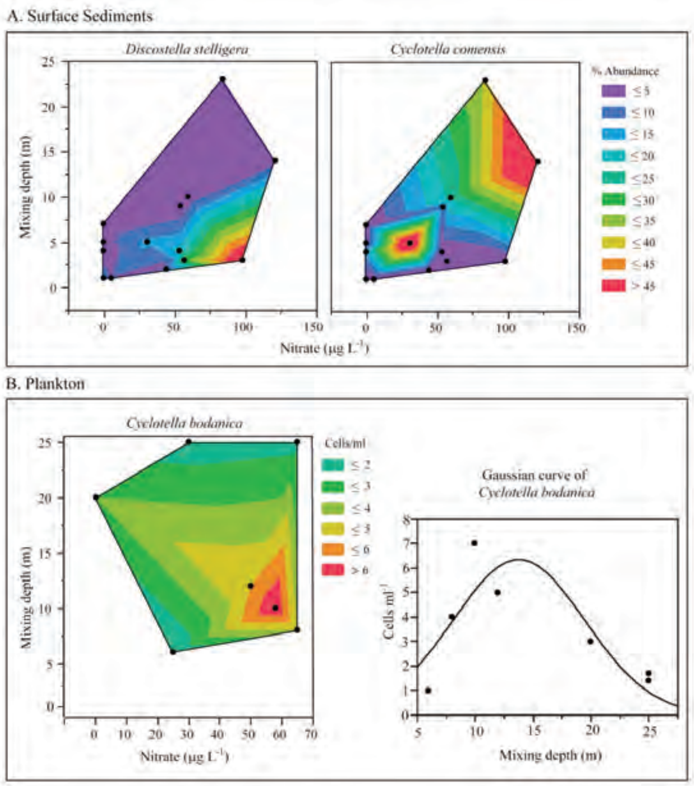

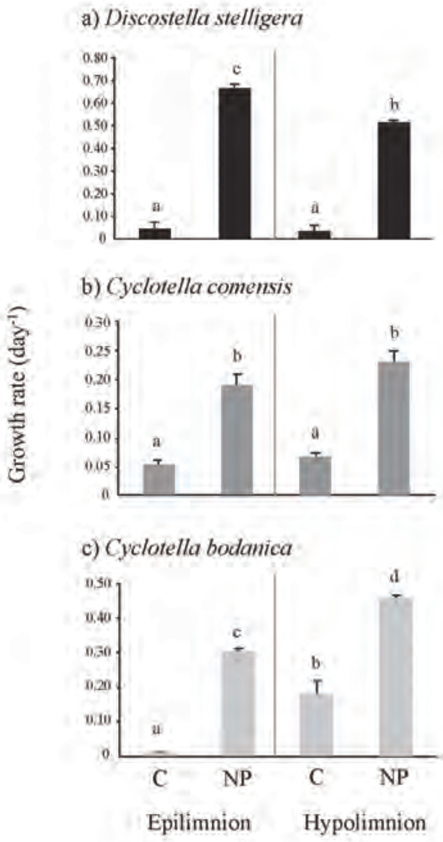

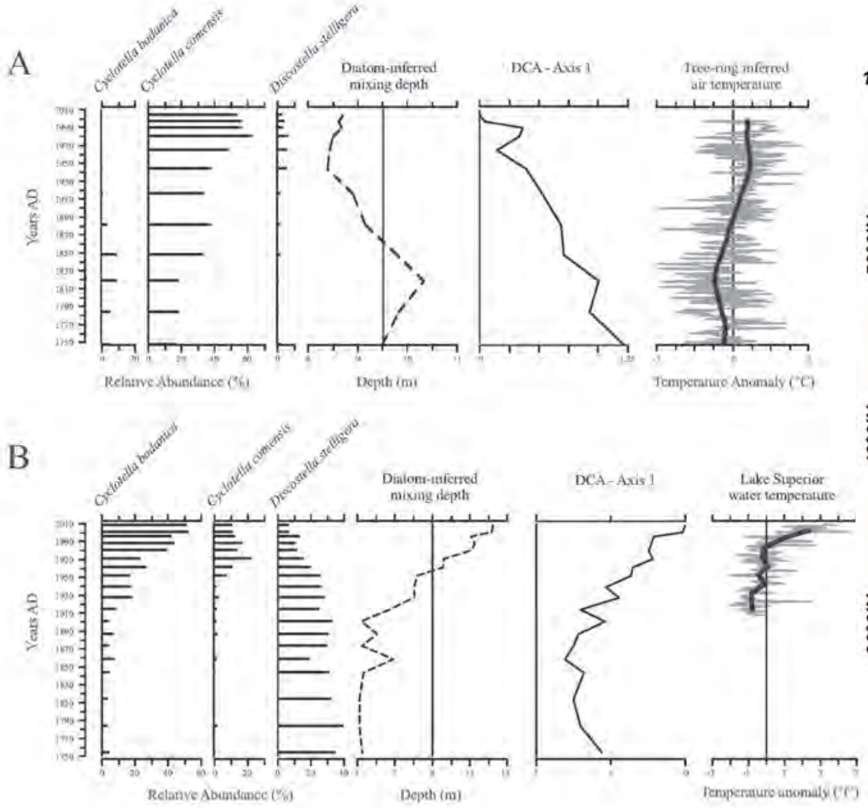

from Saros et al., 2012

August 14: Tower to Yellowstone Lake

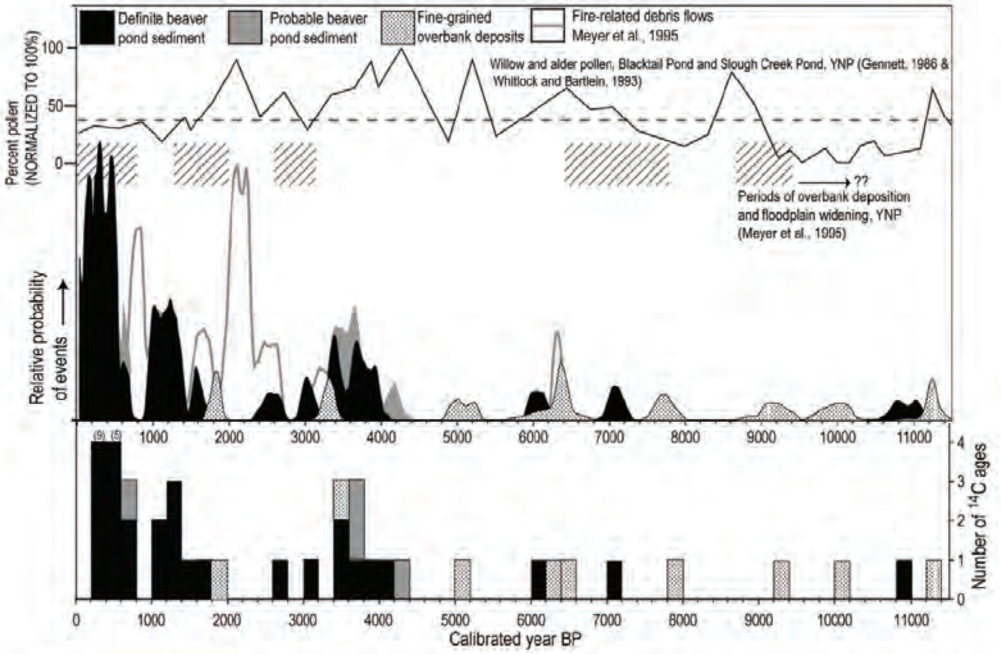

Figure 4. Chronology of beaver pond and overbank sediment in the YNP Northern Range area. Probability curves are derived by summing calibrated probability distributions for individual ^{14}C ages (e.g., Meyer et al., 1995), where each age distribution has unit probability, and then smoothing the summation using a 100-yr running mean. Histogram shows the number of ages in each data set contributing to probability curves, placing the weighted mean of calibrated age distributions in 200-yr age classes. In northeastern Yellowstone, fire-related debris flows are inferred to indicate severe fires from extreme droughts, and periods of overbank deposition and floodplain widening are interpreted to indicate higher mean streamflows (Meyer et al., 1995). Willow and alder pollen abundances in Blacktail Pond (Gennett, 1986) and Slough Creek Pond (Whitlock and Bartlein, 1993) cores represent < 5% of the total pollen, therefore are rough indications of relative abundance. Individual pollen counts for willow and alder were normalized to the core maximum and summed. Linear interpolation was used to estimate pollen abundances in the Slough Creek Pond core for radiocarbon age increments in the Blacktail Pond core. Values for the two cores were averaged to produce a single curve.

from Persico and Meyer, 2009

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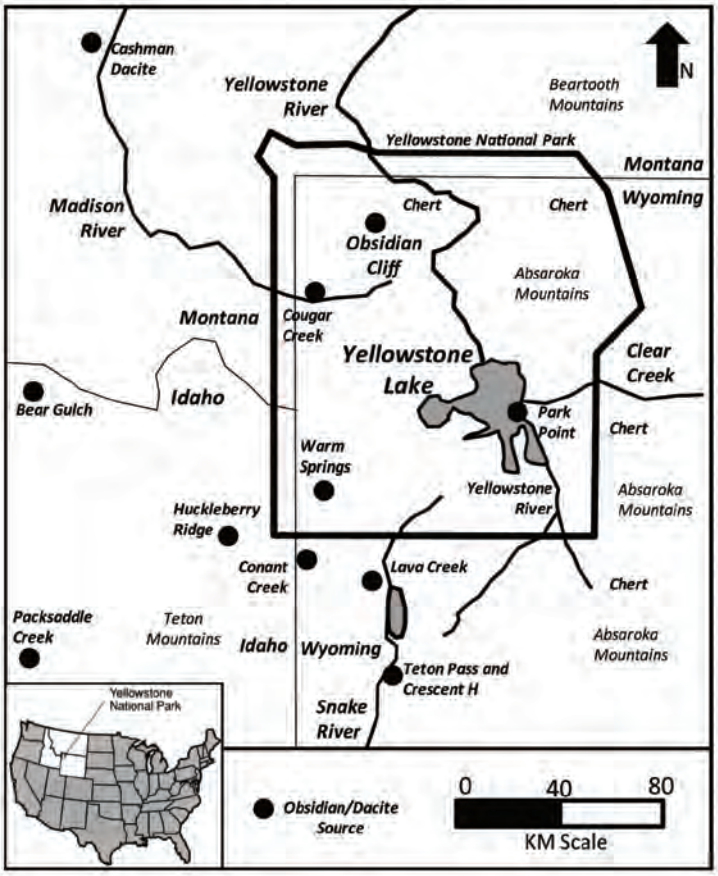

from McDonald et al., 2012

Figure 1. Map of the Greater Yellowstone Ecosystem showing Yellowstone Lake and Regional Lithic Raw Material Sources.

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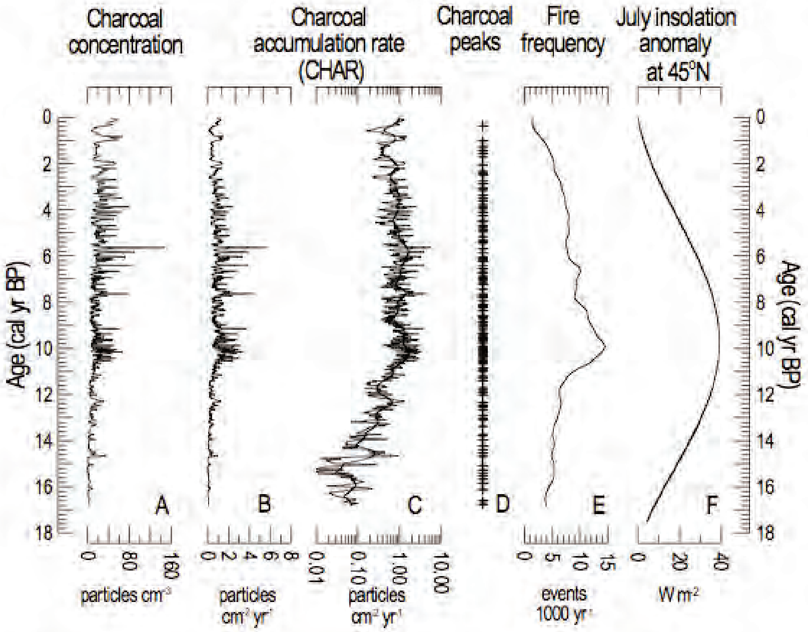

Figure 2. Charcoal results from Cygnet Lake based on an examination of macroscopic particles in contiguous 1 cm samples (total number of samples = 696). Results are presented as charcoal concentration (A) and charcoal accumulation rates (CHAR) plotted on normal scale (B) and logarithmic scale (C). Line through CHAR values in C represents CHAR background values. Charcoal peaks (+) above background levels define fire events (D), which are summarized as number of fires/1000 yr (E). Long-term trend in fire frequency compares well with July insolation anomaly (F) (Berger, 1978).

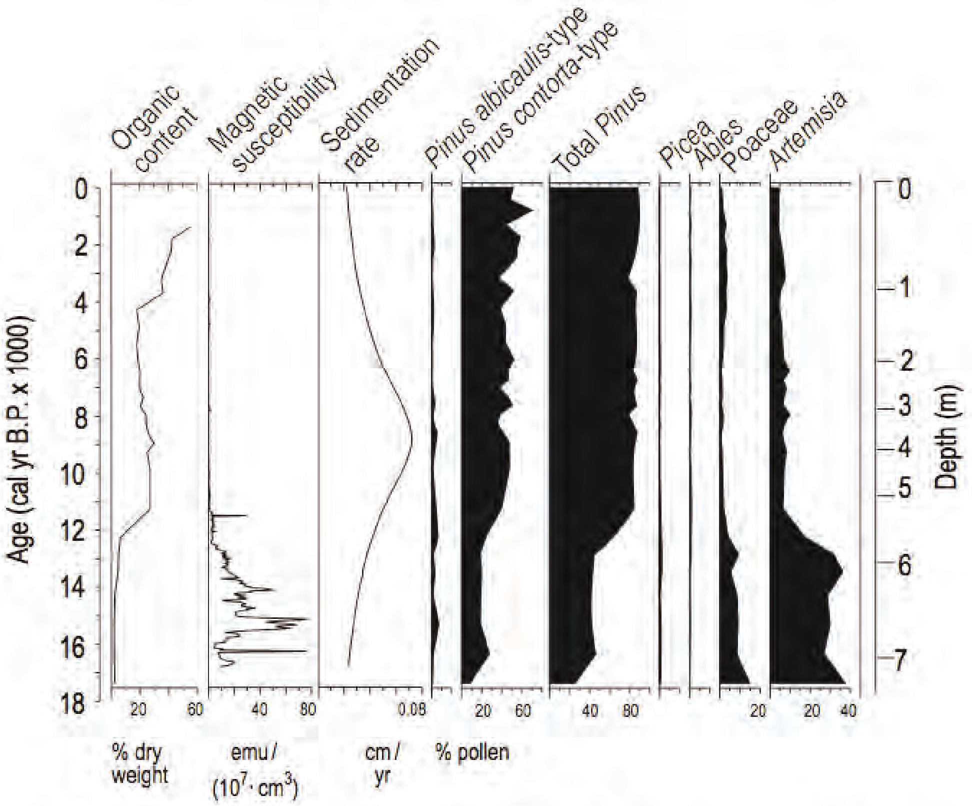

Figure 3. Profiles of organic-matter content, magnetic susceptibility, sedimentation rate, and percentages of selected pollen types.

from Millspaugh et al., 2000

August 15: Grand Teton National Park

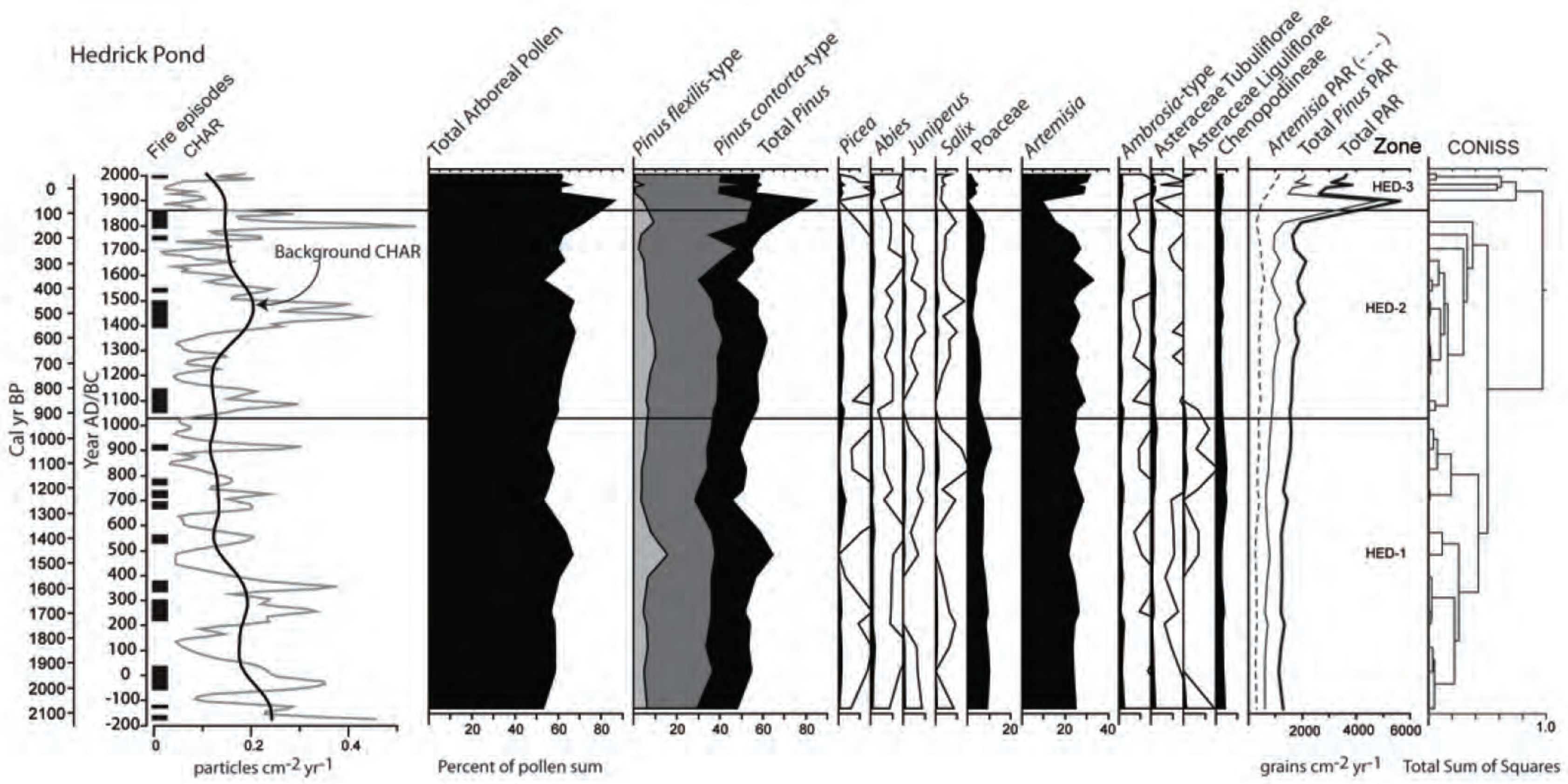

Fig. 3. Charcoal and pollen records of the last 2100 years at Hedrick Pond. Charcoal accumulation rates (CHAR) were decomposed into background (the slowly varying black line overlying the accumulation rate curve in gray). Fire episodes (black rectangles) at left are decades with higher-than-average fire (charcoal accumulation peaks above the threshold value). Pollen percentages of selected taxa and the pollen accumulation rates of *Artemisia*, total *Pinus* and total terrestrial pollen are shown. Outlined area on pollen curves is a 10X exaggeration of percentage data. CONISS dendrogram (at right) was used to define pollen zones.

from Jacobs and Whitlock, 2008

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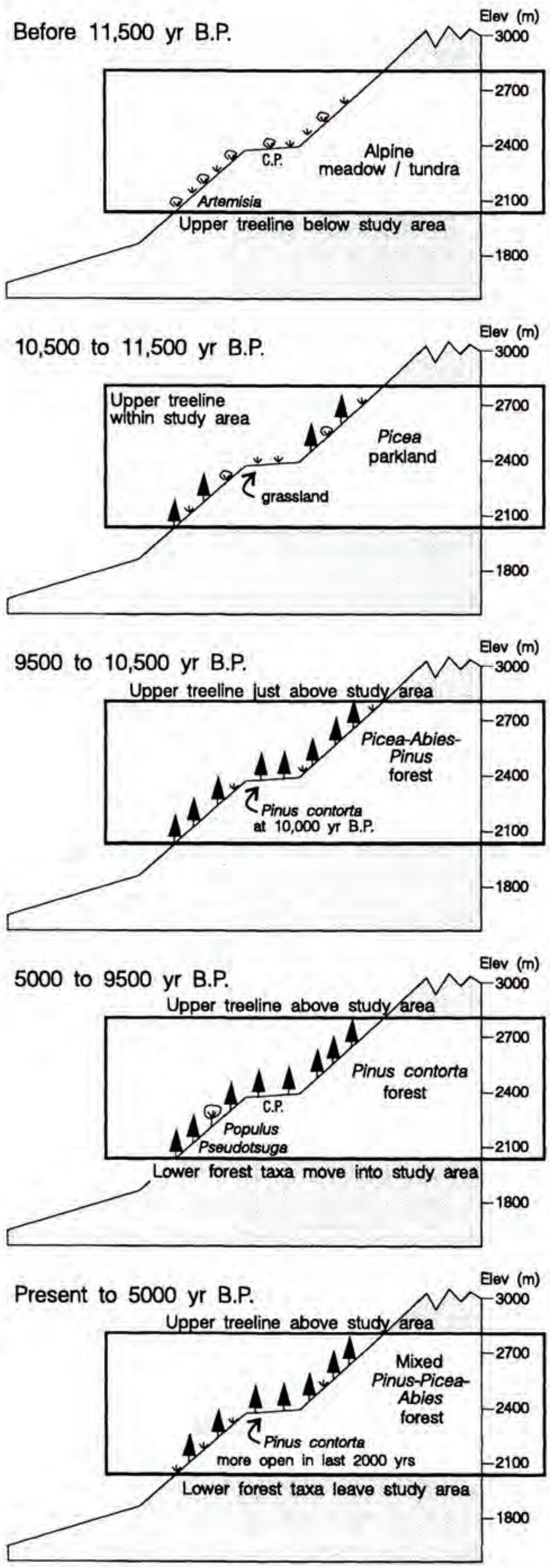


FIG. 14. Vegetation history of study area reconstructed from pollen data. C.P. = Central Plateau.

from Whitlock, 1993

August 15 Cont'd

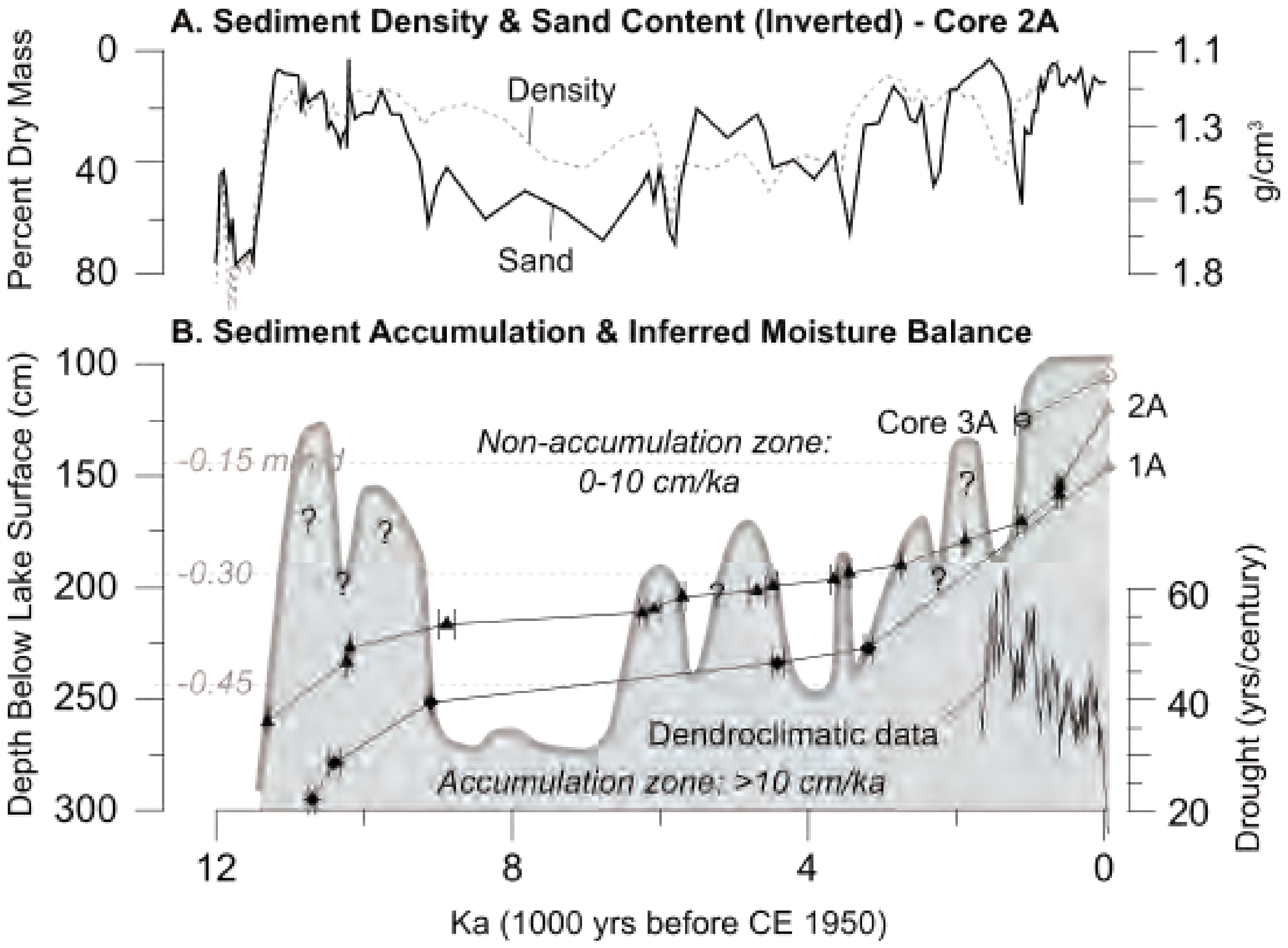
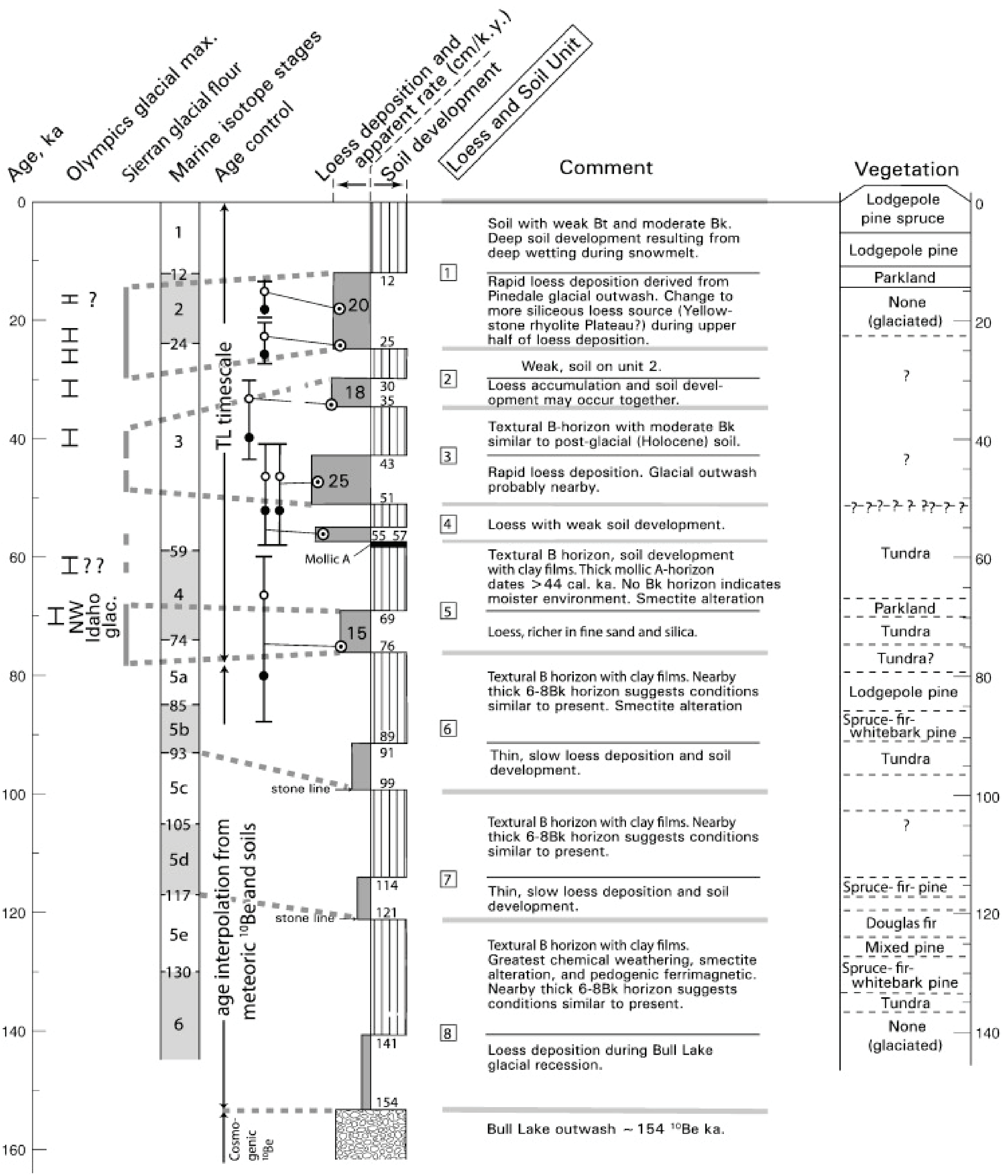


Figure 4. Lake of the Woods water levels, based on sediment sand content and net sediment accumulation rates, compared with dendroclimatic evidence [Cook and Krusic, 2004]. A) Sediment density (dashed line) and sand content (solid line) of core 2A tracks the lake-level history (B) as inferred from shifts in the extent of the lake's accumulation zone (where sediments accumulated at >10 cm/ka). B) Gray line shows the maximum elevation of the sediment accumulation zone based on the age-depth relationships of cores 1A (diamonds), 2A (triangles), and 3A (open circles). Closed symbols indicate AMS radiocarbon ages, open symbols indicate points of stratigraphic correlation, and gray symbols indicate the core tops. Dashed lines denote the mean ΔP-E, and the black line at the lower right shows the frequency of regional drought (years with Palmer Drought Severity Index of -1 or less) based on a local reconstruction using >3 tree-ring chronologies [Cook and Krusic, 2004].

from Shuman, Bryan; Pribyl, P.; Minckley, T. A.; and Shinker, J. J. (2010). "Rapid Hydrologic Shifts and Prolonged Droughts in Rocky Mountain Headwaters During the Holocene." Geophysical Research Letters 37.

August 15 Cont'd



Soil with weak Bt and moderate Bk. Deep soil development resulting from deep wetting during snowmelt.

Rapid loess deposition derived from Pinedale glacial outwash. Change to more siliceous loess source (Yellowstone rhyolite Plateau?) during upper half of loess deposition.

Weak, soil on unit 2.

Loess accumulation and soil development may occur together.

Textural B-horizon with moderate Bk similar to post-glacial (Holocene) soil.

Rapid loess deposition. Glacial outwash probably nearby.

Loess with weak soil development.

Textural B horizon, soil development with clay films. Thick mollic A-horizon dates >44 cal. ka. No Bk horizon indicates moister environment. Smectite alteration

Loess, richer in fine sand and silica.

Textural B horizon with clay films. Nearby thick 6-8Bk horizon suggests conditions similar to present. Smectite alteration

Thin, slow loess deposition and soil development.

Textural B horizon with clay films. Nearby thick 6-8Bk horizon suggests conditions similar to present.

Thin, slow loess deposition and soil development.

Textural B horizon with clay films. Greatest chemical weathering, smectite alteration, and pedogenic ferrimagnetic. Nearby thick 6-8Bk horizon suggests conditions similar to present.

Loess deposition during Bull Lake glacial recession.

Bull Lake outwash ~154 ^{10}Be ka.

Figure 16. Comparison of several climate records over the last 150 ka. From left to right: 1) Glacial maxima for the Olympic Mountains, WA, (Thackray, 2008)and NW Idaho glaciation (Colman and Pierce, 1986 and Colman and Pierce, 1992); 2) Sierran glacial flour (Bischoff and Cummins, 2001), 3) Marine oxygen isotope stages from Martinson et al. (1987); 4) intervals of loess deposition and soil development (this study); 5) comments on loess and soil intervals, and 6) Yellowstone vegetation changes from pollen and plant macrofossils (Baker, 1986). Numbers at changes between loess and soil are ages (in ka) from Fig. 7; these numbers are included for reference only, the actual age uncertainty is probably thousands of years. Loess deposition correlative with MIS 2 and 4 is expectable, but significant and apparently rapid loess deposition at about 40–50 ka, early in MIS 3, is novel. Jackson Hole loess deposition also correlates with Sierran glacial flour during MIS 2 and 4, but during MIS 3 loess deposition dates early and late in MIS 3 whereas Sierran flour dates to the middle of MIS 3. For Yellowstone vegetation, forest intervals tend to correspond to intervals of soil development in the loess section with Douglas fir (the warmest) correlating with Soil 8. Vegetation intervals of tundra or no record generally correlate with loess deposition at the Porcupine Creek section.

from Pierce et al., 2011

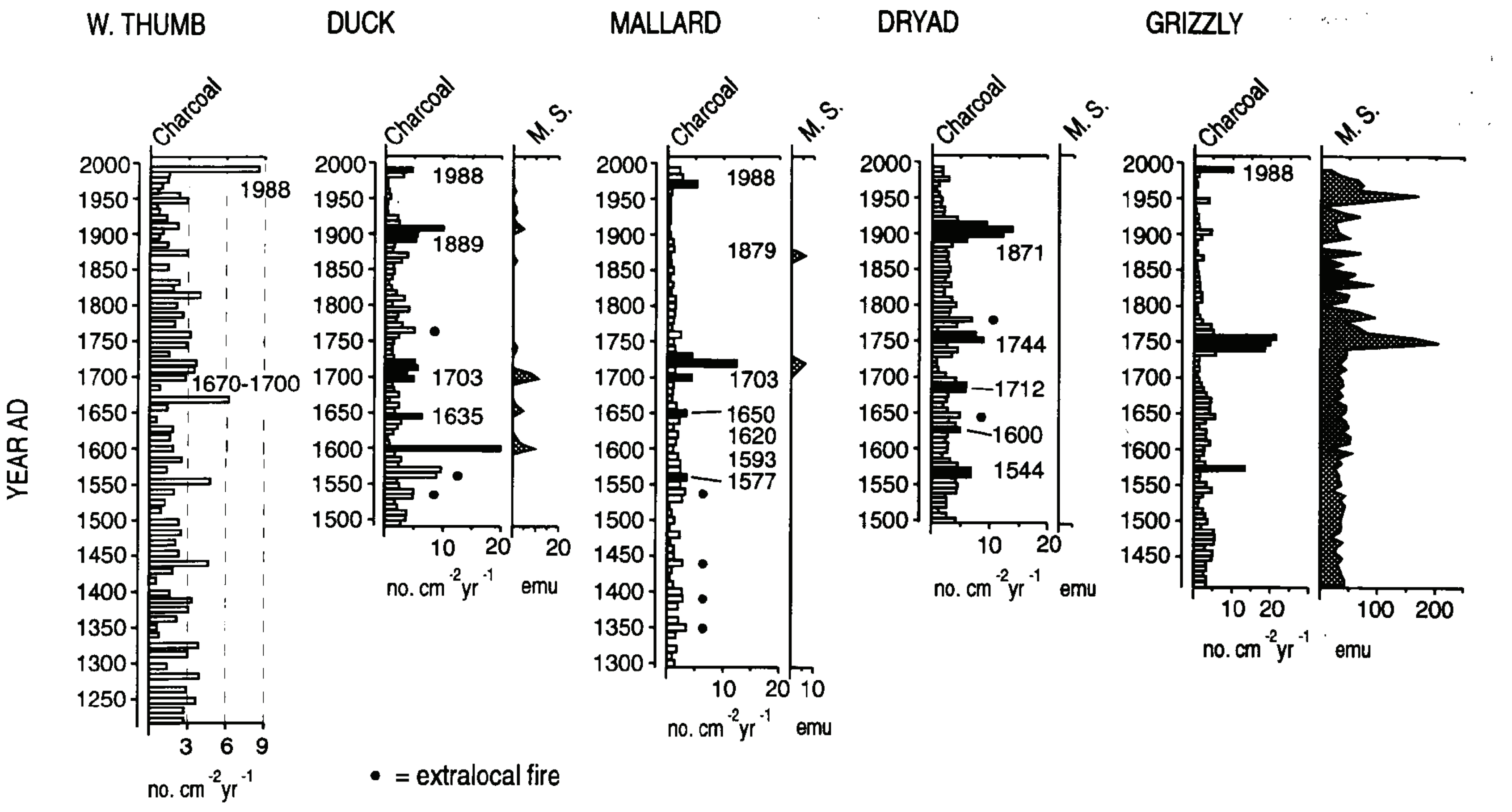


Figure 4 Charcoal and magnetic susceptibility stratigraphy for the study sites. Chronology is based on the age-versus-depth relations shown in Figure 2. Solid bars indicate charcoal peaks that are inferred to represent a local fire event. Dates of known local fires, based on dendrochronologic data (Romme and Despain, unpublished data), are shown next to the appropriate charcoal peaks. Black dots represent years of known extralocal fires that occurred near the watershed. Note that the stratigraphic data extend the fire record beyond the dendrochronologic information.

from Millspaugh and Whitlock, 1995

XXXVII International Moor Excursion
2013 Trip Map
Bozeman, Montana, USA

City Center Inn, 507 W Main St, *Lodging on Saturday (10 August) and Friday (16 August)*
Emerson Center for the Arts & Culture, 111 S Grand Ave, *Dinner on Saturday (10 August)*
I-Ho’s Korean Grill, 1216 W Lincoln St, *Dinner on Friday (16 August)*