A history of advances in *sed*aDNA research

Peter D. Heintzman

The Arctic University Museum of Norway

UiT The Arctic University of Norway

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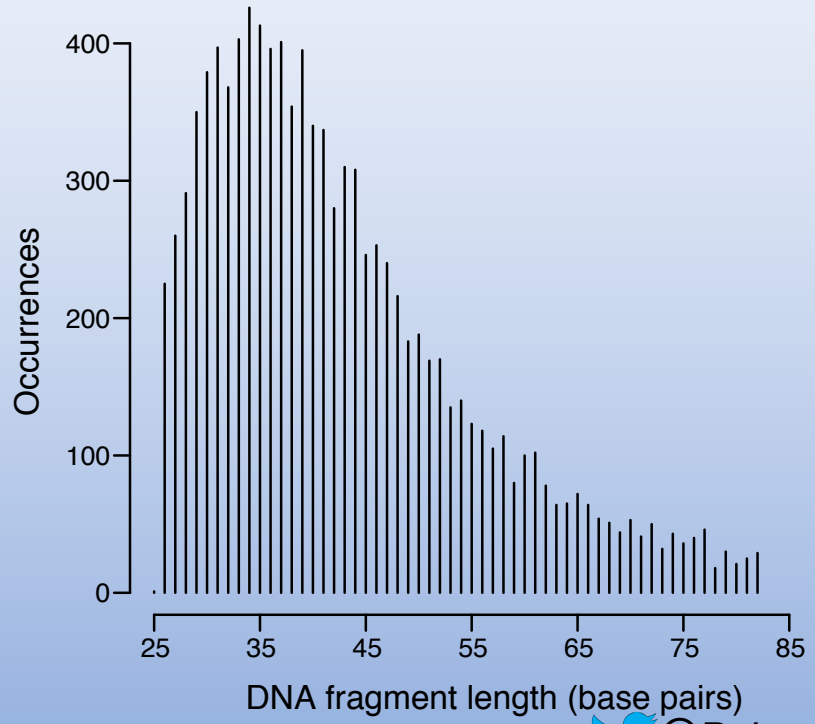
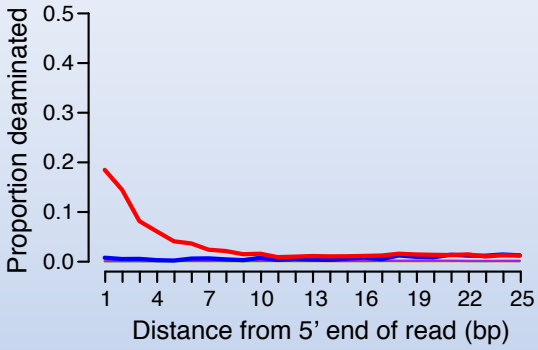
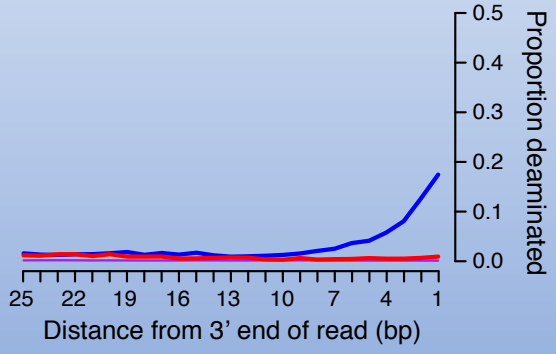
What is sedimentary ancient DNA?

“Modern DNA molecule”

“Ancient DNA molecules”







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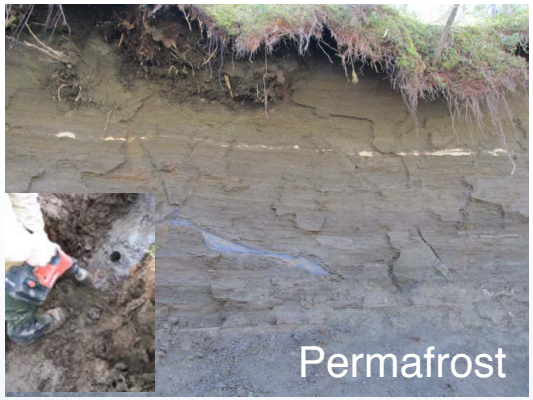

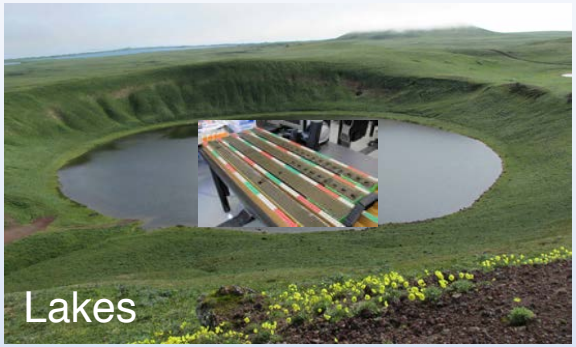

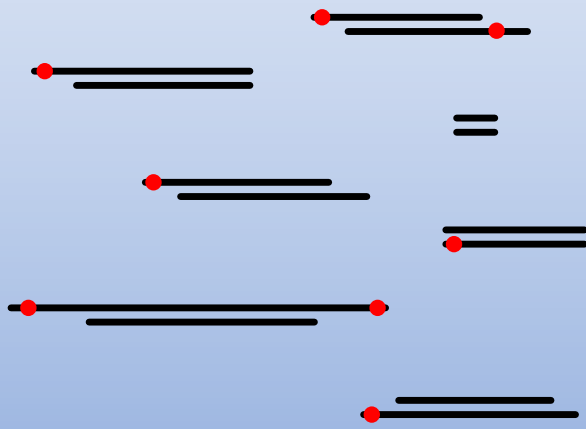

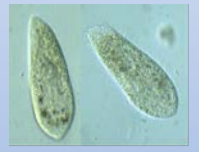

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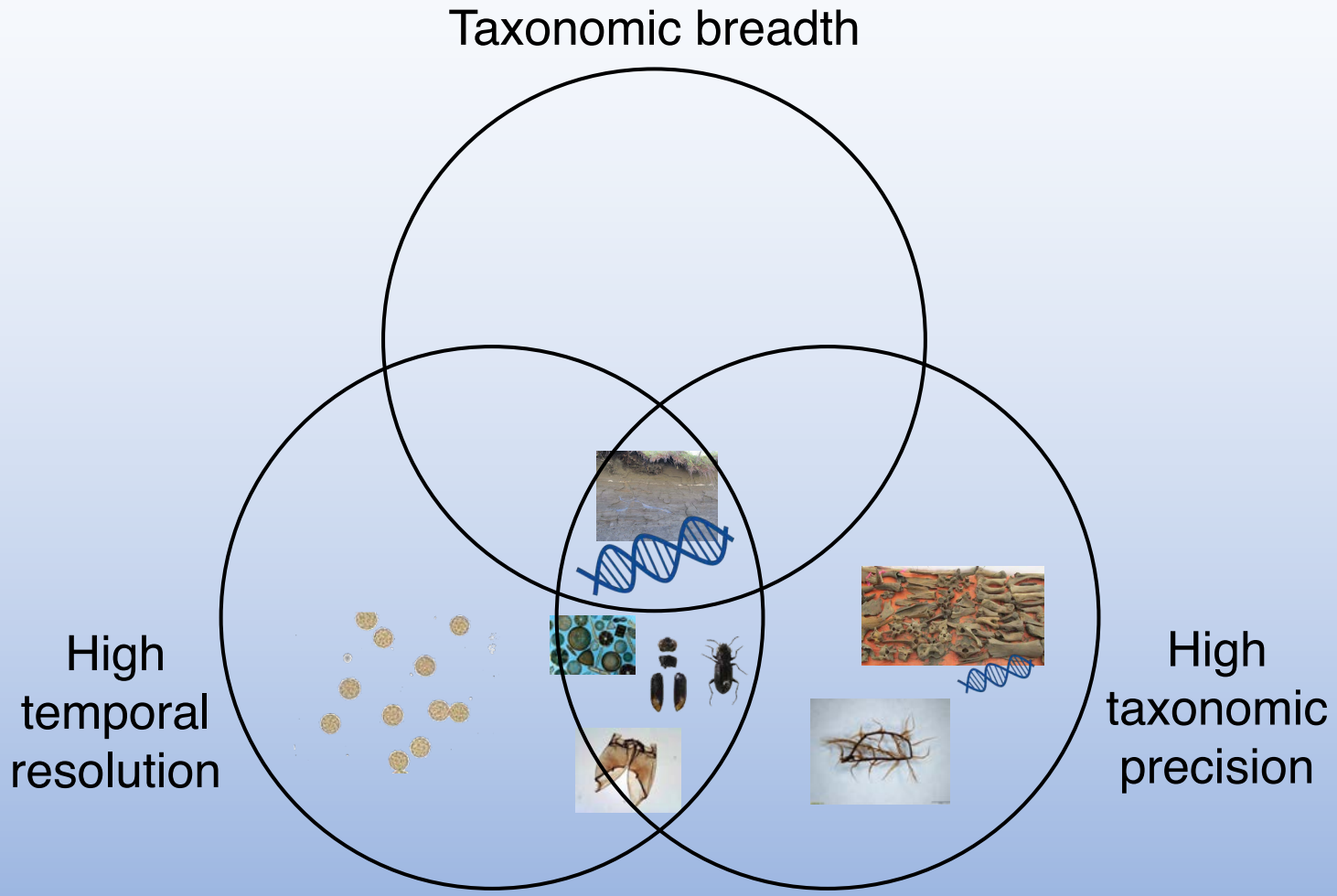
The strength of sedimentary ancient DNA



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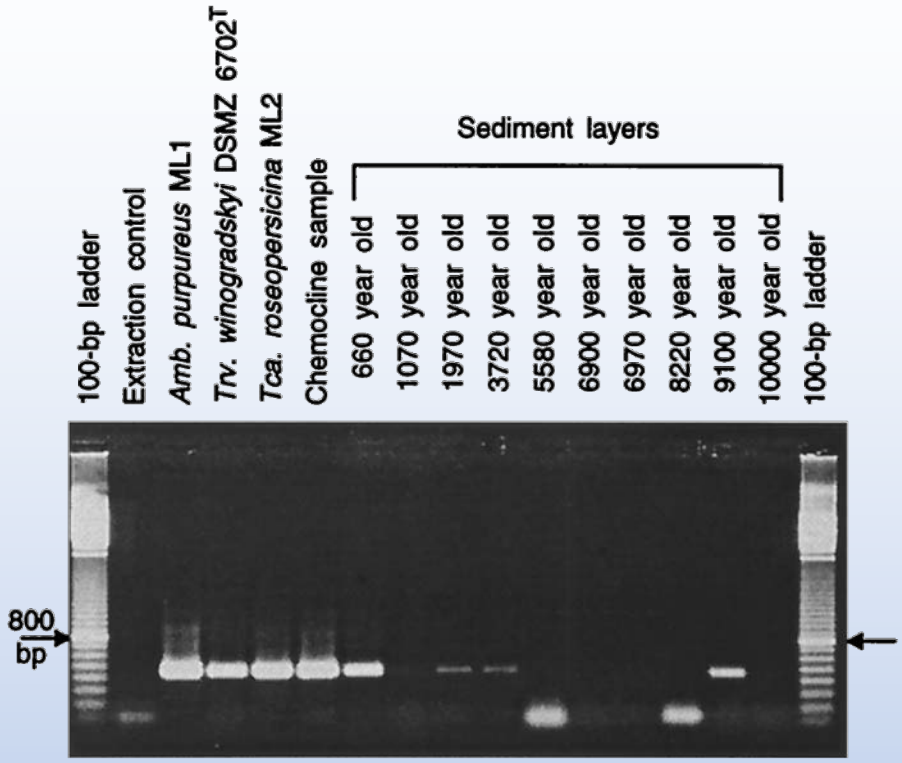
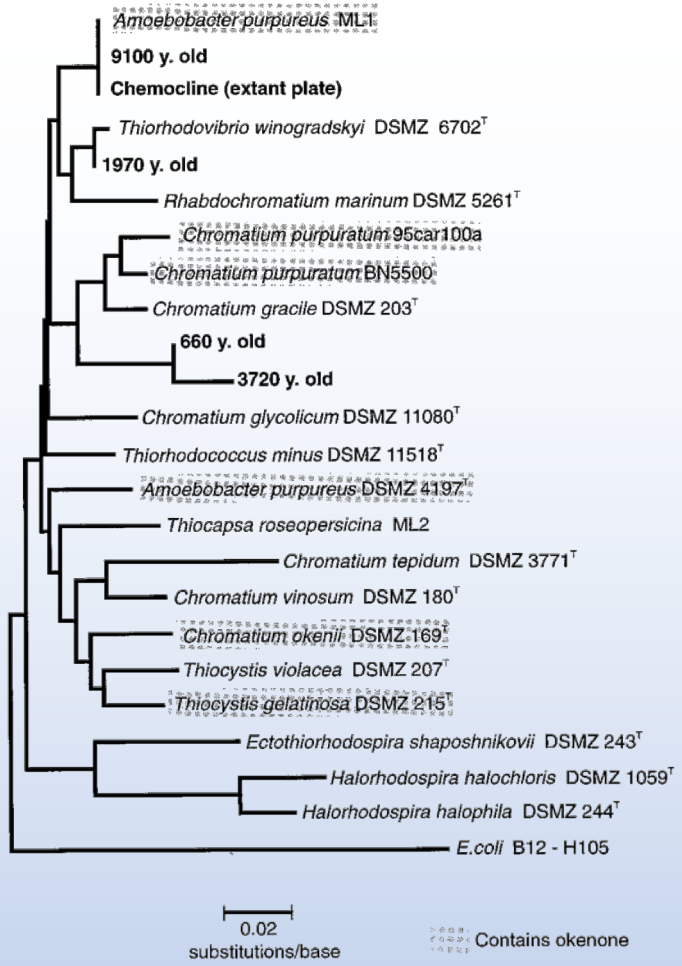
A history of advances in the field

Frits Ahlefeldt

1998





Analysis of Subfossil Molecular Remains of Purple Sulfur Bacteria in a Lake Sediment

MARCO J. L. COOLEN AND JÖRG OVERMANN*

Applied Enviro. Microbio.
64, 4513

@PalaeoPete

2003

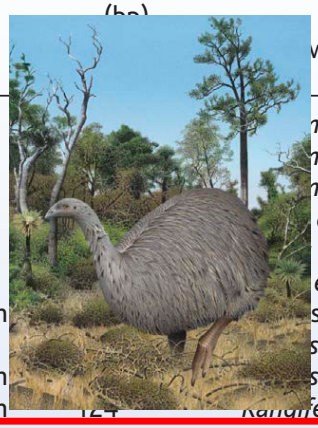
Sample age (ky B.P.)							Taxonomic identifications	
New Zealand		Siberia			Region (mtDNA)	Sequence length (bp)	Taxa with highest sequence similarity	Seq. similarity (%)
Cave 0.6	Bone 1 to 3	10.4	19	20 to 30				
		1		2	cyt b	98	*Mammuthus primigenius* (mammoth)†	98 to 99
			7		cyt b	229	*Mammuthus primigenius* (mammoth)†	99 to 100
		8	**4**	1	16*S*	92 to 93	*Mammuthus primigenius* (mammoth)†	97 to 100
			12		16*S*	90	*Equus caballus* (horse)	98 to 100
			4		16*S*	88 to 90	*Lemus lemus* (lemming)	97‡
		2			16*S*	95	*Lepus europaeus* (hare)	96
		2	1	1	Control region	124 to 125	*Bison* spp. (bison)†	98 to 100*
			1		16*S*	93	*Ovibos moschatus* (musk ox)	100
			1		Control region	129	*Ovibos moschatus* (musk ox)	82‡
		1			Control region	124	*Rangifer tarandus* (reindeer)	98
15					Control region	202 to 203	*Megalapteryx didinus* (Upland moa)†	97 to 100*
2					Control region	204	*Pachyornis elephantopus* (Heavy-	99*
	10						astal moa)†	96 to 100*
11							Upland moa)†	97 to 100
2							*elandiae* (New	98 (*29*)
Σ = 30	Σ = 10	Σ = 14	Σ =					

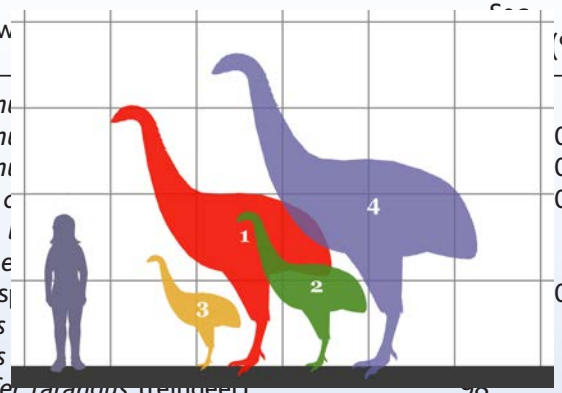
Science **300**, 791

@PalaeoPete

2003

Sample age (ky B.P.)				Taxonomic identifications	
New Zealand		Siberia	Region (mtDNA)	Sequence length (bp)	
Cave	Bone				
0.6	1 to 3				
15			Control region	202 to 203	*Megalapteryx didinus* (Upland moa)†	97 to 100*
2			Control region	204	*Pachyornis elephantopus* (Heavy-footed moa)†	99*
	10		Control region	202 to 203	*Euryapteryx curtus* (Coastal moa)†	96 to 100*
11			12S	228 to 230	*Megalapteryx didinus* (Upland moa)†	97 to 100
2			12S	234	*Cyanoramphus novaezeelandiae* (New Zealand Parakeet)	98 (*29*)
Σ = 30	Σ = 10	Σ = 14	Σ = 30	Σ = 4		





Diverse Plant and Animal Genetic Records from Holocene and Pleistocene Sediments

Eske Willerslev,[1]* Anders J. Hansen,[1]*† Jonas Binladen,[1] Tina B. Brand,[1] M. Thomas P. Gilbert,[2] Beth Shapiro,[2] Michael Bunce,[2] Carsten Wiuf,[3] David A. Gilichinsky,[4] Alan Cooper[2]

Science **300**, 791

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2003

Table 1.

ID		Families, no. different		Bootstrap %	Next closest match Family/order	Putative
		0	1			
12S	1	Megatheridea	NID	94	Mylodontidea (5)	Megatheridae
	2	NID	Cathartidae	47	Phoenicopteridae (3)	Cathartidae
	3	NID	Procyonidae	87	Procyonidae (4) Mephitinae (4)	Procyonidea
	4	Sciuridae	NID	97	Sciuridae (4)	Sciuridae
	5	Hominidae	Hominidae	NA	Hominidae	Hominidae
16S	A	Megatheridea	NID	NA	Megatheridae	Megatheridea
	B	NID	NID	NA	Cathartidae (8)	Cathartidae

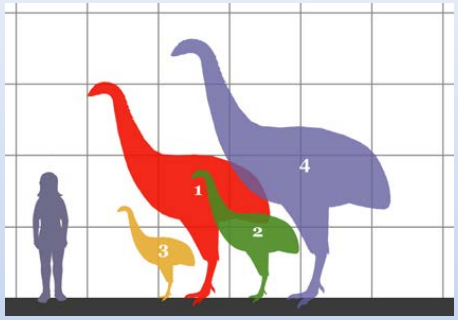
Molecular caving

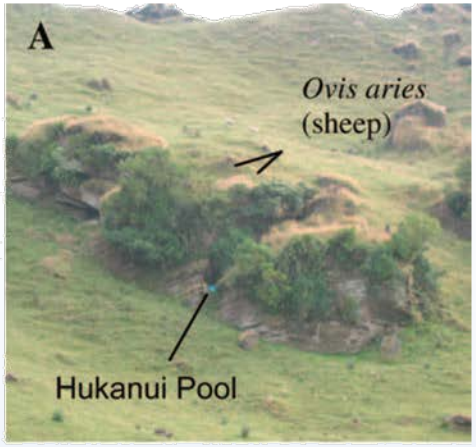
Michael Hofreiter[1], Jim I. Mead[2], Paul Martin[3] and Hendrik N. Poinar[1,4]

Current Biology **13**(18), R694

@PalaeoPete

2007





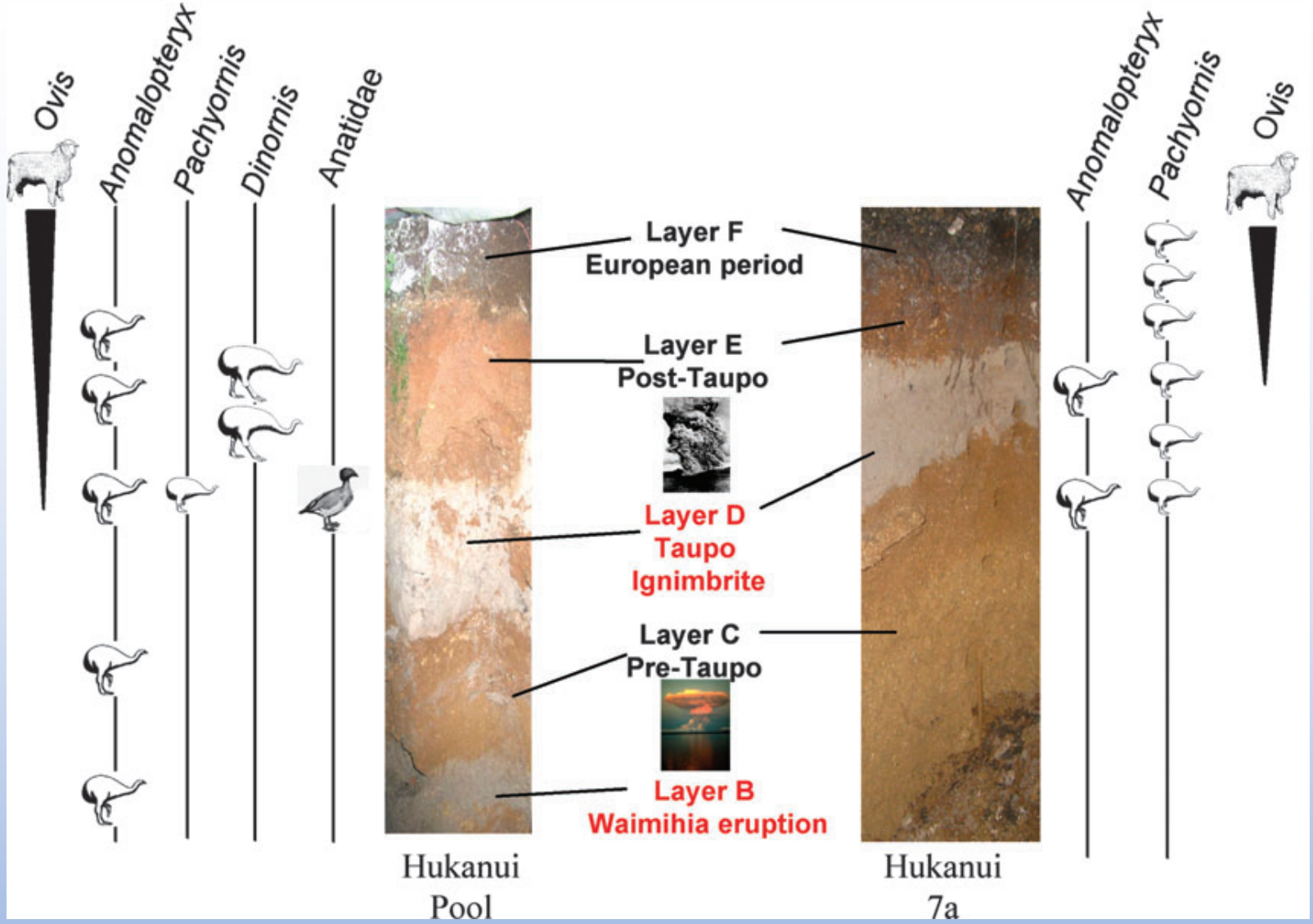
Ancient DNA Chronology within Sediment Deposits: Are Paleobiological Reconstructions Possible and Is DNA Leaching a Factor?

James Haile, Richard Holdaway,† Karen Oliver,* Michael Bunce,‡ M. Thomas P. Gilbert,§ Rasmus Nielsen,§ Kasper Munch,§ Simon Y. W. Ho,* Beth Shapiro,* and Eske Willerslev*§*

Mol. Biol. & Evol. **24**(4), 982

@PalaeoPete

2007



Mol. Biol. & Evol. **24**(4), 982

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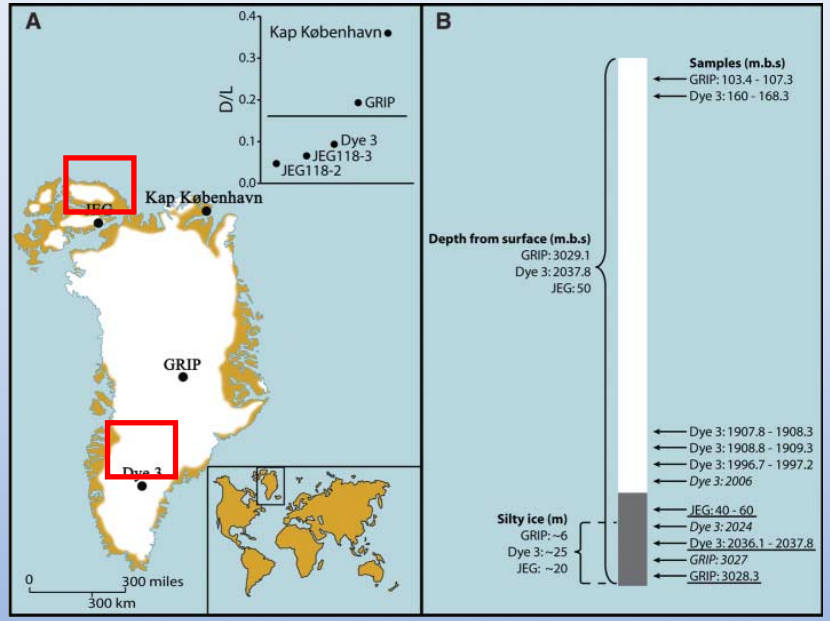
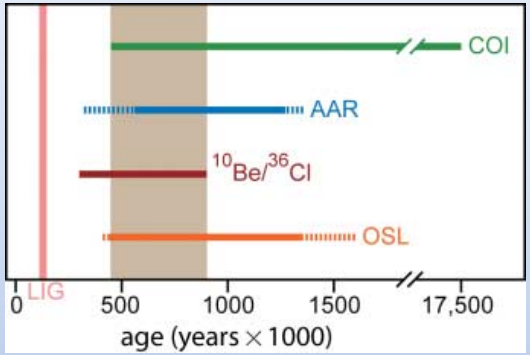
2007

Order	Marker	Clones	Support (%)	Family	Marker	Clones	Support (%)	Genus	Marker	Clones	Support (%)
JEG sample											
Rosales	*rbc*L	3	90–99								
Malpighiales	*rbc*L	2	99–100	Salicaceae	*rbc*L	2	99–100				
	*trn*L	5	99–100		*trn*L	4	100				
Saxifragales	*rbc*L	3	92–94	Saxifragaceae	*rbc*L	2	92	*Saxifraga*	*rbc*L	2	91
Dye 3 sample											
Coniferales	*rbc*L	44	97–100	Pinaceae*	*rbc*L	20	100	*Picea*	*rbc*L	20	99–100
	*trn*L	27	100		*trn*L	25	100	*Pinus*†	*trn*L	17	90–99
				Taxaceae‡	*rbc*L	23	91–98				
					*trn*L	2	100				
Poales§	*rbc*L	67	99–100	Poaceae§	*rbc*L	67	99–100				
	*trn*L	17	97–100		*trn*L	13	100				
Asterales	*rbc*L	18	90–100	Asteraceae	*rbc*L	2	91				
	*trn*L	27	100		*trn*L	27	100				
Fabales	*rbc*L	10	99–100	Fabaceae	*rbc*L	10	99–100				
	*trn*L	3	99		*trn*L	3	99				
Fagales	*rbc*L	10	95–99	Betulaceae	*rbc*L	8	93–97	*Alnus*	*rbc*L	7	91–95
	*trn*L	12	100		*trn*L	11	98–100		*trn*L	9	98–100
Lepidoptera	COI	12	97–99								





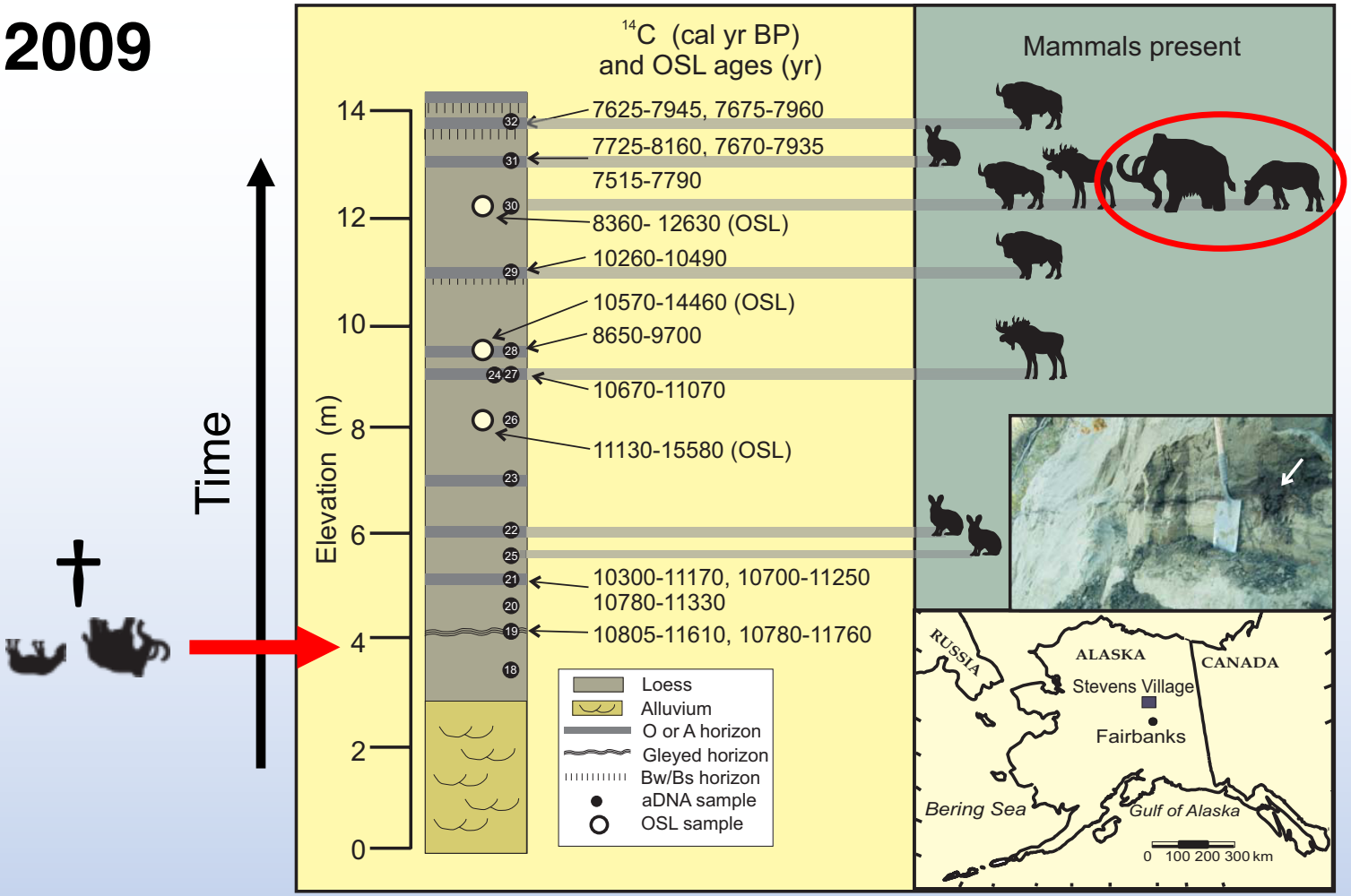
800,000-130,000 years old

Ancient Biomolecules from Deep Ice Cores Reveal a Forested Southern Greenland

Eske Willerslev,[1]* Enrico Cappellini,[2] Wouter Boomsma,[3] Rasmus Nielsen,[4] Martin B. Hebsgaard,[1] Tina B. Brand,[1] Michael Hofreiter,[5] Michael Bunce,[6,7] Hendrik N. Poinar,[7] Dorthe Dahl-Jensen,[8] Sigfus Johnsen,[8] Jørgen Peder Steffensen,[8] Ole Bennike,[9] Jean-Luc Schwenninger,[10] Roger Nathan,[10] Simon Armitage,[11] Cees-Jan de Hoog,[12] Vasily Alfimov,[13] Marcus Christl,[13] Juerg Beer,[14] Raimund Muscheler,[15] Joel Barker,[16] Martin Sharp,[16] Kirsty E. H. Penkman,[2] James Haile,[17] Pierre Taberlet,[18] M. Thomas P. Gilbert,[1] Antonella Casoli,[19] Elisa Campani,[19] Matthew J. Collins[2]

Science **317**, 111

2009



Ancient DNA reveals late survival of mammoth and horse in interior Alaska

James Haile[a], Duane G. Froese[b], Ross D. E. MacPhee[c], Richard G. Roberts[d], Lee J. Arnold[d,1], Alberto V. Reyes[b], Morten Rasmussen[a], Rasmus Nielsen[e], Barry W. Brook[f], Simon Robinson[b], Martina Demuro[d], M. Thomas P. Gilbert[a], Kasper Munch[e], Jeremy J. Austin[g], Alan Cooper[g], Ian Barnes[h], Per Möller[i], and Eske Willerslev[a,2]

PNAS **106**(52), 22352

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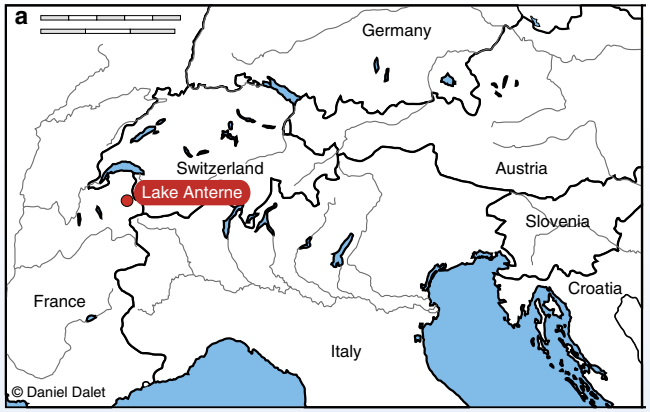
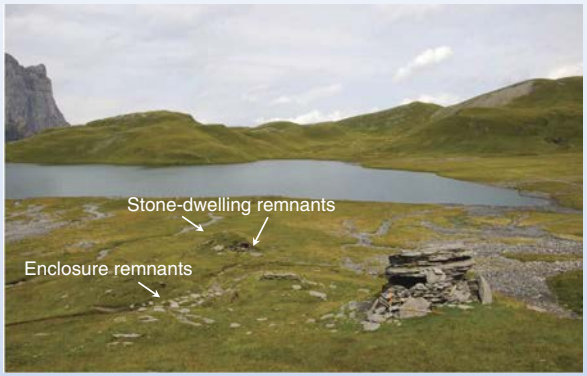
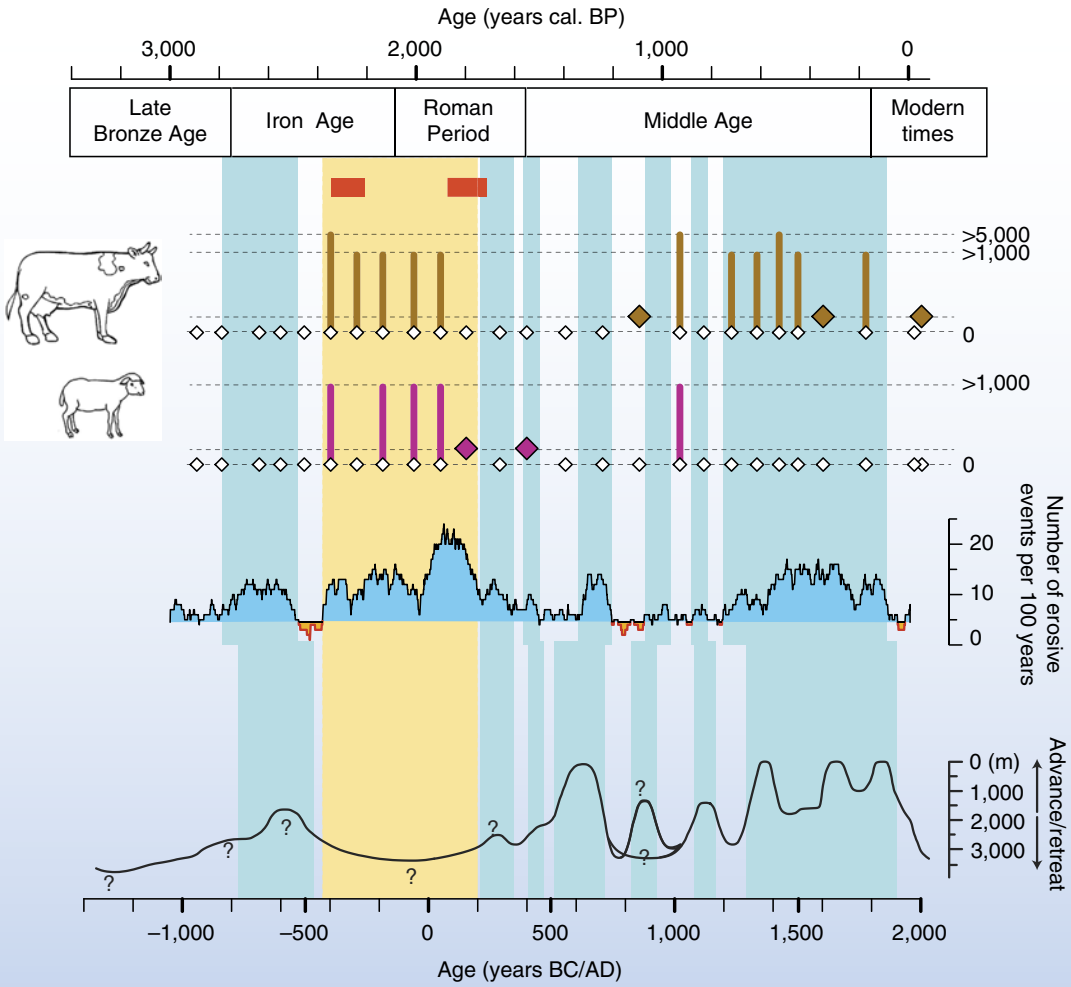
2014







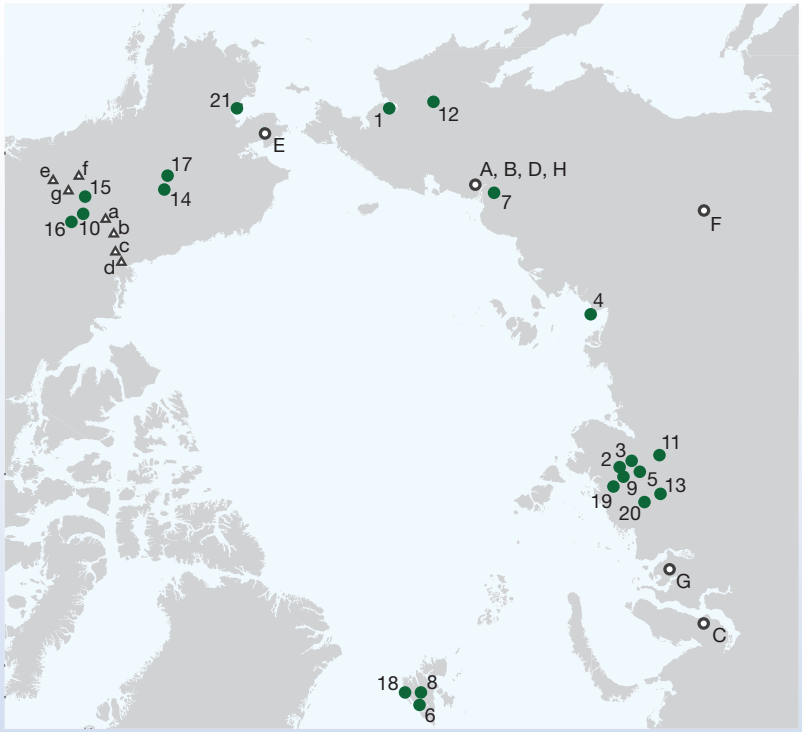
Long livestock farming history and human landscape shaping revealed by lake sediment DNA

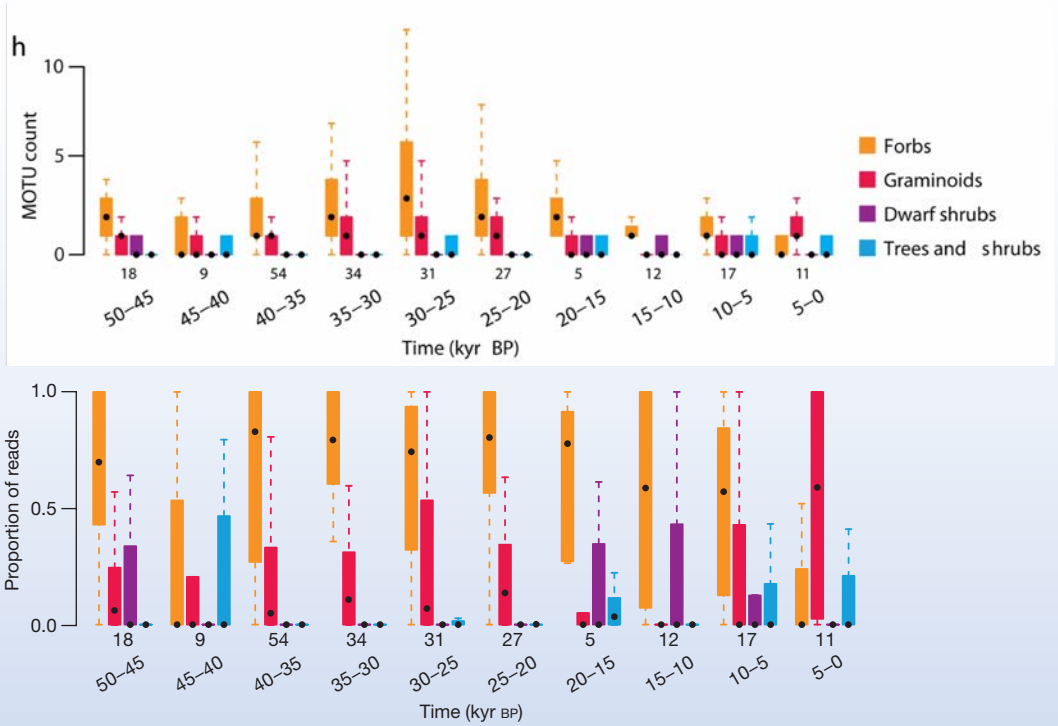
Charline Giguet-Covex[1,2,*], Johan Pansu[1,*], Fabien Arnaud[2], Pierre-Jérôme Rey[2], Christophe Griggo[2], Ludovic Gielly[1], Isabelle Domaizon[3], Eric Coissac[1], Fernand David[4], Philippe Choler[1,5], Jérôme Poulenard[2] & Pierre Taberlet[1]

Nat. Comms. ncomms4211.

@PalaeoPete

2014





Fifty thousand years of Arctic vegetation and megafaunal diet

Eske Willerslev[1]*, John Davison[2]*, Mari Moora[2]*, Martin Zobel[2]*, Eric Coissac[3]*, Mary E. Edwards[4]*, Eline D. Lorenzen[1,5]*, Mette Vestergård[1]*, Galina Gussarova[6,7]*, James Haile[1,8]*, Joseph Craine[9], Ludovic Gielly[3], Sanne Boessenkool[6]†, Laura S. Epp[6]†, Peter B. Pearman[10], Rachid Cheddadi[11], David Murray[12], Kari Anne Bråthen[13], Nigel Yoccoz[13], Heather Binney[4], Corinne Cruaud[14], Patrick Wincker[14], Tomasz Goslar[15,16], Inger Greve Alsos[17], Eva Bellemain[6]†, Anne Krag Brysting[18], Reidar Elven[6], Jørn Henrik Sønstebø[6], Julian Murton[19], Andrei Sher[20]‡, Morten Rasmussen[1], Regin Rønn[21], Tobias Mourier[1], Alan Cooper[22], Jeremy Austin[22], Per Möller[23], Duane Froese[24], Grant Zazula[25], François Pompanon[3], Delphine Rioux[3], Vincent Niderkorn[26], Alexei Tikhonov[27], Grigoriy Savvinov[28], Richard G. Roberts[29], Ross D. E. MacPhee[30], M. Thomas P. Gilbert[1], Kurt H. Kjær[1], Ludovic Orlando[1], Christian Brochmann[6]* & Pierre Taberlet[3]*

Nature **506**, 47

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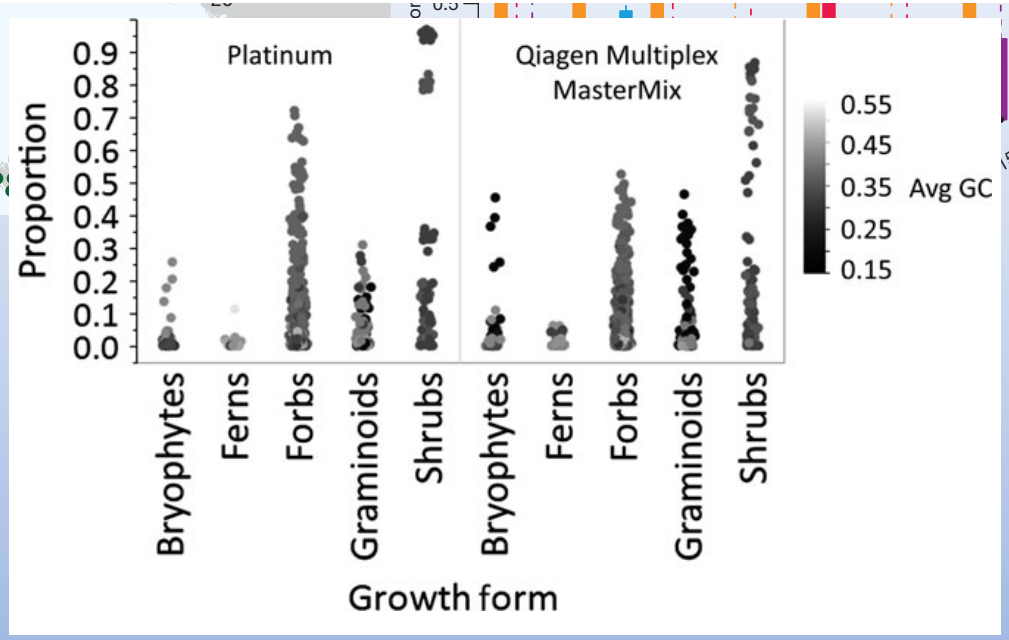
FROM THE COVER

WILEY MOLECULAR ECOLOGY RESOURCES

Minimizing polymerase biases in metabarcoding

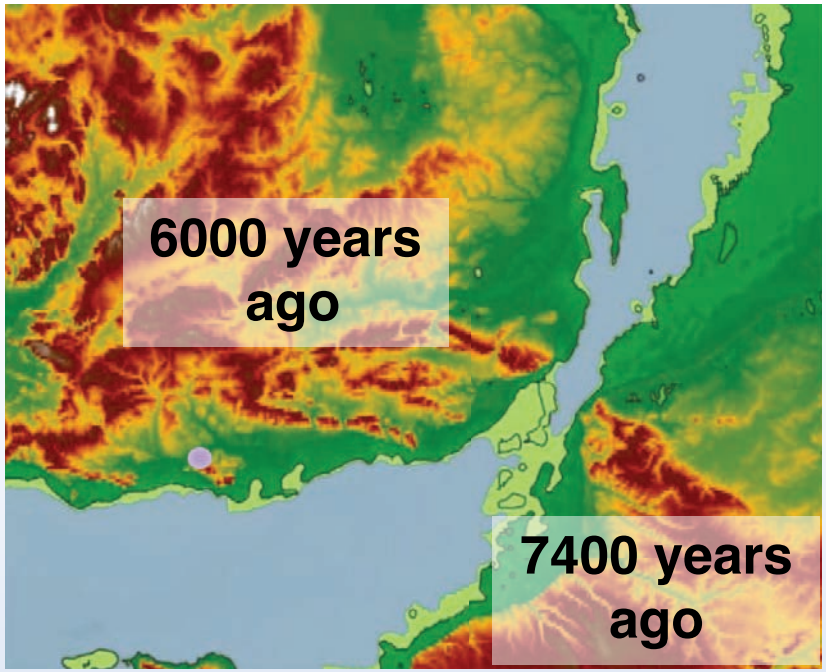
Ruth V. Nichols[1] | Christopher Vollmers[2] | Lee A. Newsom[3] | Yue Wang[4] | Peter D. Heintzman[1,5] | McKenna Leighton[2] | Richard E. Green[2] | Beth Shapiro[1]



2018 *Mol. Ecol. Resour.* **18**(5), 927

@PalaeoPete

2015



152 wheat sequences from
72 million raw sequences

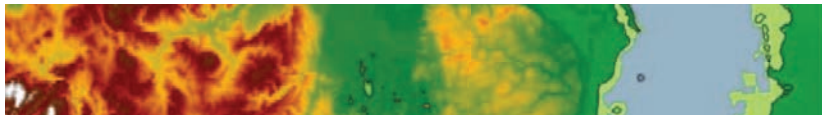
Sedimentary DNA from a submerged site reveals wheat in the British Isles 8000 years ago

Oliver Smith,[1] Garry Momber,[2] Richard Bates,[3] Paul Garwood,[4] Simon Fitch,[5] Mark Pallen,[6*] Vincent Gaffney,[7*] Robin G. Allaby[1*†]

Science **347**, 998.

@PalaeoPete

2015



Contesting the presence of wheat in the British Isles 8,000 years ago by assessing ancient DNA authenticity from low-coverage data

Clemens L Weiß[1], Michael Dannemann[2], Kay Prüfer[2], Hernán A Burbano[1]*

TECHNICAL COMMENT

ARCHAEOLOGY

Comment on "Sedimentary DNA from a submerged site reveals wheat in the British Isles 8000 years ago"

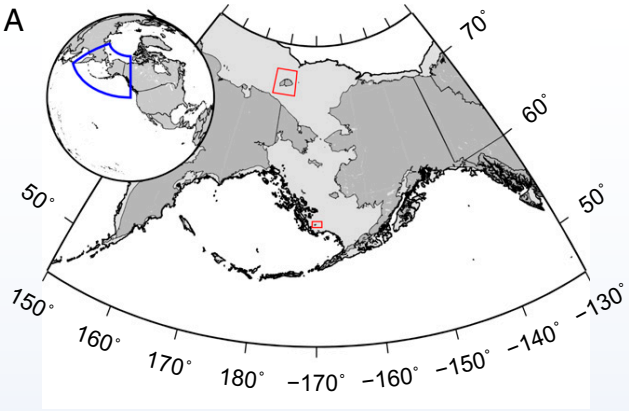
K. D. Bennett[1,2]

eLife **4**, e10005.
Science **349**, 247b.

Oliver Smith,[1] Garry Momber,[2] Richard Bates,[3] Paul Garwood,[4] Simon Fitch,[5] Mark Pallen,[6]* Vincent Gaffney,[7]* Robin G. Allaby[1]*†

@PalaeoPete

2016



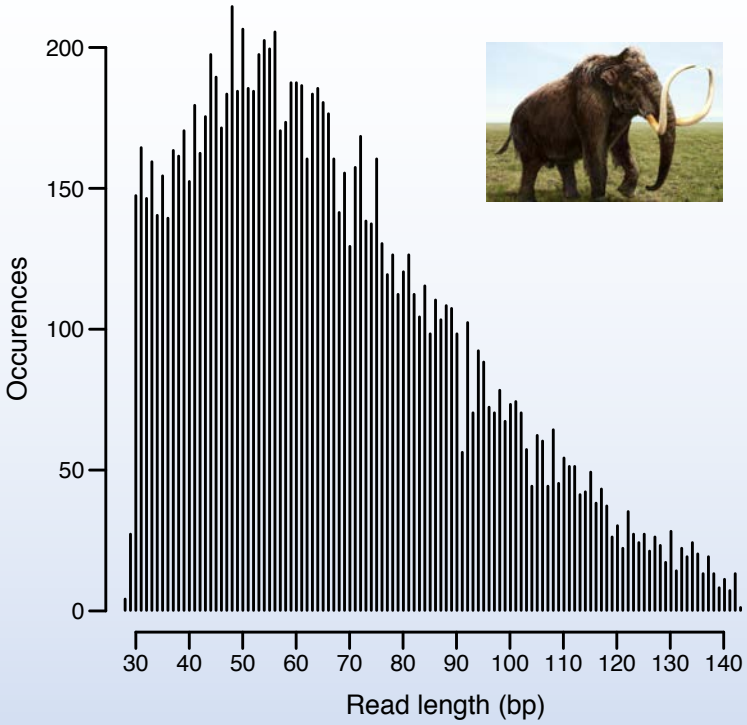
Timing and causes of mid-Holocene mammoth extinction on St. Paul Island, Alaska

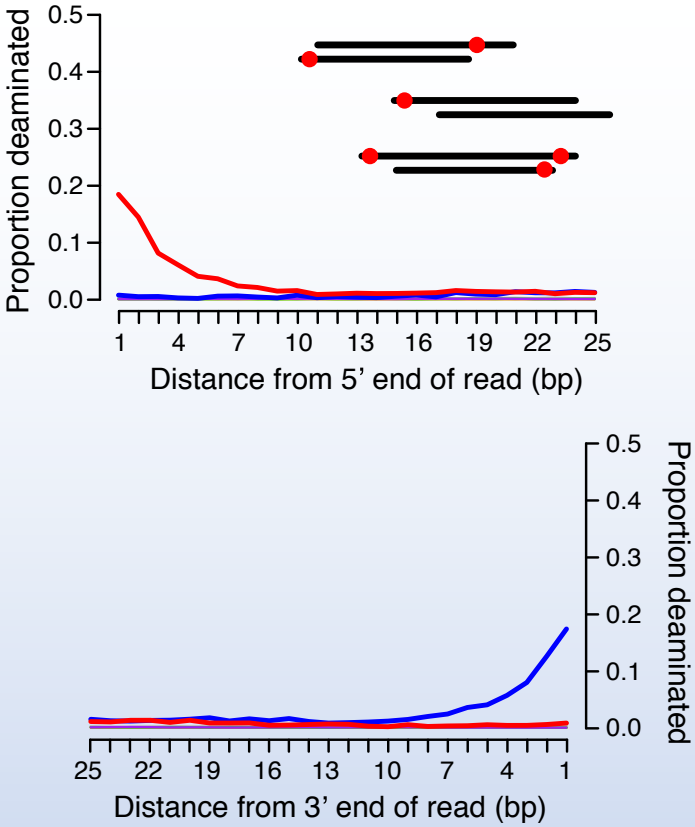
Russell W. Graham[a,1], Soumaya Belmecheri[a,b], Kyungcheol Choy[c], Brendan J. Culleton[d], Lauren J. Davies[e], Duane Froese[e], Peter D. Heintzman[f], Carrie Hritz[g], Joshua D. Kapp[f], Lee A. Newsom[h,i], Ruth Rawcliffe[c], Émilie Saulnier-Talbot[c], Beth Shapiro[f,j], Yue Wang[k], John W. Williams[k,l], and Matthew J. Wooller[c,m]

PNAS **113**(33), 9310

@PalaeoPete

2016





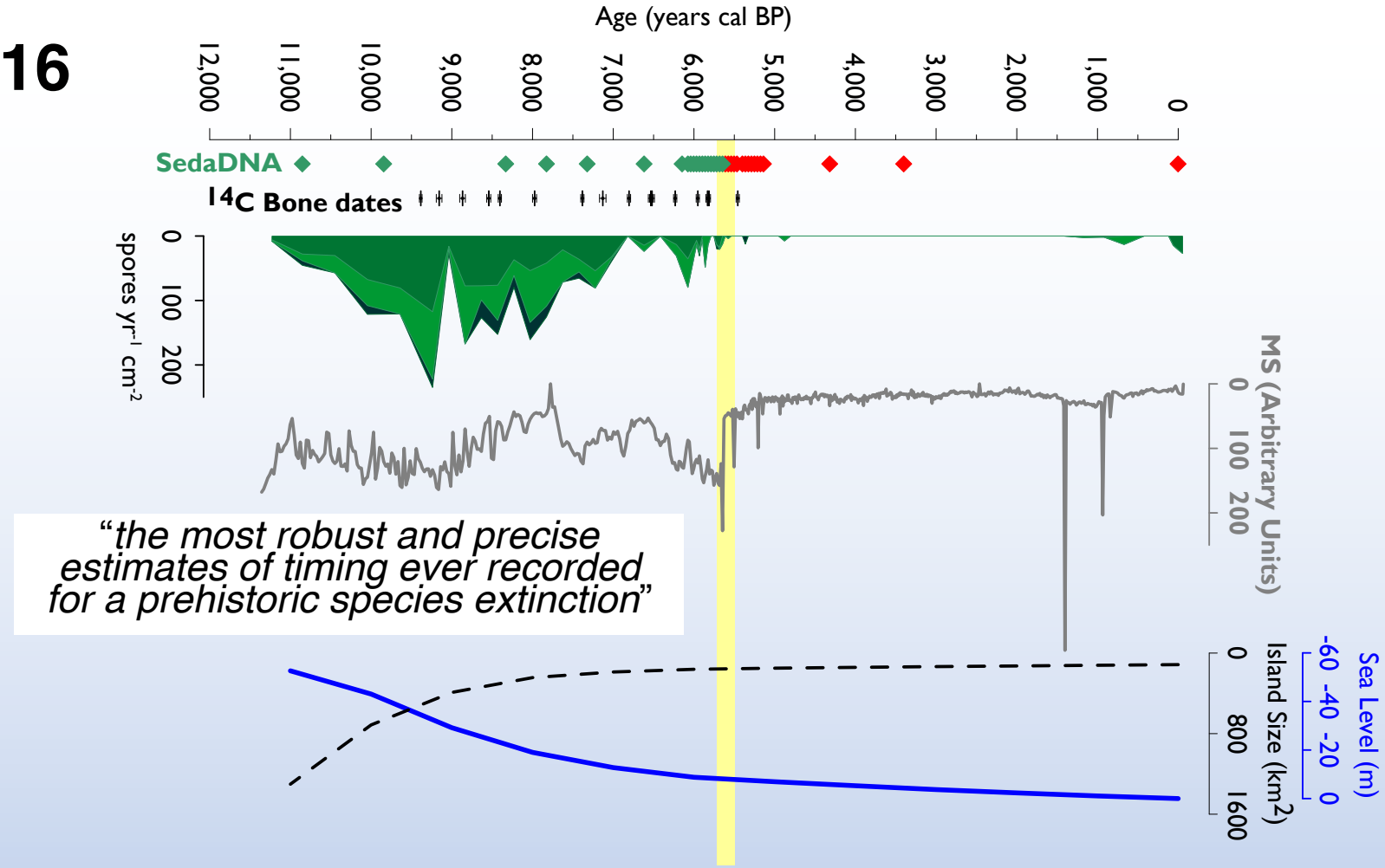
Timing and causes of mid-Holocene mammoth extinction on St. Paul Island, Alaska

Russell W. Graham[a,1], Soumaya Belmecheri[a,b], Kyungcheol Choy[c], Brendan J. Culleton[d], Lauren J. Davies[e], Duane Froese[e], Peter D. Heintzman[f], Carrie Hritz[g], Joshua D. Kapp[f], Lee A. Newsom[h,i], Ruth Rawcliffe[c], Émilie Saulnier-Talbot[c], Beth Shapiro[f,j], Yue Wang[k], John W. Williams[k,l], and Matthew J. Wooller[c,m]

PNAS **113**(33), 9310

@PalaeoPete

2016



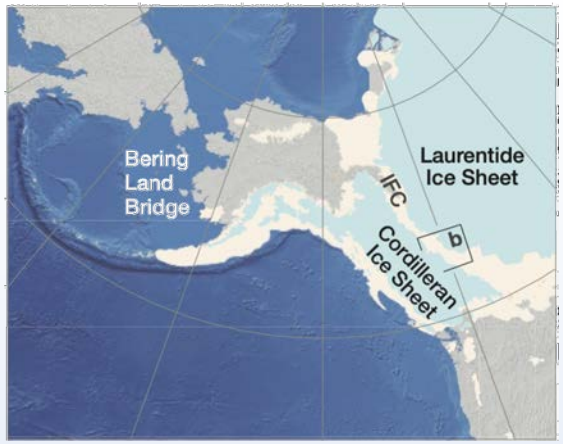
Timing and causes of mid-Holocene mammoth extinction on St. Paul Island, Alaska

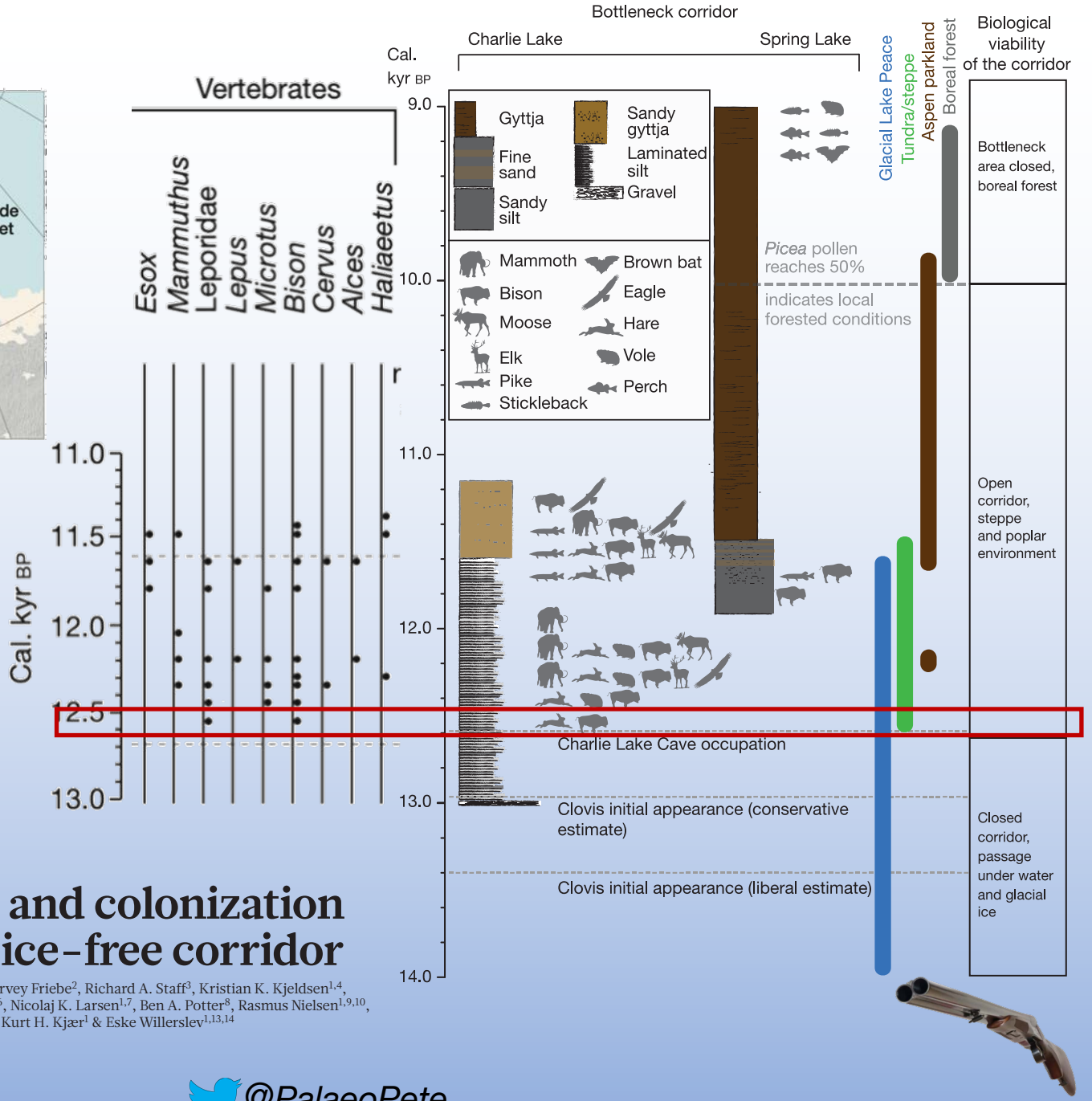
Russell W. Graham[a,1], Soumaya Belmecheri[a,b], Kyungcheol Choy[c], Brendan J. Culleton[d], Lauren J. Davies[e], Duane Froese[e], Peter D. Heintzman[f], Carrie Hritz[g], Joshua D. Kapp[f], Lee A. Newsom[h,i], Ruth Rawcliffe[c], Émilie Saulnier-Talbot[c], Beth Shapiro[f,j], Yue Wang[k], John W. Williams[k,l], and Matthew J. Wooller[c,m]

PNAS **113**(33), 9310

@PalaeoPete

2016





Postglacial viability and colonization in North America's ice-free corridor

Mikkel W. Pedersen[1], Anthony Ruter[1], Charles Schweger[2], Harvey Friebe[2], Richard A. Staff[3], Kristian K. Kjeldsen[1,4], Marie L. Z. Mendoza[1], Alwynne B. Beaudoin[5], Cynthia Zutter[6], Nicolaj K. Larsen[1,7], Ben A. Potter[8], Rasmus Nielsen[1,9,10], Rebecca A. Rainville[11], Ludovic Orlando[1], David J. Meltzer[1,12], Kurt H. Kjær[1] & Eske Willerslev[1,13,14]

2016 *Nature* **537**, 45

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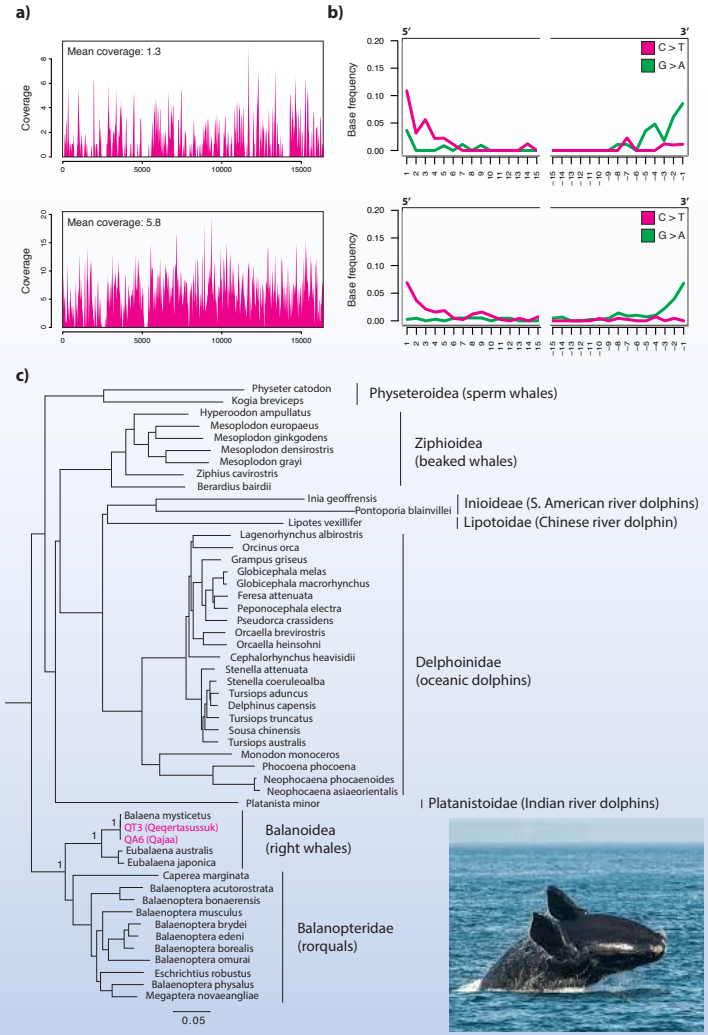
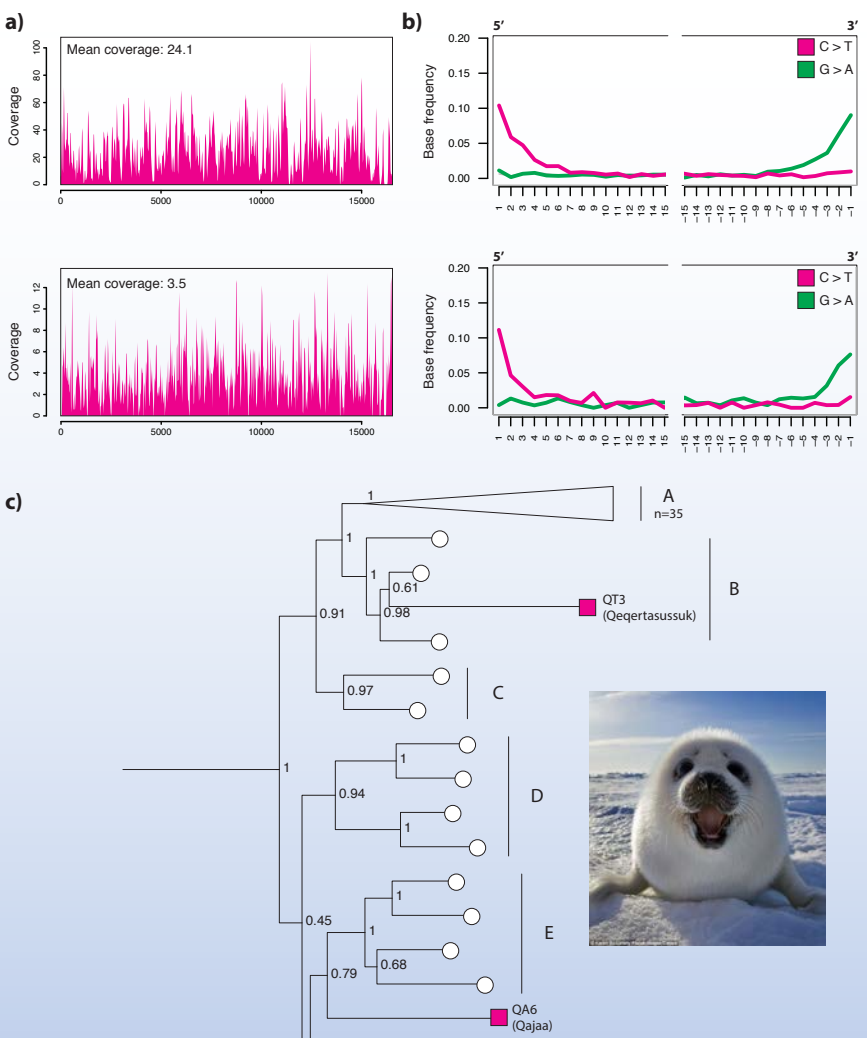
2016



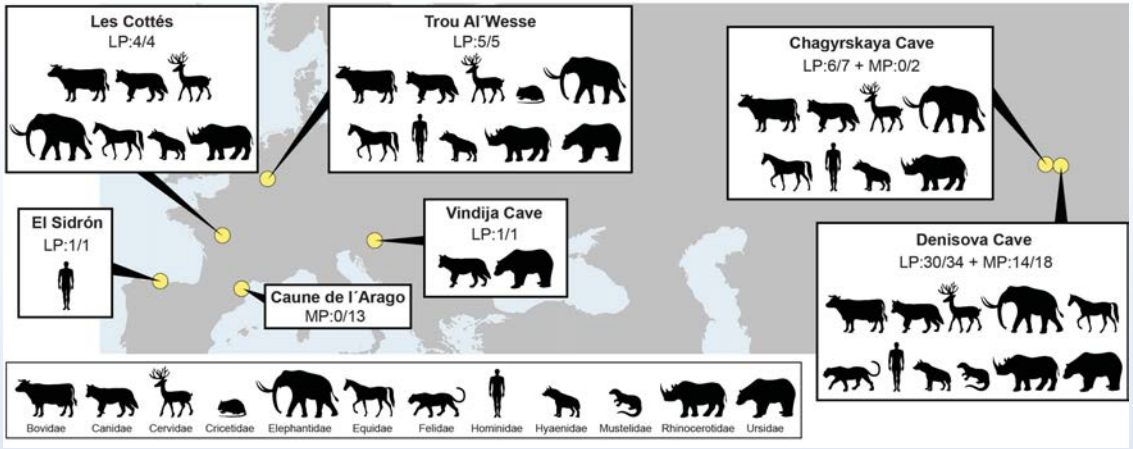


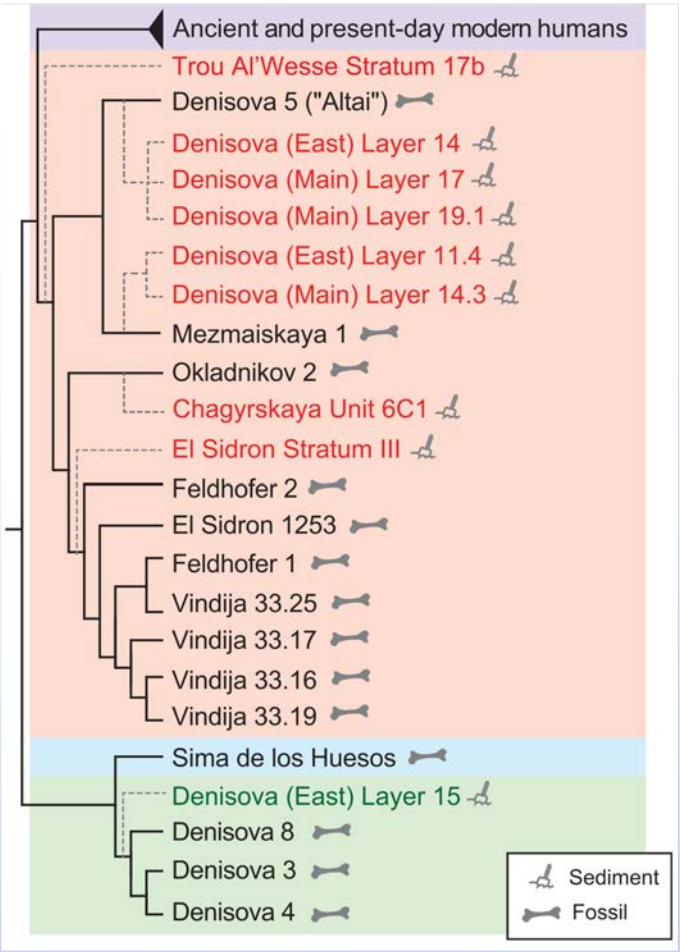
DNA evidence of bowhead whale exploitation by Greenlandic Paleo-Inuit 4,000 years ago

Frederik Valeur Seersholm[1,2,†], Mikkel Winther Pedersen[1], Martin Jensen Søe[1,3], Hussein Shokry[1], Sarah Siu Tze Mak[1], Anthony Ruter[1], Maanasa Raghavan[1,4,†], William Fitzhugh[5], Kurt H. Kjær[1], Eske Willerslev[1,4], Morten Meldgaard[1,6], Christian M.O. Kapel[3] & Anders Johannes Hansen[1]

Nat. Comm. ncomms13389

2017





Neandertal and Denisovan DNA from Pleistocene sediments

Viviane Slon,[1*] Charlotte Hopfe,[1] Clemens L. Weiß,[2] Fabrizio Mafessoni,[1] Marco de la Rasilla,[3] Carles Lalueza-Fox,[4] Antonio Rosas,[5] Marie Soressi,[6,7] Monika V. Knul,[8] Rebecca Miller,[9] John R. Stewart,[8] Anatoly P. Derevianko,[10,11] Zenobia Jacobs,[12,13] Bo Li,[12] Richard G. Roberts,[12,13] Michael V. Shunkov,[10,14] Henry de Lumley,[15,16] Christian Perrenoud,[15,17] Ivan Gušić,[18] Željko Kućan,[18] Pavao Rudan,[18] Ayinuer Aximu-Petri,[1] Elena Essel,[1] Sarah Nagel,[1] Birgit Nickel,[1] Anna Schmidt,[1] Kay Prüfer,[1] Janet Kelso,[1] Hernán A. Burbano,[2] Svante Pääbo,[1] Matthias Meyer[1*]

Science **356**, 605

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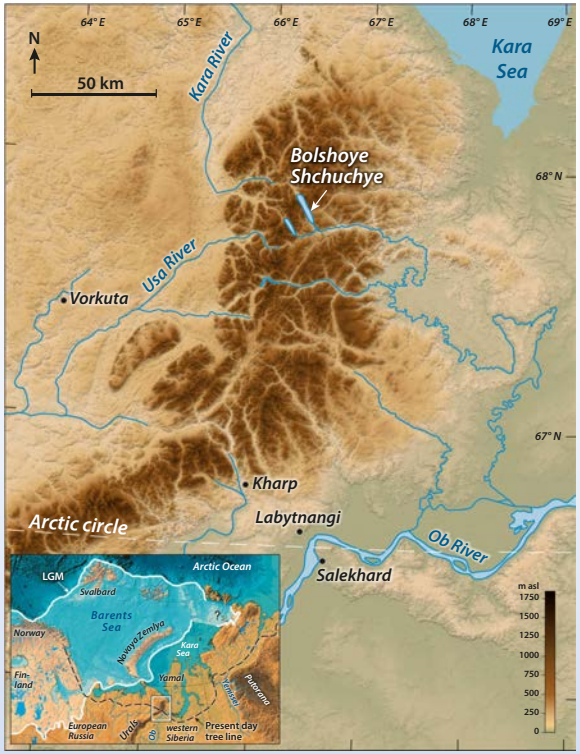
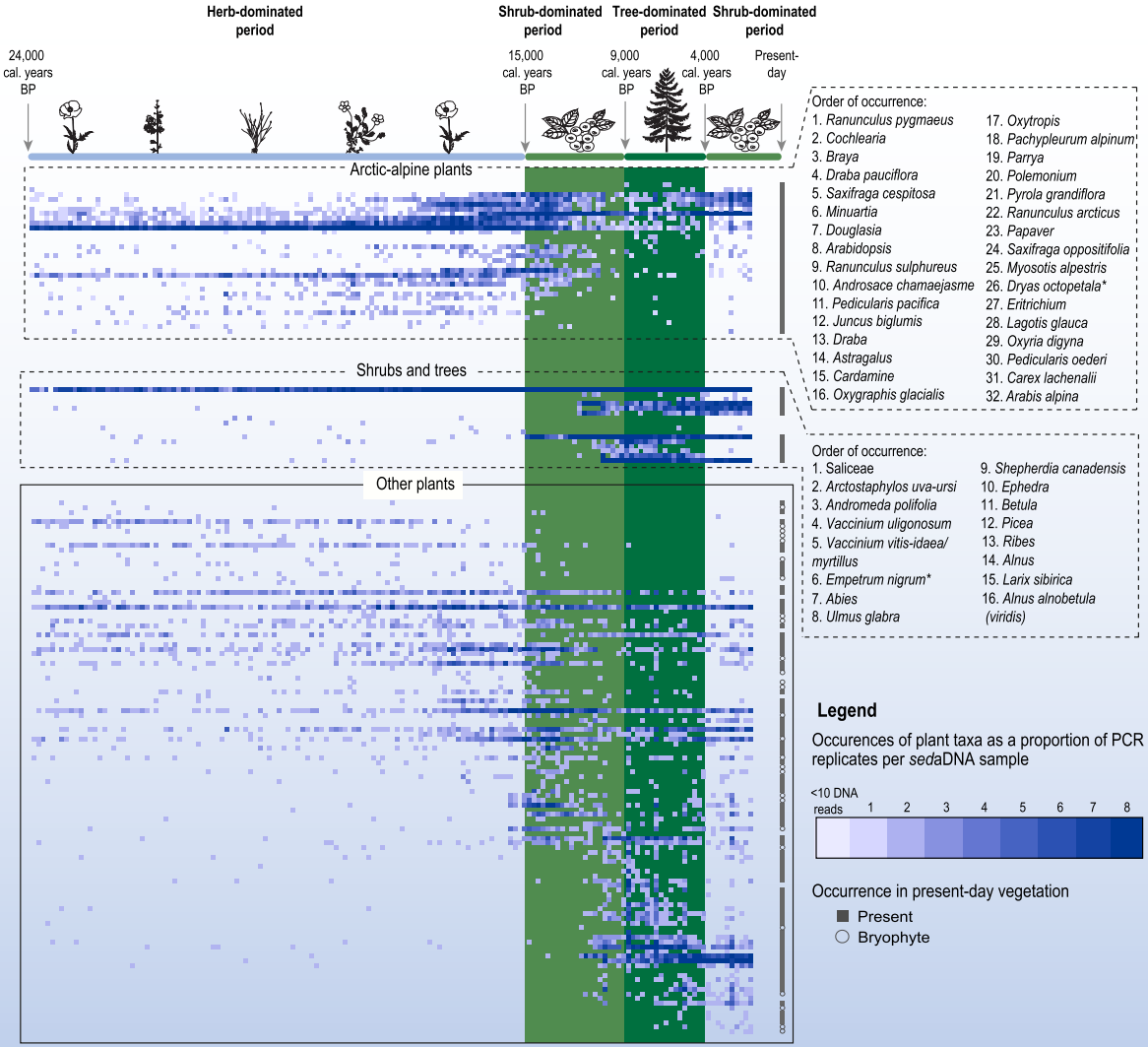
2019





Persistence of arctic-alpine flora during 24,000 years of environmental change in the Polar Urals

C. L. Clarke[1*], M. E. Edwards[1], L. Gielly[2], D. Ehrich[3], P. D. M. Hughes[1], L. M. Morozova[4], H. Haflidason[5], J. Mangerud[5], J. I. Svendsen[5] & I. G. Alsos[6]

Sci. Rep. **118**, e2019069118

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Then we had 2021-present…

2021

Hybridisation capture allows DNA damage analysis of ancient marine eukaryotes

L. Armbrecht[1]✉, G. Hallegraeff[2], C. J. S. Bolch[3], C. Woodward[4] & A. Cooper[5]

Sci. Rep. **11**, 3220

Mol. Ecol. Resour. **21**, 801

Hybridization capture of larch (*Larix* Mill.) chloroplast genomes from sedimentary ancient DNA reveals past changes of Siberian forest

Luise Schulte[1,2] | Nadine Bernhardt[1] | Kathleen Stoof-Leichsenring[1] | Heike H. Zimmermann[1] | Luidmila A. Pestryakova[3] | Laura S. Epp[1] | Ulrike Herzschuh[1,2,4]

Optimizing extraction and targeted capture of ancient environmental DNA for reconstructing past environments using the PalaeoChip Arctic-1.0 bait-set

Tyler J. Murchie[a,b]*, Melanie Kuch[a,b], Ana T. Duggan[a,b], Marissa L. Ledger[c], Kévin Roche[d,e], Jennifer Klunk[a,f], Emil Karpinski[a,f], Dirk Hackenberger[a,g], Tara Sadoway[a,h], Ross MacPhee[i], Duane Froese[j], Hendrik Poinar[a,b,g]*

2020 *Quat. Res.* **99**, 305

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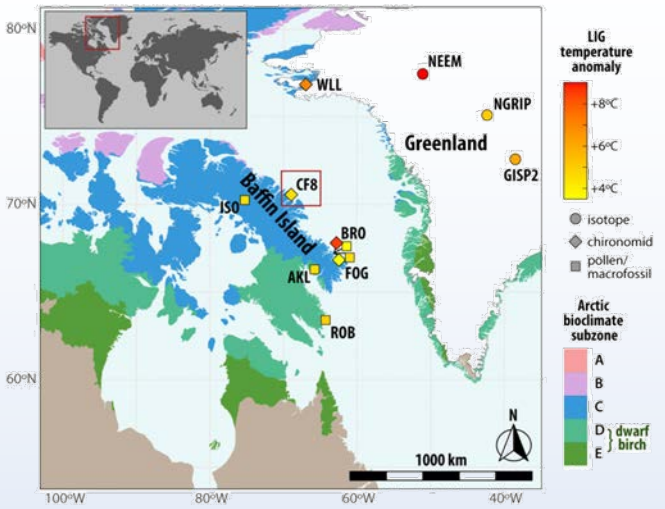
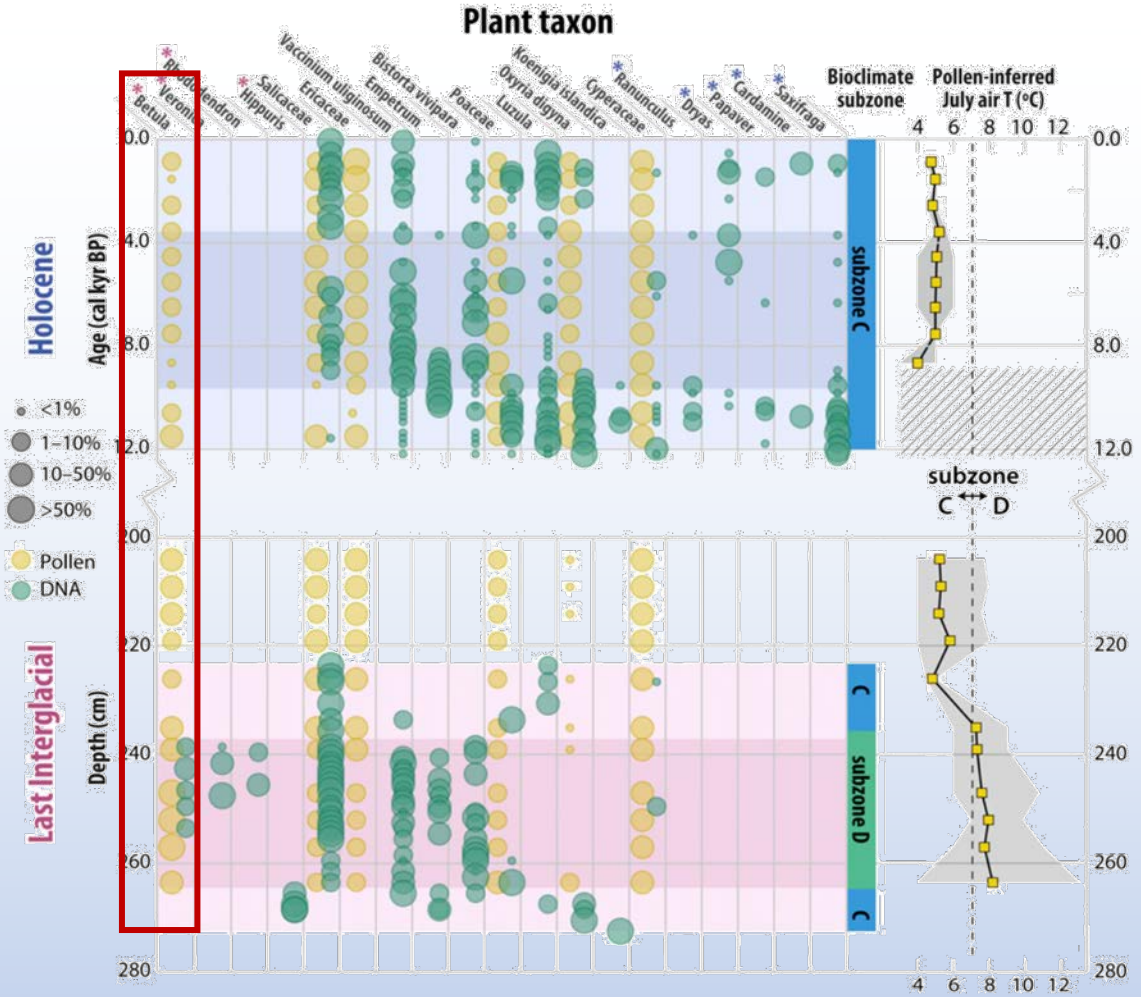
2021



~130,000 years old



Ancient plant DNA reveals High Arctic greening during the Last Interglacial

Sarah E. Crump[a,b,1], Bianca Fréchette[c], Matthew Power[d], Sam Cutler[b], Gregory de Wet[a,e], Martha K. Raynolds[f], Jonathan H. Raberg[a], Jason P. Briner[g], Elizabeth K. Thomas[g], Julio Sepúlveda[a], Beth Shapiro[b,h], Michael Bunce[d,i], and Gifford H. Miller[a]

PNAS **118**, e2019069118

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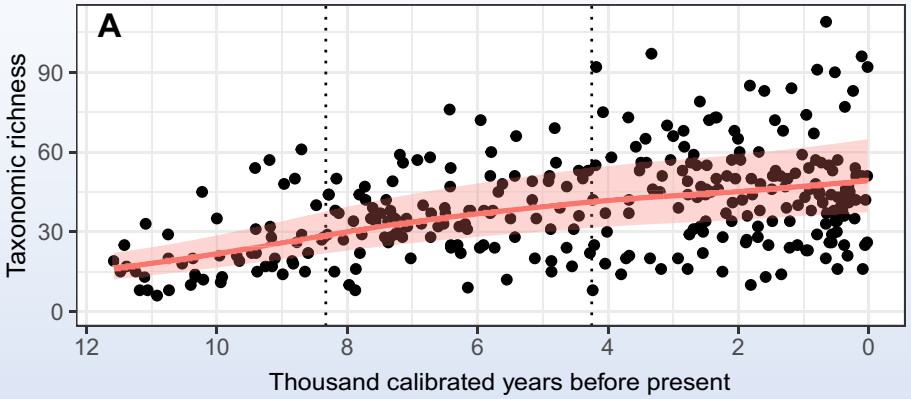
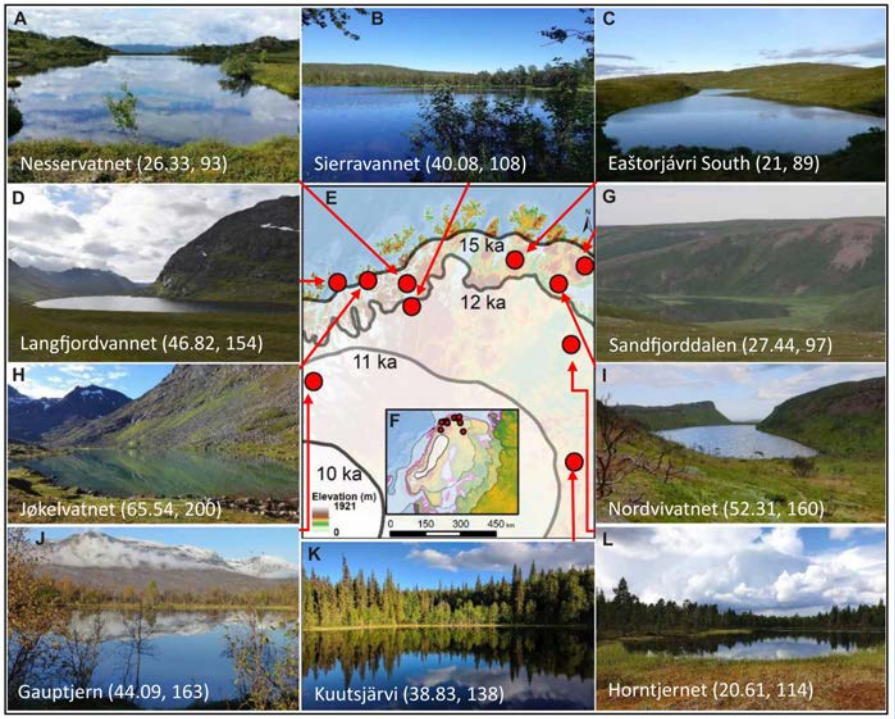
2021





ECOLOGY

Sedimentary ancient DNA shows terrestrial plant richness continuously increased over the Holocene in northern Fennoscandia

Dilli P. Rijal[1,2*†], Peter D. Heintzman[1*†], Youri Lammers[1], Nigel G. Yoccoz[2], Kelsey E. Lorberau[2], Iva Pitelkova[1], Tomasz Goslar[3,4], Francisco J. A. Murguzur[2], J. Sakari Salonen[5], Karin F. Helmens[6,7], Jostein Bakke[8], Mary E. Edwards[1,9,10], Torbjørn Alm[1], Kari Anne Bråthen[2], Antony G. Brown[1,9], Inger G. Alsos[1*†]

Sci. Adv. **7**, eabf9557

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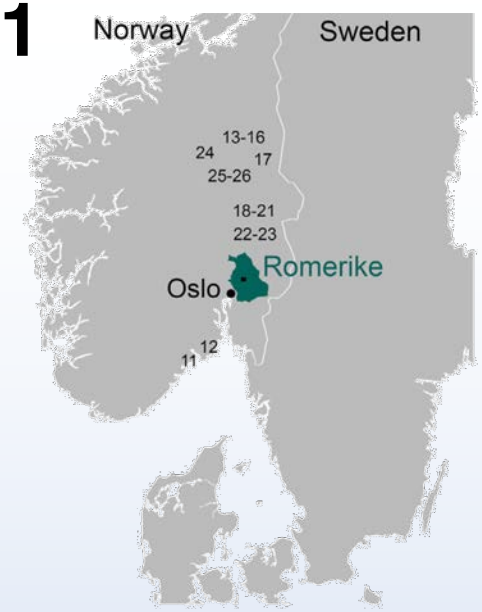
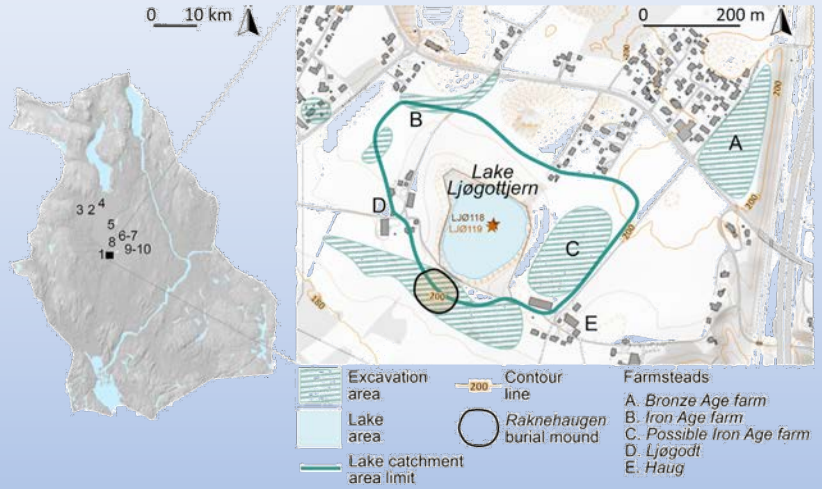
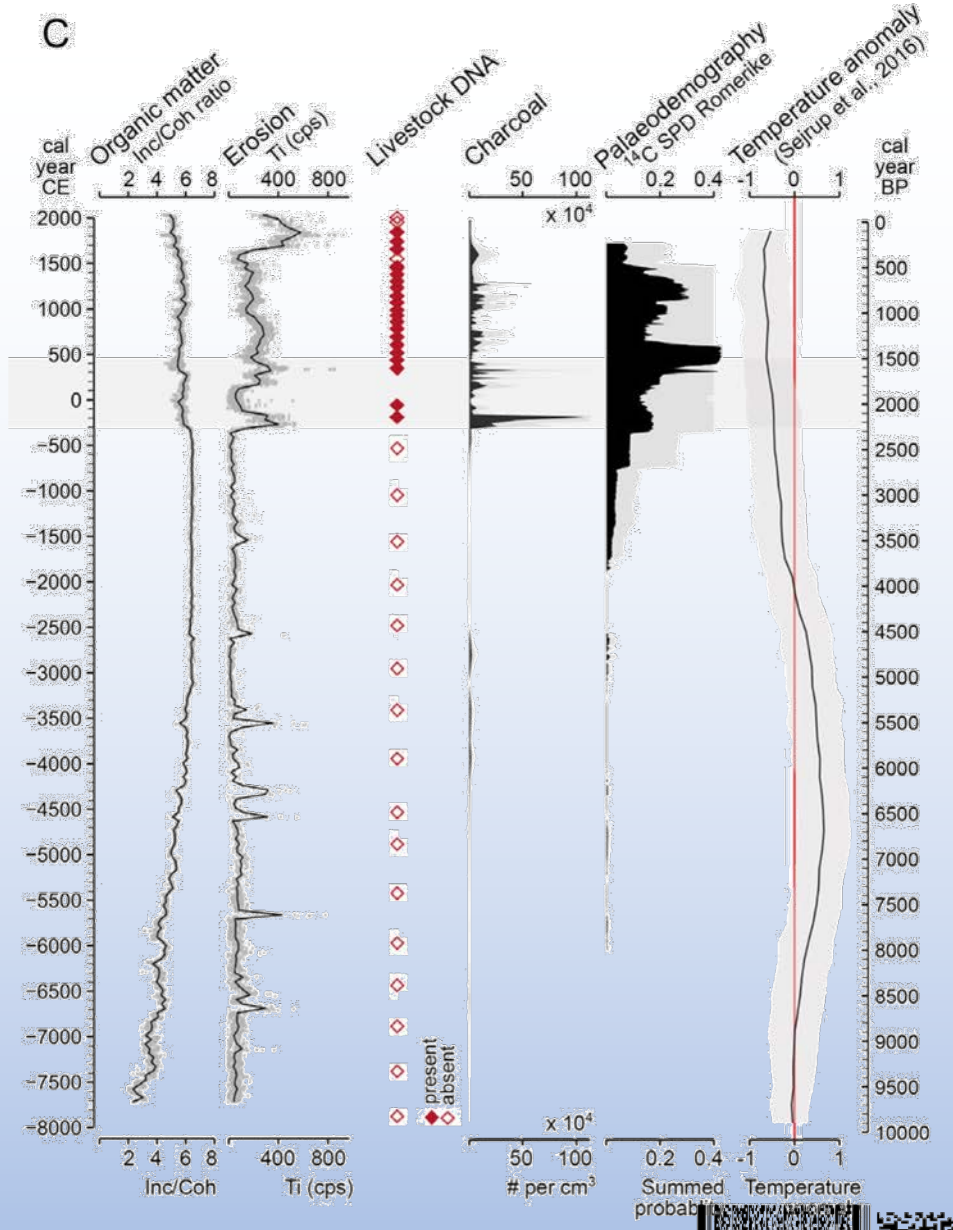
2021







Anthropogenic and environmental drivers of vegetation change in southeastern Norway during the Holocene

A.T.M. ter Schure [a, *], M. Bajard [b, c], K. Loftsgarden [d], H.I. Høeg [d], E. Ballo [b, c], J. Bakke [e], E.W.N. Støren [e], F. Iversen [d], A. Kool [f], A.K. Brysting [a], K. Krüger [b, c], S. Boessenkool [a, *]

Quat. Sci. Rev. **107175**

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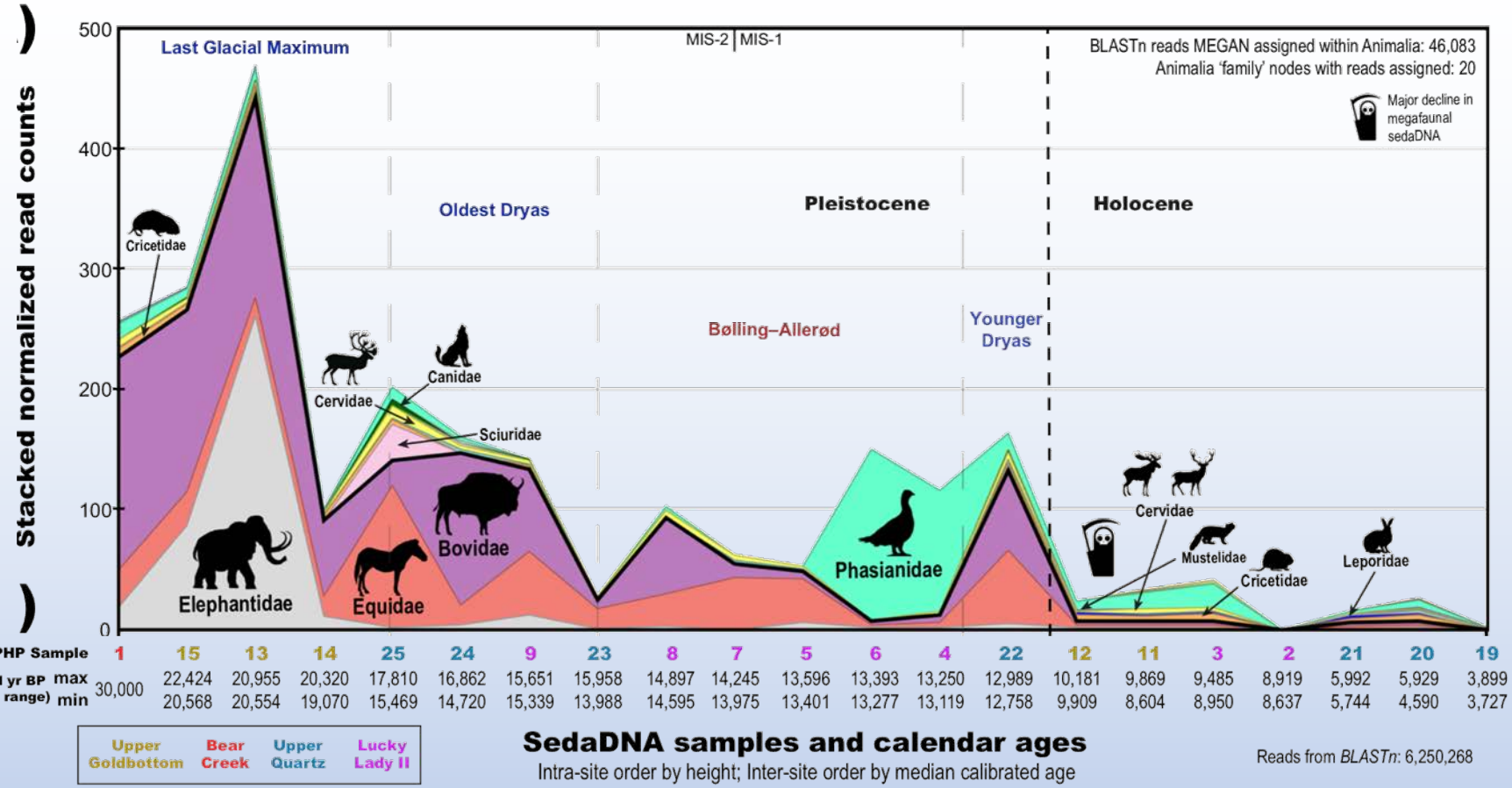
2021



Collapse of the mammoth-steppe in central Yukon as revealed by ancient environmental DNA

Tyler J. Murchie[1,2✉], Alistair J. Monteath[3,4], Matthew E. Mahony[3], George S. Long[1,5], Scott Cocker[3], Tara Sadoway[1,6], Emil Karpinski[1,5], Grant Zazula[7,8], Ross D. E. MacPhee[9], Duane Froese[3✉] & Hendrik N. Poinar[1,2,10,11,12✉]

Nat. Comms. **12**, 7120.

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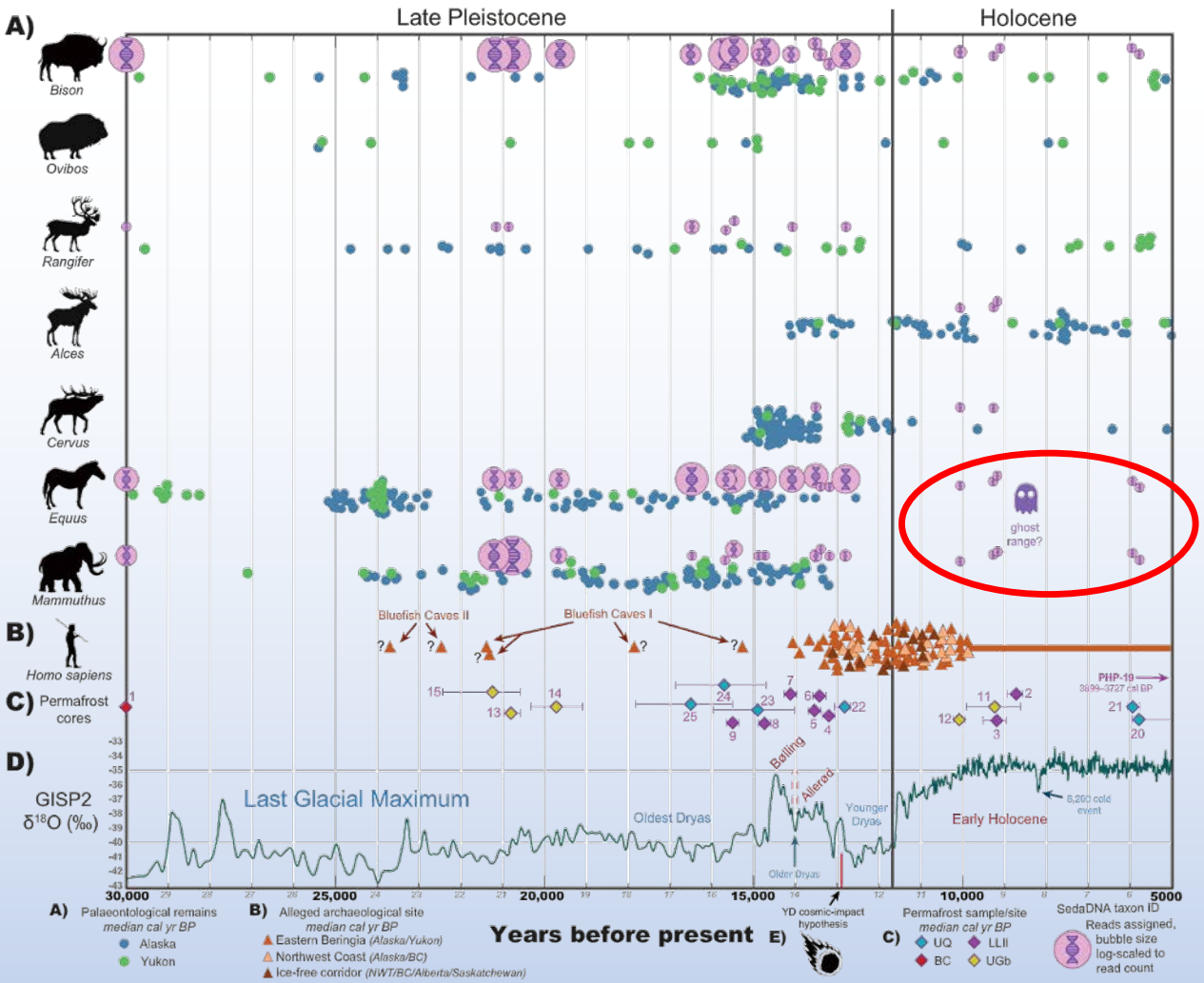
2021



Collapse of the mammoth-steppe in central Yukon as revealed by ancient environmental DNA

Tyler J. Murchie[1,2✉], Alistair J. Monteath[3,4], Matthew E. Mahony[3], George S. Long[1,5], Scott Cocker[3], Tara Sadoway[1,6], Emil Karpinski[1,5], Grant Zazula[7,8], Ross D. E. MacPhee[9], Duane Froese[3✉] & Hendrik N. Poinar[1,2,10,11,12✉]

Nat. Comms. **12**, 7120.

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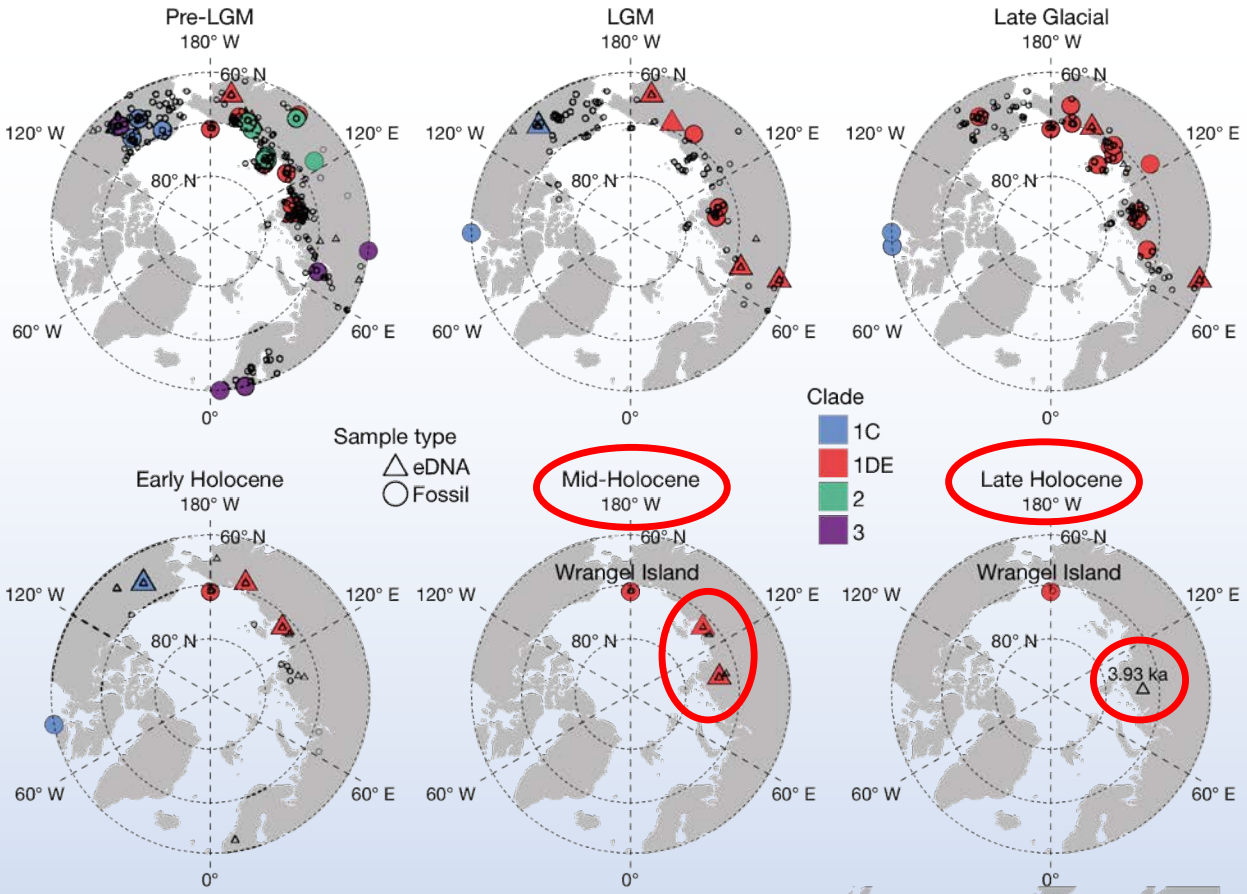
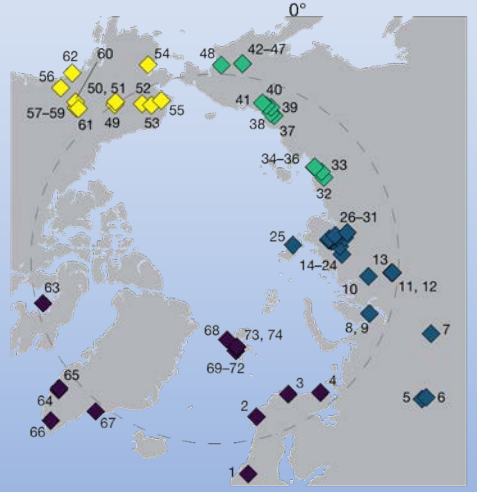
2021



Late Quaternary dynamics of Arctic biota from ancient environmental genomics

Yucheng Wang[1,2,35], Mikkel Winther Pedersen[2,35], Inger Greve Alsos[3,35], Bianca De Sanctis[1,4], Fernando Racimo[2], Ana Prohaska[1], Eric Coissac[3,5], Hannah Lois Owens[6], Marie Kristine Føreid Merkel[3], Antonio Fernandez-Guerra[2], Alexandra Rouillard[2,7], Youri Lammers[3], Adriana Alberti[8,9], France Denoeud[9], Daniel Money[1], Anthony H. Ruter[2], Hugh McColl[2], Nicolaj Krog Larsen[2], Anna A. Cherezova[10,11], Mary E. Edwards[12,13], Grigory B. Fedorov[10,11], James Haile[2], Ludovic Orlando[14], Lasse Vinner[2], Thorfinn Sand Korneliussen[2,15], David W. Beilman[16], Anders A. Bjørk[17], Jialu Cao[2], Christoph Dockter[18], Julie Esdale[19], Galina Gusarova[3,20], Kristian K. Kjeldsen[21], Jan Mangerud[22,23], Jeffrey T. Rasic[24], Birgitte Skadhauge[18], John Inge Svendsen[22,23], Alexei Tikhonov[25], Patrick Wincker[9], Yingchun Xing[26], Yubin Zhang[27], Duane G. Froese[28], Carsten Rahbek[6,29], David Bravo Nogues[6], Philip B. Holden[30], Neil R. Edwards[30], Richard Durbin[4], David J. Meltzer[2,31], Kurt H. Kjær[2], Per Möller[32] & Eske Willerslev[1,2,33,34]



Nature **600**, 86-92.

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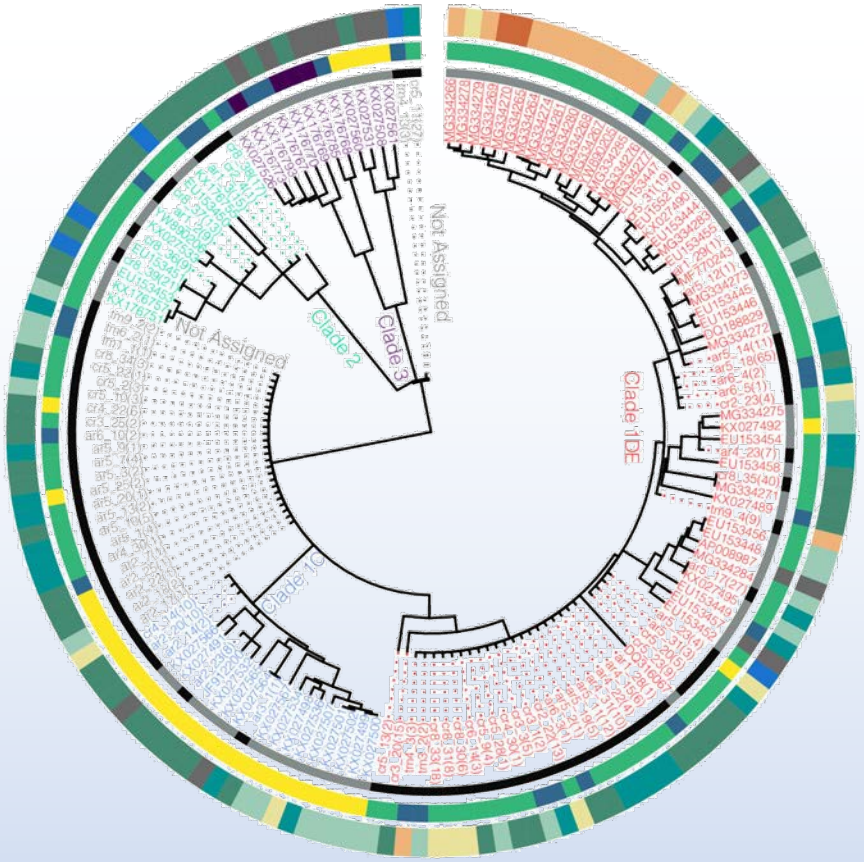
2021



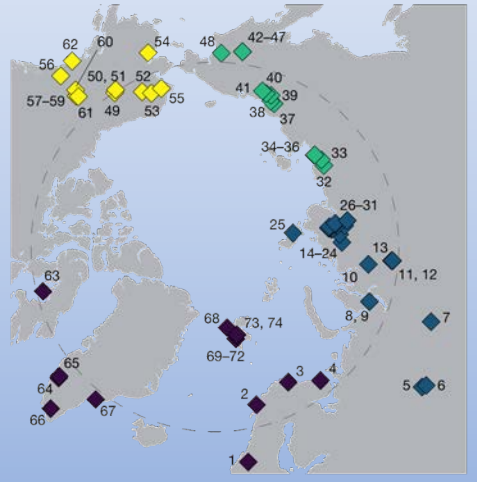
Sample type
(Inner circle)
- eDNA
- Fossil

Region
(Middle circle)
- North Atlantic
- Northwest and central Siberia
- Northeast Siberia
- North America
- Unknown

Age interval
(Outer circle)
- 50+
- Pre–LGM
- LGM
- Late Glacial
- Early Holocene
- Mid–Holocene
- Late Holocene
- Unknown

Late Quaternary dynamics of Arctic biota from ancient environmental genomics

Yucheng Wang[1,2,35], Mikkel Winther Pedersen[2,35], Inger Greve Alsos[3,35], Bianca De Sanctis[1,4], Fernando Racimo[2], Ana Prohaska[1], Eric Coissac[3,5], Hannah Lois Owens[6], Marie Kristine Føreid Merkel[3], Antonio Fernandez-Guerra[2], Alexandra Rouillard[2,7], Youri Lammers[3], Adriana Alberti[8,9], France Denoeud[9], Daniel Money[1], Anthony H. Ruter[2], Hugh McColl[2], Nicolaj Krog Larsen[2], Anna A. Cherezova[10,11], Mary E. Edwards[12,13], Grigory B. Fedorov[10,11], James Haile[2], Ludovic Orlando[14], Lasse Vinner[2], Thorfinn Sand Korneliussen[2,15], David W. Beilman[16], Anders A. Bjørk[17], Jialu Cao[2], Christoph Dockter[18], Julie Esdale[19], Galina Gusarova[3,20], Kristian K. Kjeldsen[21], Jan Mangerud[22,23], Jeffrey T. Rasic[24], Birgitte Skadhauge[18], John Inge Svendsen[22,23], Alexei Tikhonov[25], Patrick Wincker[9], Yingchun Xing[26], Yubin Zhang[27], Duane G. Froese[28], Carsten Rahbek[6,29], David Bravo Nogues[6], Philip B. Holden[30], Neil R. Edwards[30], Richard Durbin[4], David J. Meltzer[2,31], Kurt H. Kjær[2], Per Möller[32] & Eske Willerslev[1,2,33,34]



Nature **600**, 86-92.

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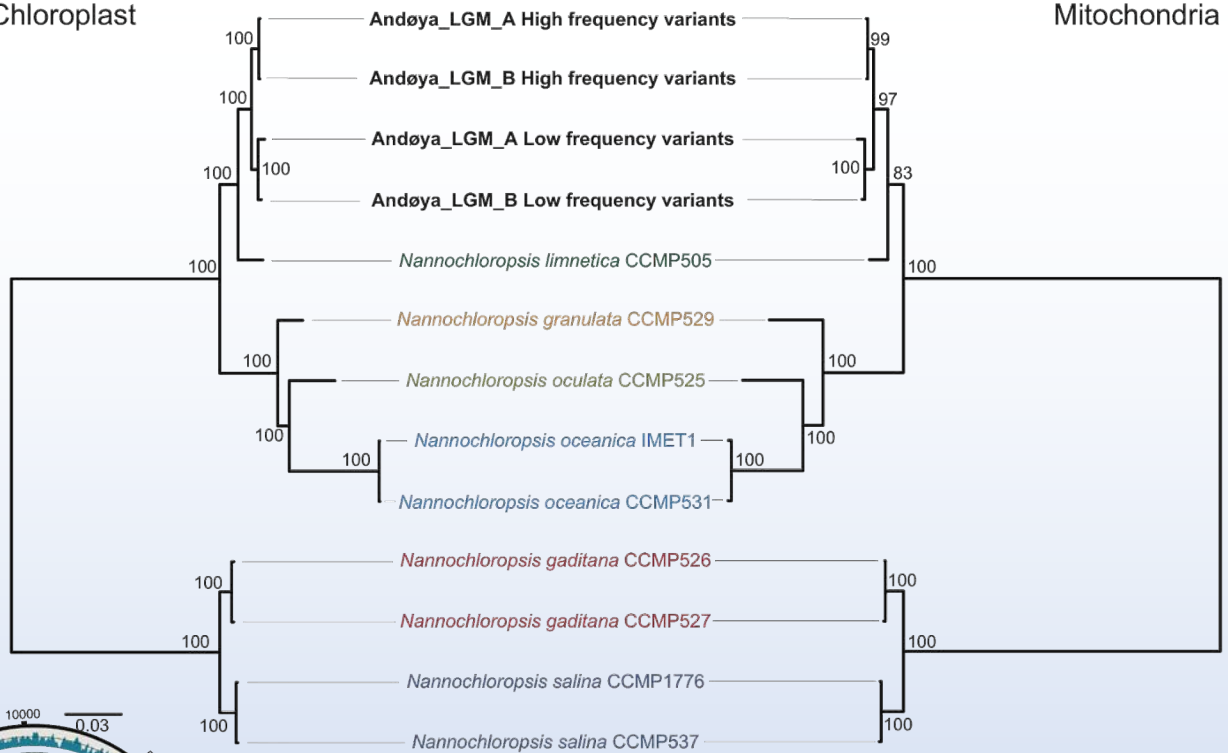
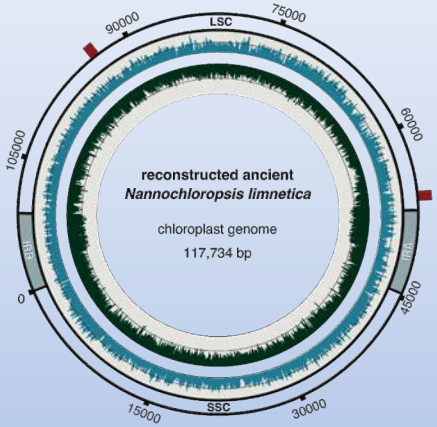
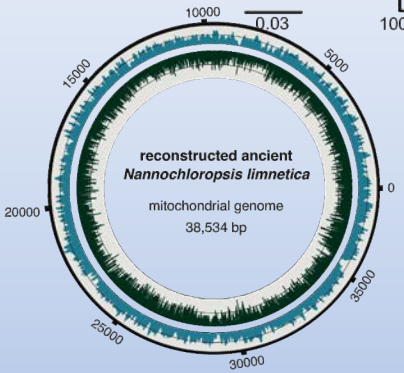
Chloroplast

Mitochondria







Environmental palaeogenomic reconstruction of an Ice Age algal population

Youri Lammers [1✉], Peter D. Heintzman [1,2] & Inger Greve Alsos [1,2]

Comms. Biol. **4**, 220

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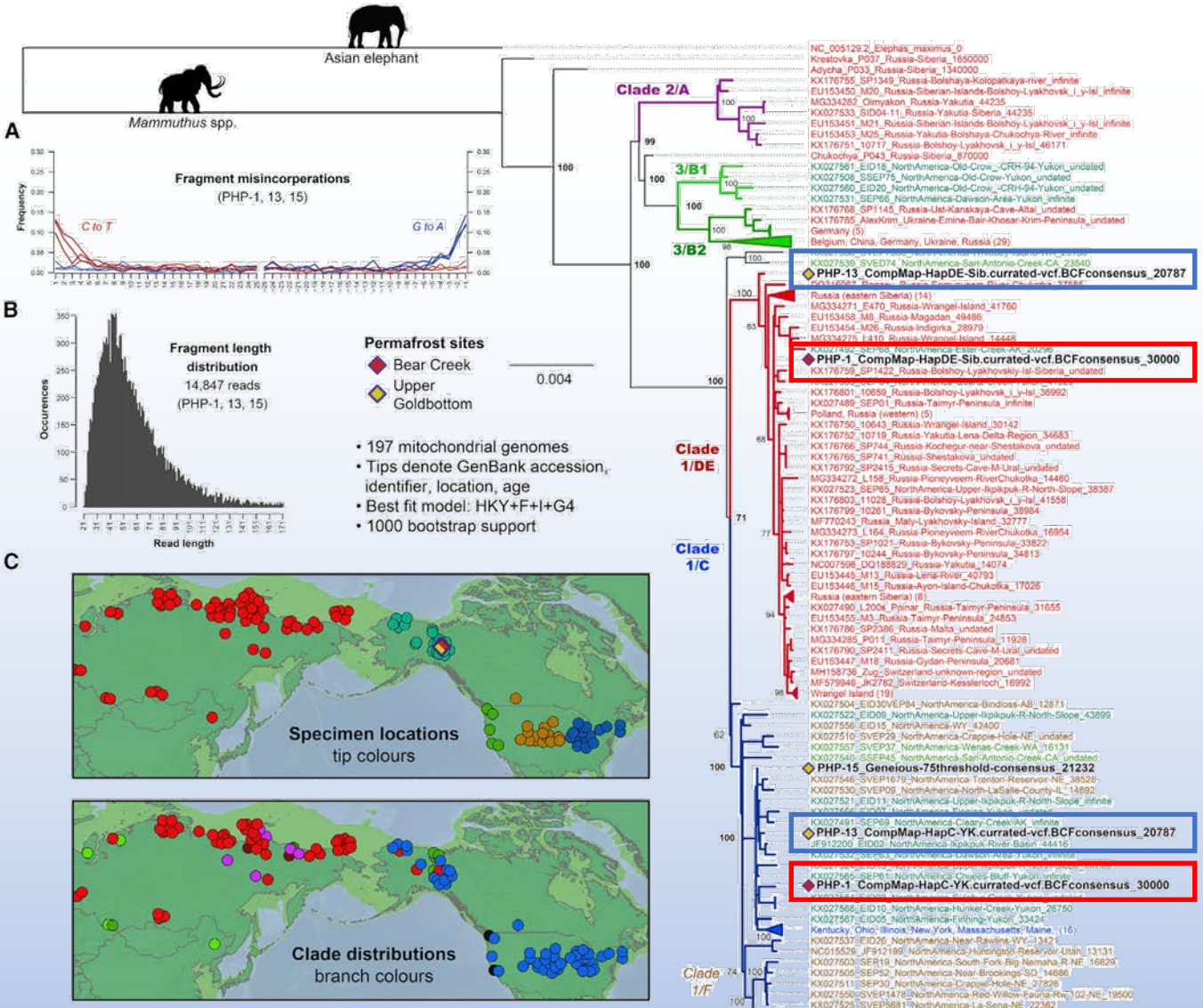

Pleistocene mitogenomes reconstructed from the environmental DNA of permafrost sediments

Tyler J. Murchie,[1,2,11,*] Emil Karpinski,[1,3] Katherine Eaton,[1,2] Ana T. Duggan,[1,2] Sina Baleka,[1] Grant Zazula,[4,5] Ross D.E. MacPhee,[6] Duane Froese,[7,*] and Hendrik N. Poinar[1,2,8,9,10,*]

Current Biology **32**, 1.

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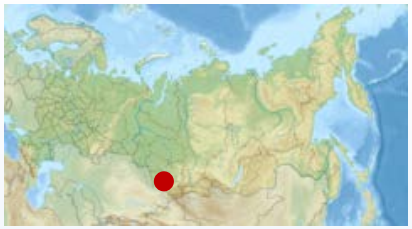
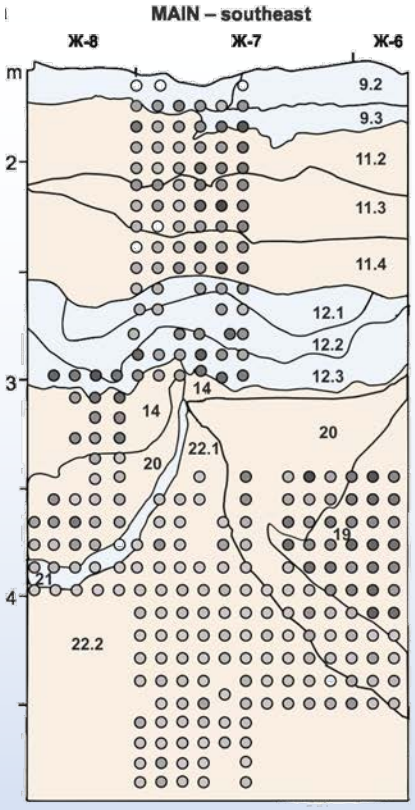
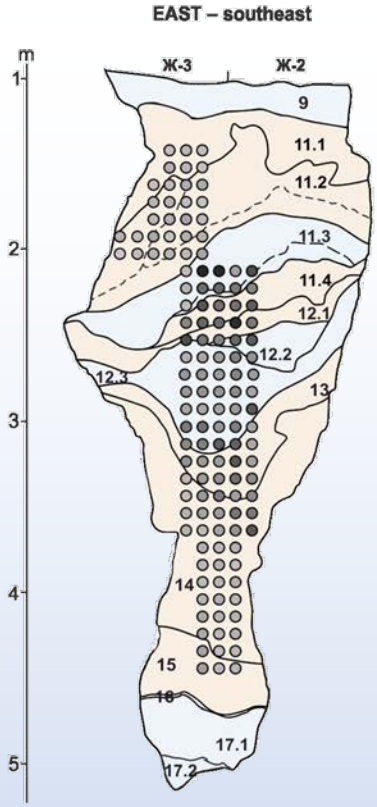
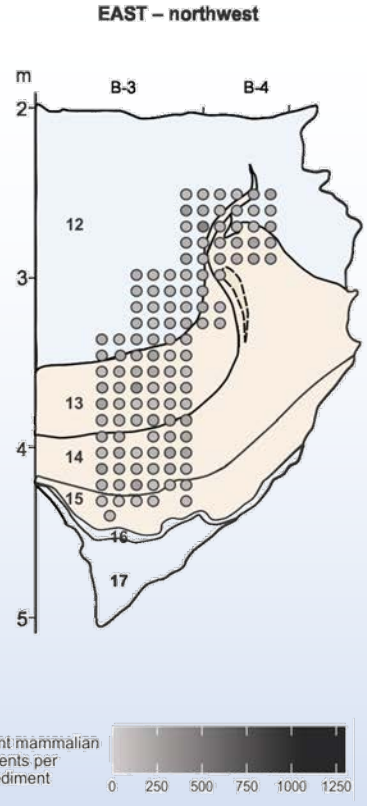
2021









Article

Pleistocene sediment DNA reveals hominin and faunal turnovers at Denisova Cave

~300,000 years old

https://doi.org/10.1038/s41586-021-03675-0
Received: 2 February 2021
Accepted: 27 May 2021
Published online: 23 June 2021

Elena I. Zavala[1]✉, Zenobia Jacobs[2,3]✉, Benjamin Vernot[1], Michael V. Shunkov[4], Maxim B. Kozlikin[4], Anatoly P. Derevianko[4], Elena Essel[1], Cesare de Fillipo[1], Sarah Nagel[1], Julia Richter[1], Frédéric Romagné[1], Anna Schmidt[1], Bo Li[2,3], Kieran O'Gorman[2], Viviane Slon[1,5,6,7], Janet Kelso[1], Svante Pääbo[1], Richard G. Roberts[2,3]✉ & Matthias Meyer[1]✉

Nature
595, 399

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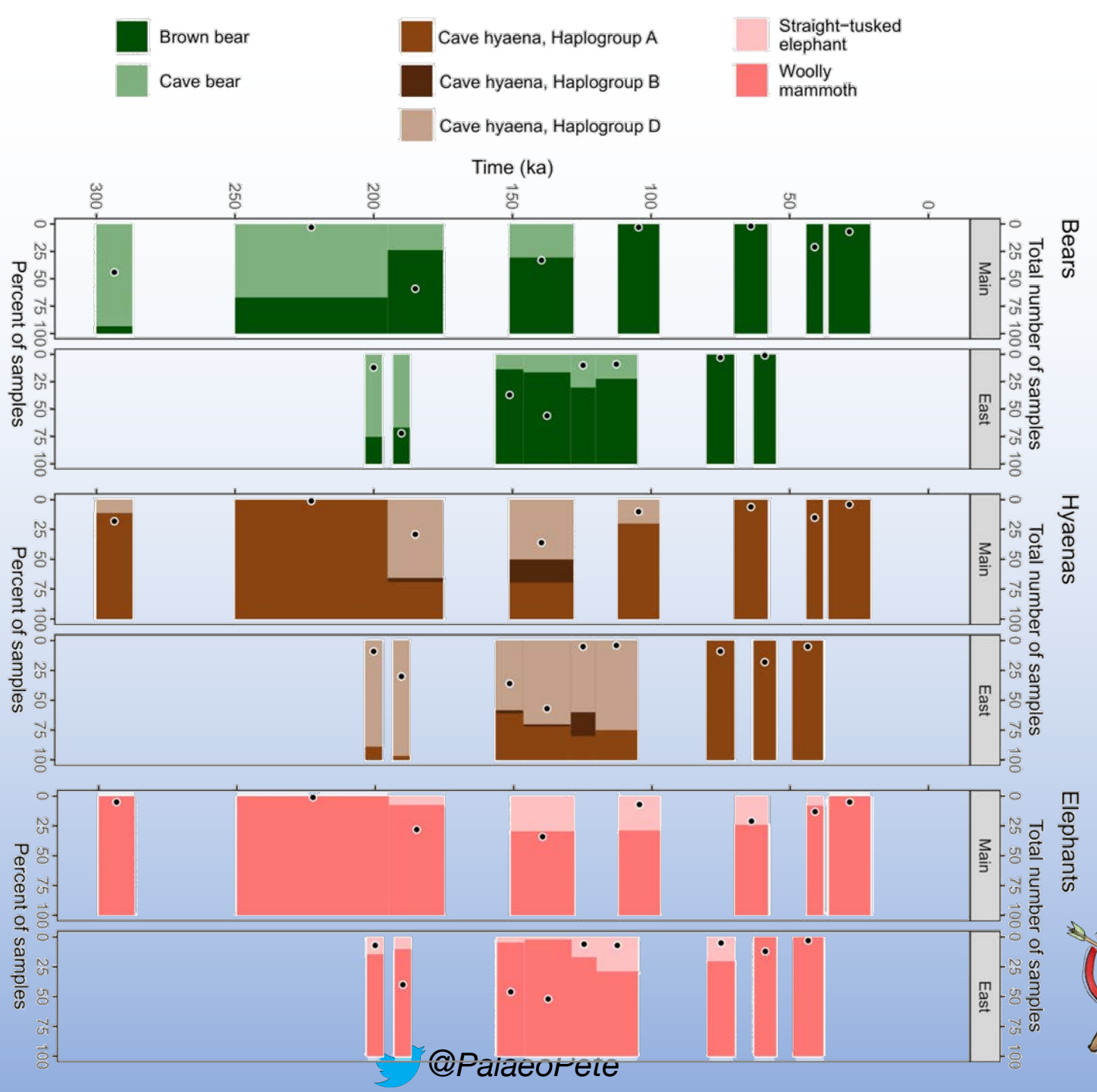
2021



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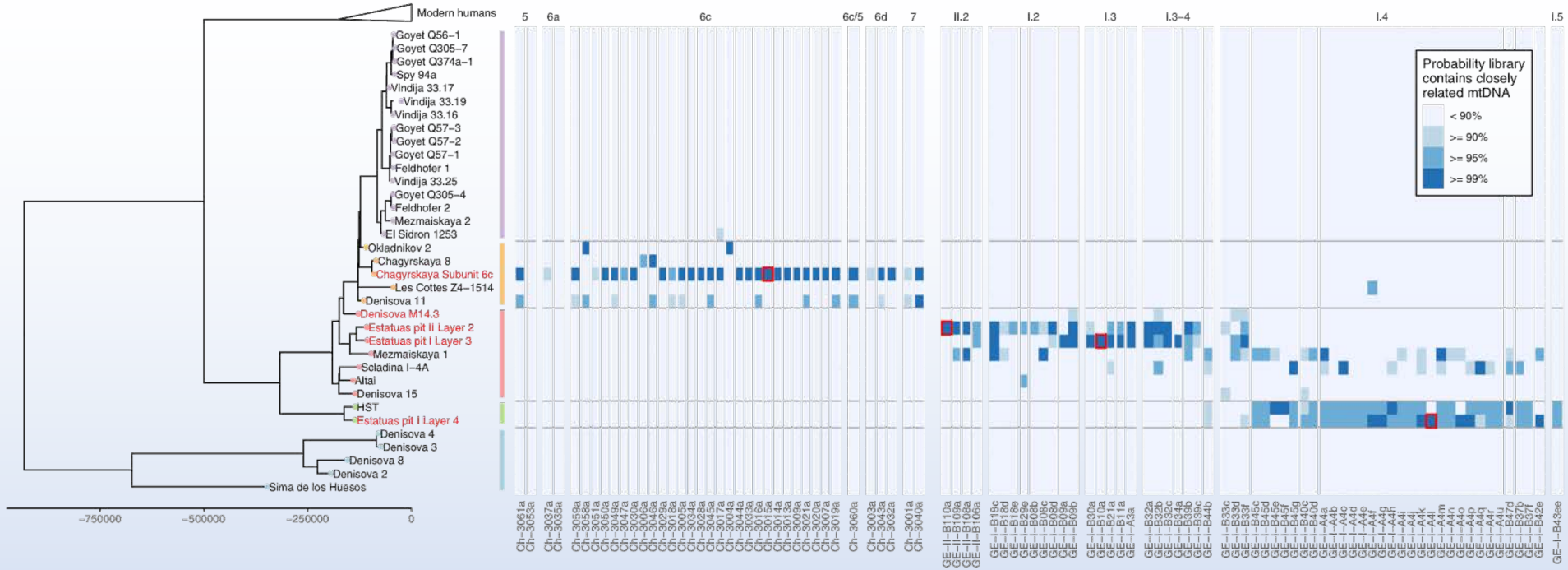
Nature
595, 399

2021



Sediment libraries - grouped by layer and sample (ordered by depth in stratigraphy)

PALEOGENOMICS

Unearthing Neanderthal population history using nuclear and mitochondrial DNA from cave sediments

Benjamin Vernot[1]*, Elena I. Zavala[1], Asier Gómez-Olivencia[2,3,4], Zenobia Jacobs[5,6], Viviane Slon[1,7,8], Fabrizio Mafessoni[1], Frédéric Romagné[1], Alice Pearson[1], Martin Petr[1], Nohemi Sala[4,9], Adrián Pablos[4,9], Arantza Aranburu[2,3], José María Bermúdez de Castro[9], Eudald Carbonell[10,11], Bo Li[5,6], Maciej T. Krajcarz[12], Andrey I. Krivoshapkin[13,14], Kseniya A. Kolobova[13], Maxim B. Kozlikin[13], Michael V. Shunkov[13], Anatoly P. Derevianko[13], Bence Viola[15], Steffi Grote[1], Elena Essel[1], David López Herráez[1], Sarah Nagel[1], Birgit Nickel[1], Julia Richter[1], Anna Schmidt[1], Benjamin Peter[1], Janet Kelso[1], Richard G. Roberts[5,6], Juan-Luis Arsuaga[4,16], Matthias Meyer[1]*

Science **372**, 6542

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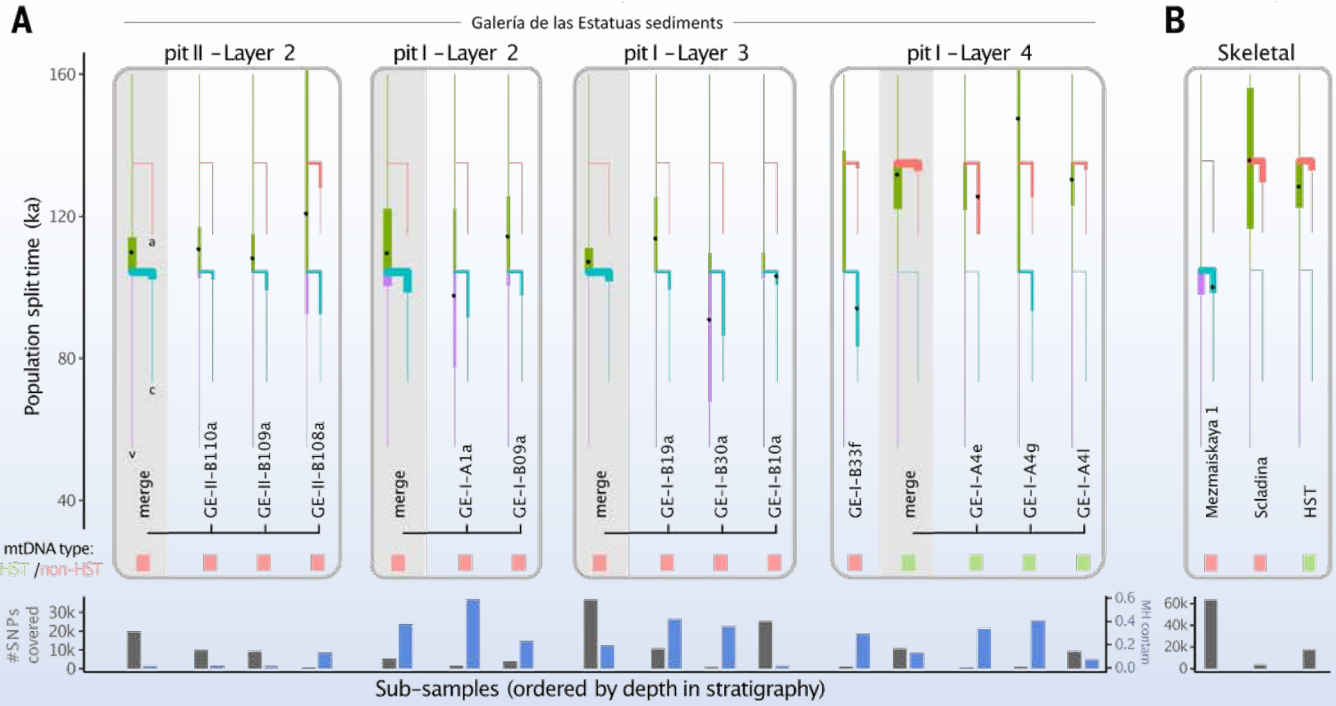
2021



PALEOGENOMICS

Unearthing Neanderthal population history using nuclear and mitochondrial DNA from cave sediments

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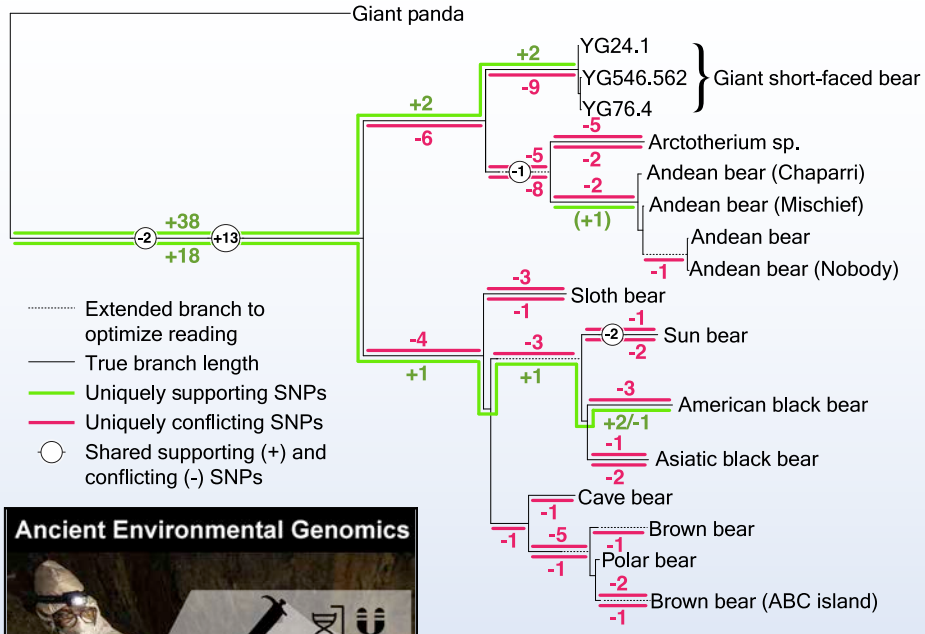

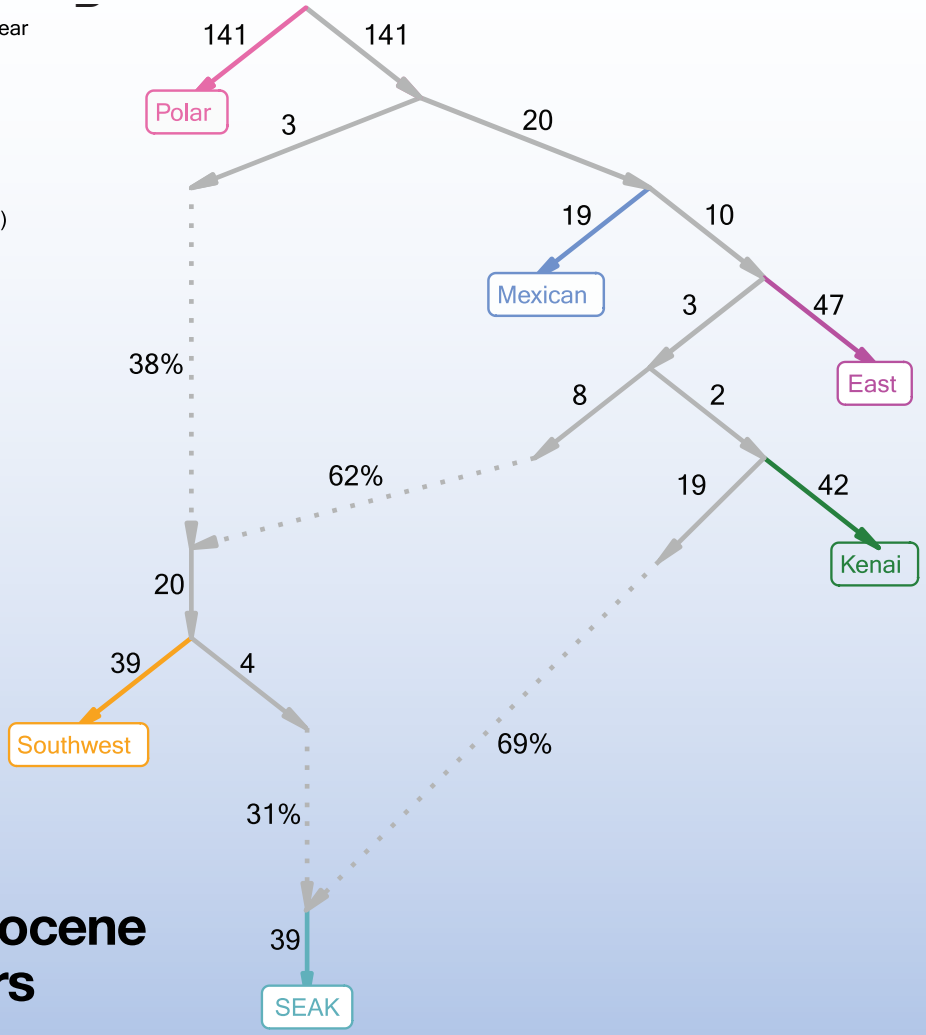

Environmental genomics of Late Pleistocene black bears and giant short-faced bears

Mikkel Winther Pedersen,[1,19,20] Bianca De Sanctis,[2,3,20] Nedda F. Saremi,[4] Martin Sikora,[1] Emily E. Puckett,[5] Zhenquan Gu,[6] Katherine L. Moon,[7] Joshua D. Kapp,[7] Lasse Vinner,[1] Zaruhi Vardanyan,[1] Ciprian F. Ardelean,[8,9] Joaquin Arroyo-Cabrales,[10] James A. Cahill,[11] Peter D. Heintzman,[12] Grant Zazula,[13] Ross D.E. MacPhee,[14,15] Beth Shapiro,[7,16,21] Richard Durbin,[3,17,21] and Eske Willerslev[1,2,17,18,21,22,*]

Current Biology **31**, 2021.04.027

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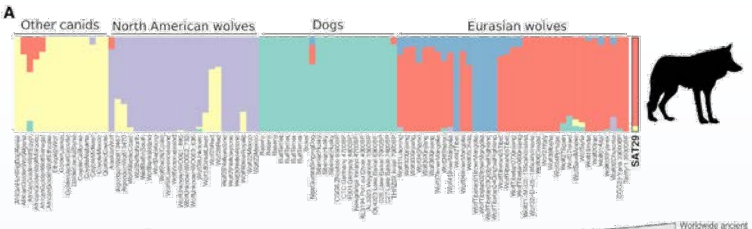

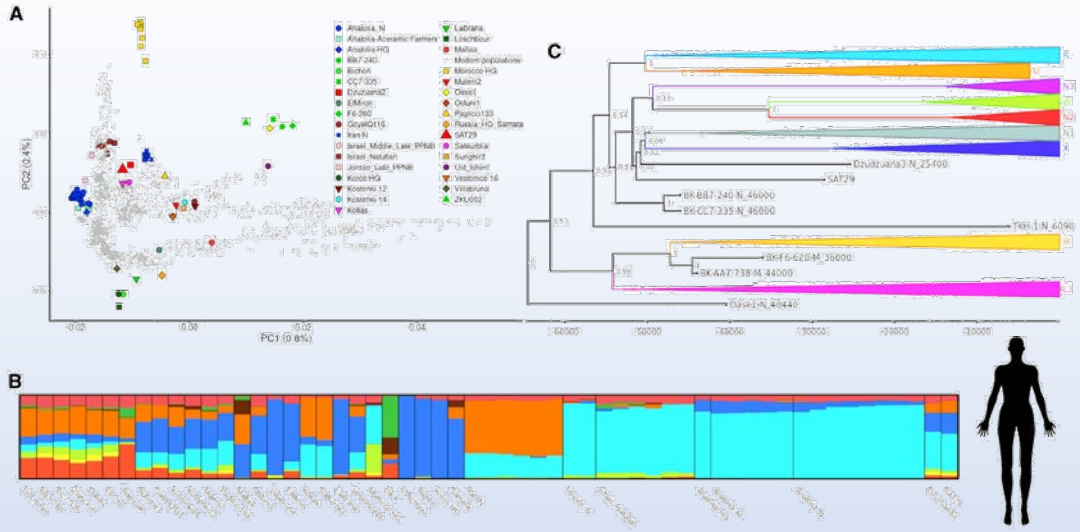

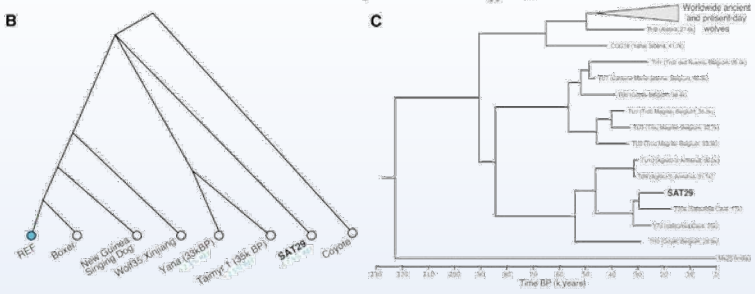

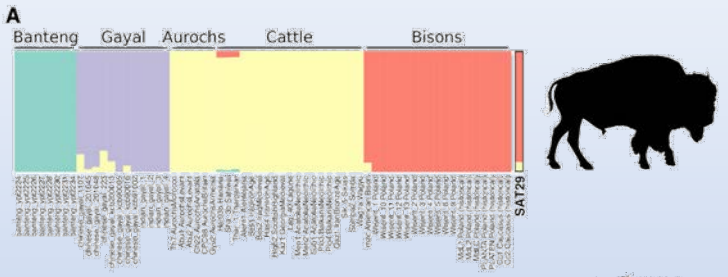

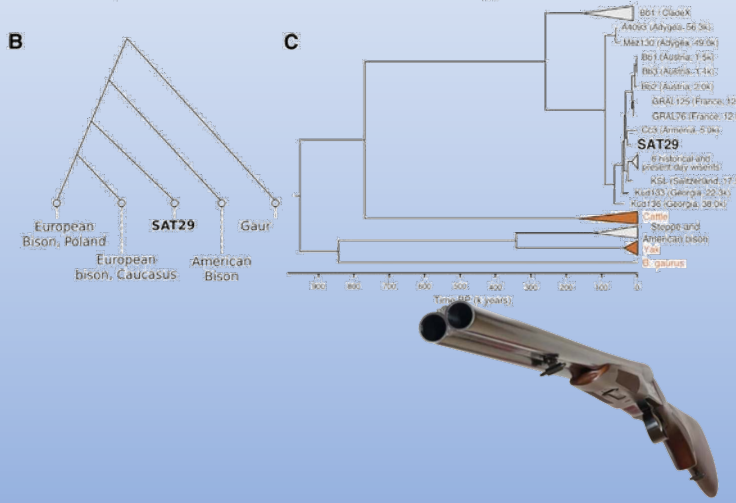

Genome-scale sequencing and analysis of human, wolf, and bison DNA from 25,000-year-old sediment

Pere Gelabert,[1,11,13,*] Susanna Sawyer,[1,11] Anders Bergström,[2,11,*] Ashot Margaryan,[3] Thomas C. Collin,[4] Tengiz Meshveliani,[5] Anna Belfer-Cohen,[6] David Lordkipanidze,[5] Nino Jakeli,[5] Zinovi Matskevich,[7] Guy Bar-Oz,[8] Daniel M. Fernandes,[1,9] Olivia Cheronet,[1] Kadir T. Özdoğan,[1] Victoria Oberreiter,[1] Robin N.M. Feeney,[4] Mareike C. Stahlschmidt,[10] Pontus Skoglund,[2,12,*] and Ron Pinhasi[1,12,*]

Current Biology **31**, 2021.06.023

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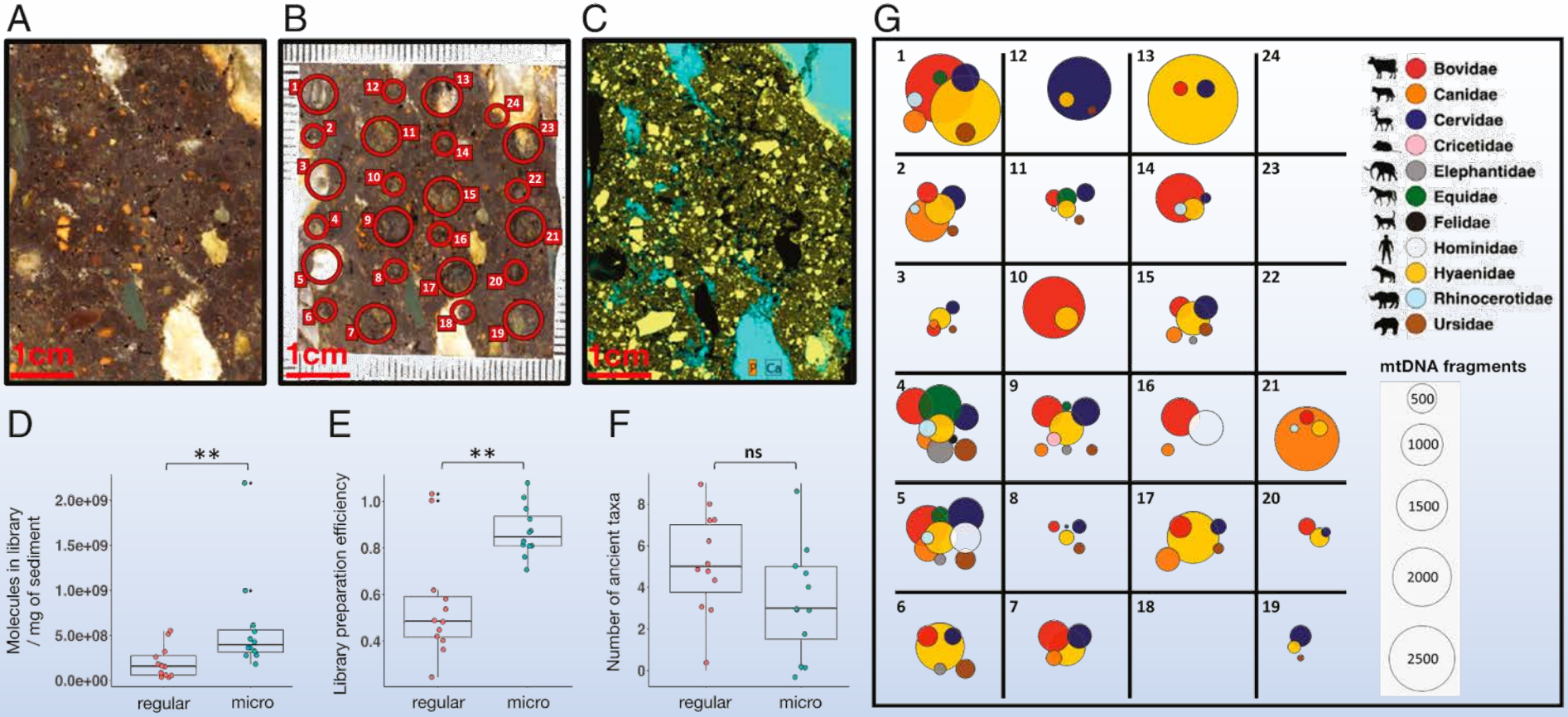

Microstratigraphic preservation of ancient faunal and hominin DNA in Pleistocene cave sediments

Diyendo Massilani[a,1], Mike W. Morley[b,1], Susan M. Mentzer[c,d], Vera Aldeias[e], Benjamin Vernot[a], Christopher Miller[c,d,f], Mareike Stahlschmidt[g], Maxim B. Kozlikin[h], Michael V. Shunkov[h], Anatoly P. Derevianko[h], Nicholas J. Conard[c,d], Sarah Wurz[f,i], Christopher S. Henshilwood[f,i], Javi Vasquez[j], Elena Essel[a], Sarah Nagel[a], Julia Richter[a], Birgit Nickel[a], Richard G. Roberts[k,l], Svante Pääbo[a,1], Viviane Slon[a,m,n,o], Paul Goldberg[d,k], and Matthias Meyer[a,1]

PNAS **119**, e2113666118.

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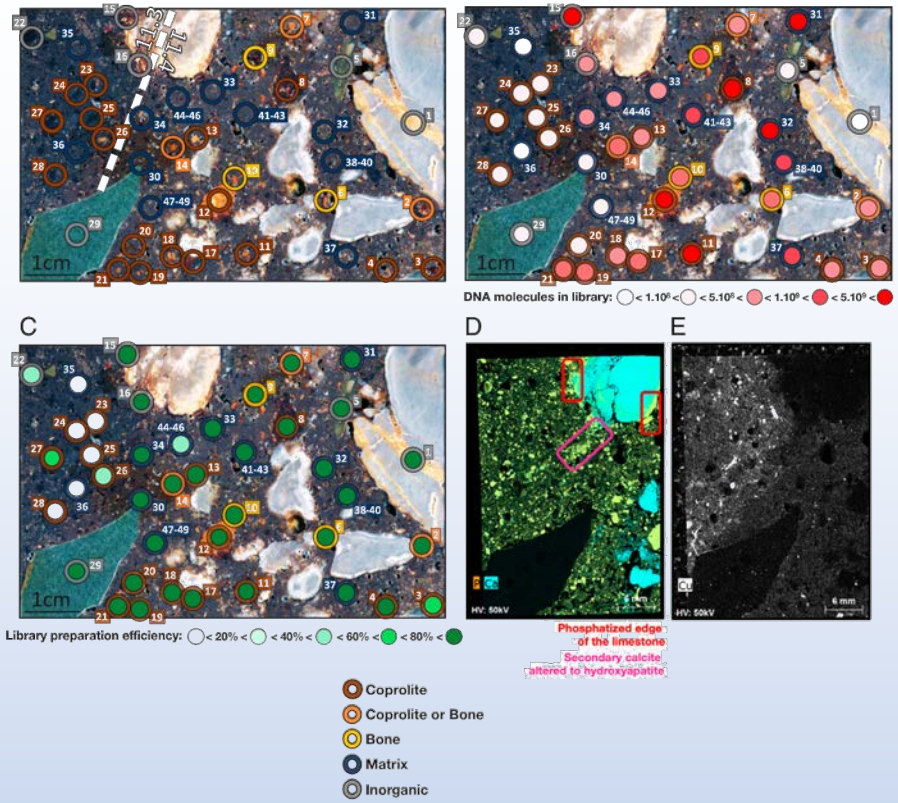

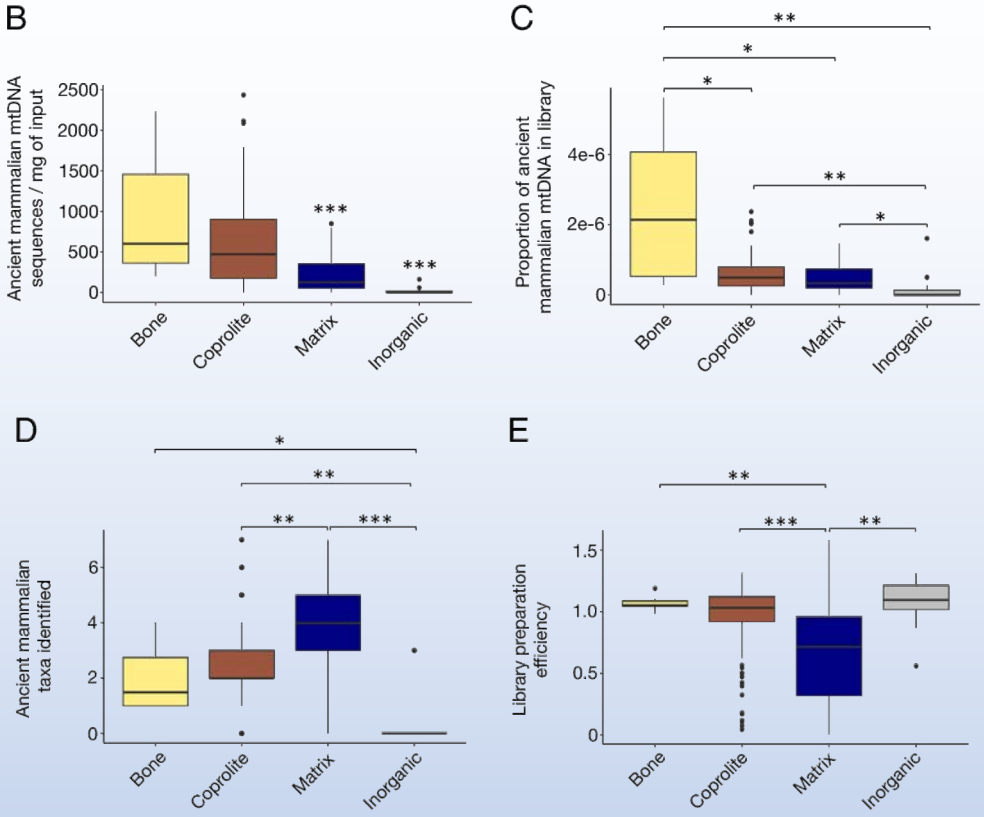

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PNAS **119**, e2113666118.

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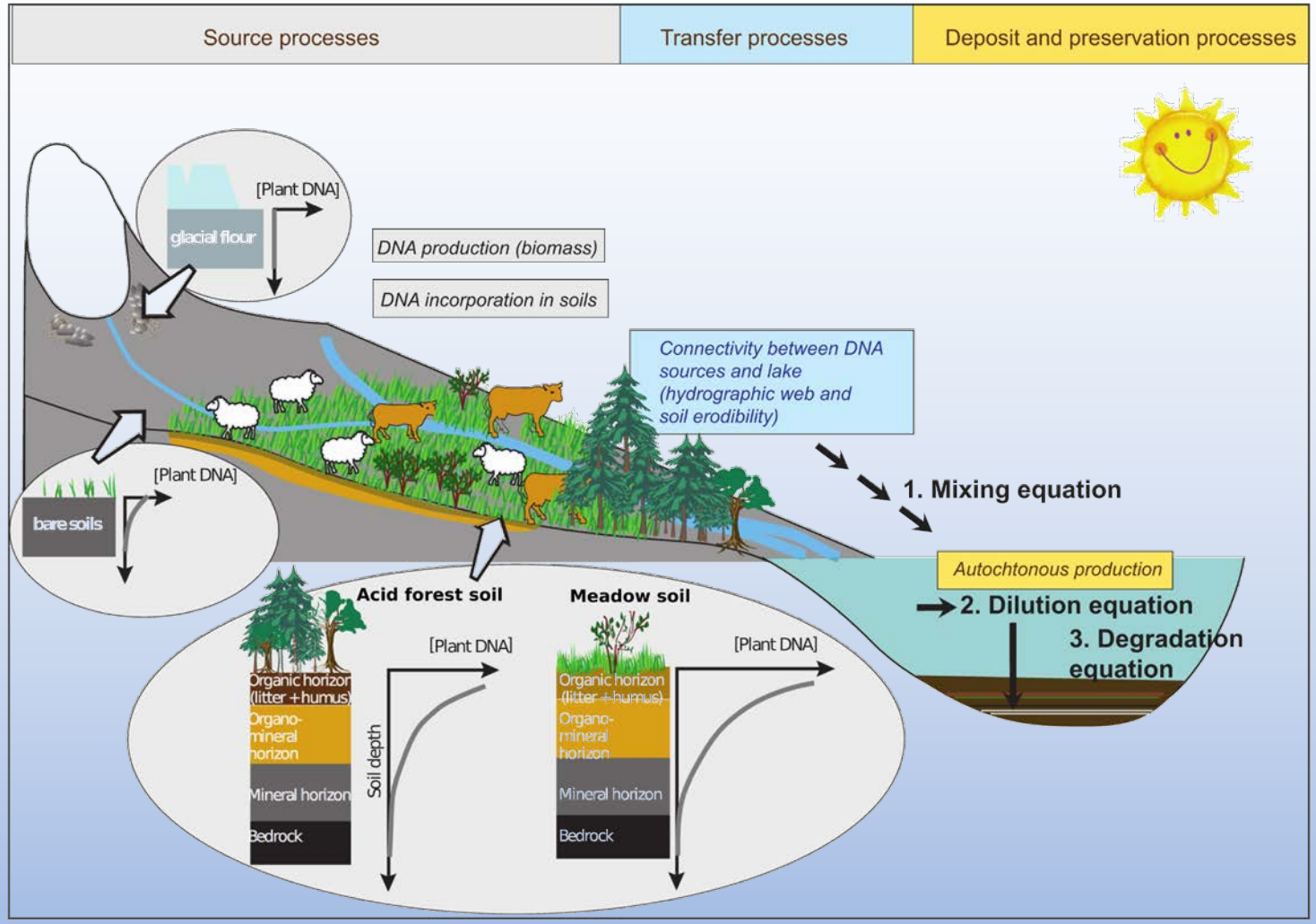
Ongoing issues in *sed*aDNA

Taphonomy



2019 *Scientific Reports* **9**, 14676

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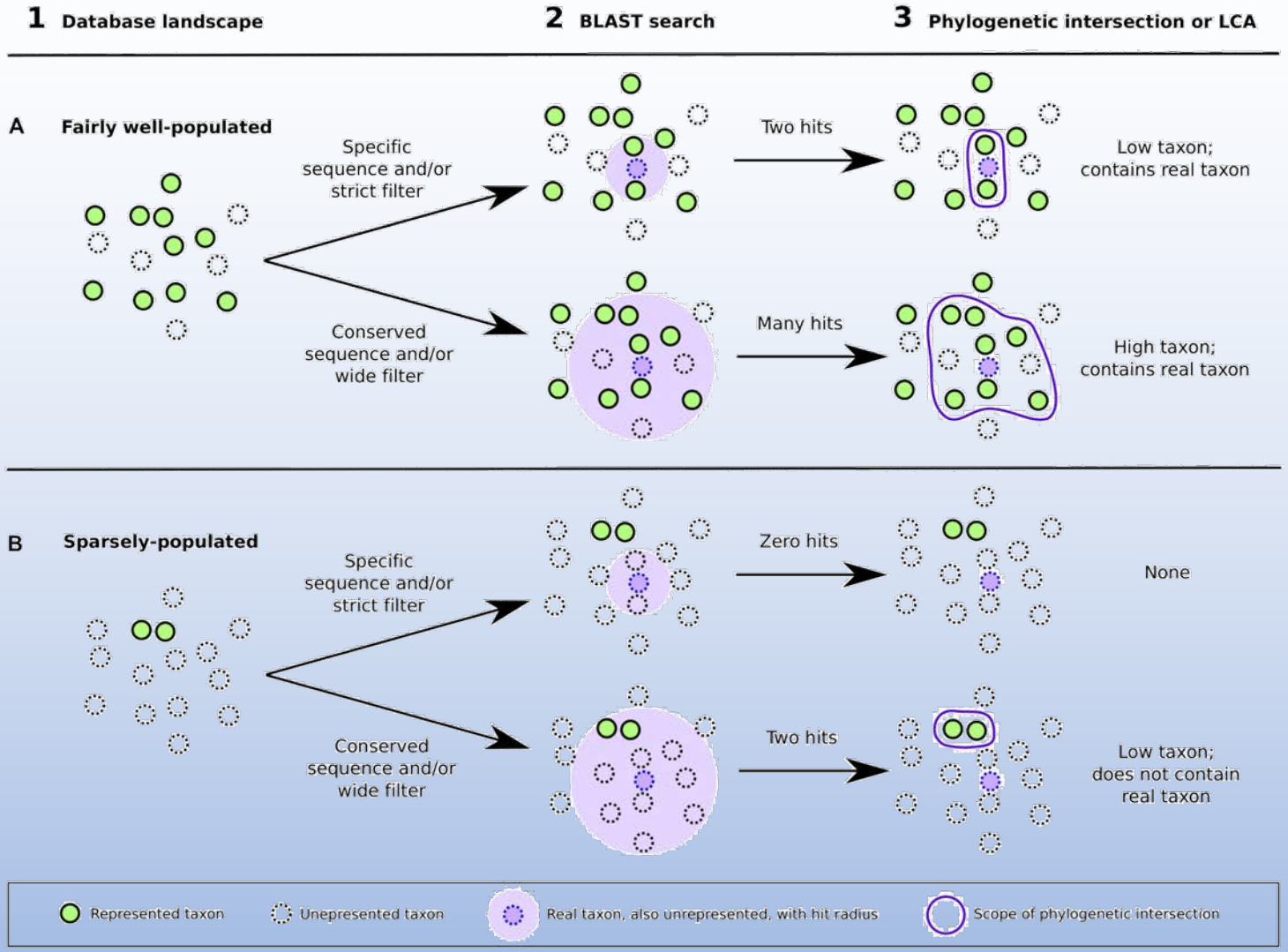
Bioinformatic refinements



2020 *Front. Ecol. Evol.* **8**, 84

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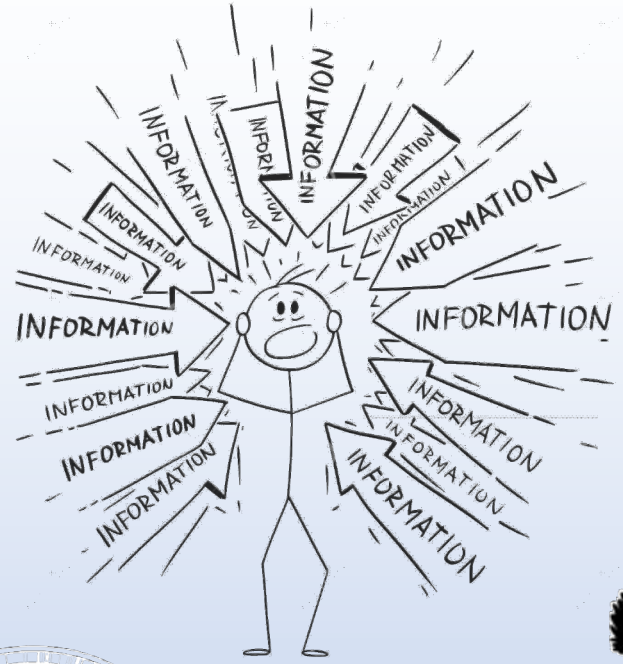
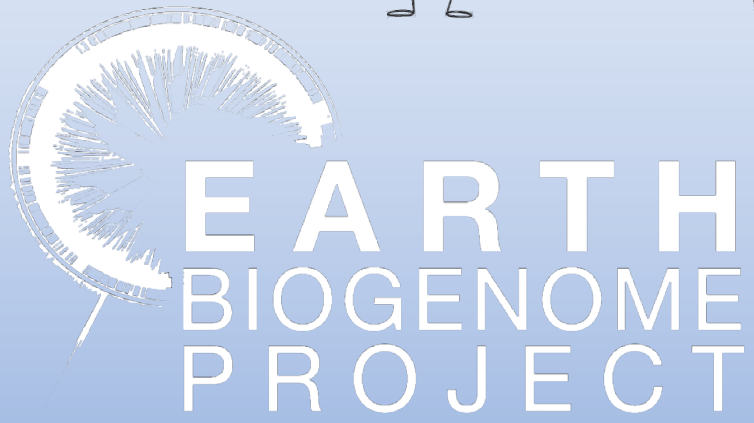
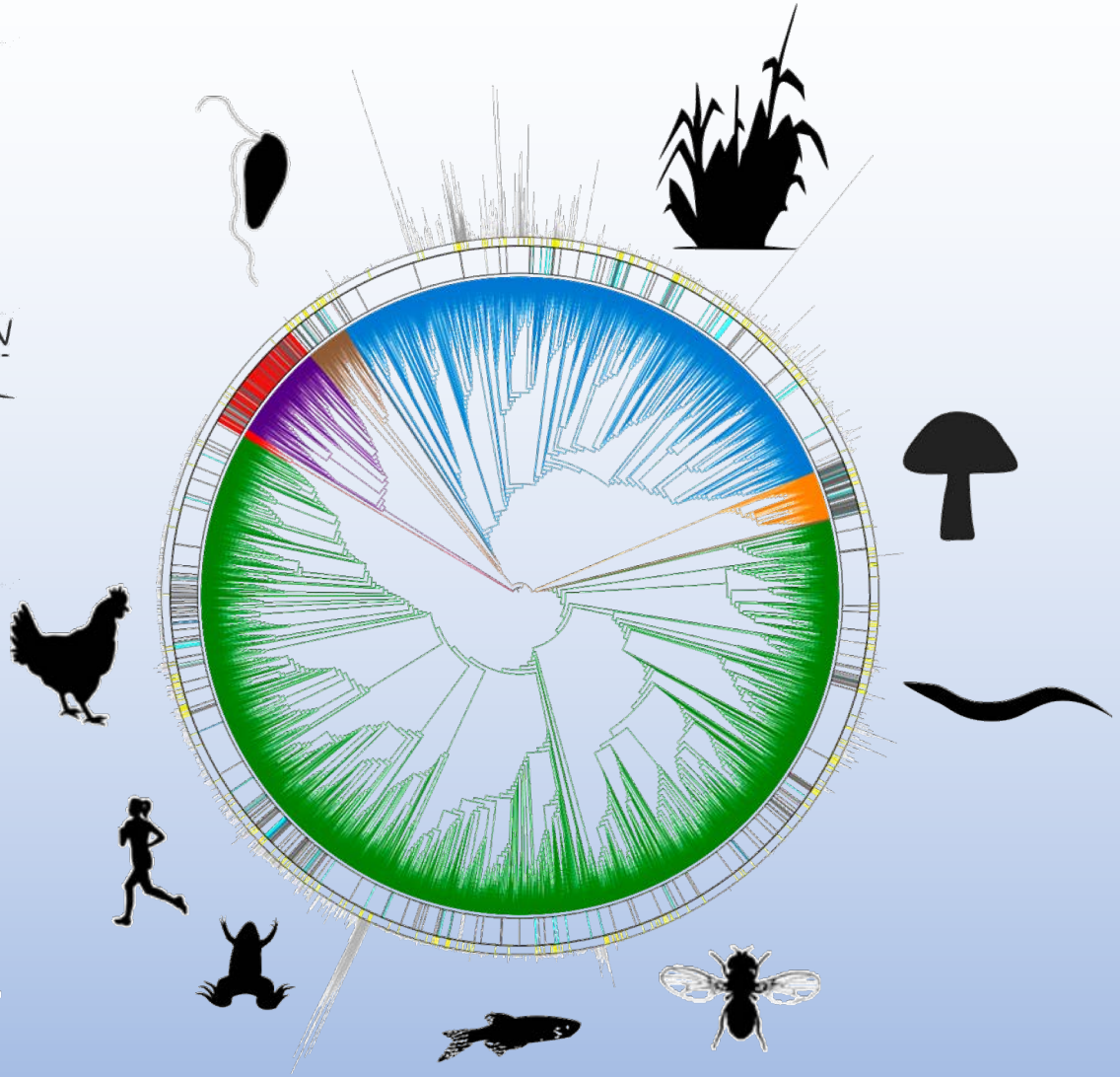
Reference databases







2018 *PNAS* **115**, 4325

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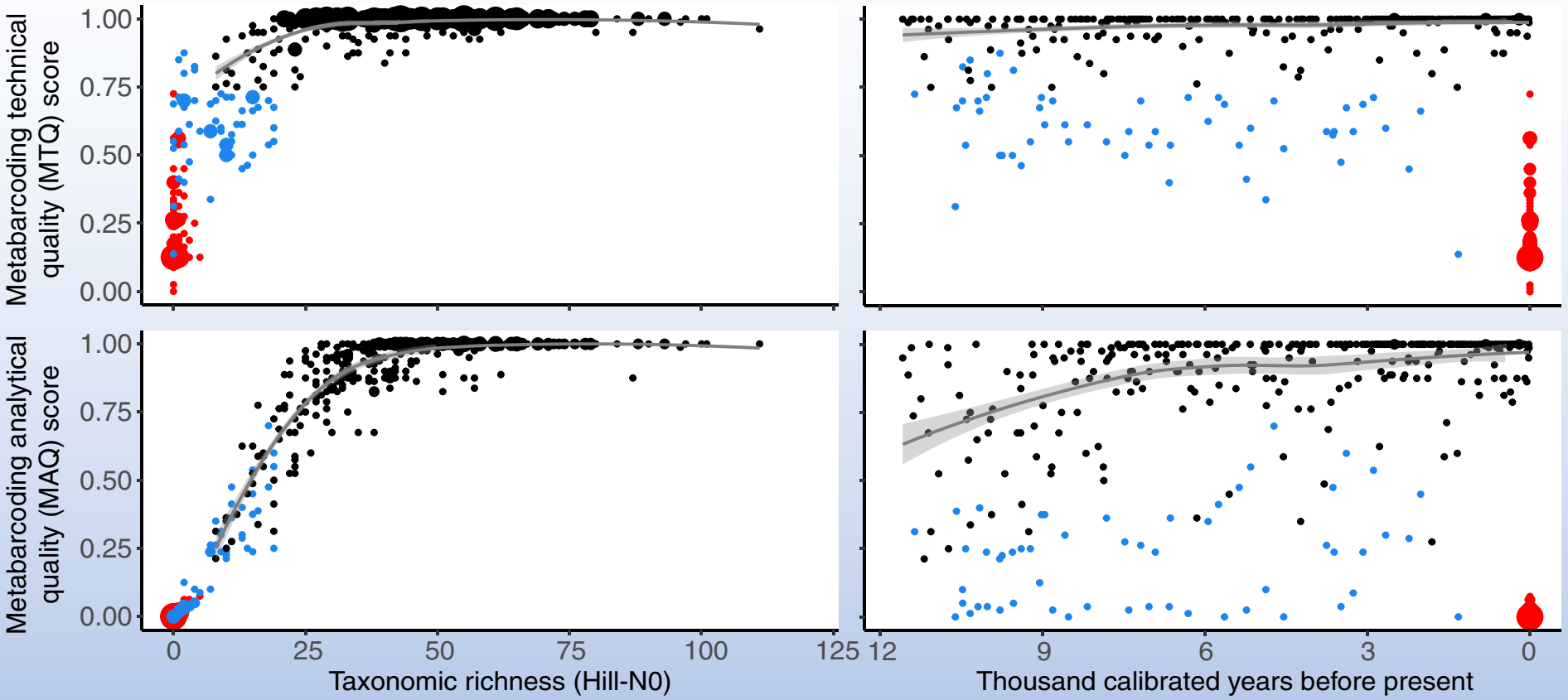
Data integration



2021 *Sci. Adv.* **7**, eabf9557

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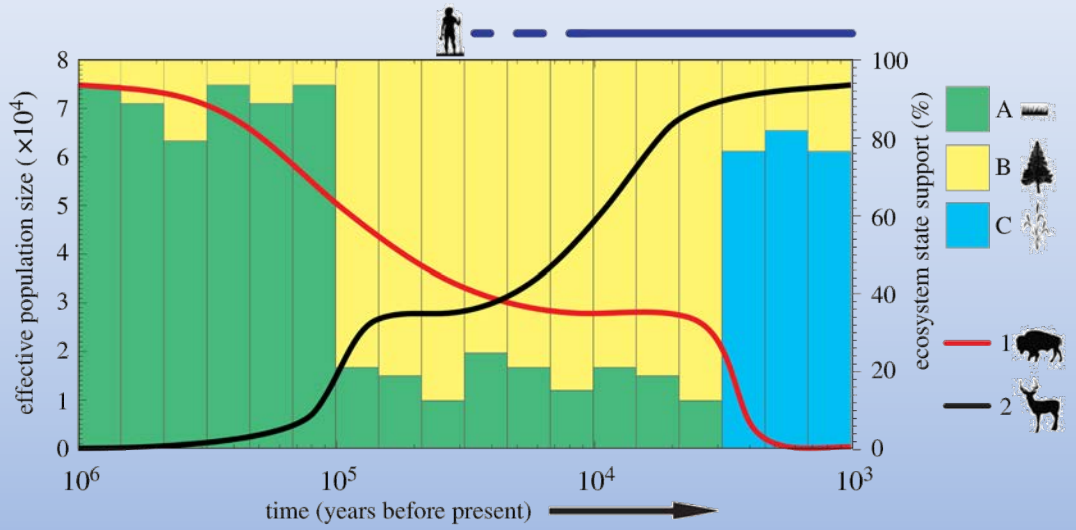
Data integration

Remains

Ancient DNA

Sediments



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Summary

- Ancient DNA from sediment can be used to reconstruct past environments over hundreds of thousands of years.
- Unknowns remain but progress is rapidly being made.
- Huge potential for environmental palaeogenomics applications.
- Many palaeoecological, environmental, and evolutionary questions still to explore!