Online Supplementary Information McInerney, Strömberg and White, *Paleobiology*, 2011

SUPPLEMENTARY TABLE 1. Purity of heavy liquid (phytolith) yields estimated by comparing relative abundances of different types of phytoliths, other biogenic silica, and non-biogenic silica.

TABLE 1A. Heavy liquid yield (dry weight) expressed as (mass extract)/(mass sample) (%), and numeric (unweighted) composition of heavy liquid yields expressed as proportion (%) in number of particles of different origin.

					Numeric (unweighted) composition (%)[1]																					
					DIP				NDG				NDO				OB				NB					
State	Sample number[2]	UWBM[3] number	Age (Ma)	Heavy liquid yield, dry weight (%)	<10 µm	10-50 µm	>50 µm	**DIP total**	<10 µm	10-50 µm	>50 µm	**NDG total**	<10 µm	10-50 µm	>50 µm	**NDO total**	<10 µm	10-50 µm	>50 µm	**OB total**	<10 µm	10-50 µm	>50 µm	**NB total**	Phytoliths, total numeric contribution	Total # particles counted
NE	**LS25**	4357	2-3	0.8	4.2	9.4	0.0	**13.5**	0.0	3.8	2.1	**5.9**	12.8	10.1	0.3	**23.3**	1.0	1.0	0.0	**2.1**	34.7	18.8	1.7	**55.2**	**42.7**	288
	LS24*	4358	2-3	3.5	0.0	0.4	0.0	**0.4**	0.0	0.4	0.0	**0.4**	1.1	3.6	0.4	**5.0**	1.8	0.7	0.0	**2.5**	57.3	32.4	2.1	**91.8**	**5.7**	281
	LS26	4359	5-5.5	2.2	5.1	14.3	0.7	**20.2**	0.0	8.8	1.8	**10.7**	10.3	20.2	0.7	**31.3**	0.7	2.6	0.4	**3.7**	19.5	12.9	1.8	**34.2**	**62.1**	272
	LS27	4360	5-5.5	1.7	9.2	8.8	0.4	**18.4**	0.0	10.7	1.5	**12.1**	19.1	10.3	1.1	**30.5**	2.9	2.6	0.0	**5.5**	21.3	10.3	1.8	**33.5**	**61.0**	272
	LS5*	4361	5-7	6.5	0.3	0.7	0.0	**1.0**	0.0	0.7	0.0	**0.7**	1.3	0.3	0.0	**1.6**	0.0	0.3	0.0	**0.3**	78.8	16.7	1.0	**96.4**	**3.3**	306
	LS4*	4362	5-7	8.9	0.0	0.0	0.3	**0.3**	0.0	0.3	0.0	**0.3**	3.0	1.3	0.0	**4.3**	0.3	0.0	0.0	**0.3**	76.6	16.8	1.3	**94.7**	**4.9**	304
	LS3	4363	5-7	1.0	0.9	1.7	0.0	**2.6**	0.0	0.6	0.0	**0.6**	2.0	1.4	0.0	**3.4**	0.0	0.0	0.0	**0.0**	83.7	9.1	0.6	**93.4**	**6.6**	350
	LS1*	4364	5-9	9.6	1.3	0.6	0.0	**1.9**	0.0	0.3	0.0	**0.3**	1.6	1.9	0.0	**3.5**	0.0	0.0	0.0	**0.0**	78.9	14.1	1.3	**94.2**	**5.8**	313
	LS13	4366	6-7	0.6	10.8	8.1	0.3	**19.2**	0.3	2.3	0.0	**2.6**	11.0	5.8	0.3	**17.2**	1.2	0.3	0.0	**1.5**	50.9	7.8	0.9	**59.6**	**39.0**	344
	LS12*	4367	6-7	1.4	0.9	1.5	0.3	**2.6**	0.0	0.3	0.0	**0.3**	1.5	2.6	0.3	**4.4**	0.0	0.0	0.0	**0.0**	50.9	40.4	1.5	**92.7**	**7.3**	344
	LS10*	4368	~7 (6-7)	0.6	0.6	1.8	0.0	**2.5**	0.0	0.9	0.3	**1.2**	1.5	1.8	0.3	**3.7**	0.3	0.0	0.0	**0.3**	73.5	16.9	1.8	**92.3**	**7.4**	325
	Kim-A2	4365	5-9	n/a	8.3	3.5	0.0	**11.8**	0.8	1.6	0.0	**2.4**	9.8	7.1	0.0	**16.9**	2.0	0.0	0.0	**2.0**	63.0	3.9	0.0	**66.9**	**31.1**	254
	LS23	4369	9-10	10.5	0.6	1.5	0.0	**2.2**	0.0	0.6	0.3	**0.9**	1.5	3.7	0.0	**5.2**	0.0	0.6	0.0	**0.6**	72.2	16.4	2.5	**91.0**	**8.3**	324
	LS19	4370	9.5-10.8	8.4	2.0	3.4	0.0	**5.4**	0.0	1.1	0.0	**1.1**	1.7	1.4	0.0	**3.1**	0.6	0.0	0.0	**0.6**	78.1	11.6	0.0	**89.8**	**9.7**	352
	LS16	4371	9.5-10.8	3.4	0.8	3.4	0.6	**4.8**	0.0	1.1	0.3	**1.4**	0.8	5.6	0.3	**6.7**	0.3	0.6	0.0	**0.8**	67.2	17.4	1.7	**86.3**	**12.9**	357
	LS22*	4372	11.55-12.18	2.3	0.3	1.3	0.3	**2.0**	0.0	1.6	0.0	**1.6**	0.0	1.3	0.3	**1.6**	0.0	0.3	0.0	**0.3**	76.0	15.5	3.0	**94.4**	**5.3**	304
	LS21	4373	11.55-12.18	2.5	0.6	0.0	0.0	**0.6**	0.0	1.4	0.0	**1.4**	0.6	2.6	1.1	**4.3**	0.3	0.6	0.0	**0.9**	76.2	15.2	1.4	**92.8**	**6.3**	349
	Dawes*	4374	17.5-18.8	n/a	0.0	0.6	0.3	**0.9**	0.0	0.3	0.0	**0.3**	0.0	2.2	0.0	**2.2**	0.3	0.0	0.0	**0.3**	72.3	21.5	2.5	**96.3**	**3.4**	325
KS	LS37	4375	5-9	5.9	0.8	1.8	0.3	**2.9**	0.0	2.1	0.0	**2.1**	1.8	2.1	0.0	**3.9**	1.0	0.0	0.0	**1.0**	57.4	31.3	1.3	**90.1**	**8.9**	383
	LS36	4376	5-9	2.0	0.8	3.0	0.5	**4.4**	0.0	1.1	0.3	**1.4**	1.1	0.8	0.3	**2.2**	0.0	1.1	0.0	**1.1**	57.8	30.1	3.0	**91.0**	**7.9**	365
	LS35*	4377	5-9	1.3	2.2	2.2	0.2	**4.7**	0.0	0.7	0.0	**0.7**	0.7	2.5	0.7	**4.0**	0.5	0.2	0.0	**0.7**	50.9	35.4	3.5	**89.8**	**9.5**	401
	LS43	4378	<8 (7-9)	1.0	1.4	1.7	0.0	**3.1**	0.0	1.0	0.2	**1.2**	1.7	3.6	0.0	**5.2**	1.7	1.0	0.0	**2.6**	57.2	29.9	0.7	**87.9**	**9.5**	421
	LS41*	4379	~8 (7-9)	1.4	2.5	2.2	0.0	**4.7**	0.0	0.3	0.3	**0.5**	1.6	1.9	0.0	**3.6**	0.0	0.0	0.0	**0.0**	75.3	15.6	0.3	**91.2**	**8.8**	365
	LS40	4380	~8 (7-9)	0.8	3.0	1.3	0.0	**4.3**	0.0	1.3	0.0	**1.3**	2.4	3.7	0.0	**6.0**	0.6	0.0	0.0	**0.6**	77.8	9.1	0.9	**87.7**	**11.7**	463
	Avg. All							**5.6**				**2.1**				**8.0**				**1.2**				**83.1**	**15.8**	
	Avg. 5 'pure'							**16.6**				**6.7**				**23.8**				**2.9**				**49.9**	**47.2**	

TABLE 1B. Volumetrically weighted composition (%) of heavy liquid yields. See text for explanation.

			Volumetric (weighted) composition (%)[1]																				
			DIP				NDG				NDO				OB				NB					
State	Sample number[2]	Age (Ma)	<10 µm	10-50 µm	>50 µm	**DIP total**	<10 µm	10-50 µm	>50 µm	**NDG total**	<10 µm	10-50 µm	>50 µm	**NDO total**	<10 µm	10-50 µm	>50 µm	**OB total**	<10 µm	10-50 µm	>50 µm	**NB total**	Phytoliths, total volumetric contribution	Purity class[4]
NE	**LS25**	2-3	0.0	12.2	0.0	**12.3**	0.0	5.0	21.7	**26.7**	0.1	13.1	3.6	**16.8**	0.0	1.4	0.0	**1.4**	0.2	24.5	18.1	**42.8**	55.8	p
	LS24*	2-3	0.0	0.6	0.0	**0.6**	0.0	0.6	0.0	**0.6**	0.0	6.2	4.9	**11.1**	0.0	1.2	0.0	**1.3**	0.5	56.2	29.7	**86.4**	12.4	np
	LS26	5-5.5	0.0	13.9	5.7	**19.6**	0.0	8.6	14.3	**22.8**	0.0	19.6	5.7	**25.4**	0.0	2.5	2.9	**5.4**	0.1	12.5	14.3	**26.8**	67.8	p
	LS27	5-5.5	0.1	10.9	3.6	**14.6**	0.0	13.1	14.5	**27.6**	0.1	12.7	10.9	**23.7**	0.0	3.2	0.0	**3.2**	0.1	12.7	18.1	**30.9**	65.9	p
	LS5*	5-7	0.0	2.4	0.0	**2.4**	0.0	2.4	0.0	**2.4**	0.0	1.2	0.0	**1.2**	0.0	1.2	0.0	**1.2**	1.4	62.1	29.2	**92.7**	6.1	np
	LS4*	5-7	0.0	0.0	8.2	**8.2**	0.0	1.0	0.0	**1.0**	0.0	4.1	0.0	**4.2**	0.0	0.0	0.0	**0.0**	1.1	52.5	32.9	**86.6**	13.4	np
	LS3	5-7	0.0	9.6	0.0	**9.6**	0.0	3.2	0.0	**3.2**	0.1	8.0	0.0	**8.1**	0.0	0.0	0.0	**0.0**	2.2	51.3	25.6	**79.1**	20.9	lp
	LS1*	5-9	0.0	2.3	0.0	**2.3**	0.0	1.2	0.0	**1.2**	0.0	7.0	0.0	**7.0**	0.0	0.0	0.0	**0.0**	1.3	51.1	37.1	**89.5**	10.5	np
	LS13	6-7	0.1	22.4	6.4	**28.9**	0.0	6.4	0.0	**6.4**	0.1	16.0	6.4	**22.5**	0.0	0.8	0.0	**0.8**	0.6	21.6	19.2	**41.4**	57.8	p
	LS12*	6-7	0.0	2.4	3.8	**6.2**	0.0	0.5	0.0	**0.5**	0.0	4.3	3.8	**8.1**	0.0	0.0	0.0	**0.0**	0.4	65.9	19.0	**85.3**	14.7	np
	LS10*	~7 (6-7)	0.0	4.4	0.0	**4.4**	0.0	2.2	5.9	**8.1**	0.0	4.4	5.9	**10.4**	0.0	0.0	0.0	**0.0**	0.8	40.7	35.5	**77.0**	23.0	lp
	Kim-A2	5-9	0.2	21.4	0.0	**21.7**	0.0	9.5	0.0	**9.5**	0.3	42.9	0.0	**43.1**	0.1	0.0	0.0	**0.1**	1.8	23.8	0.0	**25.6**	74.4	p
	LS23	9-10	0.0	3.4	0.0	**3.4**	0.0	1.4	5.4	**6.8**	0.0	8.2	0.0	**8.2**	0.0	1.4	0.0	**1.4**	0.7	36.0	43.5	**80.3**	18.4	np
	LS19	9.5-10.8	0.1	18.9	0.0	**19.0**	0.0	6.3	0.0	**6.3**	0.0	7.9	0.0	**7.9**	0.0	0.0	0.0	**0.0**	2.0	64.7	0.0	**66.7**	33.2	lp
	LS16	9.5-10.8	0.0	6.6	8.8	**15.5**	0.0	2.2	4.4	**6.6**	0.0	11.0	4.4	**15.5**	0.0	1.1	0.0	**1.1**	0.6	34.2	26.5	**61.3**	37.6	lp
	LS22*	11.55-12.18	0.0	2.7	5.3	**8.0**	0.0	3.3	0.0	**3.3**	0.0	2.7	5.3	**8.0**	0.0	0.7	0.0	**0.7**	0.7	31.3	48.0	**80.0**	19.3	np
	LS21	11.55-12.18	0.0	0.0	0.0	**0.0**	0.0	3.5	0.0	**3.5**	0.0	6.3	22.5	**28.8**	0.0	1.4	0.0	**1.4**	0.9	37.3	28.1	**66.2**	32.3	lp
	Dawes*	17.5-18.8	0.0	1.3	5.2	**6.5**	0.0	0.7	0.0	**0.7**	0.0	4.6	0.0	**4.6**	0.0	0.0	0.0	**0.0**	0.7	45.7	41.8	**88.2**	11.8	np
KS	LS37	5-9	0.0	3.6	4.2	**7.8**	0.0	4.2	0.0	**4.2**	0.0	4.2	0.0	**4.2**	0.0	0.0	0.0	**0.0**	0.5	62.5	20.8	**83.8**	16.2	np
	LS36	5-9	0.0	4.3	6.3	**10.7**	0.0	1.6	3.2	**4.7**	0.0	1.2	3.2	**4.4**	0.0	1.6	0.0	**1.6**	0.4	43.5	34.8	**78.6**	19.8	np
	LS35*	5-9	0.0	2.9	2.6	**5.5**	0.0	1.0	0.0	**1.0**	0.0	3.2	7.7	**11.0**	0.0	0.3	0.0	**0.3**	0.3	45.8	36.1	**82.2**	17.4	np
	LS43	<8 (7-9)	0.0	3.7	0.0	**3.7**	0.0	2.1	4.2	**6.3**	0.0	7.9	0.0	**7.9**	0.0	2.1	0.0	**2.1**	0.6	66.6	12.7	**79.9**	18.0	np
	LS41*	~8 (7-9)	0.0	8.9	0.0	**8.9**	0.0	1.1	8.9	**10.0**	0.0	7.7	0.0	**7.8**	0.0	0.0	0.0	**0.0**	1.4	63.1	8.9	**73.4**	26.6	lp
	LS40	~8 (7-9)	0.1	5.7	0.0	**5.8**	0.0	5.7	0.0	**5.7**	0.0	16.2	0.0	**16.3**	0.0	0.0	0.0	**0.0**	1.6	40.1	30.5	**72.2**	27.8	lp
	Avg. All					**9.4**				**7.1**				**12.8**				**0.9**				**69.9**	**29.2**	
	Avg. 5 'pure'					**19.4**				**18.6**				**26.3**				**2.2**				**33.5**	**64.3**	

[1] DIP = diagnostic phytoliths; NDG = non-diagnostic (potential) grass phytoliths (e.g., cuneiform bulliforms, elongate sinuous, echinate, and dendritic, acicular hair cells); NDO = non-diagnostic phytoliths; OB = other biosilica, including diatoms, sponge spicules, and chrysophyte cysts; NB = volcanic ash and other non-biogenic silica; Phytoliths total contribution = DIP + NDG + NDO.

[2] Samples identified in bold are "pure."

[3] UWBM = University of Washington Burke Museum of Natural History and Culture.

[4] p = pure; >50% phytoliths by volume; lp = less pure; 20-50% phytoliths by volume; np = not pure; <20% phytoliths by volume.

* Assemblages not included in quantitative assemblage analysis because of insufficient preservation.

SUPPLEMENTARY TABLE 2. Stable carbon isotope ratios and phytolith assemblage composition of biosilica extracted from Neogene paleosols from Nebraska and Kansas.[1]

			Stable carbon isotopes			Preservation		Non-biog. silica[4]		Non-phytolith biog. silica[4]			Phytolith morphotypes, relative abundance of total count (%)[5]												
													DIP		GSSC	PACMAD TOT						Tree cover			
State	Sample number	Absolute age (Ma)	$\delta^{13}C$ (‰ VPDB)	Standard deviation (‰)	# Replicate measurements	Qualitative[2]	Semi-quantitative index[3]	Secondary silica	Volcanic ash	Diatoms	Chrysophyte cysts	Sponge spicules	AQ	FI TOT (incl. Palm)	CH TOT + POOID-D + POOID-ND	PAN + CHLOR	PACMAD general	OTHG	NDG	NDO	Grass % out of DIP + NDG	FI-t ratio (%)	FI-t ratio 95% C.I. (%)	FI TOT+GSSC count	Total phytolith count
NE	**LS25**	2-3	-17.1	0.35	2	G (et, fra)	2.5	p	mab	p	n.o.	n.o.	0.3	7.5	20.5	3.6	5.2	7.8	17.6	37.5	87.5	16.8	(12.6-21.0)	309	693
	LS24*	2-3	-23	1.55	3	G	2	mab	vab	p	n.o.	n.o.	n.o.	p	p	n.o.	n.o.	p	n.o.	p	N/A	N/A	N/A	N/A	N/A
	LS26	5-5.5	-20.6	0	1	G (et, alt)	2.5	mab	p	p-mab	p	p	0.3	6.8	14.1	9.4	6.3	5.1	19.1	38.9	88.5	16.2	(12.0-20.4)	284	681
	LS27	5-5.5	-21.3	0.9	2	G (et)	2	n.o.	p	p	p	p	0.4	7.8	12.0	9.5	5.9	6.3	19.2	39.0	86.6	18.8	(14.5-23.4)	304	735
	LS5*	5-7	-25.5	0.24	2	(G-)P (et, alt)	0.5	ab	ab	p	n.o.	n.o.	n.o.	p	p	p	p	p	p	p	N/A	N/A	N/A	N/A	N/A
	LS4*	5-7	-24.8	0	1	VP (et, alt)	0	ab	vab	p	n.o.	n.o.	p	p	p	n.o.	p	p	p	p	N/A	N/A	N/A	N/A	N/A
	LS3	5-7	-25.8	0.23	2	G(-P) (et, alt)	1	ab	ab	n.o.	n.o.	n.o.	0.1	13.1	15.4	1.2	5.2	6.9	14.0	44.2	76.3	31.4	(26.8-36.1)	388	930
	LS1*	5-9	-26.5	0	1	(G-)VP (et, alt)	0.5	ab	ab	p	n.o.	n.o.	p	p	p	p	p	p	p	p	N/A	N/A	N/A	N/A	N/A
	LS13	6-7	-27.9	0.07	2	G(-P) (et)	1.5	p	mab	p	n.o.	p	0.4	3.1	27.4	1.9	10.2	14.5	9.1	33.4	94.8	5.4	(3.0-8.1)	296	518
	LS12*	6-7	-29.6	0.44	2	(G-)VP (et, alt)	0	ab	vab	n.o.	p	p	n.o.	p	p	n.o.	p	p	p	p	N/A	N/A	N/A	N/A	N/A
	LS10*	~7 (6-7)	-14.3	0.89	2	(G-)VP (et, alt)	0	ab	ab	p	n.o.	n.o.	n.o.	p	p	p	n.o.	p	p	p	N/A	N/A	N/A	N/A	N/A
	Kim-A2	5-9	-23.7	0	1	G (fra)	3	p	p	p	n.o.	n.o.	0.0	4.4	24.2	0.7	5.0	9.0	12.0	44.6	92.0	10.2	(6.8-13.9)	294	677
	LS23	9-10	-17	0.43	3	(G-)P (alt)	1	ab	ab	p	n.o.	n.o.	0.0	14.2	11.1	0.9	6.8	4.6	17.4	44.9	74.1	37.8	(31.9-44.1)	238	632
	LS19	9.5-10.8	-17.1	0.47	7	G-P (alt)	1.5	ab	ab	p	p	p	0.2	5.6	33.3	3.1	5.4	9.4	10.9	32.0	91.4	9.9	(6.6-13.6)	272	478
	LS16	9.5-10.8	-20.9	0.37	4	G	3	p	mab	p	p	p	0.4	23.1	15.5	0.9	5.7	5.9	10.7	38.0	62.0	45.4	(41.0-49.8)	478	938
	LS22*	11.55-12.18 ± 0.12	-24.3	0.24	2	VP (alt)	0	ab	vab	p	n.o.	n.o.	n.o.	p	p	n.o.	n.o.	p	p	p	N/A	N/A	N/A	N/A	N/A
	LS21	11.55-12.18 ± 0.12	-20.1	0.07	2	P(-VP) (alt)	0.5	ab	vab	p	p	n.o.	0.0	10.6	5.4	1.5	2.4	2.8	16.0	61.3	72.6	46.7	(37.1-56.2)	105	462
	Dawes*	17.5-18.8	-27.2	0	1	P(-VP) (et, alt)	0.5	mab	vab	p	n.o.	n.o.	p	p	p	n.o.	n.o.	n.o.	p	p	N/A	N/A	N/A	N/A	N/A
KS	LS37	5-9	-18.4	0	1	G	2.5	mab	ab	p	n.o.	n.o.	0.3	3.7	23.7	3.3	8.2	9.7	15.8	35.3	93.8	7.5	(4.7-10.8)	279	575
	LS36	5-9	-13.3	0	1	G (et, alt)	2	n.o.	ab	p-mab	p	n.o.	0.5	5.1	20.4	6.6	9.6	7.4	21.7	28.8	92.2	10.3	(6.9-13.7)	291	594
	LS35*	5-9	-13.5	0.78	2	VP (et, alt)	0	ab	ab	p?	p	p	n.o.	p	p	n.o.	p	p	p	p	N/A	N/A	N/A	N/A	N/A
	LS43	<8 (7-9)	-18.3	1	2	G(-P) (et)	1.5	n.o.	ab	p	p	n.o.	0.0	4.7	21.6	2.8	6.3	12.4	11.6	40.6	92.0	9.9	(6.7-13.5)	312	653
	LS41*	~8 (7-9)	-19	0.54	3	P(-VP) (et, alt)	0.5	ab	ab	n.o.	n.o.	n.o.	n.o.	p	p	n.o.	p	p	p	p	N/A	N/A	N/A	N/A	N/A
	LS40	~8 (7-9)	-24	0.03	2	G (et, alt)	2	p	mab	p	p	n.o.	0.3	6.1	22.7	1.9	5.3	12.4	12.1	39.1	89.5	12.5	(9.2-16.2)	327	675

[1] N/A = not applicable.

[2] G = good-pristine (occluded organic material and fine ornamentation routinely preserved on GSSC; elongates and bulliform cells may be etched or broken); P = poor (occluded material often missing and GSSC commonly broken or etched; elongates and bulliform cells often etched or broken); VP = very poor (phytoliths fragmentary or structurally/texturally altered to such a degree that identification is complicated); alt = altered; et = etched, fra = fragmented.

[3] 0-3; 3 = pristine, 2 = good, 1 = OK, 0 = poor-very poor.

[4] Semiquantitative estimation: n.o. = not observed; p = present (rare); mab = moderately abundant; ab = abundant; vab = very abundant.

[5] AQ = phytoliths from wetland plants (e.g., *Equisetum*, sedges); FI TOT = morphotypes typical of forest indicators (e.g., palms, woody and herbaceous dicotyledons, ferns, conifers); CH TOT = GSSCs produced primarily by members of the BE (Bambusoideae, Ehrhartoideae) clade (e.g., GPWG 2001) plus basal grasses; POOID-D + POOID-ND = GSSCs produced mainly by Pooideae; PAN + CHLOR = morphotypes of Panicoideae and Chloridoideae grasses; PACMAD general = morphotypes of (other) C_3/C_4 grasses in the PACMAD clade (Panicoideae, Arundinoideae, Chloridoideae, Micrairoideae, Aristidoideae and Danthonioideae; Duvall et al. 2007); OTHG = other, non-diagnostic or unidentified GSSC; NDG = non-diagnostic (potential) grass phytoliths; NDO = non-diagnostic and indeterminable phytoliths.

* Assemblages not included in quantitative assemblage analysis because of insufficient preservation.

SUPPLEMENTARY TABLE 3. Abundances of C_4 grasses in the Neogene of Nebraska and Kansas based on phytolith assemblages and carbon isotope ratios, respectively.[1]

				C_4 abundance in overall vegetation				C_4 abundance within grass community				
				Minimum estimate		Maximum estimate		Minimum estimate		Maximum estimate		
State	Sample number	Absolute age (Ma)	FI TOT+GSSC count	[(PAN+CHLOR) / (GSSC-OTHG)]* [GSSC/ (FI TOT +GSSC)] (%)	95% C.I. (%) [2]	[(PACMAD TOT) / (GSSC-OTHG)]* [GSSC/ (FI TOT+GSSC)] (%)	95% C.I. (%) [2]	(PAN+CHLOR) / (GSSC-OTHG) (%)	95% C.I. (%) [2]	(PACMAD TOT) / (GSSC-OTHG) (%)	95% C.I. (%) [2]	C_4 abundance based on $\delta^{13}C$ (%)
NE	**LS25**	2-3	309	10.2	(6.6-13.9)	25.0	(19.7-30.3)	12.3	(7.9-16.2)	30.0	(23.6-36.5)	83
	LS24*	2-3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	33
	LS26	5-5.5	284	26.4	(21.1-32.2)	44.2	(38.4-50.2)	31.5	(25.1-38.4)	52.7	(45.8-59.9)	53
	LS27	5-5.5	304	28.3	(23.0-33.6)	45.7	(40.0-50.9)	34.8	(28.4-41.3)	56.2	(49.3-62.7)	48
	LS5*	5-7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13
	LS4*	5-7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	18
	LS3	5-7	388	3.7	(1.7-6.1)	20.0	(16.0-24.1)	5.4	(2.5-8.9)	29.2	(23.3-35.1)	10
	LS1*	5-9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4
	LS13	6-7	296	4.6	(1.8-7.4)	29.1	(23.8-35.3)	4.9	(2.0-7.8)	30.7	(25.1-37.3)	-7
	LS12*	6-7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-22
	LS10*	~7 (6-7)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	106
	Kim-A2	5-9	294	2.2	(0.4-4.4)	17.3	(12.8-22.1)	2.5	(0.5-4.9)	19.2	(14.3-24.6)	28
	LS23	9-10	238	3.1	(1.0-5.7)	25.6	(19.9-30.8)	5.0	(1.7-9.2)	41.2	(31.9-49.6)	83
	LS19	9.5-10.8	272	6.8	(3.6-9.9)	18.5	(13.5-23.9)	7.5	(4.0-11.0)	20.5	(15.0-26.5)	83
	LS16	9.5-10.8	478	2.1	(0.8-3.7)	16.2	(12.9-19.6)	3.9	(1.5-6.8)	29.6	(23.5-35.9)	51
	LS22*	11.55-12.18 ± 0.12	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	23
	LS21	11.55-12.18 ± 0.12	105	8.7	(3.7-14.9)	22.3	(14.9-29.8)	16.3	(7.0-27.9)	41.9	(27.9-55.8)	58
	Dawes*	17.5-18.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-2
KS	LS37	5-9	279	8.7	(5.0-12.4)	30.2	(24.3-36.6)	9.4	(5.4-13.4)	32.7	(26.2-39.6)	72
	LS36	5-9	291	16.1	(12.0-20.7)	39.7	(33.9-45.5)	18.0	(13.4-23.0)	44.2	(37.8-50.7)	114
	LS35*	5-9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	113
	LS43	<8 (7-9)	312	8.1	(5.0-11.7)	26.6	(21.2-32.4)	9.0	(5.5-13.0)	29.5	(23.5-36.0)	73
	LS41*	~8 (7-9)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	67
	LS40	~8 (7-9)	327	5.6	(3.0-8.7)	21.2	(16.0-27.3)	6.4	(3.5-9.9)	24.3	(18.3-31.2)	25

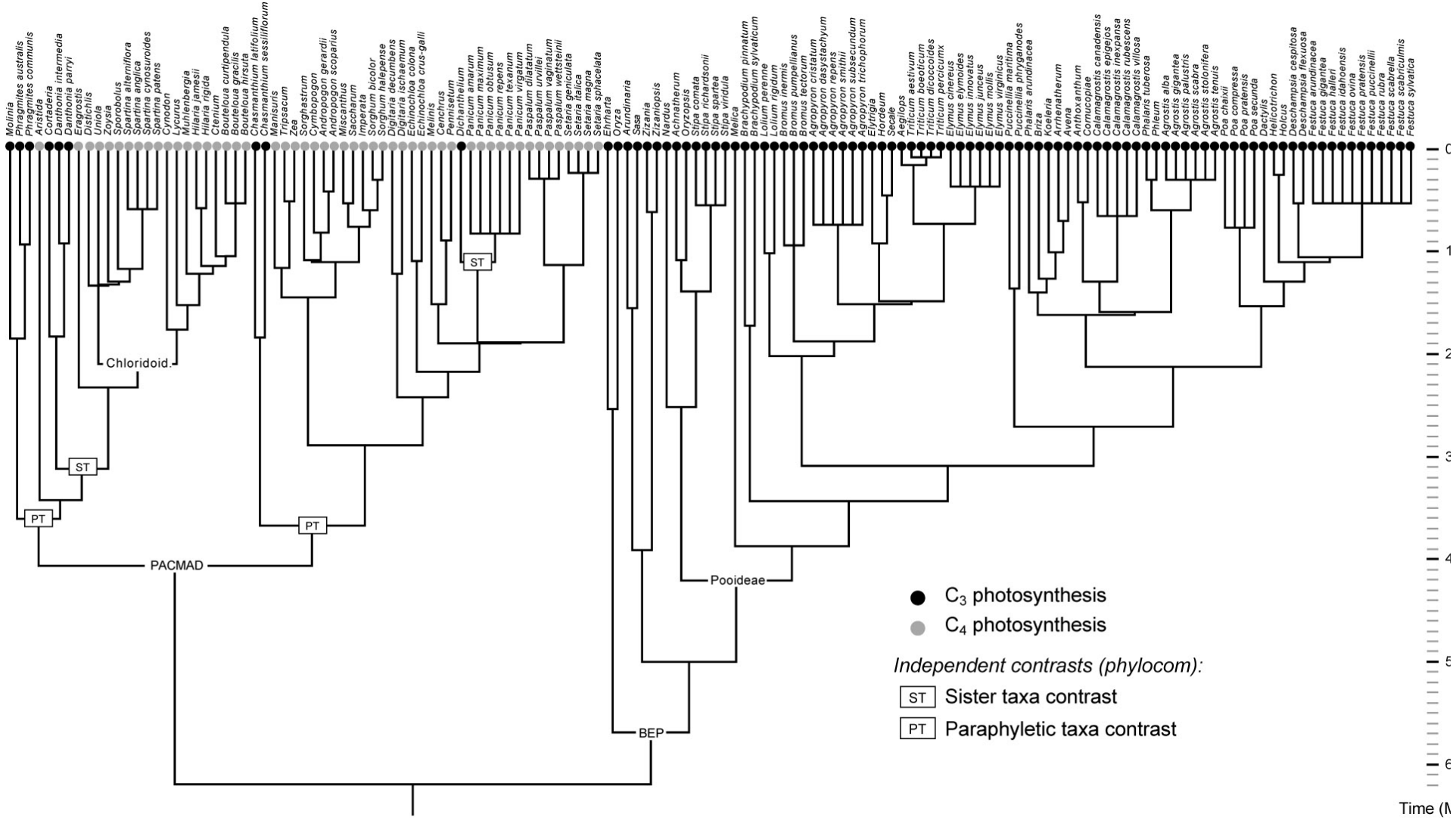
[1] N/A = not applicable. For other abbreviations, see Suppl. Table 2; for further explanations, see text.

[2] The 95% confidence intervals (C.I.) were calculated using bootstrapping with 1000 replicates (Resampling Stats 5.0, available at http://www.resample.com/).

* Assemblages not included in quantitative assemblage analysis because of insufficient preservation.

SUPPLEMENTARY TABLE 4. Relative abundance of non-GSSC phytoliths and non-diagnostic (potential) grass phytoliths (NDG) in leaf assemblage from Strömberg 's reference collection (Strömberg 2003, unpublished data).

Taxon	Clade	Photosynthetic pathway	Non-GSSC (% of total assemblage)	NDG (% of total assemblage)
Pharus lappulaceus ssp *lappulaceus*	Pharoideae	C_3	12.4	5.1
Guaduella macrostachyus	Puelioideae	C_3	5.1	2.1
Otatea acuminata ssp *aztecorum*	Bambusoideae	C_3	18.7	10.3
Olyra caudata	Bambusoideae	C_3	29.8	16.7
Chusquea patens	Bambusoideae	C_3	51.2	44.4
Streptogyna gerontogaea	Bambusoideae-Ehrhartoideae clade	C_3	13.2	7.9
Lygeum spartum	Pooideae	C_3	8.6	5.9
Glyceria striata var *striata*	Pooideae	C_3	10.1	4.2
Dactylis glomerata ssp *hispanica*	Pooideae	C_3	20.1	12.1
Triticum aestivum	Pooideae	C_3	30.4	6.9
Avena fatua	Pooideae	C_3	39.6	23.1
Deschampsia caespitosa	Pooideae	C_3	41.6	13.2
Ampelodesmos mauritanicus	Pooideae	C_3	41.9	32.5
Festuca rubra	Pooideae	C_3	53.2	18.4
Nassella pulchra	Pooideae	C_3	57.6	23.3
Nassella pulchra	Pooideae	C_3	72.8	36.1
Calamagrostis ophitidis	Pooideae	C_3	66.4	29.3
Aristida purpurea var *wrightii*	Aristidoideae	C_4	73.5	45.7
Arundo donax ssp *versicolor*	Arundinoideae	C_3	54.0	41.0
Chasmanthium latifolium	Centothecoideae	C_3	27.1	11.2
Sporobolus airoides	Chloridoideae	C_4	15.1	5.8
Eragrostis ferruginea	Chloridoideae	C_4	36.6	24.1
Danthonia sp	Danthonioideae	C_3	26.5	23.7
Panicum virgatum	Paniceae	C_4	14.7	3.6



SUPPLEMENTARY FIGURE 1. Poaceae phylogeny with C_3/C_4 photosynthetic pathway character states shown at tips and the four C_3-C_4 contrasts generated using phylocom. Dated phylogeny modified from Bouchenak-Khelladi et al. (2009).