Increasing the research potential of digitized fossils: A pilot study using Specify to attach stable isotope data to vouchered museum specimens

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FLORIDA MUSEUM OF NATURAL HISTORY

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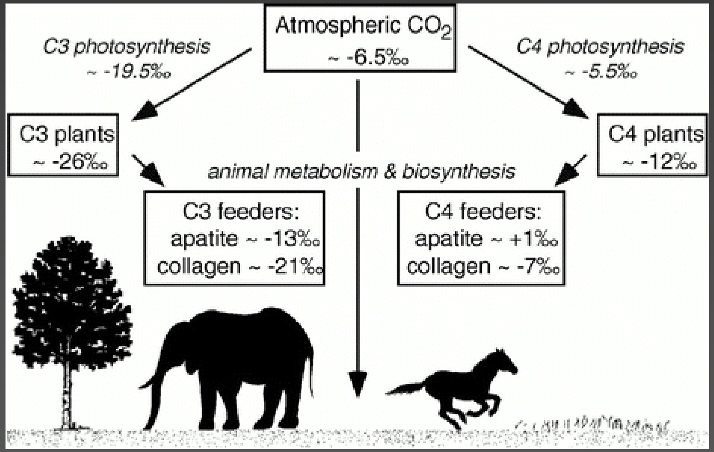
NSF

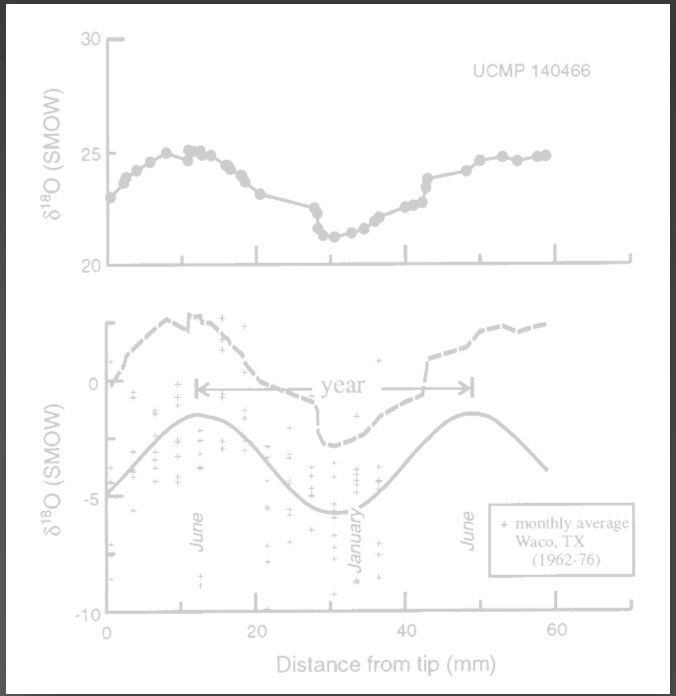
Stable Isotopes in Vertebrate Paleontology

Paleodiet ($\delta^{13}C$)



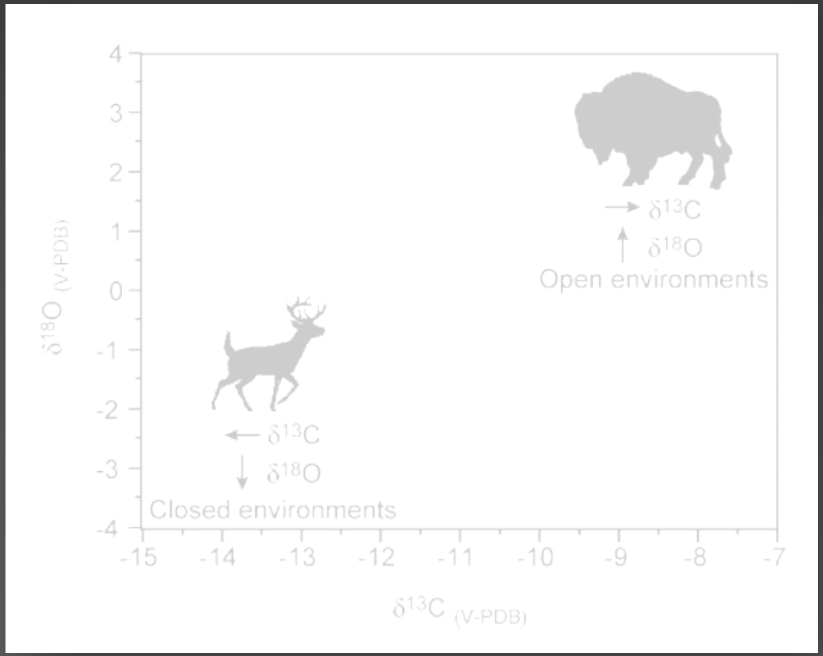
Koch, 1998

Paleoclimate ($\delta^{18}O$)



Sharp and Cerling, 1998

Paleoenvironmental Reconstruction ($\delta^{18}O$ and $\delta^{13}C$)



Feranec and MacFadden, 2006

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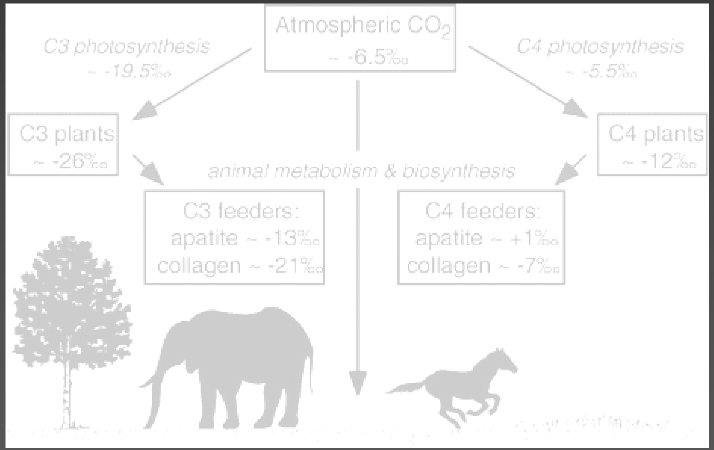
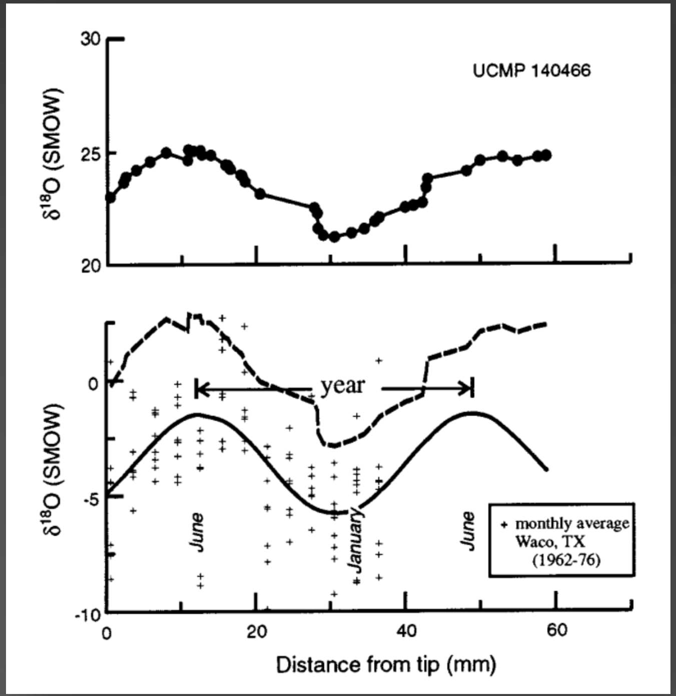
Paleodiet ($\delta^{13}C$)



Koch, 1998

Paleoclimate ($\delta^{18}O$)



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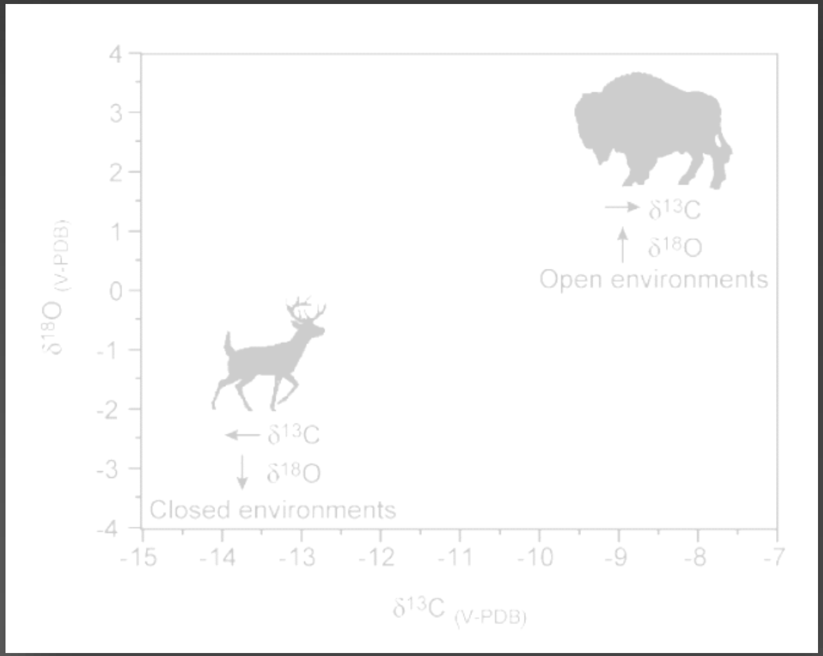

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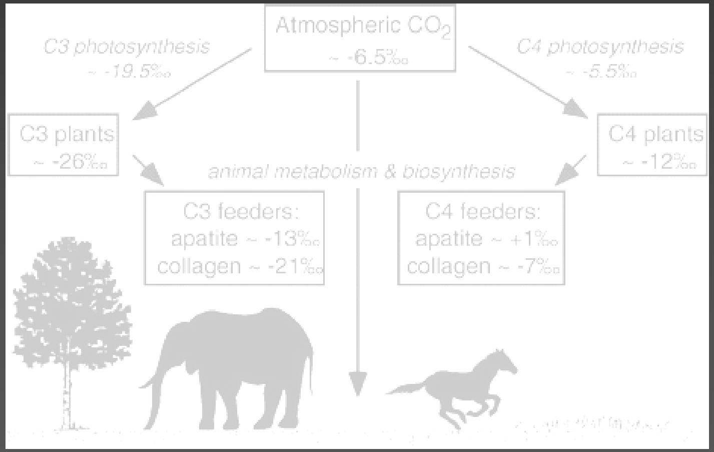

Koch, 1998

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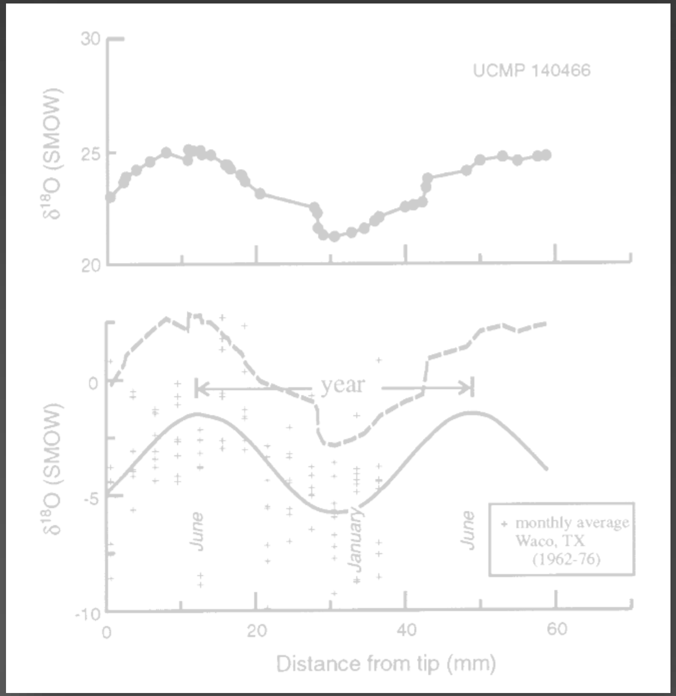
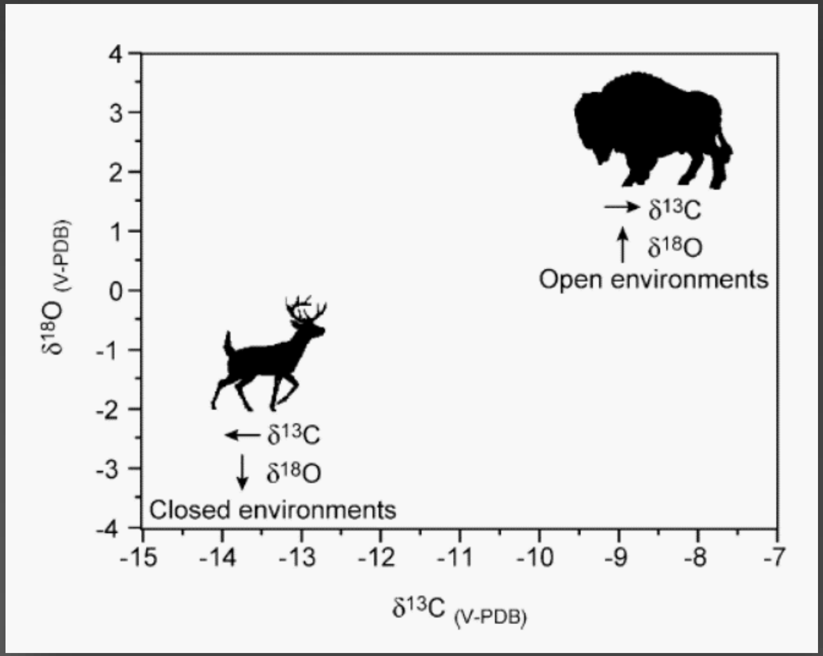


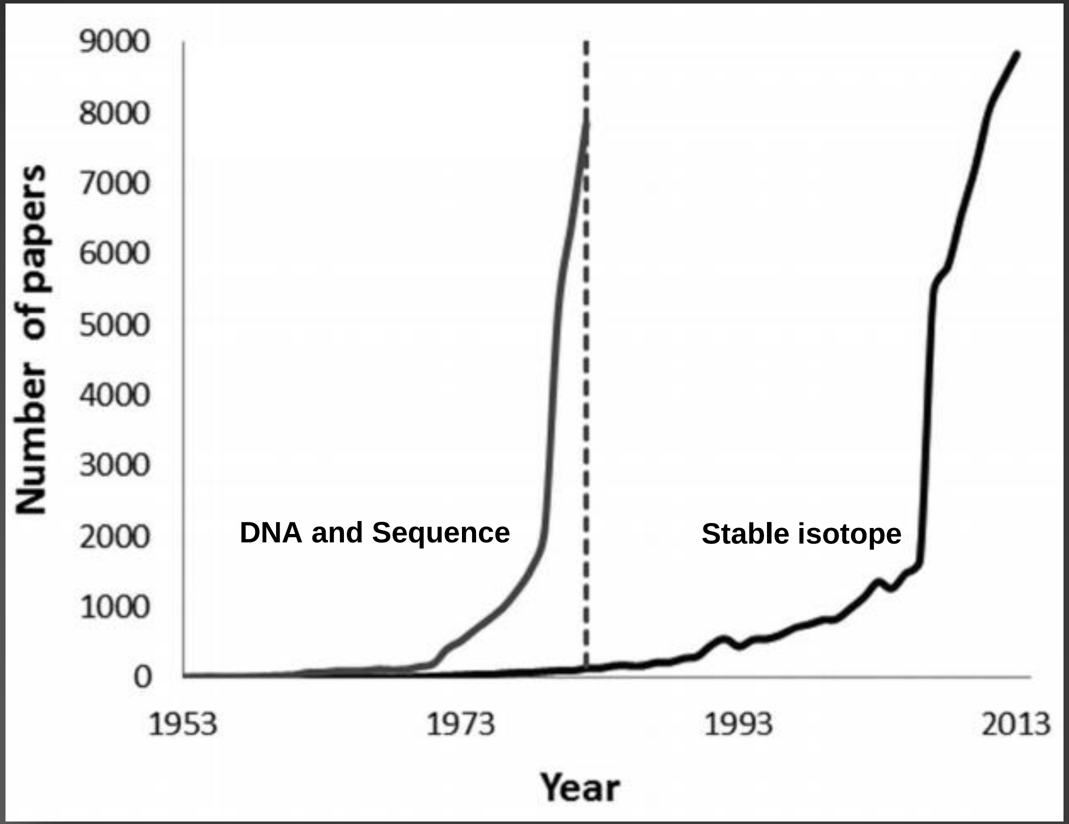
Sharp and Cerling, 1998

Paleoenvironmental Reconstruction ($\delta^{18}O$ and $\delta^{13}C$)



Feranec and MacFadden, 2006

The Need for a Global Stable Isotope Database

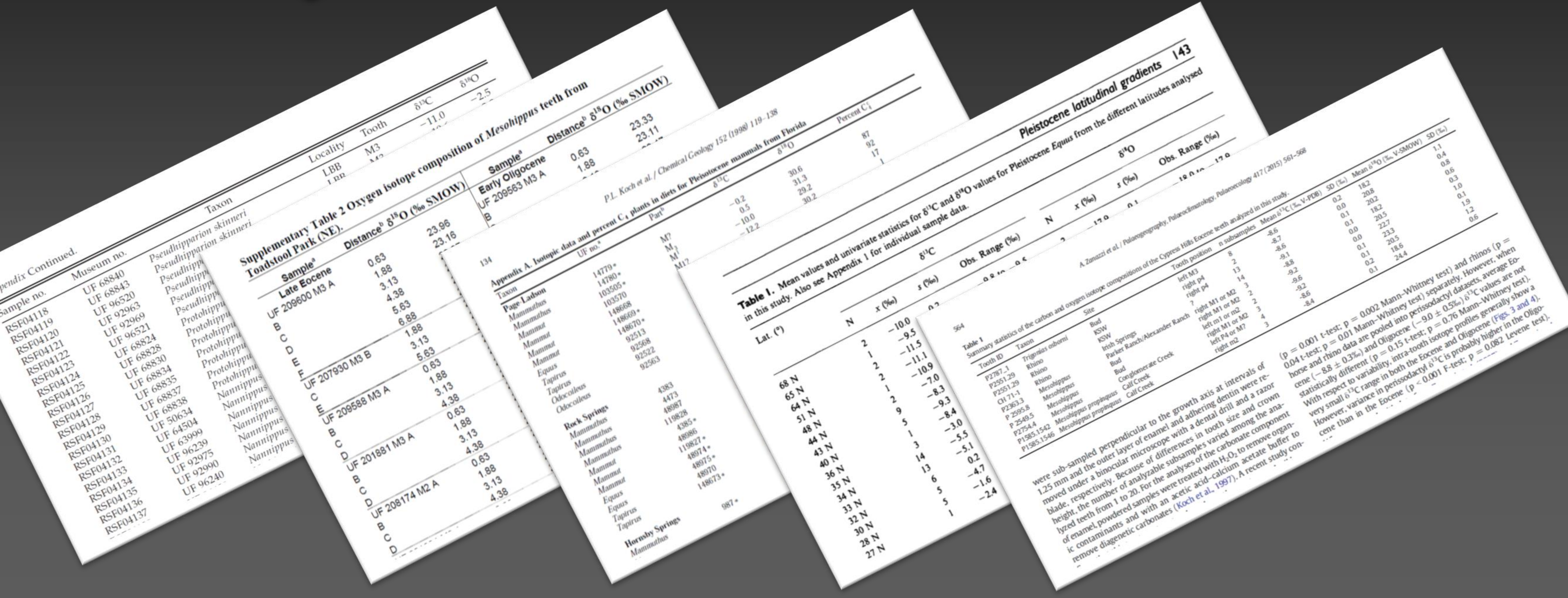


Pauli et al., 2015

ISOBANK

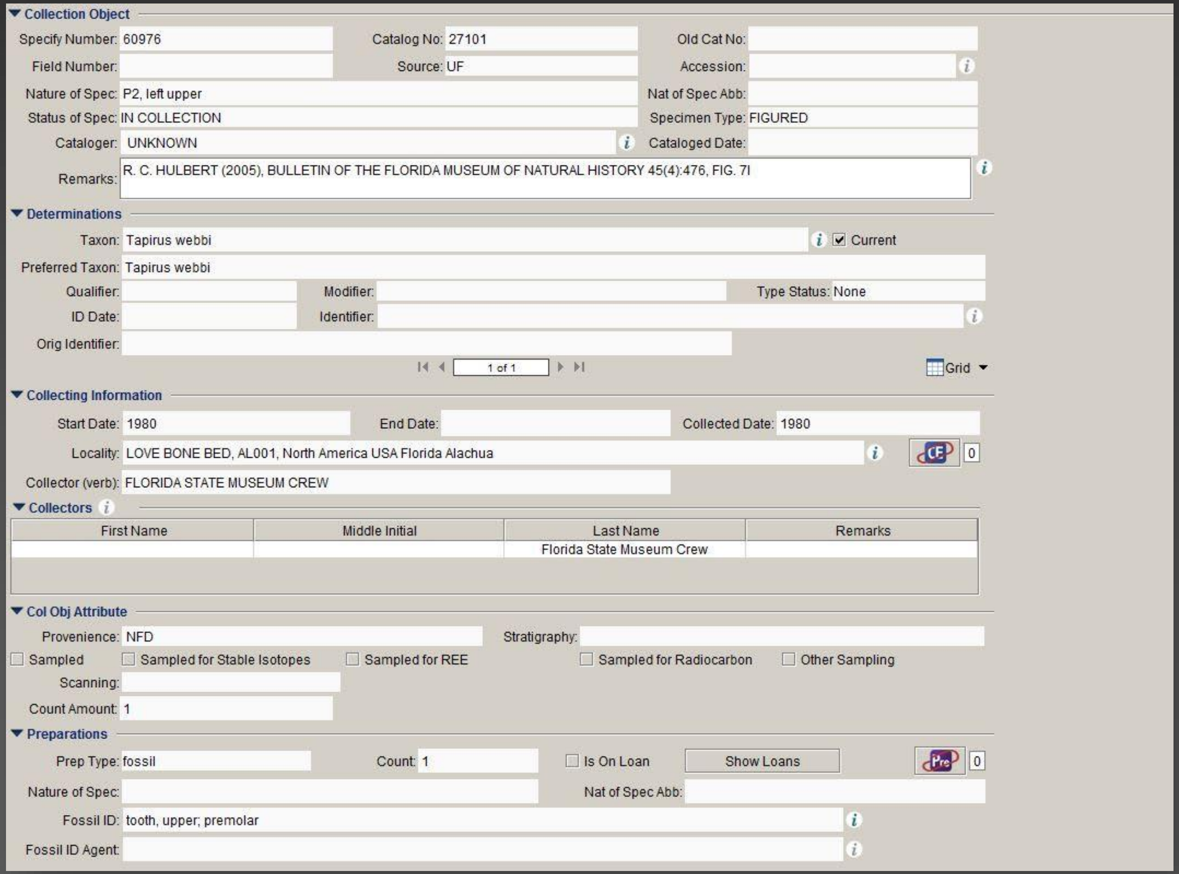
NEOTOMA PALEOECOLOGY DATABASE

Glut of Stable Isotope Data

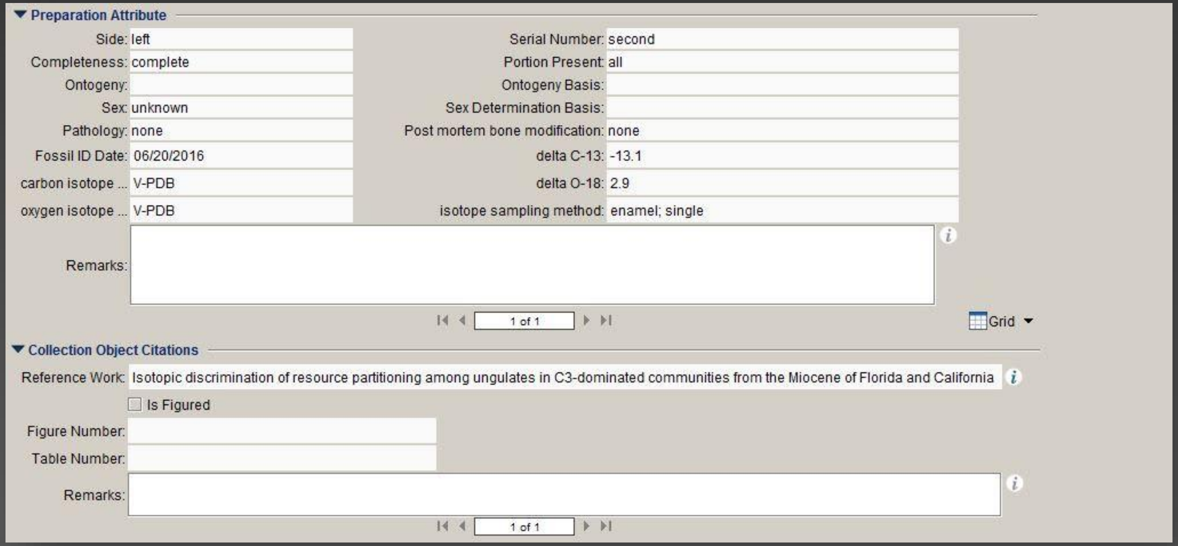


Specify

Typical Specify data record



Our insertion of isotope data fields



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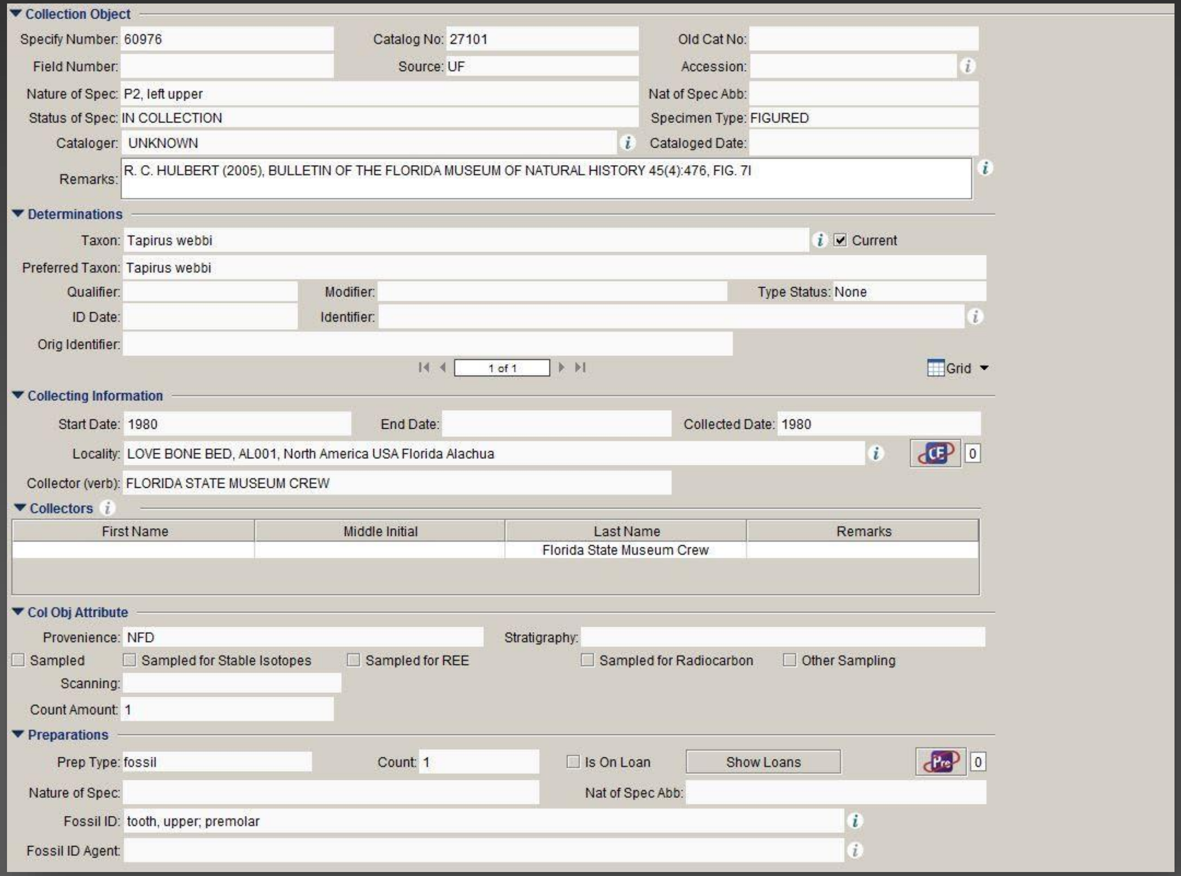

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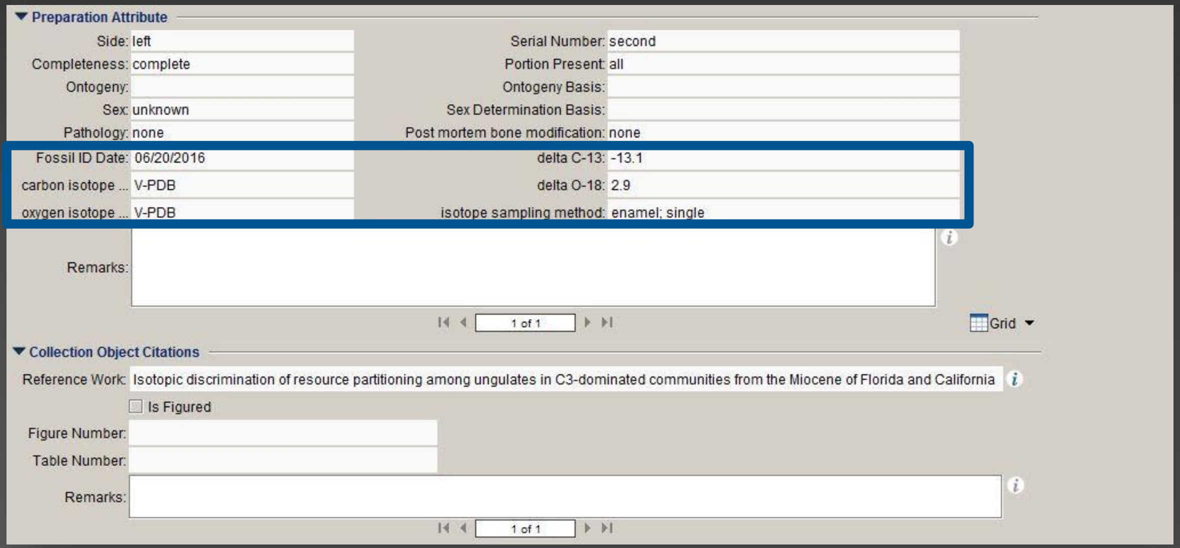


- New preparation attributes can be added for each tooth of a given specimen (e.g., m1, m2, and m3 of a dentary) with isotope data attached

An example: Easily queried records

Collection Object

Taxon

Locality

Chronostratigraphy

Paleo context

Collection object attribute

Storage

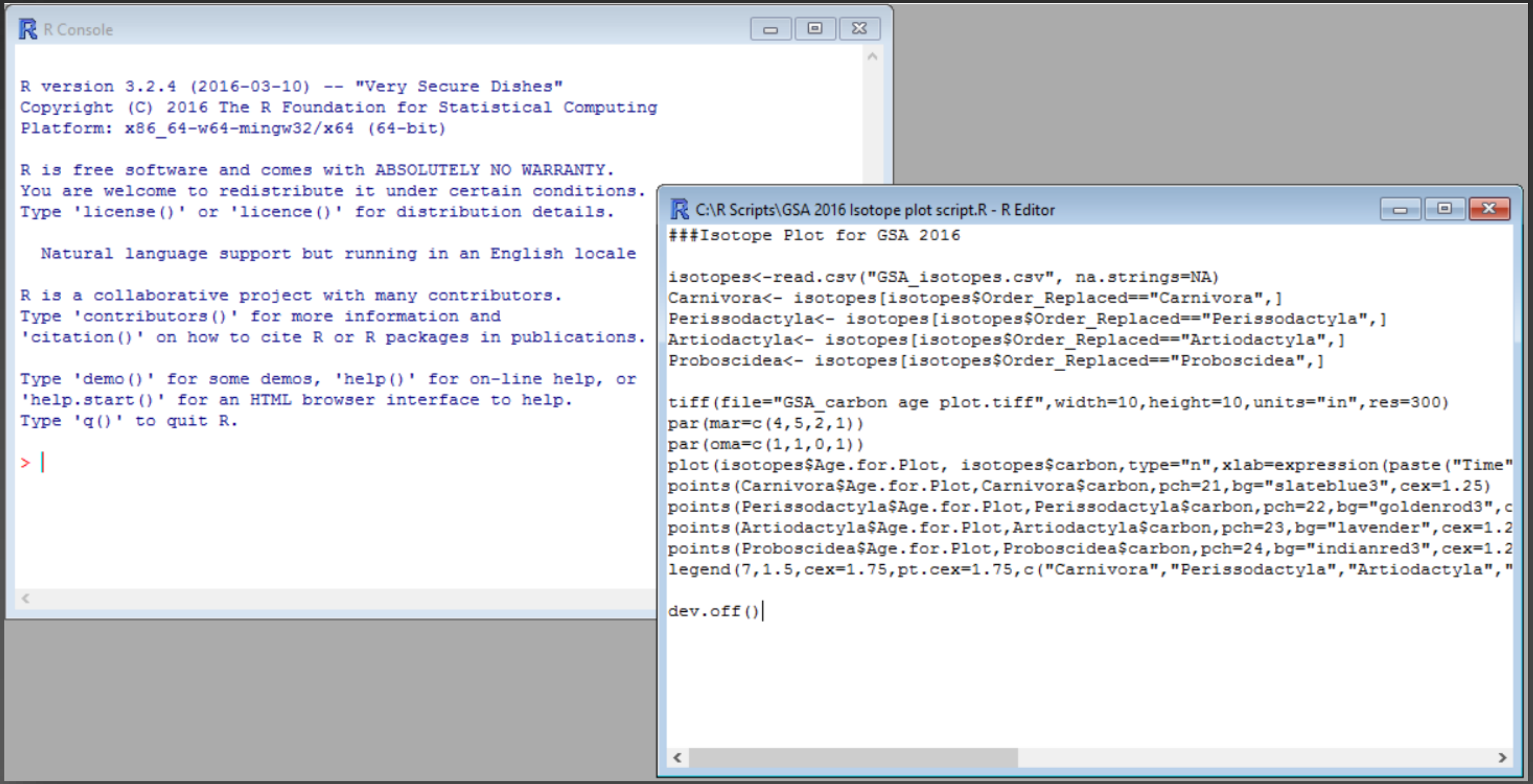
Preparation attribute

An example: Output to Excel file

	A	B	C	D	E	G	H	I	K	L	N	P	Q	R	S	T	Y	Z	AA	AB	AC	AD	AE
1	Source	Catalog Nc	Specify Nu	Class	Order	Family	Genus	Species	Nature of	Site	Site Key	Latitude1	Longitude1	Series/Epo	Land Mam	Faunal Zor	Full Name	Side	Serial Num	delta O-18	oxygen iso	delta C-13	carbon iso
2	UF/FGS	5107	18682	Mammalia	Artiodacty	Camelidae	Hemiauche	macrocepl	molar, left	SANTA FE	CO071	29.83575	-82.6832	Pleistocen	Blancan or	Racholabr	tooth, upp	left	none/NA			-9.7	V-PDB
3	UF	2855	36643	Mammalia	Artiodacty	Camelidae	Hemiauche	macrocepl	M2, right u	REDDICK 1	MR016	29.36123	-82.1856	Pleistocen	Rancholab	Ra2	tooth, upp	right	second			-14	V-PDB
4	UF	2991	36991	Mammalia	Artiodacty	Camelidae	Palaeolama		dentary, le	HAILE 8A	AL026	29.69498	-82.5824	Pleistocen	Rancholab	Ra2	tooth, low	left	first	29	V-SMOW	-8.4	V-PDB
5	UF	3224	37183	Mammalia	Artiodacty	Tayassuida	Mylohyus		dentary, le	HAILE 8A	AL026	29.69498	-82.5824	Pleistocen	Rancholab	Ra2	tooth, low	left	third	31.7	V-SMOW	-7.6	V-PDB
6	UF	3264	37223	Mammalia	Artiodacty	Camelidae	Hemiauche	macrocepl	maxilla, wi	HAILE 8A	AL026	29.69498	-82.5824	Pleistocen	Rancholab	Ra2	tooth, upp	right	first	29.2	V-SMOW	-10.5	V-PDB
7	UF	3265	37224	Mammalia	Artiodacty	Cervidae	Odocoileus		dentary, ri	HAILE 8A	AL026	29.69498	-82.5824	Pleistocen	Rancholab	Ra2	tooth, low	right	second	30.3	V-SMOW	-13.1	V-PDB
8	UF	3268	37227	Mammalia	Artiodacty	Tayassuida	Mylohyus	fossilis	dentary, le	HAILE 8A	AL026	29.69498	-82.5824	Pleistocen	Rancholab	Ra2	tooth, low	left	third	29.7	V-SMOW	-11.2	V-PDB
9	UF	3279	37238	Mammalia	Artiodacty	Tayassuida	Mylohyus	fossilis	skull, parti	HAILE 8A	AL026	29.69498	-82.5824	Pleistocen	Rancholab	Ra2	tooth, upp	left	third	29.4	V-SMOW	-11.9	V-PDB
10	UF	4051	38002	Mammalia	Artiodacty	Camelidae	Hemiauche	macrocepl	mandible,	HAILE 8A	AL026	29.69498	-82.5824	Pleistocen	Rancholab	Ra2	tooth, low	right	first	30.2	V-SMOW	-9.2	V-PDB
11	UF	7559	41496	Mammalia	Artiodacty	Bovidae	Bison	latifrons	skull, right	HAILE 8A	AL026	29.69498	-82.5824	Pleistocen	Rancholab	Ra2	tooth, low	right	third	30.5	V-SMOW	-1.1	V-PDB
12	UF	8902	42866	Mammalia	Artiodacty	Camelidae	Hemiauche	macrocepl	maxilla, rig	REDDICK 1	MR055	29.36123	-82.1856	Pleistocen	Rancholab	Ra2	tooth, upp	right	third			-9.2	V-PDB
13	UF	10252	44189	Mammalia	Artiodacty	Cervidae	Odocoileu	virginianus	SKELETON	HAILE 8A	AL026	29.69498	-82.5824	Pleistocen	Rancholab	Ra2	tooth, upp	right	third	31.6	V-SMOW	-12.3	V-PDB
14	UF	10253	44190	Mammalia	Artiodacty	Cervidae	Odocoileus		SKELETON	HAILE 8A	AL026	29.69498	-82.5824	Pleistocen	Rancholab	Ra2	tooth, low	right	second	29.9	V-SMOW	-14.2	V-PDB
15	UF	10324	44261	Mammalia	Artiodacty	Tayassuida	Mylohyus	fossilis	palate witl	HAILE 8A	AL026	29.69498	-82.5824	Pleistocen	Rancholab	Ra2	tooth, upp	right	third	29.7	V-SMOW	-11.1	V-PDB
16	UF	10935	44908	Mammalia	Artiodacty	Camelidae	Hemiauche	macrocepl	dentary, ri	HAILE 8A	AL026	29.69498	-82.5824	Pleistocen	Rancholab	Ra2	tooth, low	right	first	30.4	V-SMOW	-8.7	V-PDB
17	UF	10938	44911	Mammalia	Artiodacty	Camelidae	Hemiauche	macrocepl	DP4, right	HAILE 8A	AL026	29.69498	-82.5824	Pleistocen	Rancholab	Ra2	tooth, upp	right	fourth	31.6	V-SMOW	-9.9	V-PDB
18	UF	11503	45440	Mammalia	Artiodacty	Camelidae	Hemiauchenia		M3, left up	INTRACOA	SA017	27.08221	-82.4303	Pleistocen	Rancholab	Ra2	tooth, upp	left	third			-5	V-PDB
19	UF	11503	45440	Mammalia	Artiodacty	Camelidae	Hemiauche	macrocepl	M3, left up	INTRACOA	SA017	27.08221	-82.4303	Pleistocen	Rancholab	Ra2	tooth, upp	left	third			-5	V-PDB
20	UF	12494	46224	Mammalia	Artiodacty	Tayassuida	Mylohyus		maxilla, rig	HAILE 8A	AL026	29.69498	-82.5824	Pleistocen	Rancholab	Ra2	tooth, upp	right	first	29.1	V-SMOW	-9.1	V-PDB
21	UF	16187	50124	Mammalia	Artiodacty	Bovidae	Bison	latifrons	M1 or M2,	HAILE 8A	AL026	29.69498	-82.5824	Pleistocen	Rancholab	Ra2	tooth, upp	left	first or sec	30.4	V-SMOW	-4.7	V-PDB
22	UF	17518	51483	Mammalia	Artiodacty	Camelidae	Hemiauche	macrocepl	maxilla, lef	INGLIS 1A	CI001	29.00743	-82.6893	Pleistocen	Blancan, la	Bl3	tooth, upp	left	fourth			-10.2	V-PDB
23	UF	17519	51484	Mammalia	Artiodacty	Camelidae	Hemiauche	macrocepl	maxilla, lef	INGLIS 1A	CI001	29.00743	-82.6893	Pleistocen	Blancan, la	Bl3	tooth, upp	left	none/NA			-9.1	V-PDB
24	UF	17522	51487	Mammalia	Artiodacty	Camelidae	Hemiauche	macrocepl	mandible,	INGLIS 1A	CI001	29.00743	-82.6893	Pleistocen	Blancan, la	Bl3	tooth, low	right	third			-12.4	V-PDB
25	UF	17693	51630	Mammalia	Artiodacty	Camelidae	Hemiauche	macrocepl	m3, left lo	SANTA FE	CO003	29.83699	-82.6996	Pleistocen	Blancan or	Racholabr	tooth, low	left	third			-13.4	V-PDB
26	UF	18027	51964	Mammalia	Artiodacty	Camelidae	Hemiauche	macrocepl	right uppe	INGLIS 1A	CI001	29.00743	-82.6893	Pleistocen	Blancan, la	Bl3	tooth, upp	right	third			-11.3	V-PDB
27	UF	18028	51965	Mammalia	Artiodacty	Camelidae	Hemiauche	macrocepl	M3, right u	WITHLACC	LV041	29.01356	-82.6281	Pleistocen	Rancholab	Ra2	tooth, upp	right	third			-7.9	V-PDB
28	UF	18188	52125	Mammalia	Artiodacty	Tayassuida	Platygonus	bicalcaratu	MANDIBLE	INGLIS 1A	CI001	29.00743	-82.6893	Pleistocen	Blancan, la	Bl3	tooth, upp	right	third			-11.5	V-PDB
29	UF	18196	52133	Mammalia	Artiodacty	Tayassuida	Platygonus	bicalcaratu	right uppe	INGLIS 1A	CI001	29.00743	-82.6893	Pleistocen	Blancan, la	Bl3	tooth, upp	right	third			-12	V-PDB

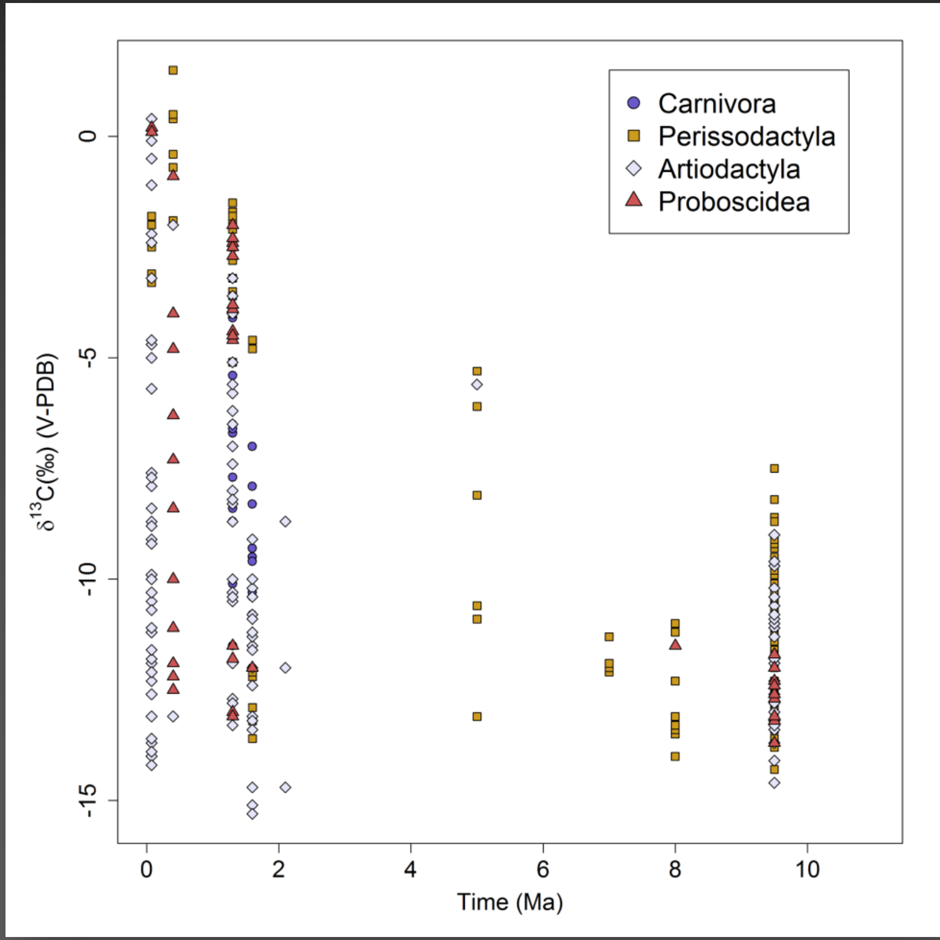
An example: Data manipulation

- Data subset by mammalian class (crocodylians not included)
- Simply plotted specimen age by $\delta^{13}C$



An example: Expansion of C4 consumption

- Increase in tooth enamel carbonate $\delta^{13}C$ in Florida over last 10 Ma
- n=369



Data included from Feranec 2003, Feranec and MacFadden 1996, MacFadden 1998, MacFadden and Cerling 1996, Yann and DeSantis 2014

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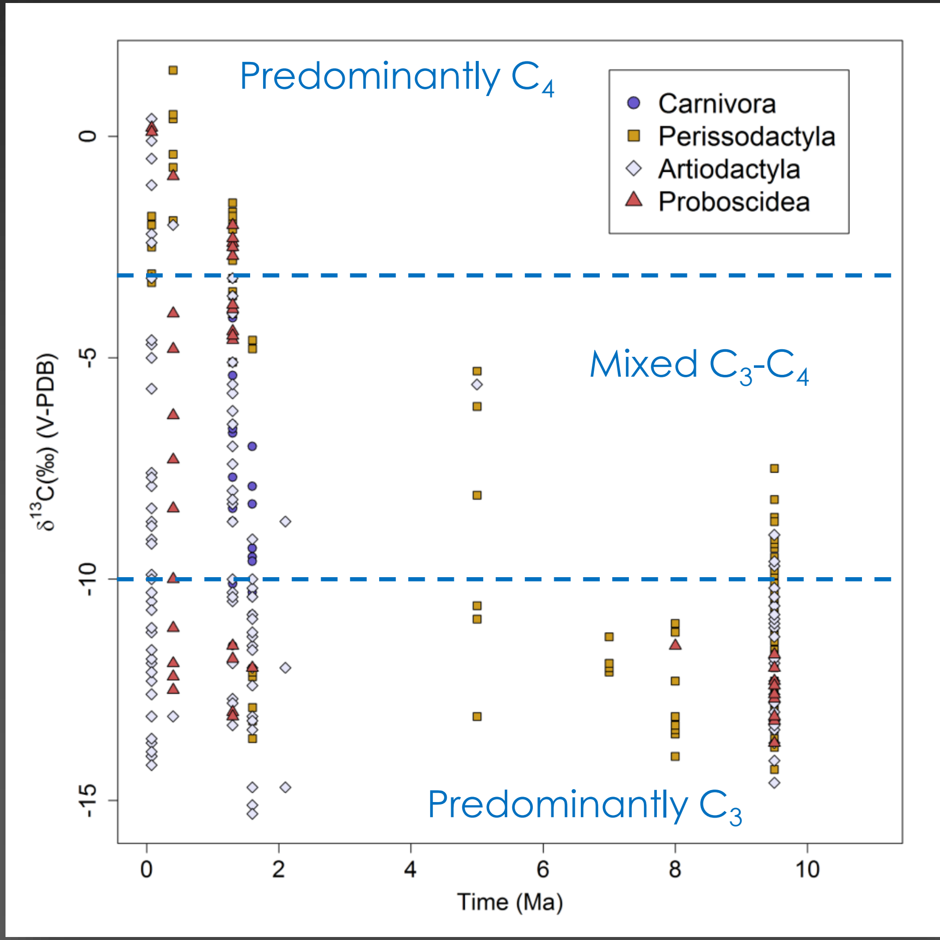

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Obstacles

Samp. No.[1]	UF Cat. no.	Family[2]	Taxon[3] (genus)	Material[4]	Locality	$\delta^{13}C$ (‰)
93	115776	Tap	*Tapirus*	p3, ml-m3	Ichetucknee	−10.1
94	19376	Bov	*Bison*	RP/M	Ichetucknee	−3.9
95	v4703	Cer	*Odocoileus*	RM2-M3	Ichetucknee	−13.8
97	None	Cam	*Hemiauchenia*	rp4	Cutler	0.4
98	None	Bov	*Bison*	LP/M	Cutler	1.5
99	None	Bov	*Bison*	lp/m	Cutler	−0.5
100	None	Tay	*Mylohyus*	rm2/m3	Cutler	−8.0
101	None	Tay	*Platygonus*	lm3	Cutler	−8.3
102A	None	Equ	*Equus*	incisor	Cutler	0.2
102B	None	Equ	*Equus*	RP3/P4	Cutler	−0.4
103	None	Equ	*Equus*	rp2	Cutler	−0.5
104	None	Equ	*Equus*	rp/m	Cutler	−0.6

MacFadden and Cerling, 1996

- Uncataloged specimens
- Incorrectly labeled specimens
- Lost specimens
- Unreported $\delta^{18}O$ data
- Data quality control
- Serially sampled specimens

Research potential and future directions

- Provides the opportunity for paleontologists to address hypotheses of the past that, until now, could only be addressed by modern ecologists.

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- Necessary to develop global standards for isotope metadata (TDWG)