Where Have All the Good Bones Gone?

Comparing Modern and Fossil Vertebrate Preservation under the Fluvial Megafan Model

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Background and Methods

Are large-scale taphonomic processes within terrestrial fluvial megafan deposits consistent across geologic time? If so, what can this information tell us about a) preservation, b) paleoecology, and c) the terrestrial fossil record overall?

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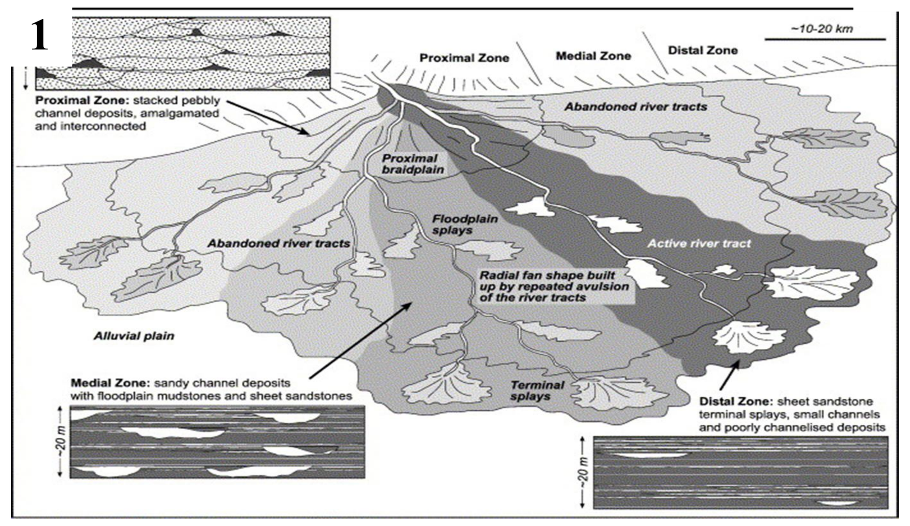

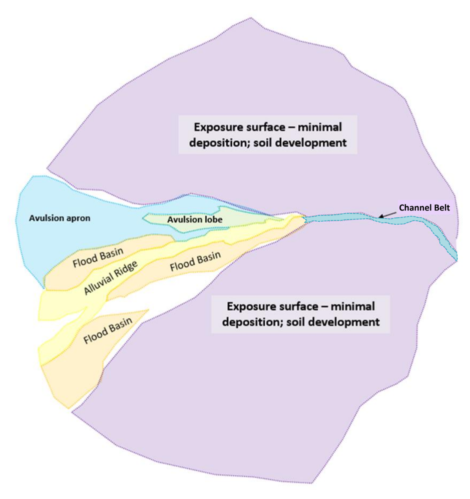

Figure 1: Map of a prograding fluvial megafan network, modified from Nichols and Fisher, 2007.
Figure 2: Representation of subenvironment geographic position, modified from the modern Taquari megafan network of Brazil (Miltenberger, 2021).

- ❖ Previous sedimentological investigations suggest that fluvial megafan networks should dominate the rock record (Weissmann et al., 2010)
- ❖ Studies along modern megafan systems demonstrate that different subenvironments have different flooding/depositional rates and thus host different parts of the riparian ecosystem (e.g. Dudgeon, 2011)
- ❖ Paleoecological and taphonomic patterns under a megafan depositional model are currently poorly characterized

By examining trends in preservation and paleoecology across both ancient and modern megafan networks, we can gain and understanding of vertebrate preservation across geologic time

- ❖ Investigation focused within Adamanian outcrops at Petrified Forest National Park (an ancient megafan network; Trendell et al., 2013) and depositional localities within the Pozo Hondo and General Diaz areas along the Río Pilcomayo (a modern megafan network)
- ❖ Taphonomic redescription of bones included taxon and element ID, relative size, bone weathering and abrasion (Behrensmeyer, 1978; Lyman and Fox, 1989; Fiorillo, 1988), modification by scavenging/predation (Haynes, 1982; Andrews, 1995), completeness (Hill and Behrensmeyer, 1984), fracture type (Lyman, 2001), photographs, and GPS coordinates
- ❖ Six different subenvironments were selected for preservational hypothesis testing (Table 1)

Megafan Network Subenvironment	Hypothesized Taphonomic Features: Weathering	Abrasion	Evidence of Scavenging/Predation	Completeness	References
Channel Belt (Active or Abandoned)	Low – Rapid Burial	High – Abundant bone-sediment interaction	Low – Rapid Burial	High – Rapid Burial	Behrensmeyer, 1982; Aslan and Behrensmeyer, 1986; Behrensmeyer, 1988; Behrensmeyer and Hook, 1992; Moore and Varricchio, 2018
Alluvial Ridge (Levee)	High –Low Deposition	Low – Limited bone-sediment interaction	High –Low Deposition	Low –Low Deposition	Bishop, 1980; Behrensmeyer and Hook, 1992
Flood Basin	High –Low Deposition	Low – Limited bone-sediment interaction	High –Low Deposition	Low –Low Deposition	Behrensmeyer, 1982; Behrensmeyer et al., 2000
Avulsion Flood Apron	Moderate – Variable Deposition	Moderate –Some bone-sediment interaction	Moderate – Variable Deposition	High – Variable Deposition (Miring)	
Avulsion Depositional Lobe	Low – Rapid Burial	High – Abundant bone-sediment interaction	Low – Rapid Burial	High – Rapid Burial	Lyman, 1994 Behrensmeyer et al., 2000
Exposure Surface	High – Low Deposition	Low – Limited bone-sediment interaction	High –Low Deposition	Low – Low Deposition	

***Table 1:** Preservational hypotheses for vertebrate material within six identifiable megafan subenvironments.*

Results

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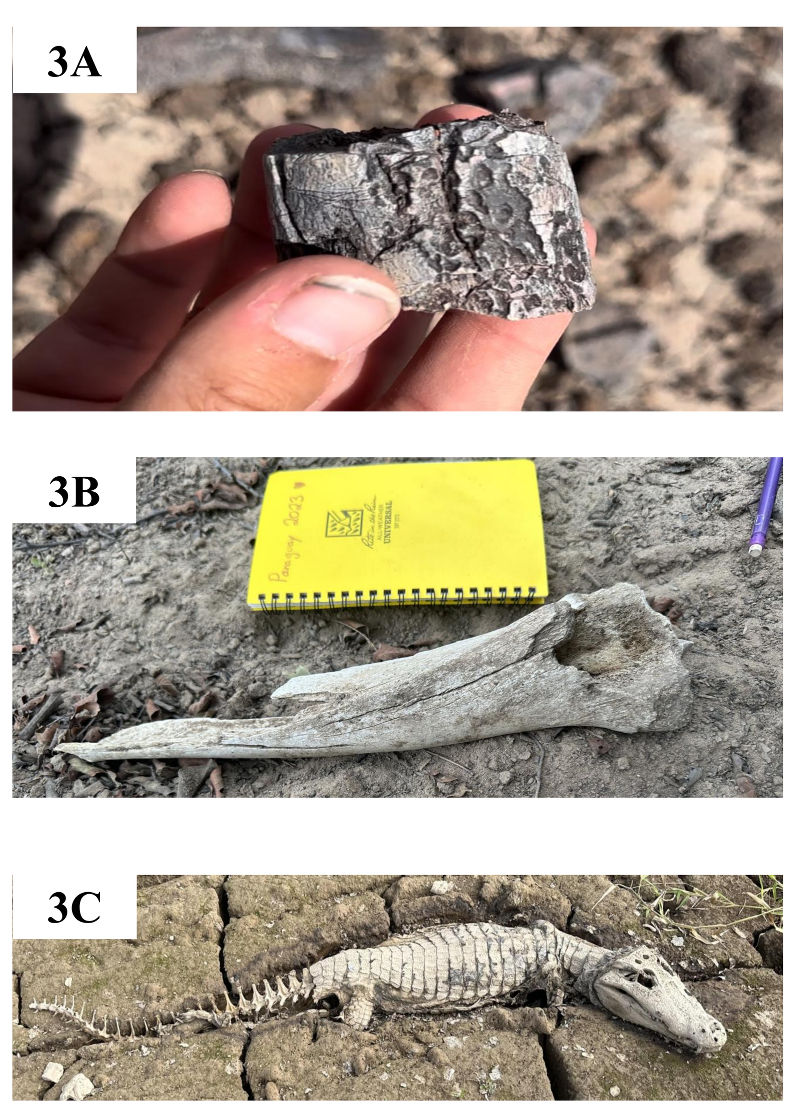
Megafan Network Subenvironments and Observed Taphonomic Features		Taphonomic Datasets: Petrified Forest National Park (Field) N = 30 – Measurement	Number of observations	Petrified Forest National Park (Collections) N = 24 – Measurement	Number of observations	Río Pilcomayo, Paraguay N = 271 – Measurement	Number of observations
Channel Belt	Avg. Weathering Stage (Behrensmeyer, 1978)	0.87	3	1.20	3	0.28	80
	Avg. Abrasion Stage (Fiorillo, 1988)	0.63		0.60		0.11	
	Proportion showing scavenging/predation marks	0.02		0.00		0.17	
	Average specimen size (cm)	4.62		10.94		21.8	
Alluvial Ridge	Avg. Weathering Stage (Behrensmeyer, 1978)	0.92	3	1.25	3	1.38	18
	Avg. Abrasion Stage (Fiorillo, 1988)	0.56		0.44		0.17	
	Proportion showing scavenging/predation marks	0.03		0.00		0.39	
	Average specimen size (cm)	4.23		6.03		35.4	
Flood Basin and Avulsion Flood Apron	Avg. Weathering Stage (Behrensmeyer, 1978)	0.92	17	0.44	14	1.21	114
	Avg. Abrasion Stage (Fiorillo, 1988)	0.61		0.24		0.39	
	Proportion showing scavenging/predation marks	0.03		0.02		0.36	
	Average specimen size (cm)	4.15		4.37		24.2	
Depositional Lobe	Avg. Weathering Stage (Behrensmeyer, 1978)	1.20	1	1.00	1	0.62	39
	Avg. Abrasion Stage (Fiorillo, 1988)	1.27		0.80		0.05	
	Proportion showing scavenging/predation marks	0.00		0.00		0.46	
	Average specimen size (cm)	3.15		5.60		39.0	
Exposure Surface	Avg. Weathering Stage (Behrensmeyer, 1978)	0.89	5	0.67	4	No exposure surface specimens recovered from the Pilcomayo survey areas	
	Avg. Abrasion Stage (Fiorillo, 1988)	0.42		0.22			
	Proportion showing scavenging/predation marks	0.04		0.11			
	Average specimen size (cm)	3.92		6.76			

***Table 2:** Average bone weathering stage (0-5), average bone abrasion stage (0-3), average bone size (cm), and proportion of scavenged features given for observed vertebrate materials within six megafan subenvironments (and the number sampled) for the Petrified Forest National Park field sampling dataset (2022-2024), the Petrified Forest Museum Collection dataset (2023-2024), and the Río Pilcomayo field sampling dataset (2023-2024). Subenvironments distinguished by color to relate to their position within the megafan network, as seen in Figure 2.*

3A
3B
3C



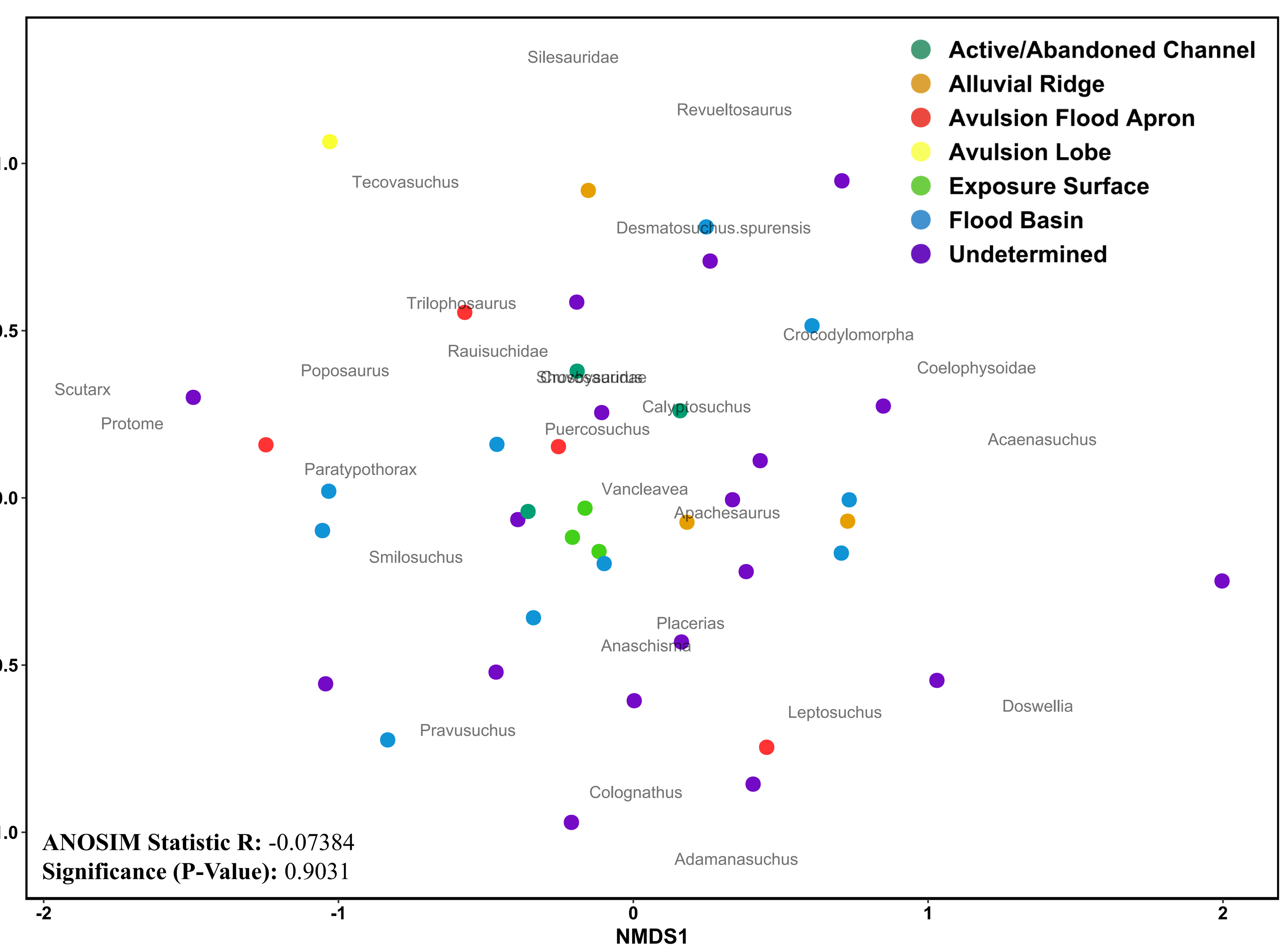


***Figure 3A:** Scavenged fossil bone material from a flood basin deposit in Petrified Forest National Park. **Figure 3B:** Scavenged modern limb bone (likely bovid) from a flood basin deposit along the Río Pilcomayo. **Figure 3C:** Nearly complete skeleton of a mired caiman within a depositional lobe deposit along the Río Pilcomayo. **Figure 4:** Results of ANOSIM testing of taxa co-occurrence within Petrified Forest National Park via subenvironmental classification (Apgar et al., 2023).*

Conclusions

- ❖ Patterns of modification within all datasets do not completely match our initial hypotheses; study of the paths to burial on the Pilcomayo and the post-burial fate of remains may be key to understanding these differences
- ❖ Bones within the Petrified Forest field-based dataset show similar patterns of modification to those from the collections-based dataset, but are generally smaller in size
- ❖ The degree of weathering appears similar between fossil and modern datasets, although some finer scale patterns are not captured
- ❖ Fossil bone materials are more abraded than those within the modern dataset, possibly reflecting increased bone-sediment interaction prior to final burial
- ❖ Vertebrate material appears much larger in the modern dataset than in the fossil datasets, likely due to the lower number of articulated fossil specimens
- ❖ Modern specimens are modified by scavenging at a much higher rate than those from Petrified Forest, although subenvironmentally-driven preservation of scavenging modification is similar across both datasets
- ❖ ANOSIM test results show no statistical significance for ordination based on subenvironmental data, but this is likely due to the number of undetermined sites

Future Directions

***Figure 3.** Photograph of a crab-eating fox (Cerdocyon thous) on a floodplain deposit along the Río Pilcomayo, taken during camera trap deployment testing.*

- ❖ Investigation into vertebrate fossil preservation potential and its impact on phylogenetic reconstruction via simulated sedimentary basin
- ❖ Gather riparian ecology data within Río Pilcomayo localities to determine relationship between live communities and death assemblages
- ❖ Reexamine Late Triassic paleoecological findings within a megafan network context (Apgar et al., 2023)

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