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Supporting Online Material for

Bone Assemblages Track Animal Community Structure over 40 Years in an African Savanna Ecosystem

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Supplementary Online Materials

BONE ASSEMBLAGES TRACK ANIMAL COMMUNITY STRUCTURE OVER 40 YEARS IN AN AFRICAN SAVANNA ECOSYSTEM

David Western and Anna K. Behrensmeyer

S1.0 Ecological Context and Bone Survey Methods

S1.1 Amboseli Ecology. The semi-arid bushed savanna falls within Ecological Zone V of Pratt et al. (S1). The ecology of the Amboseli basin has been studied intensively since the 1960s (S2-5), and habitat changes since 1950 have been described and quantified in GIS format (S14). Amboseli's ungulate populations have fluctuated widely in response to drought cycles and human impact over the last 4 decades (Table S1). Black rhinoceros went extinct in the basin in the 1990's, and Coke's Hartebeest (kongoni), waterbuck, oryx, and giraffe dropped to near extinction (S2). Impala and Thomson's gazelle populations fluctuated over a ten-fold range and elephants over a six-fold range (S4).

Kongoni populations have gone extinct several times in Amboseli over the last 40 years, typically in prolonged droughts when the taller grasses they prefer are grazed out. Small numbers tend to re-colonize the basin from the Chyulu Hills during wetter years. We therefore include kongoni in the nearly extinct rather than extinct category. The low erratic numbers in both rhino and kongoni over the last twenty five years limit representative counts for both live censuses and bone counts but not enough to affect the overall live:dead correlations.

S1.2. Bone Survey Methods Bones of vertebrate species, including fish, amphibians, reptiles, birds, and mammals, as well as substrate and vegetation conditions, were recorded along 96 ground transects in 1975-76 and a subset of 44 of these transects in 2002-04. All bones within specified distances from the central transect line were recorded, with transect total widths varying from 30 - 100m depending on visibility of bones from a vehicle driven along the center line, and transect lengths determined by the distance required to sample 20 individuals (S6-7). Portions of the transects were gridded and re-sampled on foot to control for small bones not visible from the vehicle. In practice, much of each transect was covered on foot by 2-5 individuals, especially in the 2002-04 sampling period (For details on sampling methods, see S6).

S1.3. Parsing the bone sample using weathering stages. Since bones were sampled in two blocks of multiple years, i.e., 1975-76 and 2002-04, and because most bones weather to Stage 4 by 10 years since death, each of the two surface samples includes animals that died over the proceeding ~11-12 years. Years-since-death errors are usually <1 year for bones in Weather Stage (WS) 0-2 and 2-3 years for WS 3-4 (S8). A few of the larger bones survive for decades in protective micro-environments, but given the average rate of decay, few if any bones in WS 0-4 recorded in 1975-1976 would have been identifiable by 2002-2004, ensuring against overlap in the 4 sample time intervals (bins). Bones in WS 5 were excluded from the study because they can represent extended periods of time (10-30 years since death) (S9).

S1.4. Statistical and diversity indices analysis used PAST version 1.55; Hammer, O., Harper, D.A.T. and Ryan, P.D. 2001. PAST: Palaeontological Statistics software package for education and data analysis. Palaeontologia Electronica 4(1):9 pp. http://folk.uio.no/ohammer/past

S2.0 Analytical Methods and Results

S2.1. Non-metric multidimensional scaling analysis. This test (using PAST – see S1.4) examines the integrity of live vs. dead species abundances within the four different habitats in Amboseli and the effect of change through time on this pattern. The analysis used arcsin transformed abundance data for each habitat and the least taphonomically altered temporal samples, i.e., those from time intervals 2 and 4 (Table S4, Fig. S2). The positions on the plot for live vs. dead data are similar within each habitat, and these pairs move together across through time (arrows). All habitats are distinct in the early time interval (1970-76). Bush and Woodland habitats show the most change, and Plains overlaps with Swamp in the later time interval (1998-2004). This is consistent with independently observed changes in the vegetation and faunas across the 4 decades (S4).

S2.2. Diversity indices. The Simpson, Shannon H, and Evenness indices were calculated for each time bin using the raw population counts, and the first two of these indices were plotted to show change through time (S1.4, Fig. S3). This shows close correspondence of the indices based on the live vs. dead samples, although the diversity of the bone assemblage is consistently slightly higher in both cases. There is notable consistency through time in the Simpson Index, which reflects stability in the more abundant species in spite of the major ecological changes in the Amboseli ecosystem. The Shannon H shows a decrease in diversity between time intervals (bins) 2 and 3 consistent with the shift to increased grassland and the decline of some less abundant species. The slightly higher diversity in the death assemblage may be caused by under-sampling of fragile juvenile bones in the dominant species or by conservative estimates of minimum numbers of individuals (MNI) in the bone surveys.

S2.3. Impact of taphonomic processes. Taphonomic destruction increased markedly due to a shift from lion- to hyena-dominated carcass processing in the late 1980's (S10), but this has little impact on live-dead species abundance fidelity.

Larger bones tend to survive longer on the ground surface, and this can introduce a lag effect between the disappearance of a species and the final destruction of its bones. Bones of rhino were recorded in 2004 (Table S1) although the live population became officially extinct in 1996. Based on the known date of local extinction, there is a time lag of ~6-8 years in detecting this event.

Black rhinoceros were last recorded in the live counts prior to 1993; their population had dropped from 8 in the mid-1980s to such a low level by the 1990s that they were no longer recorded in these counts. The last rhino deaths in Amboseli occurred between 1990-92, and the species finally disappeared from the Amboseli Basin in 1996 when the two remaining males were translocated to Tsavo West. Rhino bones in weathering stage 1 were found in 2004, approximately 12 years after the last animal died. These had been protected under dense *Sueda* bushes near the swamp edge, slowing bone decomposition and extending the number of years associated with normal weathering stages (S8-9). As the bushes died out in the late 1990's, the rhino bones were visible and thus recorded in the bone surveys. Rhino bones also appear to be exceptionally durable and slow to weather compared with other species of comparable size such as giraffe and hippo. Time-lags in decomposition can occur when bones are not fully exposed to UV light, temperature and moisture fluctuations that cause natural weathering (S8-9). Ecological monitoring using bones should take note of this possibility, which can lead to significant time lags in recording local extinction events, especially for larger species.

S2.4. Buried bone subset. The original bone surveys recorded all skeletal elements that were buried between 50 and 99% in the substrates of the basin, and this sub-sample of 230 individuals with at least one buried bone (Table S4) was used to test whether live:dead abundance fidelity is retained in the buried bone assemblage. Most of these buried bones are in weathering stages 0-2, which is partly a function of protection in the soil or under vegetation and partly because only stronger, low weathering stage bones can survive trampling and other bioturbation processes that incorporate them into the soil (S11). This also indicates that fossilized bones found in paleosols or land-surface accumulations should represent weathering stages 0-2.

Burial processes such as bioturbation and low energy sedimentation favor bones (and teeth) in weathering stages 0-2 that are robust enough to survive trampling, root action, and short-distance transport by wind or sheet-wash (S8, 11). Once bones are buried, Amboseli's neutral to alkaline soils provide chemical conditions conducive to mineralization (S12). In other, similar land-surface soils, buried remains in weathering stages 0-2 would be expected to accumulate continually over the duration of the soil. Repeated episodes of sediment deposition on such a surface (e.g., through flooding, volcaniclastic input, or eolian processes) would enhance rates of burial and potentially preserve a wider range of weathering stages in fossil assemblages representing ancient land surface accumulations.

Table S1A. Primary data for Amboseli live-dead comparisons. Body weights are based on Western, 1975 and Smith et al. 2003, (S3, S13) herbivores are classified as grazer, browser or mixed feeder according to Hoffman's anatomical classification (S15). Transformed data = ASIN(SQRT(Proportion)) for each species. Data for living population counts, with years selected to correspond as closely as possible with years represented by the bone surveys (Table S2).

					Live Counts (Individuals)						
TAXON	**Common Name**	**Code**	**MASS (kg)**	**Feeding Guild**	**Live: 1967-69**	**Live: 1970-75**	**Live: 1993-98**	**Live: 1999-2004**	**Total Live**	**Prop. Total Live**	**Transf. Prop. Live**
Loxodonta africana	Elephant	EL	3940	Mixed	485	1881	759	1040	4165	0.025	0.158
Diceros bicornis	Black Rhino	RH	1181	Browser	52	183	0	0	234	0.001	0.037
Giraffa camelopardalis	Giraffe	GF	900	Browser	328	1507	41	24	1900	0.011	0.106
Syncerus caffer	Cape Buffalo	BF	580	Grazer	766	832	347	1079	3024	0.018	0.134
Equus burchelli	Burchell's Zebra	ZB	276	Grazer	11014	16195	14523	9514	51246	0.303	0.583
Kobus ellipsiprymnus	Waterbuck	KO	210	Grazer	42	158	7	1	208	0.001	0.035
Connochaetes taurinus	Wildebeest	WB	180	Grazer	12891	30456	15575	9628	68550	0.405	0.690
Alcelaphus bucelaphus	Kongoni	KG	171	Grazer	486	251	1	14	752	0.004	0.067
Oryx beisa	Oryx	OR	169	Grazer	726	954	12	29	1721	0.010	0.101
Stuthio camelus	Ostrich	OS	100	Grazer	444	2234	379	364	3421	0.020	0.143
Phacochoerus aethiopicus	Warthog	WH	70	Grazer	25	639	627	159	1450	0.009	0.093
Gazella granti	Grant's gazelle	GG	55	Browser	4239	11617	1342	1177	18375	0.109	0.336
Aepyceros melampus	Impala	IM	53	Mixed	1831	2170	220	113	4334	0.026	0.161
Litocranius walleri	Gerenuk	GE	38	Browser	0	271	1	11	283	0.002	0.041
Gazella thompsoni	Thomson's Gazelle	TG	20	Mixed	2996	3396	1763	1418	9573	0.057	0.240
				Totals	36326	72741	35597	24571	169235		

Table S1B. Primary data for individuals recorded in the bone surveys. Transformed data = ASIN(SQRT(Proportion)) for each species. Buried subset represents the dead individuals with at least one bone buried 50-99% in the soil surface.

					Taphonomic Surveys (Individuals)									
TAXON	**Common Name**	**Code**	**MASS (kg)**	**Feeding Guild**	**Dead: ~1964 -69**	**Dead: ~1970 -76**	**Dead: ~1993- 98**	**Dead: ~1999 -2004**	**Total Dead**	**Prop. Total Dead**	**Transf. Prop. Dead**	**Buried Subset**	**Prop. Buried**	**Transf. Prop. Buried**
Loxodonta africana	Elephant	EL	3940	Mixed	17	12	13	7	49	0.033	0.182	3	0.013	0.114
Diceros bicornis	Black Rhino	RH	1181	Browser	21	9	5	1	36	0.024	0.155	5	0.022	0.148
Giraffa camelopardalis	Giraffe	GF	900	Browser	36	4	6	2	48	0.032	0.180	10	0.043	0.210
Syncerus caffer	Cape Buffalo	BF	580	Grazer	26	27	19	25	97	0.065	0.257	13	0.057	0.240
Equus burchelli	Burchell's Zebra	ZB	276	Grazer	133	114	61	91	399	0.266	0.541	61	0.265	0.541
Kobus ellipsiprymnus	Waterbuck	KO	210	Grazer	1	2	0	0	3	0.002	0.045	1	0.004	0.066
Connochaetes taurinus	Wildebeest	WB	180	Grazer	118	218	139	111	586	0.390	0.675	103	0.448	0.733
Alcelaphus bucelaphus	Kongoni	KG	171	Grazer	9	17	3	0	29	0.019	0.139	7	0.030	0.175
Oryx beisa	Oryx	OR	169	Grazer	3	1	1	0	5	0.003	0.058	0	0.000	0.000
Stuthio camelus	Ostrich	OS	100	Grazer	5	8	2	1	16	0.011	0.103	2	0.009	0.093
Phacochoerus aethiopicus	Warthog	WH	70	Grazer	1	7	5	16	29	0.019	0.139	1	0.004	0.066
Gazella granti	Grant's gazelle	GG	55	Browser	27	59	4	10	100	0.067	0.261	8	0.035	0.188
Aepyceros melampus	Impala	IM	53	Mixed	9	30	2	5	46	0.031	0.176	2	0.009	0.093
Litocranius walleri	Gerenuk	GE	38	Browser	1	1	1	0	3	0.002	0.045	0	0.000	0.000
Gazella thompsoni	Thomson's Gazelle	TG	20	Mixed	10	26	4	16	56	0.037	0.194	14	0.061	0.249
				Totals	417	535	265	285	1502			230		

Table S2. Time interval correspondence of live vs. bone surveys.

Survey Years Correspondence: Live vs. Dead

	Time Interval 1 (WS 3-4)	**Time Interval 2 (WS 0-2)**	**Time Interval 3 (WS 3-4)**	**Time Interval 4 (WS 0-2)**
Live Census	1967-69	1970, 1973-75	1993-98	1999-04
Bone Census	1964-69	1970-76	1993-98	1999-04

Tables S3 A-D. Live and bone counts and relative abundance of 15 species by habitat for each of four time intervals.

S3A.

1964-69

TAXON	CODE	SWAMP.LIVE.67.69	SWAMP.BONE.64.69	PLAINS.LIVE.67.69	PLAINS.BONE.64.69	BUSH.LIVE.67.69	BUSH.BONE.64.69	WOOD.LIVE.67.69	WOOD.BONE.64.69	SWAMP.LIVE.67.69	SWAMP.BONE.64.69	PLAINS.LIVE.67.69	PLAINS.BONE.64.69	BUSH.LIVE.67.69	BUSH.BONE.64.69	WOOD.LIVE.67.69	WOOD.BONE.64.69
ELEPHANT	EL	0	5	275	2	0	0	210	9	0.000	0.096	0.014	0.011	0.000	0.000	0.014	0.076
RHINO	RH	0	3	27	5	2	1	23	12	0.000	0.058	0.001	0.029	0.001	0.017	0.002	0.102
GIRAFFE	GF	2	9	106	7	36	1	184	18	0.051	0.173	0.005	0.040	0.022	0.017	0.013	0.153
BUFFALO	BF	0	7	471	3	0	3	295	12	0.000	0.135	0.023	0.017	0.000	0.051	0.020	0.102
ZEBRA	ZB	0	12	6839	72	691	19	3485	26	0.000	0.231	0.340	0.414	0.414	0.322	0.240	0.220
KOBUS	KO	5	0	2	0	0	0	35	0	0.128	0.000	0.000	0.000	0.000	0.000	0.002	0.000
WILDEBEESTE	WB	1	14	7689	63	173	15	5028	21	0.026	0.269	0.382	0.362	0.104	0.254	0.347	0.178
KONGONI	KG	0	0	389	6	3	1	94	2	0.000	0.000	0.019	0.034	0.002	0.017	0.006	0.017
ORYX	OR	23	0	270	1	128	2	305	0	0.590	0.000	0.013	0.006	0.077	0.034	0.021	0.000
OSTRICH	OS	7	0	147	1	66	3	224	1	0.179	0.000	0.007	0.006	0.040	0.051	0.015	0.008
WARTHOG	WH	0	0	1	1	0	0	24	0	0.000	0.000	0.000	0.006	0.000	0.000	0.002	0.000
GRANT'S GAZELLE	GG	1	0	1556	3	474	13	2208	10	0.026	0.000	0.077	0.017	0.284	0.220	0.152	0.085
IMPALA	IM	0	0	130	2	3	0	1698	7	0.000	0.000	0.006	0.011	0.002	0.000	0.117	0.059
GERENUK	GE	0	0	0	0	0	1	0	0	0.000	0.000	0.000	0.000	0.000	0.017	0.000	0.000
THOMSON'S GAZELLE	TG	0	2	2215	8	91	0	690	0	0.000	0.038	0.110	0.046	0.055	0.000	0.048	0.000
		39	52	20117	174	1667	59	14503	118	1	1	1	1	1	1	1	1

S3B.

1970-76

TAXON		SWAMP.LIVE.73-75	SWAMP.BONE.70.76	PLAINS.LIVE.70-75	PLAINS.BONE.70.76	BUSH.LIVE.70-75	BUSH.BONE.70.76	WOOD.LIVE.70.75	WOOD.BONE.70.76	SWAMP.LIVE.73-75	SWAMP.BONE.70.76	PLAINS.LIVE.70-75	PLAINS.BONE.70.76	BUSH.LIVE.70-75	BUSH.BONE.70.76	WOOD.LIVE.70.75	WOOD.BONE.70.76
ELEPHANT	EL	125	3	1147	1	12	0	597	7	0.006	0.029	0.077	0.005	0.001	0.000	0.036	0.043
RHINO	RH	38	2	133	0	12	0	0	6	0.002	0.019	0.009	0.000	0.001	0.000	0.000	0.037
GIRAFFE	GF	367	0	73	1	505	0	562	2	0.018	0.000	0.005	0.005	0.023	0.000	0.034	0.012
BUFFALO	BF	138	10	250	3	0	0	444	6	0.007	0.095	0.017	0.016	0.000	0.000	0.027	0.037
ZEBRA	ZB	5470	24	2364	45	5153	9	3208	28	0.271	0.229	0.158	0.243	0.240	0.225	0.193	0.173
KOBUS	KO	0	1	25	0	0	0	133	1	0.000	0.010	0.002	0.000	0.000	0.000	0.008	0.006
WILDEBEESTE	WB	12876	44	5182	97	6361	10	6037	46	0.637	0.419	0.346	0.524	0.296	0.250	0.364	0.284
KONGONI	KG	13	5	198	8	40	1	0	3	0.001	0.048	0.013	0.043	0.002	0.025	0.000	0.019
ORYX	OR	0	0	45	0	909	1	0	0	0.000	0.000	0.003	0.000	0.042	0.025	0.000	0.000
OSTRICH	OS	25	3	666	2	1234	1	309	2	0.001	0.029	0.044	0.011	0.057	0.025	0.019	0.012
WARTHOG	WH	13	1	83	0	13	0	530	6	0.001	0.010	0.006	0.000	0.001	0.000	0.032	0.037
GRANT'S GAZELLE	GG	672	5	2613	14	6354	16	1979	23	0.033	0.048	0.174	0.076	0.295	0.400	0.119	0.142
IMPALA	IM	188	1	0	1	0	0	1982	27	0.009	0.010	0.000	0.005	0.000	0.000	0.119	0.167
GERENUK	GE	0	0	12	0	121	1	138	0	0.000	0.000	0.001	0.000	0.006	0.025	0.008	0.000
THOMSON'S GAZELLE	TG	298	6	2201	13	213	1	684	5	0.015	0.057	0.147	0.070	0.010	0.025	0.041	0.031
		20220	105	14991	185	20927	40	16603	162	1	1	1	1	1	1	1	1

S3C.

1993-98

TAXON		**SWAMP.LIVE.93.98**	**SWAMP.BONE.93.98**	**PLAINS.LIVE.93.98**	**PLAINS.BONE.93.98**	**BUSH.LIVE.93.98**	**BUSH.BONE.93.98**	**WOOD.LIVE.93.98**	**WOOD.BONE.93.98**	**SWAMP.LIVE.93.98**	**SWAMP.BONE.93.98**	**PLAINS.LIVE.93.98**	**PLAINS.BONE.93.98**	**BUSH.LIVE.93.98**	**BUSH.BONE.93.98**	**WOOD.LIVE.93.98**	**WOOD.BONE.93.98**
ELEPHANT	EL	132	5	77	3	70	0	287	3	0.082	0.096	0.008	0.023	0.023	0.000	0.022	0.091
RHINO	RH	0	3	0	0	0	0	0	1	0.000	0.058	0.000	0.000	0.000	0.000	0.000	0.030
GIRAFFE	GF	3	0	5	2	29	1	3	2	0.002	0.000	0.000	0.015	0.009	0.029	0.000	0.061
BUFFALO	BF	32	6	28	9	0	1	141	1	0.020	0.115	0.003	0.068	0.000	0.029	0.011	0.030
ZEBRA	ZB	688	10	4691	30	1154	11	4921	9	0.429	0.192	0.457	0.227	0.372	0.314	0.378	0.273
KOBUS	KO	0	0	0	0	0	0	7	0	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
WILDEBEESTE	WB	485	27	4217	76	337	18	7422	15	0.302	0.519	0.411	0.576	0.109	0.514	0.570	0.455
KONGONI	KG	0	0	0	2	1	1	0	0	0.000	0.000	0.000	0.015	0.000	0.029	0.000	0.000
ORYX	OR	0	0	2	0	3	0	0	0	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
OSTRICH	OS	68	0	92	1	100	1	0	0	0.042	0.000	0.009	0.008	0.032	0.029	0.000	0.000
WARTHOG	WH	140	0	41	5	10	0	71	0	0.087	0.000	0.004	0.038	0.003	0.000	0.005	0.000
GRANT'S GAZELLE	GG	20	0	152	1	976	1	0	0	0.012	0.000	0.015	0.008	0.315	0.029	0.000	0.000
IMPALA	IM	0	0	0	0	124	0	46	2	0.000	0.000	0.000	0.000	0.040	0.000	0.004	0.061
GERENUK	GE	0	0	0	0	1	1	0	0	0.000	0.000	0.000	0.000	0.000	0.029	0.000	0.000
THOMSON'S GAZELLE	TG	36	1	956	3	295	0	130	0	0.022	0.019	0.093	0.023	0.095	0.000	0.010	0.000
		1604	52	10261	132	3100	35	13028	33	1	1	1	1	1	1	1	1

S3D.

1999-2004

TAXON		**SWAMP.LIVE.99-04**	**SWAMP.BONE.99-04**	**PLAINS.LIVE.99-04**	**PLAINS.BONE.99-04**	**BUSH.LIVE.99-04**	**BUSH.BONE.99-04**	**WOOD.LIVE.99-04**	**WOOD.BONE.99-04**	**SWAMP.LIVE.99-04**	**SWAMP.BONE.99-04**	**PLAINS.LIVE.99-04**	**PLAINS.BONE.99-04**	**BUSH.LIVE.99-04**	**BUSH.BONE.99-04**	**WOOD.LIVE.99-04**	**WOOD.BONE.99-04**
ELEPHANT	EL	425	5	13	1	87	0	190	1	0.252	0.053	0.001	0.008	0.036	0.000	0.024	0.022
RHINO	RH	0	1	0	0	0	0	0	0	0.000	0.011	0.000	0.000	0.000	0.000	0.000	0.000
GIRAFFE	GF	1	0	0	1	19	0	1	0	0.001	0.000	0.000	0.008	0.008	0.000	0.000	0.000
BUFFALO	BF	67	11	344	6	2	0	410	7	0.040	0.116	0.037	0.050	0.001	0.000	0.052	0.156
ZEBRA	ZB	385	25	3900	43	811	3	3390	17	0.228	0.263	0.415	0.361	0.331	0.250	0.426	0.378
KOBUS	KO	0	0	0	0	0	0	1	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WILDEBEESTE	WB	631	39	4073	52	457	4	3496	10	0.374	0.411	0.434	0.437	0.187	0.333	0.440	0.222
KONGONI	KG	0	0	14	0	0	0	0	0	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000
ORYX	OR	10	0	13	0	6	0	0	0	0.006	0.000	0.001	0.000	0.002	0.000	0.000	0.000
OSTRICH	OS	123	0	84	0	47	0	0	0	0.073	0.000	0.009	0.000	0.019	0.000	0.000	0.000
WARTHOG	WH	7	4	90	8	11	0	15	3	0.004	0.042	0.010	0.067	0.004	0.000	0.002	0.067
GRANT'S GAZELLE	GG	35	4	154	1	814	4	0	1	0.021	0.042	0.016	0.008	0.332	0.333	0.000	0.022
IMPALA	IM	0	0	0	1	29	0	84	4	0.000	0.000	0.000	0.008	0.012	0.000	0.011	0.089
GERENUK	GE	0	0	0	0	11	0	0	0	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000
THOMSON'S GAZELLE	TG	2	6	708	6	155	1	363	2	0.001	0.063	0.075	0.050	0.063	0.083	0.046	0.044
		1686	95	9393	119	2449	12	7950	45	1	1	1	1	1	1	1	1

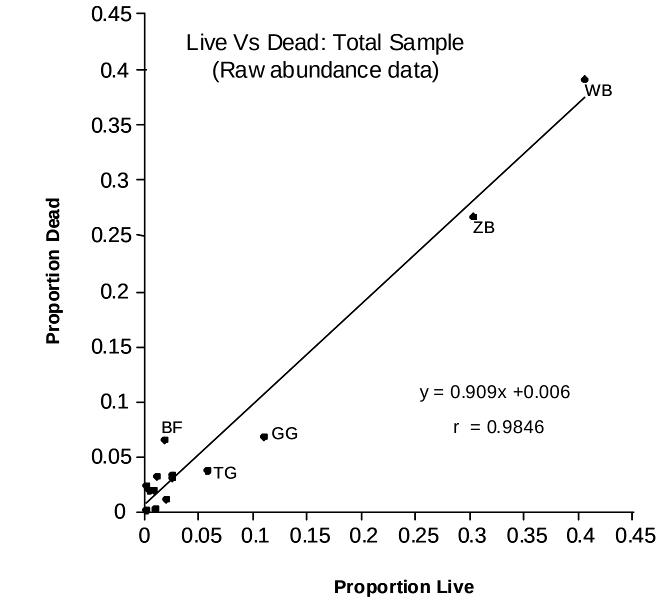
Table S4. ArcSin transformed abundance data used for non-metric Multidimensional Scaling Analysis (Fig. S3). Code for row labels: L= Live, D = Dead; B1= Bin (=Interval) 1, B2 = Bin 2, SW=Swamp, PL=Plains, BH=Bush, WD=Woodland. For column labels (species) see Table S1; decreasing body weight from left to right.

	EL	**RH**	**GF**	**BF**	**ZB**	**KO**	**WB**	**KG**	**OR**	**OS**	**WH**	**GG**	**IM**	**GE**	**TG**
L.B2.SW	0.0783	0.0428	0.1344	0.0821	0.5437	0.0000	0.9169	0.0247	0.0000	0.0350	0.0247	0.1823	0.0959	0.0000	0.1211
D.B2.SW	0.1698	0.1385	0.0000	0.3137	0.4985	0.0977	0.7041	0.2200	0.0000	0.1698	0.0977	0.2200	0.0977	0.0000	0.2414
L.B2.PL	0.2803	0.0943	0.0698	0.1295	0.4084	0.0408	0.6285	0.1152	0.0548	0.2123	0.0745	0.4306	0.0000	0.0283	0.3932
D.B2.PL	0.0736	0.0000	0.0736	0.1277	0.5158	0.0000	0.8097	0.2095	0.0000	0.1042	0.0000	0.2787	0.0736	0.0000	0.2683
L.B2.BH	0.0006	0.0006	0.0241	0.0000	0.2462	0.0000	0.3040	0.0019	0.0434	0.0590	0.0006	0.3036	0.0000	0.0058	0.0102
D.B2.BH	0.0000	0.0000	0.0000	0.0000	0.2250	0.0000	0.2500	0.0250	0.0250	0.0250	0.0000	0.4000	0.0000	0.0250	0.0250
L.B2.WD	0.0360	0.0000	0.0338	0.0267	0.1932	0.0080	0.3636	0.0000	0.0000	0.0186	0.0319	0.1192	0.1194	0.0083	0.0412
D.B2.WD	0.0432	0.0370	0.0123	0.0370	0.1728	0.0062	0.2840	0.0185	0.0000	0.0123	0.0370	0.1420	0.1667	0.0000	0.0309
L.B4.SW	0.5260	0.0000	0.0244	0.2007	0.4982	0.0000	0.6583	0.0000	0.0771	0.2735	0.0645	0.1446	0.0000	0.0000	0.0344
D.B4.SW	0.2315	0.1028	0.0000	0.3472	0.5387	0.0000	0.6954	0.0000	0.0000	0.0000	0.2067	0.2067	0.0000	0.0000	0.2540
L.B4.PL	0.0372	0.0000	0.0000	0.1926	0.7002	0.0000	0.7188	0.0386	0.0372	0.0947	0.0980	0.1284	0.0000	0.0000	0.2781
D.B4.PL	0.0918	0.0000	0.0918	0.2265	0.6449	0.0000	0.7222	0.0000	0.0000	0.0000	0.2623	0.0918	0.0918	0.0000	0.2265
L.B4.BH	0.1896	0.0000	0.0882	0.0286	0.6132	0.0000	0.4467	0.0000	0.0495	0.1390	0.0671	0.6145	0.1090	0.0671	0.2543
D.B4.BH	0.0000	0.0000	0.0000	0.0000	0.5236	0.0000	0.6155	0.0000	0.0000	0.0000	0.0000	0.6155	0.0000	0.0000	0.2928
L.B4.WD	0.1552	0.0000	0.0112	0.2291	0.7115	0.0112	0.7250	0.0000	0.0000	0.0000	0.0435	0.0000	0.1030	0.0000	0.2153
D.B4.WD	0.1496	0.0000	0.0000	0.4054	0.6619	0.0000	0.4909	0.0000	0.0000	0.0000	0.2612	0.1496	0.3027	0.0000	0.2124

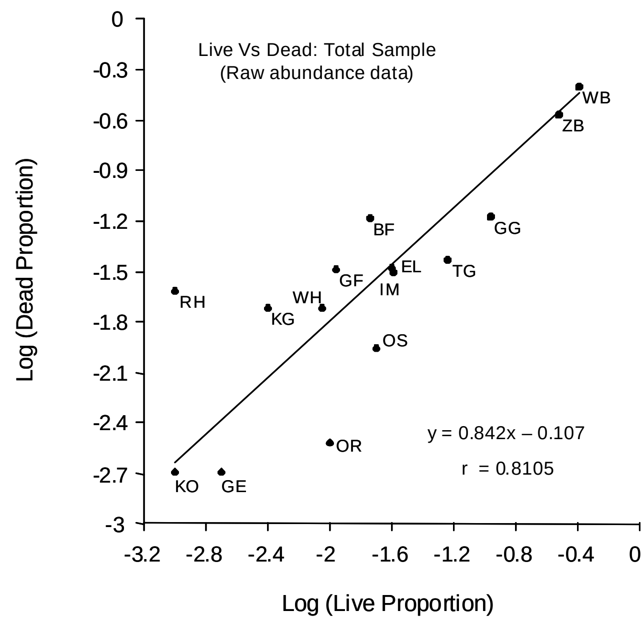
Supplementary Figures.

Fig. S1

A.

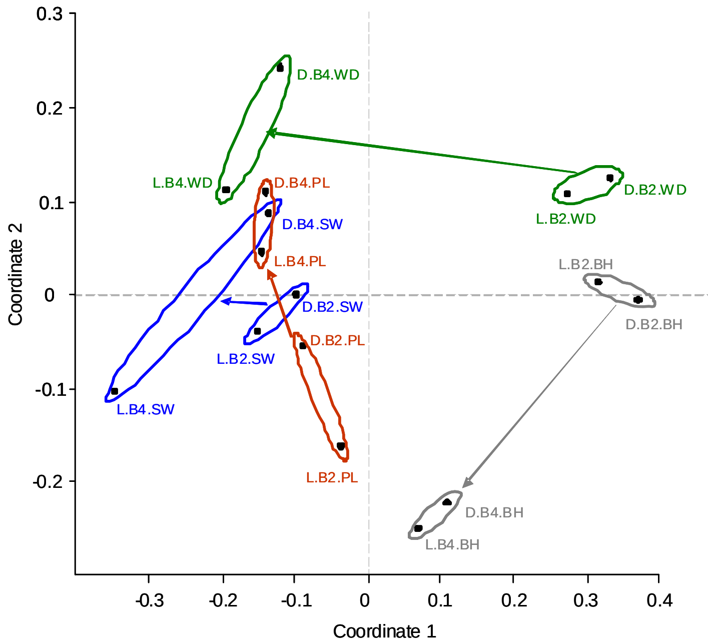


B.



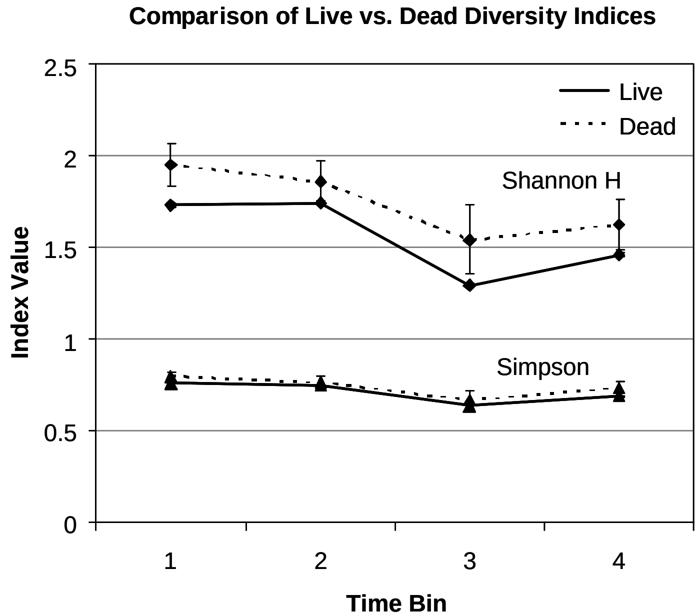
Caption S1. RMA analysis of total live (N=169,235 individual counts) against the total dead (1502 individuals), using relative abundances of 15 herbivore species between 20 and 4000 kg (14 mammal species and ostrich. **A.** Plot using raw abundance data; see Table S1 for species codes. This relationship is significant at the p<.001 level (Table 1). **B.** Log-log plot of same data as in A. See Table S1 for numerical data and Text Figure 2 for plot of transformed data using ASIN(SQRT(Proportion)) for each species.

Fig. S2



Caption S2. Results of a non-metric multidimensional scaling analysis of transformed relative abundance data for live and dead data sets, using the lower weathering stage sub-set (bone weathering stages 0-2), i.e., Time Intervals (Bins) 2 (1970-76) and 4 (1999-2004) (Table S4). Live-Dead pairs connected by ovals, habitat samples for Bins 2 and 4 connected by arrows to show shifts through time. Code for labels: L= Live, D = Dead, B = Bin, SW=Swamp, PL=Plains, BH=Bush, WD=Woodland, thus L.B2.WD = Live sample from Bin 2, Woodland habitat. Calculated stress for this analysis using Euclidean distances =.1617.

Fig. S3



Caption S3. Plots showing tracking of two diversity indices based on live population and bone survey raw abundance data (Table S1). Time bins: 1=1964-69; 2=1970-76, 3=1993-97, 4=1998-2004. Error-bars show 95% confidence intervals (not visible for live data because of large sample sizes).

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