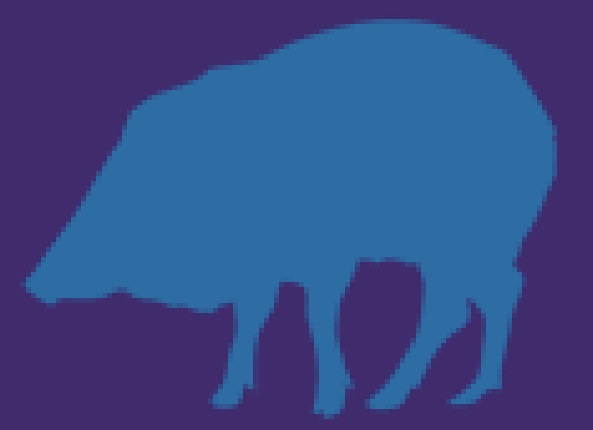# Late Holocene Climate Change and the Emergence of Hunter-Gatherer Territoriality in the Late Archaic Texas Coastal Plains: An Analysis using Bioavailable $^{87}Sr/^{86}Sr$

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Introduction

This poster presents the preliminary analyses of data used to assess territoriality in the Texas Coastal Plains (TCP) by comparing Late Archaic human $^{87}Sr/^{86}Sr$ to bioavailable $^{87}Sr/^{86}Sr$ obtained from modern fauna. The results will help determine if $^{87}Sr/^{86}Sr$ is a useful tool for the study of emergent hunter-gatherer territoriality during the context of Late Holocene climate and cultural changes.

Background

The TCP Late Archaic (ca 4000-1200 BP) was a time of sea level stability, increased moisture, and abundant resources.

Existing models suggest that this change set the stage for population packing and circumscribed mobility that led to the emergence of distinctive territorial behavior among TCP hunter-gatherer populations.

During Late Archaic there was a peak increase in size and number of hunter-gatherer mortuary sites compared to previous time periods. This change is often interpreted as evidence of increasing territorial behavior, but there is no direct evidence for this assumption.

Because $^{87}Sr/^{86}Sr$ are linked to particular geologic locations, it maybe a useful means of interpreting these patterns with direct archaeological evidence.

Study Area

The TCP extends from Galveston Bay southwestward to the Nueces River from the Gulf of Mexico inwards to the Balcones Escarpment [Figure 1].

The TCP is a geologically "young" region with most geological units dating to the Tertiary and Quaternary periods but is noted to be, "complex and controversial, with disagreement over which units are equivalent in age and how they correlate to each other" (Chowdhury & Turco 2006:45). [Figure 2]

The TCP is divided into three ecological zones: 1) the Coastal Zone; 2) the Riverine Zone, and 3) the Inland Zone. While not corresponding exactly with geological zones, they are important to understanding resource acquisition and mobility.

Hard & Katzenberg (2011) show that by 2500 BP, Coastal Zone inhabitants do not appear to have been exploiting Riverine Zone resources (25 km) away and this is seen as evidence for territoriality.

Human $^{87}Sr/^{86}Sr$ data was analyzed from Loma Sandia (41LK28); a short duration (200 year use) Late Archaic mortuary site located in Live Oak County Texas near the confluence of the Nueces River and two of its tributaries. [Figure 1]

Methods

Molar samples (N=103) were collected from a combination of deer, javelina, wild hog, and nilgai. Specimens were collected from Wildlife Management areas and private ranches.

Human tooth samples (N=53) from Loma Sandia were selected for destructive analysis with permission from the Texas Historical Commission and the Center for Archaeological Research (CAR), University of Texas at San Antonio.

All samples were pre-processed at CAR in order to eliminate organic components and isolate the enamel apatite using a combination of procedures described by Garvie-Lok et al. (2004) and Price et al. (2000).

Ion chromatography and Thermal Ionization Mass Spectrometry was preformed at the University of North Carolina at Chapel Hill Isotope Geochemistry Laboratory, Department of Geosciences, under supervision of Dr. Ryan Mills and laboratory staff.

Disclaimers:
No animals were harmed for the purposes of this research. All faunal specimens were donated by hunters as part of their regular hunting activity or died of natural causes. All specimens were collected by TPWD wildlife biologists or on a private ranch by the researcher with permission of ranch owners.
This NSF funded project was completed with permission from the Texas Historical Commission and the Center for Archaeological Research, University of Texas at San Antonio, for destructive analysis of 54 enamel samples from 41LK28. At the time of this study, the remains of Loma Sandia were classified as unaffiliated according to the Native American Graves Protection and Repatriation Act.

Preliminary Analysis

Data was analyzed using IBM SPSS v.25 and JMP PRO 13.

USGS unit ages and TCP Ecological Zones were combined to form 7 geo-ecological regions for analysis and data was trimmed 10%.

One-way ANOVAs and independent-sample t-tests were run to compare each geo-ecological region with Loma Sandia.

Geo-Ecological Zones Trimmed Data Summary Statistics

Statistics	Holocene-Coastal	Miocene-Riverine	Holocene-Inland/Riverine	Pleistocene & Holocene-Inland/Riverine	Loma Sandia-Inland/Riverine	Oligocene-Inland/Riverine	Middle Eocene-Inland Low	Paleocene to Eocene 1-Inland High	Paleocene to Eocene 2-Inland High
N	23	11	11	16	43	11	43	4	7
Mean 87s/86sr	0.708166	0.707885	0.707858	0.708002	0.708081	0.708062	0.708535	0.708819	0.710225
Median	0.708159	0.707877		0.707992	0.708083	0.708064	0.708521	0.708882	0.710268
Variance	8.000E-09	1.5041E-09		6.069E-09	3.1074E-09	1.13066E-08	1.0278E-08	6.1752E-08	3.1657E-08
Std. Deviation	0.0000894	0.0000388		0.0000779	0.0000557	0.0001063	0.0001014	0.0002485	0.0001779
Minimum	0.70820	0.707824		0.707888	0.707994	0.707896	0.708399	0.708661	0.709966
Maximum	0.708336	0.707936		0.708156	0.708193	0.708169	0.708671	0.709253	0.710413
Range	0.000316	0.000112		0.000268	0.000209	0.000273	0.000272	0.000592	0.000447
Interquartile Range	0.0001310	0.0000690		0.0000940	0.0000710	0.0001510	0.0002060	0.0004673	0.0001780
Shapiro-Wilk p value	0.7347	0.3869		0.6047	0.3132	0.5825	0.1504	0.7964	0.2039

Table 1: Summary statistics of data after a 10% trim of all geo-ecological zones and the Loma Sandia human data.
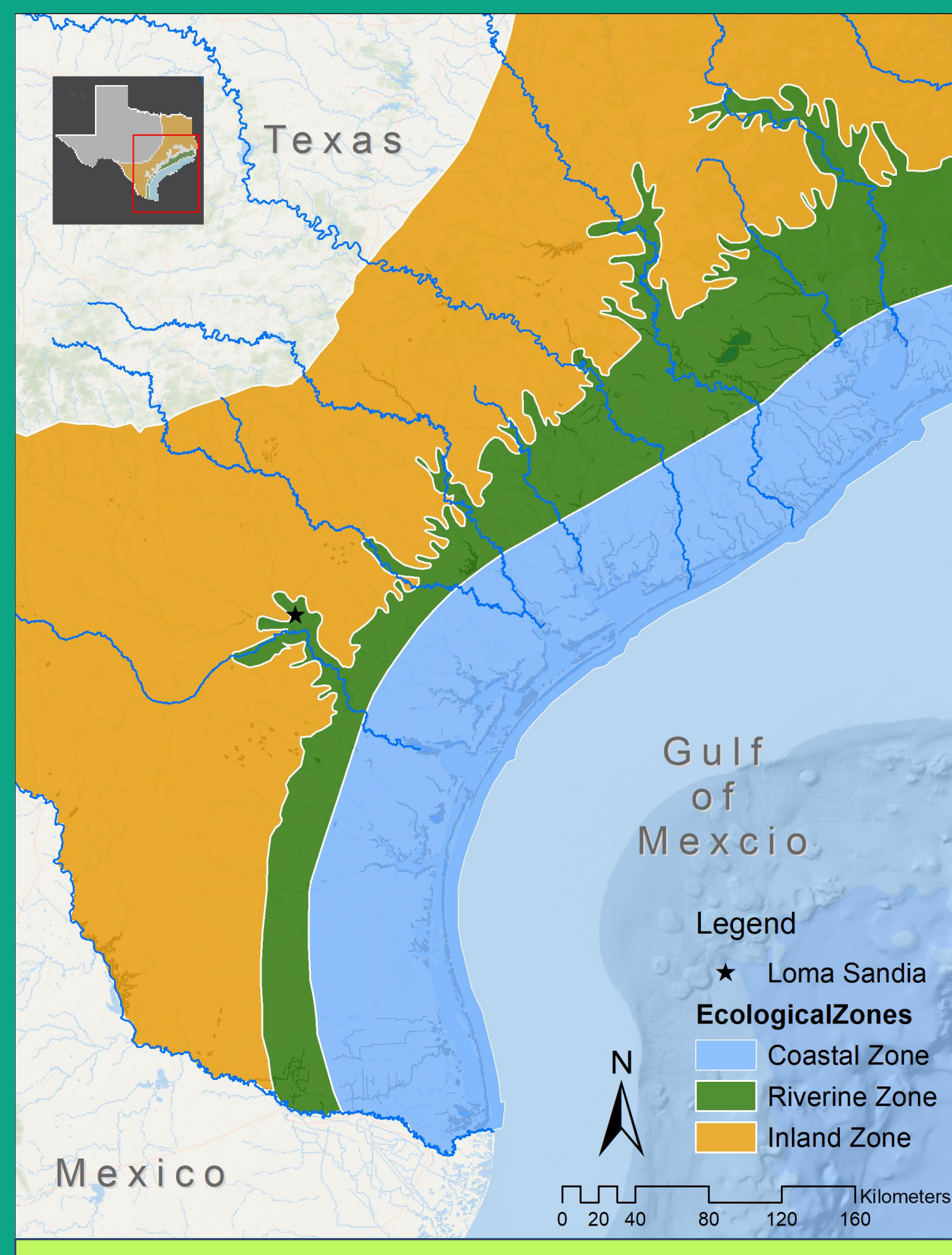

Figure 1: Ecological Zones of the TCP. Loma Sandia is located further inland than most Riverine sites and was designated as a Riverine/Inland Zone Geo-ecological area for analysis.
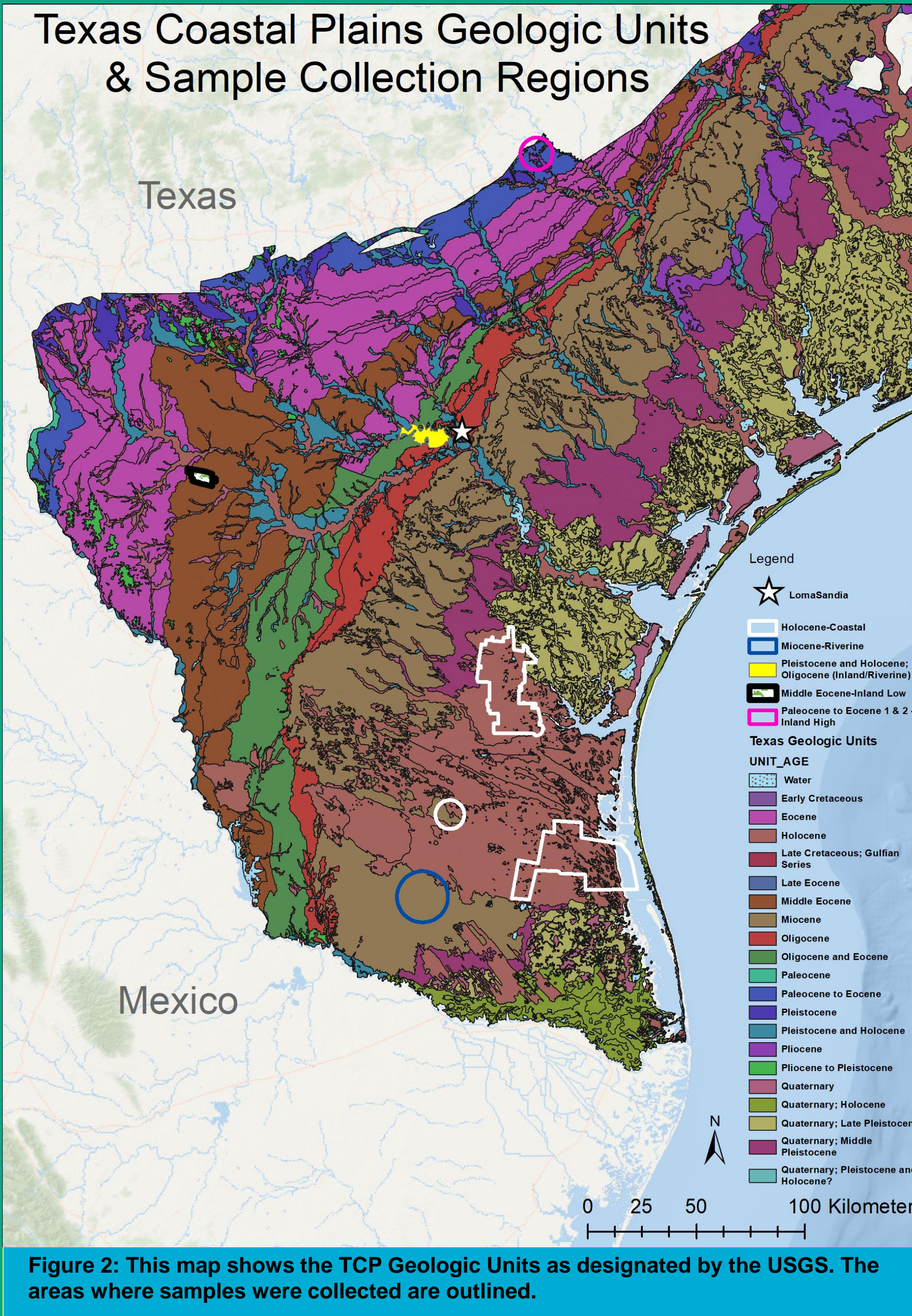
Legend
★ Loma Sandia
EcologicalZones
Coastal Zone
Riverine Zone
Inland Zone

Figure 2: This map shows the TCP Geologic Units as designated by the USGS. The areas where samples were collected are outlined.

$^{87}Sr/^{86}Sr$

Geo-ecological region means compared to Loma Sandia mean		Levene's Test				Sig.(2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the		Result
		F	Sig.	t	df				Lower	Upper	
Holocene-Coastal	Equal variances assumed	6.536	0.013	4.7320	64	<.0001	0.000850	0.000018	0.000049	0.00012	Significant difference between means.
	Equal variances not assumed			4.1276	31.38	0.0003	0.000850	0.0002	0.00048	0.00123	
Miocene-Riverine	Equal variances assumed	1.061	0.308	-10.9719	52	<.0001	-0.000200	0.0001788	-0.0023	-0.00016	Significant difference between means.
	Equal variances not assumed			-13.5665	21.9	<.0001	-0.000200	0.0001446	-0.00023	-0.0017	
Pleistocene and Holocene-Inland/Riverine	Equal variances assumed	2.448	0.123	-4.3570	57	<.0001	-0.000080	0.0001826	-0.00012	-0.000043	Significant difference between means.
	Equal variances not assumed			-3.7432	20.99	0.0012	-0.000080	0.0001125	-0.00012	-4.54E-05	
Oligocene-Inland/Riverine	Equal variances assumed	2.947	0.091	-0.6659	46	0.5088	-0.000020	0.0000291	-0.00782	3.934E-05	No significant difference between means. Caution: small sample size
	Equal variances not assumed			-0.4026	4.26	0.7067	-0.000020	0.0000491	-0.00015	0.0001	
Middle Eocene-Inland Low	Equal variances assumed	11.306	0.001	20.0667	53	<.0001	0.000454	0.0000409	0.00049	0.00049	Significant difference between means.
	Equal variances not assumed			14.3139	11.59	<.0001	0.000454	0.000317	0.00044	0.00057	
Paleocene to Eocene 1-Inland High	Equal variances assumed	23.334	<.0001	19.1420	45	<.0001	0.000838	0.0000444	0.00075	0.00092	Significant difference between means.
	Equal variances not assumed			6.7300	3.03	0.0065	0.000838	0.0001225	0.00044	0.0012	
Paleocene to Eocene 2-Inland High	Equal variances assumed	26.140	<.0001	44.3755	48	<.0001	0.002144	0.0000483	0.00207	0.00221	Significant difference between means.
	Equal variances not assumed			31.6268	6.19	<.0001	0.002144	0.000068	0.00179	0.00250	

Table 2: Results of independent sample t-tests of seven geo-ecological regions and Loma Sandia.
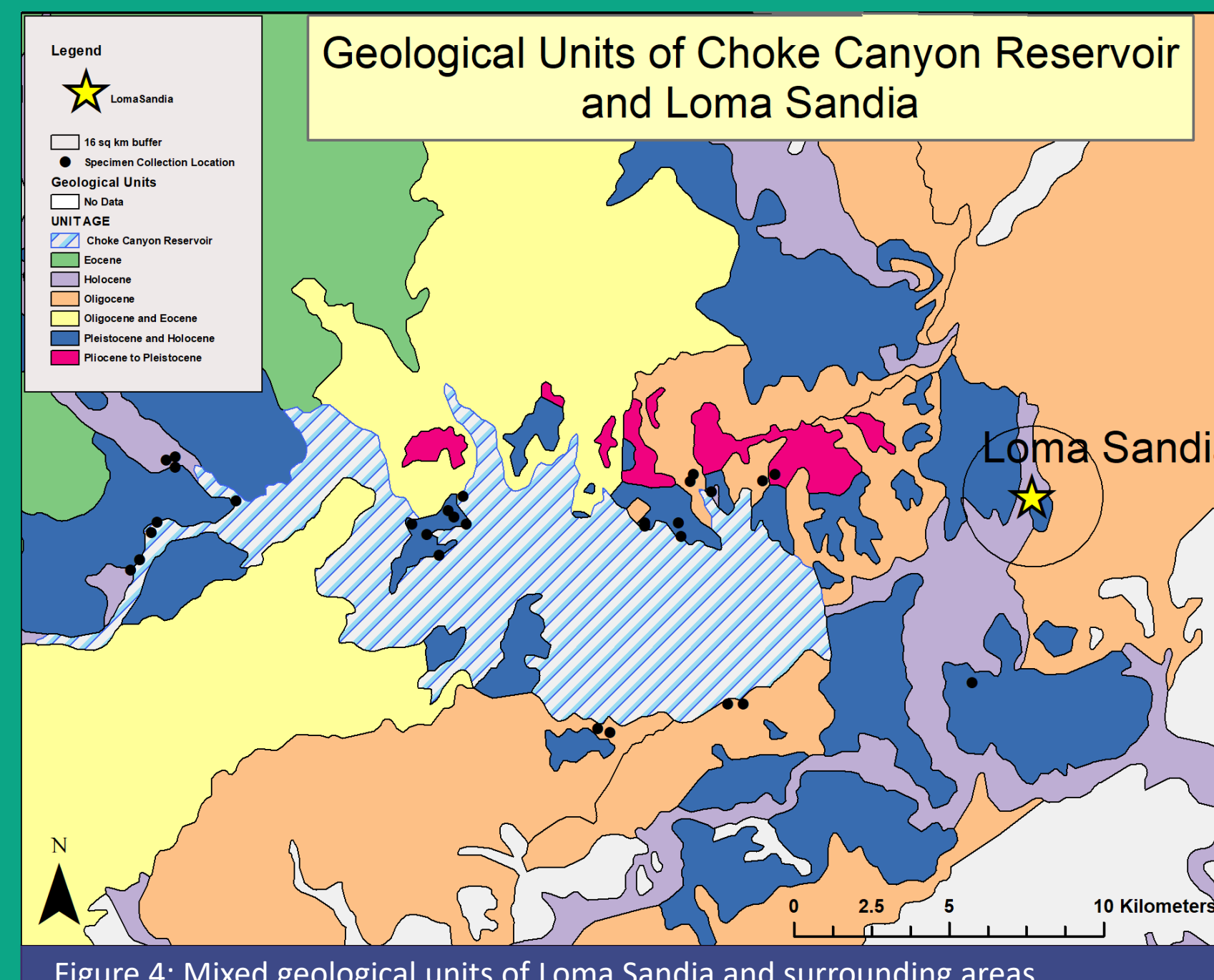
Figure 4: Mixed geological units of Loma Sandia and surrounding areas

RESULTS

The $^{87}Sr/^{86}Sr$ of each trimmed geo-ecological region was assessed by the Shapiro-Wilk's normality test (H_0 = The data is from a normal distribution; H_0 is rejected if p < 0.05) The p-values produced were >0.05 concluding that the null hypotheses H_0 cannot be rejected. Caution should still be taken as some sample sizes were very small. [Table 1]

Independent-sample t-tests between each geo-ecological region and human data show that 6 out of 7 geo-ecological have significant differences in mean $^{87}Sr/^{86}Sr$ ratios compared to Loma Sandia data [Table 2].

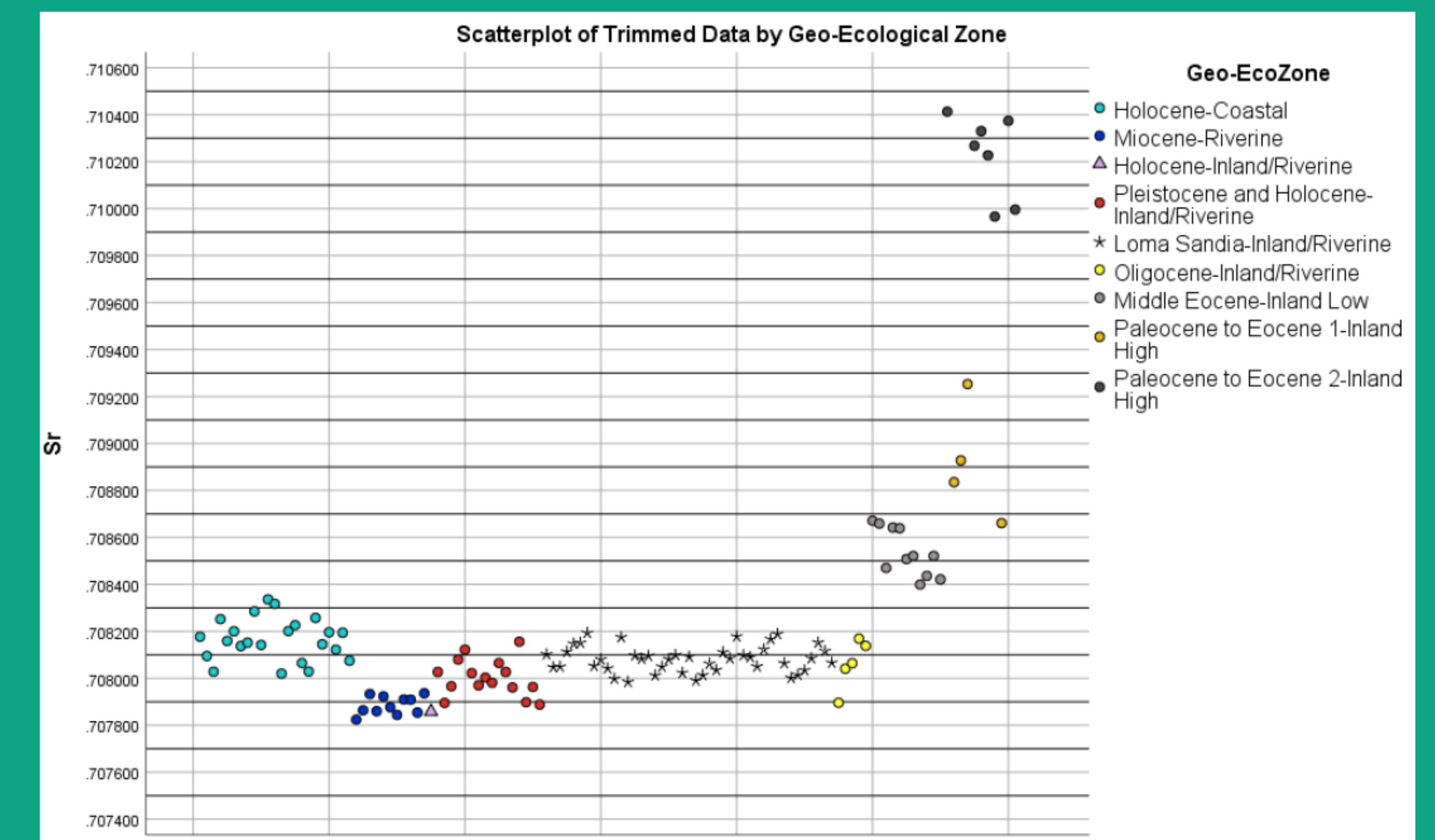A Scatter plot shows that the Loma Sandia human data overlaps with 3 out of 7 zones [Figure 3, below].

Figure 3: Scatter plot of all data after 10% trim. Note singular Holocene-Riverine point is much lower than Holocene-Coastal data.

Discussion: A Closer Look at Loma Sandia

The human data from Loma Sandia overlap with "Oligocene" and "Pleistocene and Holocene" data.

A 16 km² area around Loma Sandia [Figure 4] shows that the surrounding region contains a mix of the geological units, providing a possible explanation for the overlapping data.

The "Oligocene-Inland/Riverine" and "Pleistocene and Holocene-Inland/Riverine" samples were collected around the Choke Canyon Reservoir (<10 km from Loma Sandia) [Figure 4].

The overlap in data and the proximity of the reservoir suggests that the inhabitants of Loma Sandia were utilizing the Inland/Riverine region's resources.

The Loma Sandia data does not overlap with the Miocene-Riverine data, suggesting they were not utilizing resources from eastern Riverine regions.

Some Loma Sandia data overlaps with Holocene-Coastal data. However, the IQR of Loma Sandia is smaller than that of the Holocene-Coastal region [Table 1] suggesting that Loma Sandia inhabitants were also not utilizing the coast.

Coastal data should be looked at with caution. Previous $^{87}Sr/^{86}Sr$ studies have shown that sea spray and oceanic precipitation to impact bioavailable $^{87}Sr/^{86}Sr$ (Burton and Hahn 2016, Pestle 2013).

A singular Holocene-Riverine data point shows a lower Sr ratio than Holocene-Coastal data.

Conclusions and Future Research

The preliminary data shows some promising patterns. If the inhabitants of Loma Sandia were not utilizing nearby Riverine or Coastal resources, it suggests circumscribed mobility and territoriality occurred shortly after the Late Holocene sea level stabilization.

The following research suggestions may help further refine the data and interpretations:

1. Stable oxygen isotope analysis of the Loma Sandia samples to further refine the data.

2. $^{87}Sr/^{86}Sr$ analysis of archaeological samples to compare with the modern faunal samples to rule out modern contaminants.

3. An analysis of possible oceanic contaminates

4. Analysis of additional samples from the Holocene-Riverine Zone

See Supplemental Material folder for references.