


Inventory, Research and Monitoring for Covered Plant Species Technical Conditions

PROJECT REPORT

2009-2010

For work performed by the

National Park Service, Lake Mead National Recreation Area

Funding received from the Clark County Multiple Species Habitat Conservation Plan

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Table of Contents

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FIGURES

TABLES

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EXECUTIVE SUMMARY

The Clark County Multiple Species Habitat Conservation Plan (MSHCP) objectives for the four covered species *Arctomecon californica* Torr. & Frém. (Las Vegas bearpoppy), *Anulocaulis leiosolenus* (Torr.) Standl. var. *leiosolenus* (ringstem), *Astragalus geyeri* A. Gray var. var. *triquetrus* M.E. Jones (threecorner milkvetch), and *Eriogonum viscidulum* J.T. Howell (sticky buckwheat) are 1) no net unmitigated loss or fragmentation of habitat in intensively managed areas; and 2) maintain stable or increasing populations within these areas.

The project, "Inventory, Research and Monitoring for Covered Plant Species Technical Conditions" (2005-NPS-609E) was funded to supplement project 2005-NPS-535P. The purpose of this study was to collect and analyze the soil at several monitoring sites (project 2005-NPS-535P) to determine why the rare plants occur and do not occur in areas with visually identical environments. The soil collection occurred in habitats that occupied ringstem, Las Vegas bearpoppy, threecorner milkvetch, and sticky buckwheat. Samples were analyzed for macro and micronutrients to determine differences between soils populated by these rare plants and those that are not.

The soils analyses determined what elements were present, and how chemical attributes P & K, sulfur, C & N, pH and particle size differ in the soil between each rare plant population and adjacent habitat where no rare plants occur. The actual chemical attributes tested for in the soil analysis were pH, EC, Sodium (Na), Potassium (K), Magnesium (Mg), Calcium (Ca), Manganese (Mn), Iron (Fe), Nickel (Ni), Copper (Cu), Zinc (Zn), Cobalt (Co), Boron (B), Molybdenum (Mo), Lead (Pb), Cadmium (Cd), Chlorine (Cl), Sulfate (SO4), Nitrate (NO3), Available P, Calcium Carbonate (CaCO3), Total Carbon (Total C), Total Nitrogen (Total N), Clay, Silt, Sand, Total Energy, and Bulk Density.

Methods varied by species habitat in order to gather applicable data for sand loving rare plants versus gypsum loving rare plants. We sought to quantify the heterogeneity of soil component concentrations within Las Vegas bearpoppy and ringstem habitat islands and determine the effects on the plants' distribution. The extreme concentrations of the soil components in our habitat islands spectrum were sandy, high saline soils and alkaline, clay rich soils. Our findings concluded that within these habitat islands Las Vegas bearpoppy occupied the less extreme plots within the extreme transects, where as ringstem preferred more sandy, high saline soils.

No conclusions could be drawn from the sandy soil analyses as too few samples were taken for statistical analysis.

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INTRODUCTION

DESCRIPTION OF THE PROJECT

The project, “Inventory, Research and Monitoring for Covered Plant Species Technical Conditions” was designed to address Clark County Multiple Species Habitat Conservation Plan (MSHCP) goals for four covered plant species: *Arctomecon californica* Torr. & Frém. (Las Vegas bearpoppy), *Anulocaulis leiosolenus* (Torr.) Standl. var. *leiosolenus* (ringstem), *Astragalus geyeri* A. Gray var. *triquetrus* M.E. Jones (threecorner milkvetch) and *Eriogonum viscidulum* J.T. Howell (sticky buckwheat). MSHCP NPS 609E was funded to supplement the work completed on MSHCP NPS 535P-Inventory, Research, and Monitoring for Covered Plant Species.

MANAGEMENT ACTIONS ADDRESSED

The following MSHCP (RECON, 2000) conservation management actions were addressed by this project (2005-NPS-609E).

- Conservation Management Action NPS (3) - Cooperate in the identification, development, and implementation of research projects located on Federal lands. Emphasis shall be placed on research that addresses management concerns and the conservation of Covered and Evaluation Species.

- Conservation Management Action NPS (6) - Coordinate inventory of *Astragalus geyeri* var. *triquetrus* (threecorner milkvetch), and *Eriogonum viscidulum* (sticky buckwheat) with other survey efforts on Federal lands.

- Conservation Management Action NPS (15) - Monitor Las Vegas bearpoppy populations.

- Conservation Management Action NPS (51) - Assure full and continuing implementation of existing management policies and actions, and monitoring of sensitive habitats and species.

BACKGROUND AND NEED FOR THE PROJECT

In addition to addressing Clark County goals and objectives, this project supported National Park Service (NPS) compliance with federal management guidelines. NPS Management Policies direct managers at Lake Mead National Recreation Area (LMNRA) to survey for, protect and manage state and locally listed species and other native species of special concern (NPS, 2006). These directives are to be achieved by maintaining the species’ natural distribution and abundance (NPS, 2006).

The MSHCP lists specific goals for the management of rare plant species which are further outlined in the Low Elevation Rare Plant Conservation Management Strategy (TNC, 2007). The key purposes of the MSHCP are to achieve a balance between 1) long-term conservation and recovery of the diversity of natural habitats and native species of plants and animals, 2) the orderly and beneficial use of land in order to promote the economy, health, well-being, custom and culture of Clark County residents (TNC, 2007), as well as, having no net unmitigated loss or fragmentation of habitat in intensively managed areas and maintain stable or increasing plant populations. In addition, the MSHCP objectives for the four covered species: *Arctomecon californica* Torr. & Frém. (Las Vegas bearpoppy), *Anulocaulis leiosolenus* (Torr.) Standl. var. *leiosolenus* (ringstem), *Astragalus geyeri* A. Gray var. var. *triquetrus* M.E. Jones (threecorner milkvetch), and *Eriogonum viscidulum* J.T. Howell (sticky buckwheat) are 1) no net unmitigated loss or fragmentation of habitat in intensively managed areas; and 2) maintain stable or increasing populations within these areas.

DESCRIPTION OF THE SPECIES

LAS VEGAS BEARPOPPY

The Las Vegas bearpoppy is an endemic rare plant found on gypsum soils (Figure 2). Along with being listed as a Covered Species under the Clark County MSHCP (RECON, 2000), Las Vegas bearpoppy is currently listed Critically Endangered by the State of Nevada, Nevada Native Plant Society (NNPS) as a Threatened Species (this means that NNPS believes it meets the Endangered Species Act (ESA) definition of threatened), and a Sensitive Species by the BLM. Las Vegas bearpoppy is globally and state-ranked G3 and S3, respectively (NNHP, 2005).

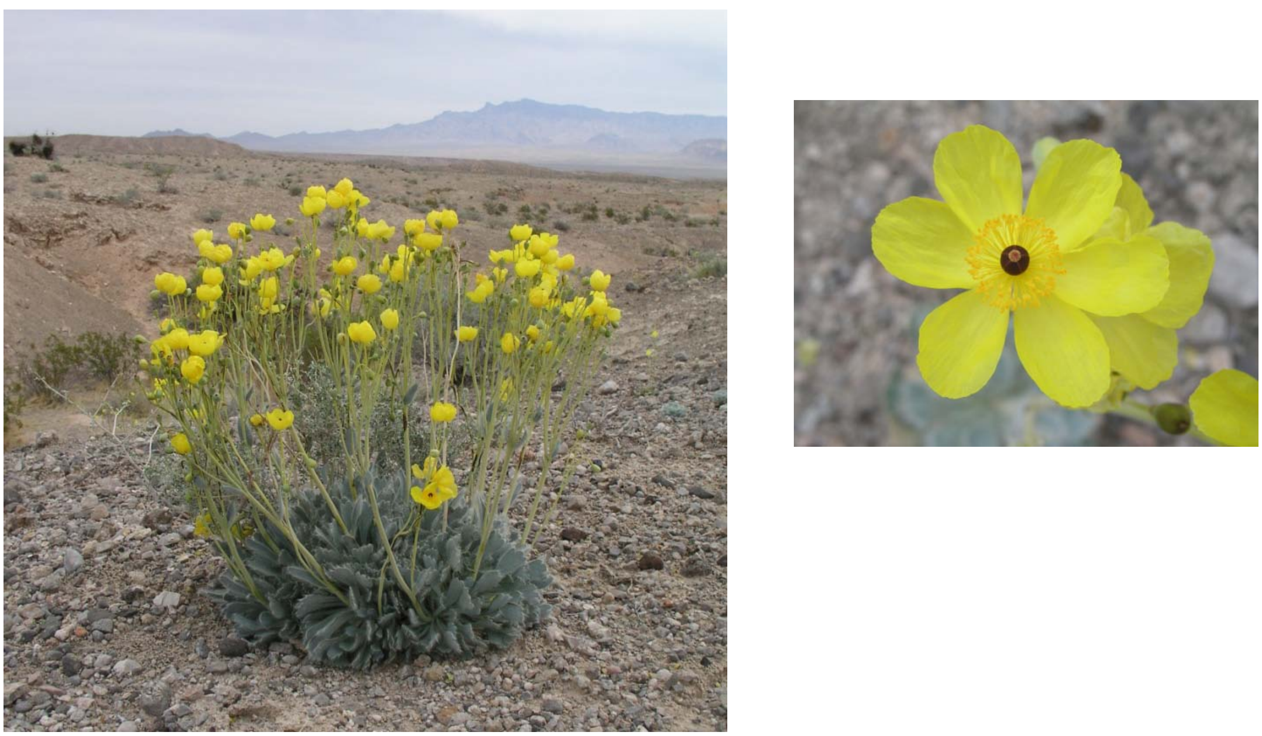

Figure 1. Photos of the Las Vegas bearpoppy. Las Vegas bearpoppy plant; Las Vegas bearpoppy flower.

In the most recent large scale survey of Las Vegas bearpoppy ending in 1996, 91 Clark County populations were found, with an additional 8 populations occurring in northwestern Mojave County, Arizona (Mistretta *et al.*, 1996). The various sites are managed by a variety of state and federal agencies, private land owners, and the Hualapai Indian Reservation (Mistretta *et al.*, 1996). Las Vegas bearpoppies have a limited distribution. They range from the southern base of the Virgin Mountains to south of Bonelli Bay at LMNRA, and from the lower part of the Grand Canyon to Las Vegas Valley (Mistretta *et al.*, 1996).

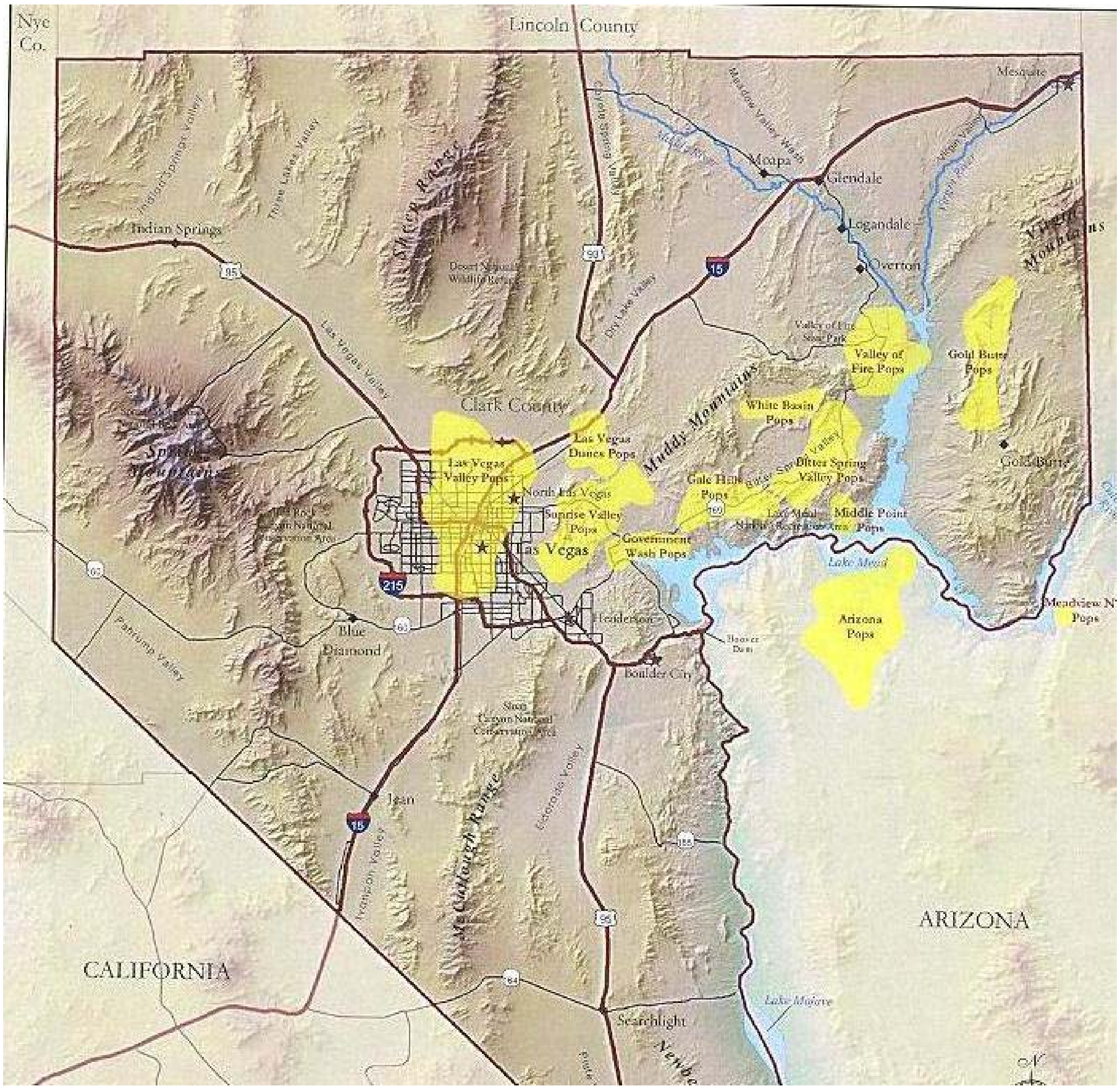

Figure 2. Reproduced from TNC 2007 delineating the Clark County distribution of Las Vegas bearpoppy.

RINGSTEM

Ringstem is a long-lived perennial endemic to the arid regions of the south-western United States and adjacent Mexico. Ringstem (Figure 4) occurs within LMNRA in Clark County, Nevada, Mohave County, Arizona, as well as New Mexico, Texas and Mexico (Flora of North America, 2003). Ringstem is listed as a Covered Species under the Clark County MSHCP (RECON, 2000), and is on the NNHP At-Risk List. Ringstem is globally and state-ranked G4T3 and S2 respectively (NNHP, 2005).

Figure 3. Photos of ringstem. Ringstem plant; Ringstem sticky node; Ringstem flower.

There are four recognized varieties of *Anulocaulis leiosolenus*, which in addition to *A. l. leiosolenus* includes: *A. l.* var. *gypsogenus* (Waterf.) Spellenb. & T. Wootten, var. *lasianthus* I.M. Johnst., and var. *howardii* Spellenb. & Wootton. In Arizona, ringstem has been recorded from the Big Gyp Hills within LMNRA, the Grand Canyon (bottom of Bright Angel Trail) and from Camp Verde (located 86 miles north of Phoenix, Arizona). The New Mexico populations of ringstem are found along the southern portion of the Rio Grande down into Texas near El Paso and Ciudad Juarez, Mexico (MSHCP 2005-NPS-535P). While there are four recognized varieties of *Anulocaulis leiosolenus*, the taxonomy of the genera, *Anulocaulis* spp. remains questionable (MSHCP 2005-NPS-535P).

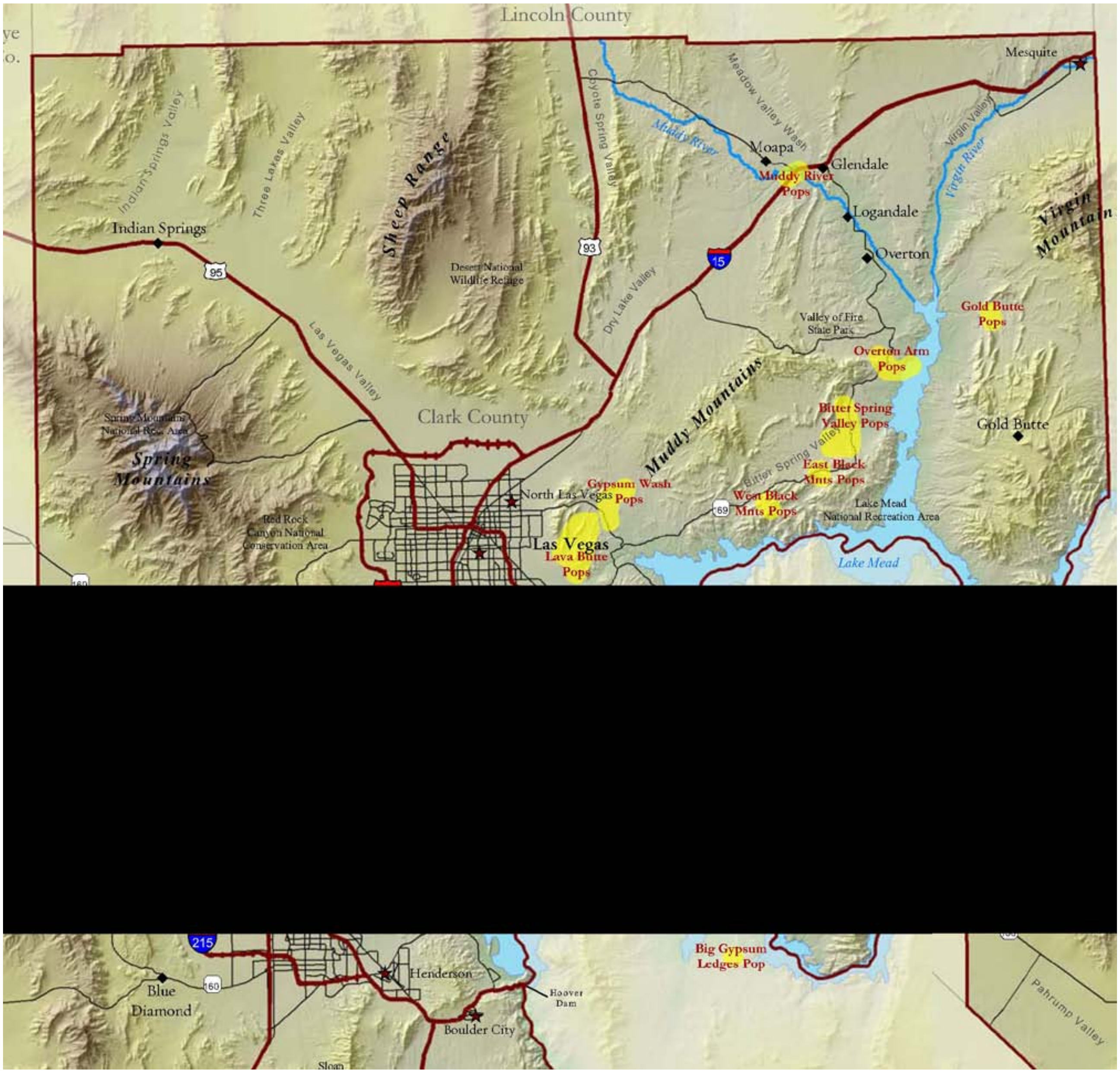

Figure 4. Reproduced from TNC 2007 delineating the known Clark County distribution of ringstem.

THREECORNER MILKVETCH

Threecorner milkvetch is a rare, sand-loving, annual plant endemic to Clark and Lincoln Counties in southern Nevada and Mojave County in northwestern Arizona (Figure 6). This species is listed as a Covered Species under the Clark County MSHCP (RECON, 2000), is on the NNHP At-Risk List, is currently listed Critically Endangered by the State of Nevada, Nevada Native Plant Society (NNPS) as a Threatened Species (this means that NNPS believes it meets the Endangered Species Act (ESA) definition of threatened), and a Sensitive Species by the BLM. Threecorner milkvetch is globally and state-ranked G4T2T3 and S2S3 respectively (NNHP, 2005).

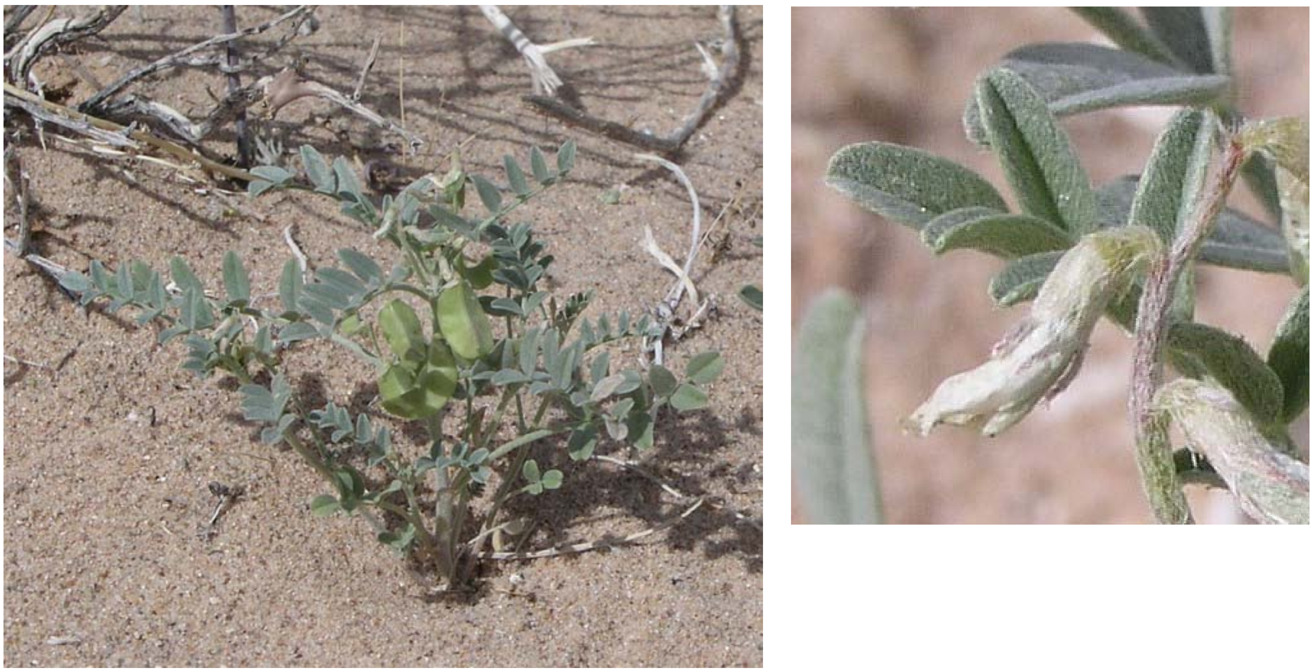

Figure 5. Photos of three corner milkvetch. Threecorner milkvetch plant with fruit; Threecorner milkvetch flower

The northern and eastern most distributions of this species are at Sand Hollow Wash in Lincoln County and at Coon Creek in Mojave County. Threecorner milkvetch reaches a southern extension at Sandy Cove on the north shore of the Boulder Basin LMNRA and a western extension at Dry Lake Valley in Clark County (Niles *et al.*, 1995). A comprehensive survey for threecorner milkvetch was conducted by Niles *et al.* (1995). Niles *et al.* (1995) conducted surveys of all known and potential locations of threecorner milkvetch within LMNRA and adjacent regions of Nevada and Arizona and identified 19 threecorner milkvetch sites. In 2001, there were estimated to be just over 4000 individuals at about 39 sites covering an unknown amount of area in Nevada (Morefield, 2001). As an annual species, population size can vary widely from year to year. After the record rainfall year of 2005, 8,000 plants were estimated on Sandy Cove (LMNRA), currently the largest known population of threecorner milkvetch (Bangle, 2005).

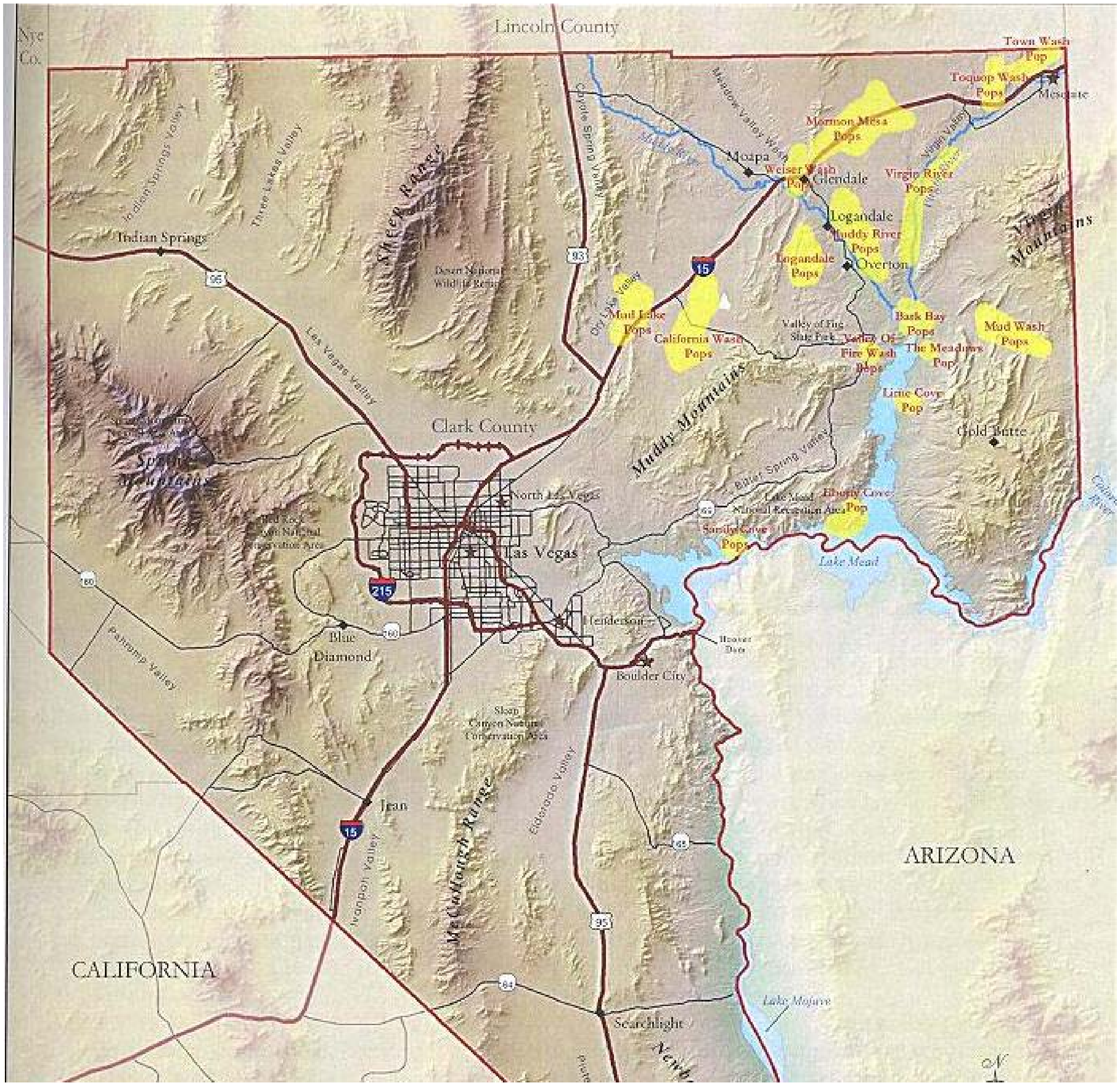

Figure 6. Reproduced from TNC 2007 delineating the known Clark County distribution of threecorner milkvetch.

STICKY BUCKWHEAT

Sticky buckwheat is a Covered Species under the Clark County MSHCP (RECON, 2000), is on the NNHP At-Risk List, is currently listed Critically Endangered by the State of Nevada, Nevada Native Plant Society (NNPS) as a Threatened Species (this means that NNPS believes it meets the Endangered Species Act (ESA) definition of threatened), and a Sensitive Species by the BLM. Sticky buckwheat is globally and state-ranked G2 and S2 (NNHP, 2005).

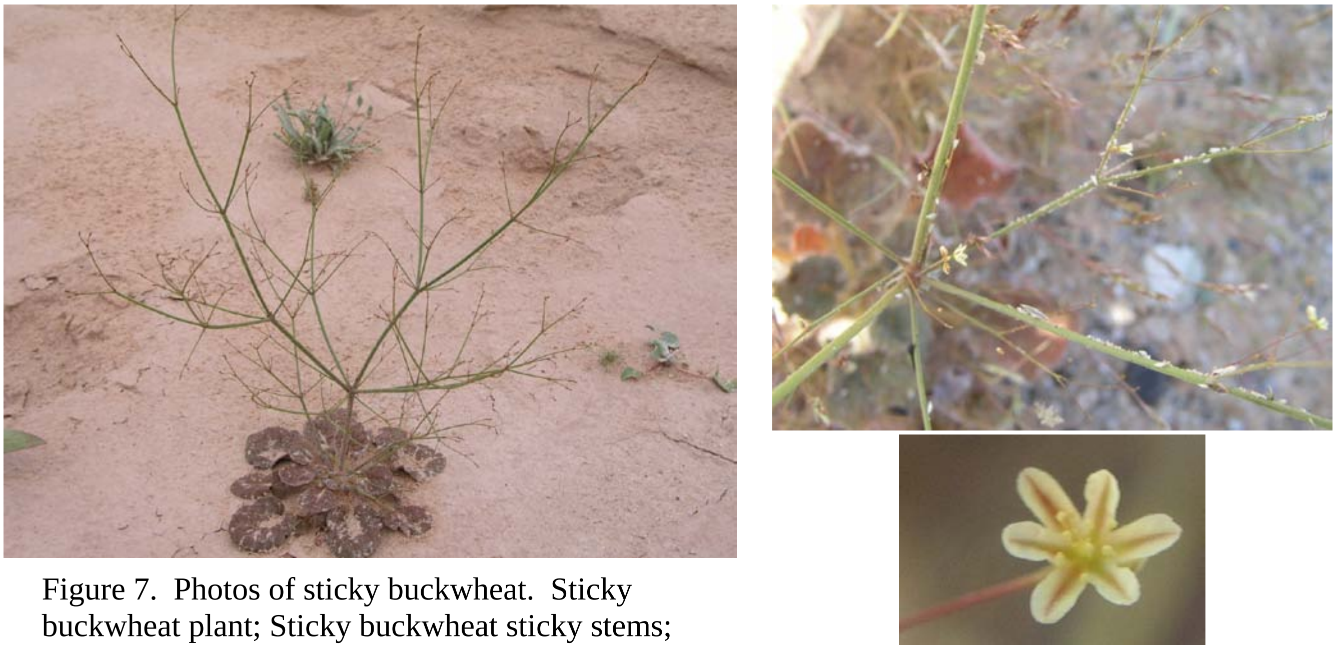

Figure 7. Photos of sticky buckwheat. Sticky buckwheat plant; Sticky buckwheat sticky stems; Sticky buckwheat flower.

Sticky buckwheat (Figure 8) is an annual plant endemic to Clark and Lincoln Counties in southern Nevada and Mojave County in northwestern Arizona (Howell, 1942). The northern and eastern most distributions of this rare species are found at Sand Hollow Wash in Lincoln County and just across the state border at Coon Creek in Mojave County. Sticky buckwheat reaches its southern and western extensions in Nevada at Middle Point within LMNRA and Weiser Wash on BLM land, respectively (Niles *et al.*, 1995).

Sticky buckwheat was first collected and described by Alice Eastwood and John T. Howell at the Riverside Bridge on the Virgin River, Clark County, Nevada (Howell, 1942). In the mid-1990s, Niles *et al.* (1995) conducted an inventory (March through June 1995) of all known locations of sticky buckwheat, as well as searches for additional localities within LMNRA and adjacent regions of Nevada and Arizona. Aerial reconnaissance was used to identify areas of suitable sticky buckwheat habitat for future surveys.

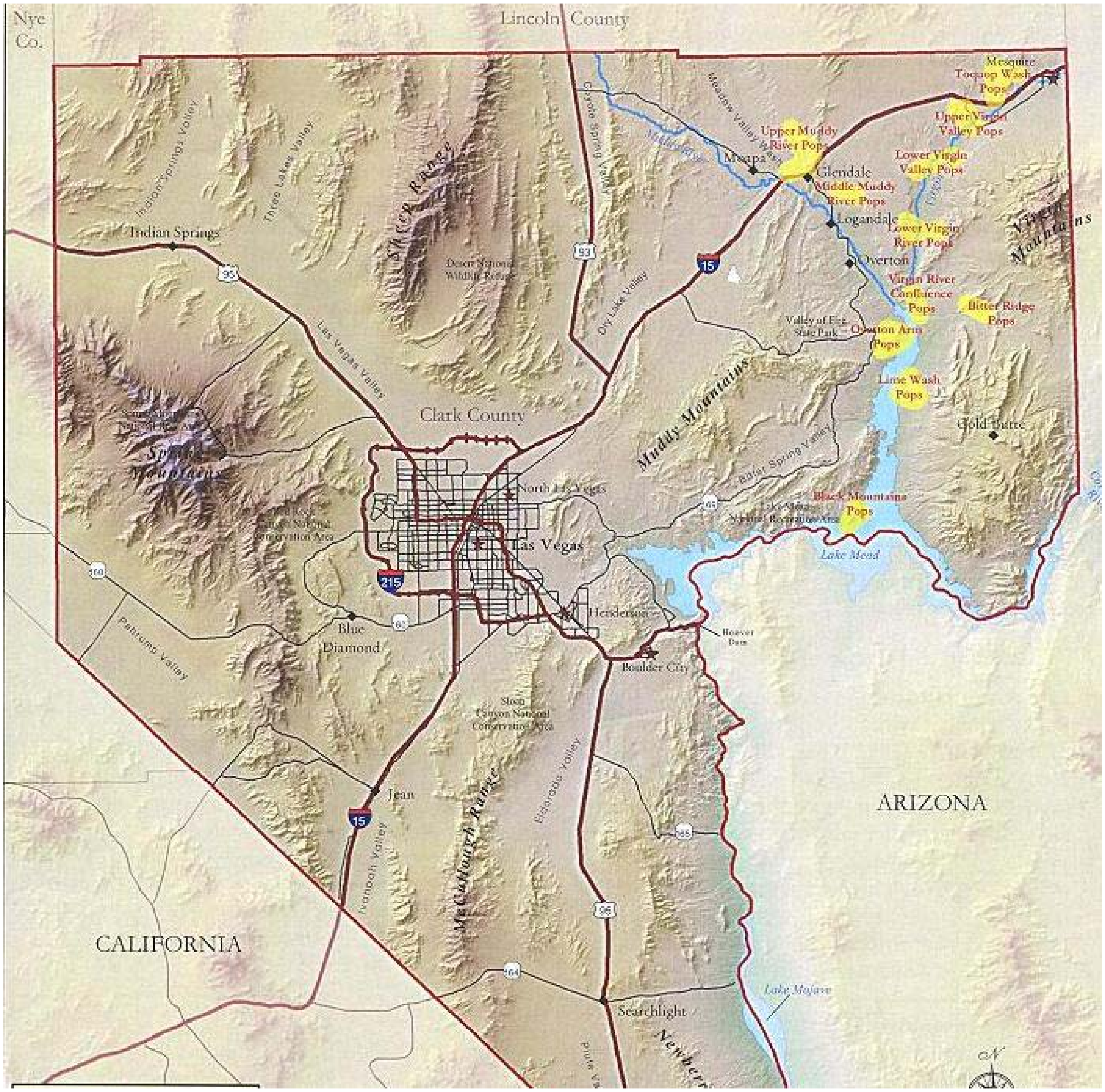

Figure 8. Reproduced from TNC 2007 delineating the known Clark County distribution of sticky buckwheat.

METHODS AND MATERIALS

Gypsum Sites

Field Methods

Surveys were conducted at seven sites (Gold Butte, Blue Point, Valley of Fire (2), Road 100, Gale Hills, and Sunrise Hills) in 2009 and 2010. The two rare plants at these gypsum sites are Las Vegas bearpoppy (*Arctomecon californica*) and Ringstem (*Anulocaulis leiosolenus* var. *leiosolenus*). A transect ranging from 200 to 300 m (varied at each site) was placed randomly in previously known locations of the rare plants. The ends of each transect were permanently marked with rebar and located with a 0.5 meter accuracy GPS unit (Trimble Geo XT). Each transect contained three distinct densities of the rare plant: high density, low density, and no density. No density equaled no ringstem or Las Vegas bearpoppy within 40 meters parallel to the transect. Low density had 10 or less ringstem or Las Vegas bearpoppy within the 40 meter belt. High density was more than 10 ringstem or Las Vegas bearpoppy within the 40 meter belt. Data were recorded on datasheets while in the field. One meter square plots were placed randomly within each density type. From the center of the 1- meter square we measured in meters to the six nearest ringstem and/or Las Vegas bearpoppy and marked whether they were alive or dead as well as the compass bearing to the rare plant. Other data gathered associated with the 1-meter square plot included: percent cover of all live perennial plant species; percent cover of rock/gravel, disturbance, and biological crust; penetrometer measurements; and a sample of the biological crust. A dynamic cone penetrometer was used at the same corner for all 1-meter square plots; however, if there was a rock present at that particular corner then the opposite corner was used. The penetrometer results were used to calculate the soil compaction at each site, or total energy (Herrick, 2002). Percent cover was classified as: 1) 0-1%, 2) 1-2%, 3) 2-5%, 4) 5-10%, 5) 10-25%, 6) 25-50%, 7) 50-75%, 8)75-95% and 9) >95%.

Within the 1 meter square plot locations we randomly chose 9 plots (3 within each density type) to collect soil via the compliant cavity method (USDA-NRCS, 2004). Each soil sample was placed in a ziploc plastic bag and labeled accordingly. Each soil hole was divided into approximately three layers totaling a depth of 15 inches, when possible. The top layer was measured at two inches; the remaining layers were divided between the remaining depth to 15 inches. Las Vegas bearpoppy roots grow to about 40 cm (15.7 inches) in the soil column, therefore, we chose to dig down to 15 inches as a good soil representation (Mistretta *et al.*, 1996). There were some soil holes that we were unable to dig past the second layer due to reaching rock. The actual depth was recorded on the datasheet. Soil samples were analyzed for pH; Electrical Conductivity (EC), measured in µS/cm; Sodium (Na), Potassium (K), and Magnesium (Mg), Calcium (Ca) were measured in mg/L; Manganese (Mn), Iron (Fe), Nickel (Ni), Copper (Cu), Zinc (Zn), Cobalt (Co), Boron (B), Molybdenum (Mo), Lead (Pb), and Cadmium (Cd) were measured in µg/L; Chlorine (Cl), Sulfate (SO4), and Nitrate (NO3) were measured in mg/L; Available P was measured in mg/kg; Calcium carbonate (CaCO3), Total Carbon (Total C), Total Nitrogen (Total N), Clay, Silt, and Sand were measured as a percentage; Total Energy was measured in $kg*(m/s)^2$; and Bulk Density was measured in g/cm^3, All analyses were conducted by the UNLV Soil Science Lab. Soil bulk density is the ratio of the mass of dry soil to the volume of the soil. The volume includes the volume of the soil and of the pore space (Blake, 1986). The Munsell color system was used to record the soil color of each sample.

Vegetation data consisting of percent cover and quantity of all perennial plants were collected for a 5-meter radius around each of the soil sample locations.

Location of NPS sites

Two sites (Valley of Fire) are located along the powerline road north of Blue Point Springs located in drygyp-bluegyp association soil. Road 100 site is located on the south side of Northshore Drive in the Pinto Valley area in baseline-callville-badland association soil. Blue Point site is between Roger's Spring and Blue Point Spring located on drygyp-bluegyp association soil. See Figure 9 below.

Location of BLM sites

Gale Hills site is located on whitebasin-upperline-hardbasin association in the vicinity of Anniversary Mine. Gold Butte site is near Red Bluff Spring on the east side of the Overton arm on guardian-baseline-guardian association soil. Sunrise Hills is in the Rainbow Gardens area, just north of Lake Las Vegas on guardian-baseline association soil. See Figure 9 below.

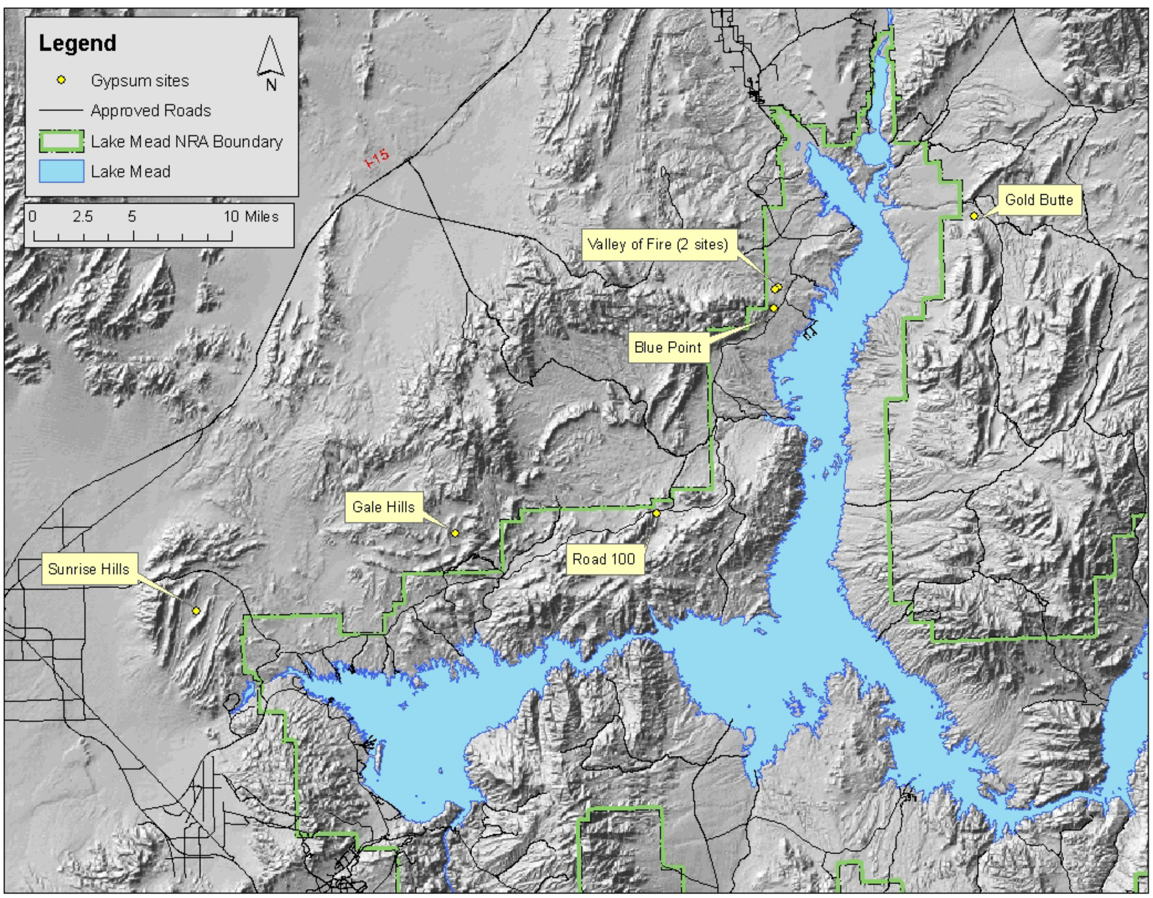

Figure 9. Locations of gypsum sites.

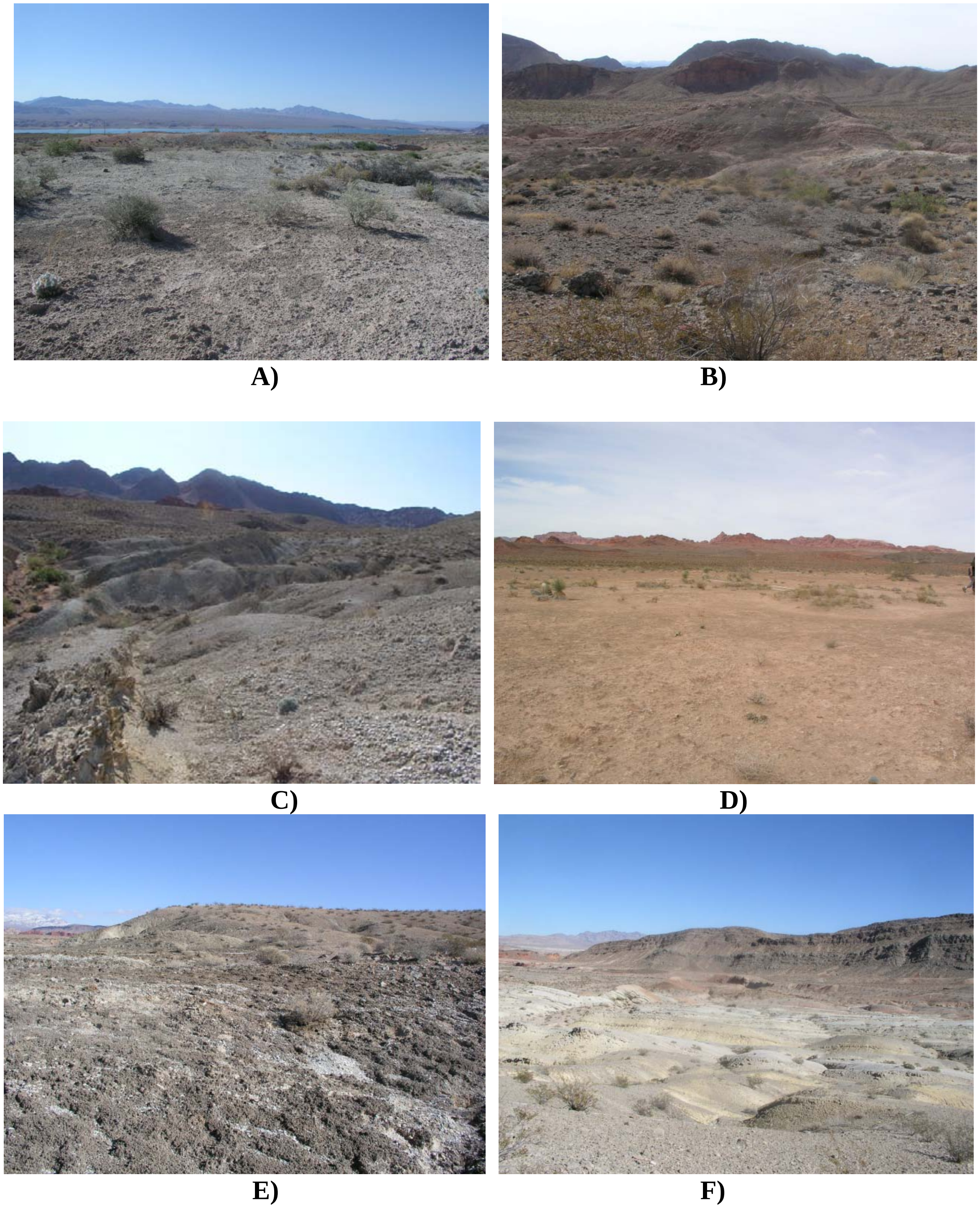

Figure 10. Gypsum sites; A) Blue Point Springs; B) Gale Hills; C) Road 100; D) Valley of Fire (2 sites); E) Gold Butte; F) Sunrise Hills.

Methods of Analysis

Transects and plots were located entirely within visually distinct gypsum barren patches. All transects surveyed contained Las Vegas bearpoppy present/absent plots. To detect soil variability that affects Las Vegas bearpoppy distribution within occupied gypsum barren patches, all Las Vegas bearpoppy present plots were compared with all Las Vegas bearpoppy absent plots. Ringstem present plots occurred in 5 of the 9 transects. To detect soil variable differences between gypsum barren patches containing ringstem and those that do not, plot data from ringstem present transects were compared with plot data from ringstem absent transects. To detect soil variability that affects ringstem distribution within occupied gypsum barren patches, ringstem present plot data was also compared with ringstem absent data only within the 5 transects containing ringstem presence.

To test for difference between species composition (measured by density) on Las Vegas bearpoppy present/absent plots we used the non-parametric Multi Response Permutation Procedure (MRPP; Mielke and Berry 2001) using the software PC-ORD 4.28 (McCune and Medford 1999). Using PC-ORD 4.28 (McCune and Medford 1999) we applied Non Metric Multidimensional Scaling (NMS; Mather 1976) in Autopilot mode with Sorenson (Bray/Curtis) distance measure to vegetation density data for creation of ordinations and interpretation of plot groupings. Soil crust species data were analyzed using Chi square analysis.

Soils data were analyzed using Statistical Analysis Software (SAS) Version 9.1 (SAS Institute, Cary, NC). Mean differences in measured soil characteristics were compared among Las Vegas bearpoppy present plots and Las Vegas bearpoppy absent plots for all transects combined for layers 1 and 2 using a student's t-statistical test. Mean differences in measured soil characteristics were also compared between ringstem present and ringstem absent plots within transects which contained ringstem as well as between transects which contained ringstem and those which did not. A correlation matrix was prepared for all variables. Independent variables which were significantly collinear ($p<0.05$) with Las Vegas bearpoppy or ringstem density and have a co linearity coefficient >0.4 were reported. A stepwise multiple linear regression was applied to explore the linear relationship between the predictor variable, density of Las Vegas bearpoppy or ringstem (plants/Ha) and the criterion soil variables of layers one and two. Prior to the application of stepwise multiple linear regression, skewness and kurtosis were corrected using log and square root transformation respectively and tests for multicolinearity were applied to the data and criterion soil variables with a correlation coefficient > 0.8 were removed from the analysis and are not represented in the final model. A stepwise logistic regression was applied to explore the relationship between the predictor variable, the presence or absence of Las Vegas bearpoppy or ringstem on a sampled site and the criterion variables of soil characteristics.

<u>Sandy Sites</u>

Field Methods

Surveys were conducted at five sites in 2010. The rare plants at these sandy sites are threecorner milkvetch (*Astragalus geyeri* var. *triquetrus*) and Sticky buckwheat (*Eriogonum viscidulum*). At each site six plots were randomly selected from previous year's population data on plant locations. Four of the plots were placed in high density and two in no density of the rare plant;

however Lime Cove and Glory Hole sites had three plots placed in high density and three in no density of the rare plant. A soil sample was taken at each plot using the compliant cavity method previously described in the gypsum site field methods. One layer of soil was collected down to six inches. Some of the soil holes we were unable to dig to six inches because of hitting a rock layer, and thus recorded the actual depth on the datasheets. The Munsell color system was used to record the color of the soil. Data collected at each plot was percent cover of all perennial species and percent cover of dead tamarisk and Russian thistle within a 5 meter radius. Percent cover of rock, gravel, and sand was collected within a 1 meter square. Percent cover was classified as: 1) 0-1%, 2) 1-2%, 3) 2-5%, 4) 5-10%, 5) 10-25%, 6) 25-50%, 7) 50-75%, 8)75-95% and 9) >95%.

Location of sites

Four of the five sites are on NPS land, along the Lake Mead shoreline: Sandy Cove, Ebony Cove, Lime Cove, Glory Hole. The soils at Sandy Cove and Ebony Cove are composed of Rositas-riverbend association. Lime Cove and Glory Hole had cheme-huevi association soils. The fifth site was located in Weiser Wash, (BLM jurisdiction), on badland association soils.

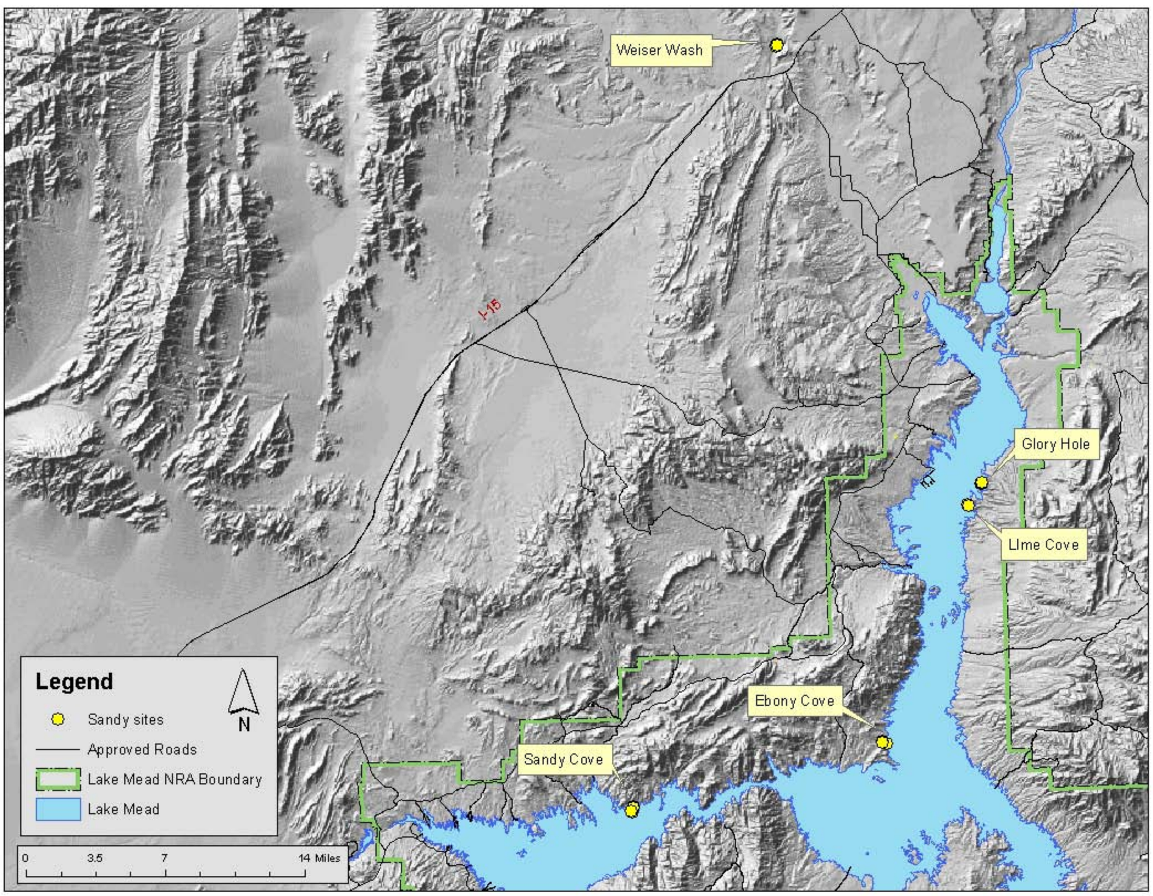

Figure 11. Locations of sandy sites.


A) **B)**


C) **D)**

E)

Figure 12. Sandy sites; A) Glory Hole; B) Lime Cove; C) Ebony Cove; D) Weiser Wash; E) Sandy Cove.

Methods of Analysis

The original protocol had 6 holes being dug at each of the 5 sites. This turned out to not be sufficient replication for statistical analysis to be performed on the data. Therefore, a descriptive analysis on the 5 sandy sites will be discussed in the results section.

RESULTS

Gypsum Sites

Las Vegas bearpoppy

There is a significant difference between vegetation on Las Vegas bearpoppy present and absent plots with a Chance-Corrected within-group Agreement of A = 0.081 ($p < .001$). The A statistic denotes the difference among groups (present, absent) with 1 being completely different and -1 being identical. A NMS ordination (final solution with 3 dimensions) with joint plot overlay of soil variables and designation of three groups was created (Figure 13). Las Vegas bearpoppy present and absent plots are separated along axis 1 and Las Vegas bearpoppy absent plots are further separated into two groups along axis 2. The Las Vegas bearpoppy absent plots at the distal extreme of axis 2 are characterized by high salinity and sandy transects that support halophytic gypsum barren vegetation such as goldenweed, and alkali sacaton. These sites also support gypsophilic species Palmer's phacelia and Parry's sandpaper plant. These plots were mostly located on the Valley of Fire transects. At the opposite extreme of axis 2 are the Las Vegas bearpoppy absent sites which are characterized by high clay and silt content and lower pH. Further, this group has lower concentrations of factors that indicate gypsum presence. These plots support less gypsum preferent species and are characterized by the presence of creosote, torrey ephedra and bursage. The most representative plots of this grouping were located on the Gold Butte and Road 100 transects. Las Vegas bearpoppy present plots are characterized by lower bulk densities in layer 2 and the presence of gypsum preferent species such as Las Vegas bearpoppy, desert sunray and indigo bush. In fact, the gypsophile desert sunray, was almost exclusively associated with Las Vegas bearpoppy presence. The Las Vegas bearpoppy present group shares the gypsovag shadscale, with the high salinity group and shares the gypsaovag torrey ephedra with the low salinity group. The majority of Las Vegas bearpoppy present plots occupy a range intermediary to the other two extremes. The Las Vegas bearpoppy present plots which occupy the same high saline transects as Las Vegas bearpoppy absent plots have lower concentrations of Na. The high levels of Na in this high salinity group could indicate the presence of a shallow water table and conditions which preclude Las Vegas bearpoppy presence within these gypsum barren areas. Las Vegas bearpoppy present plots which occupy the same transects as Las Vegas bearpoppy absent plots in the low salinity group are distinguished by higher concentrations of $CaCO_3$. Univariate analysis results help reveal the separation between the Las Vegas bearpoppy present group and all Las Vegas bearpoppy absent plots along Axis 1.

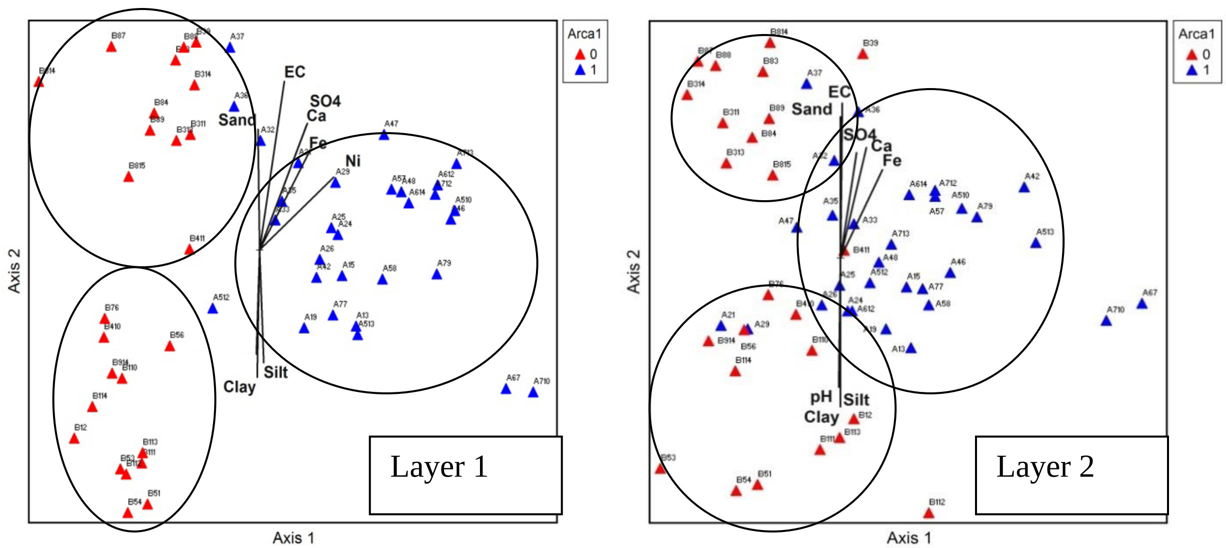

Figure 13. NMS ordination of Las Vegas bearpoppy vegetation density plots with joint overlay of secondary environmental matrices for layers 1 and 2. ▲= Las Vegas bear poppy absent. ▲=Las Vegas bearpoppy present.

Analysis of biological crust cover

Chi Square analysis found no significant differences in proportions of crust species on Las Vegas bearpoppy present or absent plots. We found a total of six lichen taxa and nine moss taxa. Road 100 was the most diverse site, with one sample containing nine taxa. Road 100 plots also contained the moss *Crossidium seriatum* which is a known gypsophile (Rosentreter 2007), a species of concern in Clark County and an evaluation species under the MSHCP. Seven plots in the high salinity Valley of Fire transects contained cyanobacteria only. Several species occurred only once in the data set, unlike the common lichen *Collema tenax s.lat.*, which was found on all crust containing plots with the exception of the cyanobacteria only plots.

<u>Las Vegas bearpoppy Layer 1 analyses</u>

Univariate

Analysis of data reveal significantly higher levels of EC, Ca, Fe, Ni, Co, SO4, CaCO3, Inorganic C, and Total C ($p<.05$) in Las Vegas bearpoppy present plots compared with Las Vegas bearpoppy absent plots and significantly lower amounts of K, B, Mo, and Bulk Density ($p<.05$) (Table 1). Ca, Ni, SO_4, Inorganic C and total C were positively correlated with Las Vegas bearpoppy density ($p<0.05$) and have a correlation coefficient >.40. Potassium was negatively correlated with Las Vegas bearpoppy density. Only those variables with a $p > 0.05$ were reported.

Table 1. t-test results for Las Vegas bearpoppy layer 1 absent–present.

	Mean Diff.	95% CL Mean		Pr > |t|	**=<0.05 *=<0.1
pH	0.079	-0.032	0.190	0.158	
EC	-454.200	-893.400	-14.996	0.043	**
Na	26.287	-1.113	53.687	0.060	*
K	4.092	0.608	7.576	0.022	**
Mg	5.898	-1.279	13.074	0.105	
Ca	-286.600	-446.900	-126.200	0.001	**
Mn	-3.589	-8.266	1.089	0.130	
Fe	-682.100	-1087.300	-277.000	0.001	**
Ni	-9.525	-14.091	-4.958	<.001	**
Cu	3.950	-4.853	12.753	0.373	
Zn	-31.346	-70.915	8.223	0.118	
Co	-0.320	-0.473	-0.166	<.001	**
B	108.000	22.606	193.300	0.014	**
Mo	3.332	0.783	5.882	0.011	**
Pb	0.022	-0.008	0.051	0.143	
Cd	-0.011	-0.028	0.005	0.172	
Cl	24.883	-1.035	50.802	0.060	*
SO4	-686.300	-1051.800	-320.800	<.001	**
NO3	-0.484	-1.000	0.032	0.065	*
Available P	1.777	-0.108	3.661	0.064	*
CaCO3	-12.215	-20.968	-3.462	0.007	**
Total C	-1.325	-2.445	-0.205	0.021	**
Total N	0.000	-0.006	0.005	0.899	
Clay	0.632	-0.718	1.983	0.352	
Silt	-1.572	-8.146	5.002	0.633	
Sand	0.942	-6.887	8.771	0.810	
Total Energy	37.890	-73.567	149.300	0.498	
Bulk Density	0.169	0.054	0.285	0.005	**

Multiple Linear Regression

The final, selected model was significant and described 62.06% of the variance in the density of Las Vegas bearpoppy observed among experimental sites (r^2=0.6206, F=16.68, p<0.0001). The selected model reports variance of inflation factors (VIF) all less than 2. Standardized beta coefficients in the final selected model were tested to be statistically significant (p<=0.05) and are summarized in Table 2. Beta coefficients which demonstrated larger influences on the predictor variable (density of Las Vegas bearpoppy) included those associated with soil potassium concentration and SO_4 concentration in layer one. These coefficients had the highest levels of significance in the model and made the greatest contributions to the overall r^2 value for the final model. It should be noted that the sample size for layer one used in the final model (n=57) just satisfies the minimum sample size requirements for the multiple linear regression technique employed. The final model indicates that the density of Las Vegas bearpoppy is most impacted by the concentrations of K, Zn, and SO_4, in layer one of the soil. Analyses of soils should include tests for K, Zn, SO_4 as well as the percentage of sand in layer one since it is an easy test to perform and contributes another 0.15 towards to the overall r^2 of the model.

Table 2. Correlation coefficients for multiple regression Las Vegas bearpoppy layer 1.

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	1.84453	1.52655	1.04915	1.46	0.2325
K	-0.60558	0.22164	5.36471	7.47	0.0086
Zn	0.08304	0.03448	4.1671	5.8	0.0197
SO4	0.4303	0.06747	29.22699	40.67	<.0001
CaCO3	0.29143	0.18655	1.75374	2.44	0.1244
Sand	-0.04436	0.01461	6.62418	9.22	0.0038

The resulting equation which predicts density of Las Vegas bearpoppy in plants/Ha is:

$$y = 3.95 - 0.75(K) + 0.07(Zn) + 0.45(SO4) - 0.06(Sand)$$

Logistic Regression

The final model had a positive goodness of fit test (Hosmer Lemeshow Chi Square=6.4582, p=0.249). Furthermore, the final model selected had both a significant likelihood ratio result (Chi Square=51.6308, p<0.0001) and a Wald Test result (Chi Square=10.5015, p=0.0328). The final model had the lowest Akaike Information Criterion score (AIC) of the six models considered using the stepwise method. Standardized beta coefficients in the final model were tested to be statistically significant (p<=0.05) and are detailed in Table 3. Cross validation against existing data was performed and the model predicted 96.8% of the presence of Las Vegas bearpoppy and only 3.2% of sites with

Las Vegas bearpoppy absent. Hence the selected model is an accurate predictor of the presence of Las Vegas bearpoppy but a poor predictor of the absence of Las Vegas bearpoppy. The final model then has a high sensitivity for Las Vegas bearpoppy but a low specificity.

Criterion variables of soil characteristics which were retained in the final model included: EC, Cd, SO4, and Sand. The EC (units) in layer 1 is negatively associated with the presence of Las Vegas bearpoppy (OR=0.492, 95% CI: 0.292, 0.830). Similarly, the percentage of sand in soil layer 1 was negatively associated with the presence of Las Vegas bearpoppy (OR=0.891, 95% CI: 0.799, 0.992). The concentrations of Cd and SO4 in layer 1 of soil are positively associated with the presence of Las Vegas bearpoppy at each site. Odds ratios associated with criterion variables should be viewed with caution as the sample size for layer 1 used in the final model (n=57) is less than the minimum sample size requirements for a stepwise logistic regression.

Table 3. Analysis of maximum likelihood estimates.

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	- 25.4188	13.3933	3.6019	0.0577
EC	1	-0.709	0.2667	7.0689	0.0078
Cd	1	16.7476	8.2449	4.126	0.0422
SO4	1	8.7296	3.27	7.1269	0.0076
Sand	1	-0.1158	0.0551	4.4139	0.0356

The resulting equation gives:

$$\ln(y/(1-y)) = -25.42 - 0.71(EC) + 16.75(Cd) + 8.73(SO4) - 0.12(Sand)$$

Las Vegas bearpoppy Layer 2 analyses

Univariate

Within transects containing Las Vegas bearpoppy, analysis of data reveal significantly higher amounts of EC, Ca, Fe, Ni, Co, Cd, and SO4 ($p<.05$) in Las Vegas bearpoppy present plots compared with Las Vegas bearpoppy absent plots and significantly lower amounts of pH, Na, K, Mg, B, Mo, Cl, Available P, Clay and Bulk Density ($p<.05$) (Table 4). Ca, Fe, Ni, Co and SO_4 were positively correlated with Las Vegas bearpoppy density ($p<0.05$) and have a correlation coefficient >.40. Na, K, B, and bulk density were negatively correlated with Las Vegas bearpoppy density. Only those variables with a $p > 0.05$ were reported.

Table 4. t-test results for Las Vegas bearpoppy layer 2 absent–present.

	Mean Diff.	95% CL Mean		Pr > |t|	**=<0.05 *=<0.1
pH	0.146	0.023	0.269	0.021	**
EC	-10.751	-17.617	-3.884	0.003	**
Na	1.374	0.599	2.150	0.001	**
K	0.524	0.168	0.880	0.005	**
Mg	0.287	-0.231	0.805	0.270	
Ca	-1.637	-2.388	-0.885	<0.001	**
Mn	-0.116	-0.394	0.161	0.404	
Fe	-1.085	-1.588	-0.583	<0.001	**
Ni	-0.977	-1.402	-0.552	<0.001	**
Cu	0.216	-0.125	0.557	0.210	
Zn	-0.933	-2.529	0.663	0.247	
Co	-0.219	-0.313	-0.126	<0.001	**
B	6.601	2.745	10.457	0.001	**
Mo	0.640	0.129	1.152	0.015	**
Pb	0.006	-0.014	0.026	0.526	
Cd	-0.065	-0.110	-0.020	0.005	**
Cl	2.438	0.608	4.267	0.010	**
SO4	-2.273	-3.309	-1.236	<0.001	**
NO3	-0.017	-0.158	0.124	0.813	
Available P	0.273	0.002	0.543	0.048	**
CaCO3	-0.225	-0.708	0.257	0.354	
Total C	-0.639	-1.531	0.253	0.157	
Total N	0.001	-0.001	0.004	0.379	
Clay	1.283	0.002	2.564	0.050	**
Silt	2.693	-3.729	9.115	0.405	
Sand	-3.976	-11.603	3.650	0.301	
Total Energy	30.924	-78.679	140.500	0.574	
Bulk Density	0.146	0.059	0.233	0.002	**

Multiple Linear Regression

The final, selected model was significant and described 62.81% of the variance in the density of Las Vegas bearpoppy observed among experimental sites ($r2=0.6281$, $F=14.36$, $p<0.0001$). The selected model reports variance of inflation factors (VIF) all less than 2. Standardized beta coefficients in the final selected model were tested to be statistically significant (p<=0.05) and are summarized in Table 5.

Beta coefficients which demonstrated larger influences on the predictor variable (density of Las Vegas bearpoppy) included those associated with: soil Na concentration (units), Bulk Density (units), and NO3 concentration (units) in layer 2. These coefficients had the highest levels of significance in the model and made the greatest contributions to the overall r2 value for the final model. It should be noted that the sample size for layer 1 used in the final model (n=58) just satisfies the minimum sample size requirements for the multiple linear regression technique employed.

Table 5. Correlation coefficients for multiple regression Las Vegas bearpoppy layer 2.

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	0.79208	0.72722	0.84745	1.19	0.2812
EC	0.04813	0.01034	15.4711	21.66	<.0001
Na	-0.36934	0.07716	16.36804	22.91	<.0001
Zn	0.09245	0.04249	3.38147	4.73	0.0342
NO3	-0.91621	0.44144	3.07719	4.31	0.043
Total_C	0.30254	0.07905	10.46279	14.65	0.0004
Bulk_Density	-2.32273	0.71845	7.4664	10.45	0.0022

The resulting equation which predicts density of Las Vegas bearpoppy in plants/Ha is:

$$y = 0.79 + 0.048(EC) - 0.37(Na) + 0.09(Zn) - 0.92(NO3) + 0.30(Total\ C) - 2.32(Bullk\ Density)$$

Logistic Regression

The final model had a positive goodness of fit test (Hosmer Lemeshow Chi Square=3.2603, p=0.9170). Furthermore, the final model selected had both a significant likelihood ratio result (Chi Square=50.3912, p<0.0001) and a Wald Test result (Chi Square=12.7719, p=0.0124). The final model had the lowest Akaike Information Criterion score (AIC) of the six models considered using the stepwise method (AIC=39.945). Standardized beta coefficients in the final model were tested to be statistically significant (p<=0.05) and are detailed in Table 6. Cross validation against existing data were performed and the model predicted 95.5% of the presence of Las Vegas bearpoppy and only 4.5% of sites with Las Vegas bearpoppy absent. Hence the selected model is an accurate predictor of the presence of Las Vegas bearpoppy but a poor predictor of the absence of Las Vegas bearpoppy. The final model then has a high sensitivity for Las Vegas bearpoppy but a low specificity.

Criterion variables of soil characteristics which were retained in the final model included: Ni, B, Cd, and Total N. The concentration of B (units) in layer 2 is negatively associated with the presence of Las Vegas bearpoppy (OR=0.749, 95% CI: 0.630, 0.892). The concentrations of Ni, Cd and Total N in layer 2 of the soil are positively associated with the presence of Las Vegas bearpoppy at each site. Odds ratios associated with criterion variables should be viewed with caution as the sample size for layer 1 used in the final model (n=58) is less than the minimum sample size requirements for a stepwise logistic regression.

Table 6. Analysis of maximum likelihood estimates.

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-15.8249	5.4693	8.3718	0.0038
Ni	1	4.3514	1.4539	8.9573	0.0028
B	1	-0.2884	0.089	10.5064	0.0012
Cd	1	18.2959	9.2028	3.9525	0.0468
Total_N	1	444.3	163.5	7.3804	0.0066

The resulting equation gives:

$$\ln(y/(1-y)) = -15.82 + 4.35(Ni) - 0.29(B) + 18.30(Cd) + 444.3(Total\ N)$$

Ringstem Layer 1 analyses

To detect soil variability that affects ringstem distribution within occupied gypsum barren patches, ringstem present plot data were compared with ringstem absent data only within the five transects containing ringstem presence. Ringstem present plots occurred in five of the nine transects. To detect soil variable differences between gypsum barren patches containing ringstem and those that do not, plot data from ringstem present transects were compared with plot data from ringstem absent transects. Ringstem present plots in vegetation density ordination (Figure 14 next page) were located opposite plots which had high pH, clay and Available P. We therefore expected the results of between transect tests to reflect ringstem affinity for gypsum patches with high soluble salt concentrations and percentage sand. Within these gypsum patches containing ringstem, tests reveal an association with plots higher in the gypsum constituents, SO4 and Ca. This would be expected with a plant that is considered a true gypsocline (Meyers, 1986).

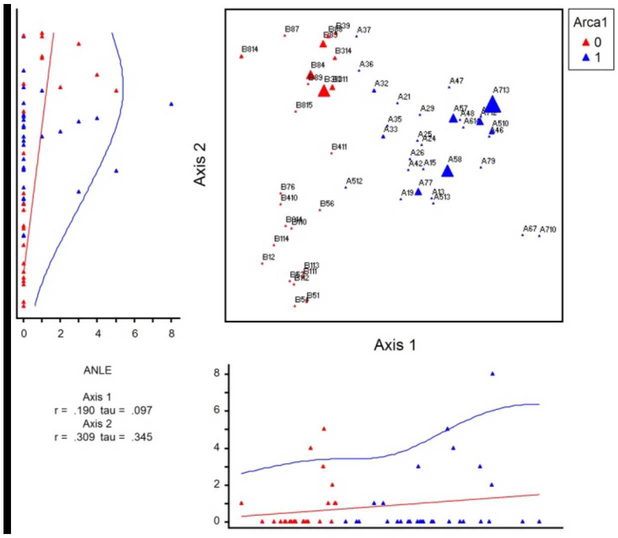

Figure 14. Analysis of variable, ringstem density, in Las Vegas bearpoppy NMS ordination.

Univariate

Within transects containing ringstem, analysis of data reveal significantly higher Ca, Fe, Ni, and SO4 (p<.05) in ringstem present plots compared with ringstem absent plots and significantly lower amounts of pH, Pb, Available P, and Total N (p<.05) (Table 7). Between transects containing ringstem and transects which do not, analysis of data reveal significantly higher amounts of EC, Na, Ni, B, and CaCO3 (p<.05) in ringstem present transects compared with ringstem absent transects and significantly lower amounts of Mn, Cu, and Total Energy (p<.05) (Table 8). Within ringstem transects Cu and total N were negatively correlated with Las Vegas bearpoppy density (p<0.05) and had a correlation coefficient >.40. No correlations >0.40 were detected between ringstem present transects and ringstem absent transects.

Table 7. t-test results for Ringstem layer 1 within absent–present.

	Mean Diff.	95% CL Mean		Pr > |t|	** =<0.05 * =<0.1
pH	0.143	0.010	0.275	0.036	**
EC	-8.931	-18.751	0.888	0.073	*
Na	-0.036	-1.263	1.191	0.953	
K	0.389	-0.193	0.971	0.183	
Mg	-0.046	-0.898	0.807	0.914	
Ca	-1.157	-2.044	-0.270	0.012	**
Mn	-0.227	-0.792	0.338	0.419	
Fe	-0.722	-1.345	-0.099	0.025	**
Ni	-0.677	-1.180	-0.174	0.010	**
Cu	0.452	-0.057	0.961	0.080	*
Zn	-1.142	-4.132	1.848	0.422	
Co	-0.111	-0.233	0.011	0.073	*

B	-0.106	-6.124	5.912	0.972	
Mo	0.290	-1.101	1.682	0.672	
Pb	0.040	0.002	0.078	0.041	**
Cd	0.029	-0.054	0.112	0.485	
Cl	-0.276	-4.279	3.726	0.889	
SO4	-1.577	-2.803	-0.352	0.013	**
NO3	0.019	-0.249	0.287	0.887	
Available P	0.414	0.031	0.797	0.035	**
CaCO3	0.199	-0.632	1.029	0.628	
Total C	-0.004	-1.867	1.860	0.997	
Total N	0.007	0.001	0.012	0.015	**
Clay	1.150	-0.462	2.763	0.155	
Silt	7.665	-1.023	16.352	0.082	*
Sand	-8.815	-18.984	1.354	0.087	*
Total Energy	10.986	-100.700	122.600	0.842	
Bulk Density	0.130	-0.023	0.282	0.092	*

Table 8. t-test results for Ringstem layer 1 between absent–present.

	Mean Diff.	95% CL Mean		Pr > |t|	**=<0.05 *=<0.1
pH	-0.050	-0.168	0.068	0.396	
EC	-611.600	-1132.400	-90.880	0.022	**
Na	-37.673	-72.755	-2.592	0.036	**
K	-5.246	-15.181	4.689	0.295	
Mg	-17.810	-42.473	6.854	0.154	
Ca	-178.700	-360.700	3.377	0.054	*
Mn	5.407	0.770	10.045	0.023	**
Fe	-267.300	-765.600	231.000	0.284	
Ni	-6.655	-11.632	-1.678	0.010	**
Cu	17.308	9.635	24.981	< 0.001	**
Zn	-0.815	-47.716	40.087	0.968	
Co	-0.136	-0.320	0.049	0.146	
B	-148.100	-276.800	-19.378	0.025	**
Mo	-5.678	-13.250	1.895	0.139	
Pb	-0.017	-0.046	0.012	0.243	
Cd	-0.017	-0.044	0.009	0.200	
Cl	-41.541	-90.378	7.296	0.094	*
SO4	-316.000	-757.500	125.600	0.156	
NO3	-0.453	-0.977	0.071	0.089	*
Available P	-0.537	-2.583	1.510	0.599	
CaCO3	-9.362	-18.554	-0.170	0.046	**

Total C	-1.132	-2.292	0.028	0.056	*
Total N	0.003	-0.002	0.009	0.188	
Clay	1.121	-0.335	2.578	0.127	
Silt	5.036	-1.171	11.243	0.110	
Sand	-6.157	-13.642	1.328	0.105	
Total Energy	155.900	52.001	259.800	0.004	**
Bulk Density	-0.011	-0.140	0.119	0.871	

Within Sites Multiple Linear Regression

A stepwise multiple linear regression was applied to explore the linear relationship between the predictor variable, density of ringstem (plants/Ha) and the criterion variables of soil composition measured in layer 1 within sites. Prior to the application of stepwise multiple linear regression, tests for multicolinearity were applied to the data and criterion variables within sites for layer 1 with a correlation coefficient > 0.8 were removed from the analysis and are not represented in the final model. The final, selected model was significant and described 60.95% of the variance in the density of ringstem observed between experimental sites (r^2=0.6095, F=6.76, p=0.0002). Standardized beta coefficients in the final selected model were tested to be statistically significant (p<=0.05) and are summarized in Table 9.

Beta coefficients which demonstrated larger influences on the predictor variable (density of ringstem) included those associated with: soil Pb concentration and Bulk Density in layer 1 within sites. These coefficients had the highest levels of significance in the model and the largest beta coefficients. VIF for the criterion variables of concentration of Ni (VIF=2.57) and Bulk Density (VIF=2.78) in layer 1 were greater than two and hence the associated beta coefficients should be evaluated cautiously in terms of their contribution to the final model. It should be noted that the sample size for layer one used in the final model (n=33) does not satisfy the minimum sample size requirements for the multiple linear regression technique employed.

Table 9. Correlation coefficients for multiple regression ringstem layer 1 within transects.

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	-0.82133	1.10972	0.13123	0.55	0.4659
Ni	0.52778	0.21053	1.50556	6.28	0.0188
Cu	-0.67805	0.16298	4.14667	17.31	0.0003
Zn	0.07353	0.03047	1.39529	5.82	0.0232
Pb	-5.29913	1.84073	1.98543	8.29	0.0079
Total_Energy	-0.00188	0.000615	2.24587	9.37	0.0051
Bulk_Density	2.25584	0.76117	2.10414	8.78	0.0064

The resulting equation which predicts density of ringstem in plants/Ha is:

$$y = 1.799 - 0.785(Cu) + 0.096(Zn) - 4.967(Pb) - 0.002(Total\ Energy) + 0.812(Bulk\ Density)$$

Between Sites Multiple Linear Regression

A stepwise multiple linear regression was applied to explore the linear relationship between the predictor variable, density of ringstem (plants/Ha) and the criterion variables of soil composition measured in layer 1 between sites. Prior to the application of stepwise multiple linear regression, tests for multicolinearity were applied to the data and criterion variables for layer 1 with a correlation coefficient > 0.8 were removed from the analysis and are not represented in the final model. The final, selected model was significant and described 55.56% of the variance in the density of ringstem observed between experimental sites (r^2=0.5067, F=13.61, p<0.0001). Standardized beta coefficients in the final selected model were tested to be statistically significant (p<=0.05) and are summarized in Table 10.

Beta coefficients which demonstrated larger influences on the predictor variable (density of ringstem) included those associated with soil Cd concentration and the percentage of Silt in layer 1. These coefficients had the highest levels of significance in the model and the largest beta coefficients. VIF for the criterion variables of concentration of B (VIF=2.65) and Cd (VIF=2.53) in layer 1 were greater than two and hence the associated beta coefficients should be evaluated cautiously in terms of their contribution to the final model. It should be noted that the sample size for layer 1 used in the final model (n=58) just satisfies the minimum sample size requirements for the multiple linear regression technique employed.

Table 10. Correlation coefficients for multiple regression ringstem layer 1 between transects.

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	2.13111	0.43889	30.64468	23.58	<.0001
B	0.00332	0.000999	14.36188	11.05	0.0016
Cd	-19.69642	4.84143	21.51215	16.55	0.0002
NO3	-0.42077	0.17584	7.44246	5.73	0.0204
CaCO3	0.09475	0.01292	69.85709	53.75	<.0001
Silt	-0.10001	0.0172	43.91856	33.79	<.0001

The resulting equation which predicts density of ringstem in plants/Ha is:

$$y = 2.051 + 0.003(B) - 20.414(Cd) + 0.083(CaCO3) - 0.099(Silt)$$

The final model indicates that the density of ringstem is most impacted by the concentrations of Cd, CaCO3, and B, in layer 1 of the soil. Analysis of soils should include tests for these elements and compounds as well as the percentage of silt in layer one since it is an easy test to perform and contributes another 0.24 towards to the overall r^2 of the model.

Within Sites Logistic Regression

A stepwise logistic regression was applied to explore the relationship between the predictor variable, the presence or absence of ringstem on a sampled site and the criterion variables of soil characteristics in layer 1 within sites. No model of any statistical significance was obtained and we cannot reject the null hypothesis that at least one beta coefficient is equal to zero. This is probably due to the low sample size (n=33).

Between Sites Logistic Regression

A stepwise logistic regression was applied to explore the relationship between the predictor variable, the presence or absence of ringstem on a sampled site and the criterion variables of soil characteristics in layer 1 between sites. The final model had a negative goodness of fit test (Hosmer Lemeshow Chi Square=23.06, p=0.0033) so we are not able to accept this model as statistically significant. However, the final model selected had both a significant likelihood ratio result (Chi Square=25.3208, p<0.0001) and a Wald Test result (Chi Square=12.2377, p=0.0022). This might underscore a need to replicate the study using a larger sample size and focus soil chemical assays on Cu and Available P. The final model had the lowest AIC of the three models considered using the stepwise method. Standardized beta coefficients in the final model were tested to be statistically significant (p<=0.05) and are detailed in Table 11. Cross validation against existing data were performed and the model predicted 90.7% of the presence of ringstem and only 9.1% of sites with ringstem absent. Hence, while not statistically significant, the selected model is an accurate predictor of the presence of ringstem but a poor predictor of the absence of ringstem. The final model then has a high sensitivity for ringstem but a low specificity.

Criterion variables of soil characteristics which were retained in the final model included: the concentration of Cu and Available P. The soil concentration of Cu (units) in layer 1 between sites is negatively associated with the presence of ringstem (OR=0.876, 95% CI: 0.813, 0.943). The amount of Available P in the soil at layer 1 was positively associated with the presence of ringstem (OR=1.414, 95% CI: 1.057, 1.891). Odds ratios associated with criterion variables should be viewed with caution as the overall model was not found to be statistically significant.

Table 11. Analysis of maximum likelihood estimates.

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	0.9224	0.551	2.8025	0.0941
Cu	1	-0.1326	0.038	12.2001	0.0005
Available_P	1	0.3462	0.1483	5.4464	0.0196

The resultant equation:

$$\ln(y/(1-y)) = 0.92 - 0.13(\boldsymbol{Cu}) + 0.35(\boldsymbol{Available\ P})$$

Ringstem Layer 2 analyses

Univariate

Within transects containing ringstem, analysis of soils data reveal significantly higher EC, Ca, Fe, Ni, Co, SO4, NO3, and Sand (p<.05) in ringstem present plots compared with ringstem absent plots and significantly lower Available P, Total N, Clay, Silt, and Bulk Density (p<.05) (Table 12). Between transects containing ringstem and transects which do not, analysis of data reveal significantly higher EC, Na, Mg, Ca, Ni, B, Pb, Cl, and Sand (p<.05) in ringstem present transects compared with ringstem absent transects and significantly lower amounts of pH, Cu, Clay, Silt and Total Energy (p<.05) (Table 13). Within ringstem present transects total N is negatively correlated with ringstem density (p<0.05) and has a correlation coefficient >.40. Between ringstem present and ringstem absent transects, Cu is negatively correlated with ringstem density.

Table 12. t-test results for Ringstem layer 2 within present– absent.

Ringstem layer 2 within

	Mean Diff.	95% CL Mean		Pr > |t|	**=<0.05 *=<0.1
pH	0.177	0.011	0.343	0.037	**
EC	-10.042	-19.074	-1.009	0.031	**
Na	-0.387	-1.737	0.962	0.562	
K	0.126	-0.427	0.680	0.645	
Mg	-0.238	-1.041	0.564	0.549	
Ca	-1.155	-2.091	-0.219	0.017	**
Mn	-0.070	-0.438	0.298	0.701	

Fe	-0.804	-1.475	-0.133	0.020	**
Ni	-0.719	-1.265	-0.174	0.011	**
Cu	0.218	-0.181	0.616	0.272	
Zn	0.434	-2.165	3.033	0.736	
Co	-0.155	-0.288	-0.021	0.025	**
B	-2.556	-9.087	3.976	0.430	
Mo	-0.334	-1.191	0.523	0.433	
Pb	0.002	-0.022	0.026	0.866	
Cd	-0.014	-0.080	0.052	0.665	
Cl	-1.005	-4.174	2.163	0.522	
SO4	-1.554	-2.853	-0.255	0.021	**
NO3	-0.164	-0.314	-0.014	0.034	**
Available P	0.357	0.038	0.677	0.030	**
CaCO3	0.351	-0.347	1.048	0.313	
Total C	0.610	-0.652	1.872	0.332	
Total N	0.005	0.001	0.009	0.017	**
Clay	1.921	0.156	3.686	0.034	**
Silt	10.659	1.260	20.057	0.028	**
Sand	-12.580	-23.625	-1.535	0.027	**
Total Energy	10.923	-100.800	122.600	0.843	
Bulk Density	0.155	0.032	0.278	0.016	**

Table 13. t-test results for Ringstem layer 2 between absent–present.

Ringstem layer 2 between

	Mean Diff.	95% CL Mean		Pr > |t|	**=<0.05 *=<0.1
pH	0.137	0.008	0.266	0.037	**
EC	-9.541	-16.962	-2.120	0.013	**
Na	-1.224	-1.968	-0.481	0.002	**
K	-0.110	-0.459	0.239	0.530	
Mg	-0.611	-1.078	-0.144	0.011	**
Ca	-0.913	-1.183	-0.008	0.048	**
Mn	0.034	-0.235	0.303	0.800	
Fe	-0.549	-1.156	0.059	0.076	*
Ni	-0.580	-1.078	-0.082	0.023	**
Cu	0.475	0.183	0.768	0.002	**
Zn	0.169	-1.364	1.703	0.826	
Co	-0.109	-0.220	0.001	0.053	*
B	-6.411	-9.988	-2.834	0.001	**
Mo	-0.860	-1.317	-0.402	<.001	**

Pb	0.001	-0.018	0.019	0.932		
Cd	-0.016	-0.056	0.024	0.422		
Cl	-3.133	-4.777	-1.489	<.001		**
SO4	-1.209	-2.435	0.017	0.053		*
NO3	-0.065	-0.162	0.033	0.189		
Available P	0.057	-0.221	0.335	0.683		
CaCO3	0.140	-0.310	0.591	0.536		
Total C	-0.052	-0.848	0.744	0.896		
Total N	0.001	-0.002	0.004	0.362		
Clay	1.388	0.016	2.760	0.048		**
Silt	8.035	1.569	14.502	0.016	**	
Sand	-9.423	-17.167	-1.679	0.018	**	
Total Energy	113.000	14.990	211.000	0.025	**	
Bulk Density	0.032	-0.061	0.124	0.498		

Within Sites Multiple Linear Regression

A stepwise multiple linear regression was applied to explore the linear relationship between the predictor variable, density of ringstem (plants/Ha) and the criterion variables of soil composition measured in layer two within sites. Prior to the application of stepwise multiple linear regression, tests for multicolinearity were applied to the data and criterion variables for layer 2 with a correlation coefficient > 0.8 were removed from the analysis and are not represented in the final model. The final, selected model was significant and described 34.01% of the variance in the density of ringstem observed between experimental sites ($r^2=0.3401$, $F=4.98$, $p=0.0066$). Standardized beta coefficients in the final selected model were tested to be statistically significant and are summarized in Table 14. Beta coefficients which demonstrated larger influences on the predictor variable (density of ringstem) included those associated with Total N in layer 2. The coefficient for Total N had the highest levels of significance in the model and the largest beta coefficients. All VIF for the criterion variables were less than two. It should be noted that the sample size for layer 2 used in the final model (n=33) does not satisfy the minimum sample size requirements for the multiple linear regression technique employed.

Table 14. Correlation coefficients for multiple regression ringstem layer 2 within transects.

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	0.7098	0.26217	2.66069	7.33	0.0113
NO3	0.97823	0.47707	1.52623	4.2	0.0495
Total_C	0.10499	0.06393	0.9791	2.7	0.1113
Total_N	-64.87327	19.25314	4.1213	11.35	0.0021

The resulting equation which predicts density of ringstem in plants/Ha is:

$$y = 0.71 + 0.98(NO3) + 0.10(Total\ C) - 64.87(Total\ N)$$

Between Sites Multiple Linear Regression

Stepwise multiple linear regression was applied to explore the linear relationship between the predictor variable, density of ringstem (plants/Ha) and the criterion variables of soil composition measure in layer 2 between sites. Again, before the application of stepwise multiple linear regression, tests for multicolinearity were applied to the data and criterion variables for layer 2 with a correlation coefficient > 0.8 were removed from the analysis and are not represented in the final model. The final, selected model was significant and described 37.13% of the variance in the density of ringstem observed among experimental sites (r2=0.3713, F=6.61, p<0.0001). The selected model reports variance of inflation factors (VIF) all less than 2. Standardized beta coefficients in the final selected model were tested to be statistically significant (p<=0.08) and are summarized in Table 15.
Beta coefficients which demonstrated larger influences on the predictor variable (density of ringstem) included those associated with: soil Total N (units), NO3 concentration (units), and concentration of Cu (units) in layer 2. These coefficients had the highest levels of significance in the model and made the greatest contributions to the overall r2 value for the final model. It should be noted that the sample size for layer 2 used in the final model (n=62) just satisfies the minimum sample size requirements for the multiple linear regression technique employed.

Table 15. Correlation coefficients for multiple regression ringstem layer 2 between transects.

Variable	Parameter Estimate	Standard Error	Type II SS	F Value	Pr > F
Intercept	0.58658	0.29502	0.94754	3.95	0.0517
Cu	-0.24019	0.1117	1.10825	4.62	0.0359
Mo	0.12757	0.06802	0.84314	3.52	0.0659
NO3	0.77449	0.33812	1.25755	5.25	0.0258
Total_C	0.08338	0.04716	0.74943	3.13	0.0825
Total_N	-36.32843	12.82348	1.92357	8.03	0.0064

The resulting equation which predicts density of ringstem in plants/Ha is:

$$y = 0.59 - 0.24(Cu) + 0.13(Mo) + 0.77(NO3) + 0.08(Total\ C) - 36.32(Total\ N)$$

Between and Within Sites Logistic Regression

For both within transects and between transects, a stepwise logistic regression was applied to explore the relationship between the predictor variable, the presence or absence of ringstem on a sampled site and the criterion variables of soil characteristics in layer 2. No model of any statistical significance was obtained and we cannot reject the null hypothesis that at least one beta coefficient is equal to zero.

Sandy Sites

The soil analyses on 30 soil samples was conducted by the UNLV Soil Science Lab. There were 30 variables tested for in the soil analysis; only Mo was consistently higher in the absent plots over all the five sites. We were unable to do any significant statistical tests due to insufficient replications. A literature search on threecorner milkvetch and sticky buckwheat resulted in no significant data to compare our results as well. The vegetation data that was collected is compiled in a species list (Appendix 7). Again there were not enough data to analyze vegetation differences between the sites or within the sites. More research needs to be done on these sites to discover any real differences.

Table 16. Average soil analysis on 5 sand sites for absent rare plants and present rare plant plots. Absent was determined by no rare plants previously known in the area of the plot, and present plots were located from previously known populations.

	Lime Cove		Glory Hole		Ebony Cove		Sandy Cove		Weiser Wash	
Average #'s	Absent	Present	Absent	Present	Absent	Present	Absent	Present	Absent	Present
pH	7.798	8.157	7.897	8.238	8.181	8.269	8.039	7.850	7.946	8.041
EC µS/cm	249.367	84.227	150.880	65.477	78.695	68.438	98.625	96.303	84.395	90.470
Na	18.122	2.699	7.162	6.292	1.745	1.973	1.722	1.955	1.515	1.459
K	10.893	3.184	9.555	2.911	5.041	4.750	3.801	7.252	3.860	4.001
Mg	7.924	1.863	3.247	1.241	2.270	2.196	1.043	1.219	1.347	1.266
Ca	14.510	7.045	11.368	3.777	11.128	8.437	7.393	8.784	7.411	8.594
Mn	6.606	8.284	5.000	8.938	35.081	79.216	3.316	7.359	12.505	4.544
Fe	255.785	261.494	249.322	273.080	1441.847	2435.462	158.064	170.180	592.288	233.361
Ni	2.655	0.966	2.273	0.624	2.585	2.812	0.788	1.536	1.382	1.103
Cu	45.169	9.954	39.241	7.140	24.039	19.724	11.803	31.680	21.809	24.559
Zn	8.090	3.770	38.332	11.426	10.062	155.793	1.610	5.971	6.185	2.961
Co	0.552	0.195	0.362	0.148	0.916	1.157	0.195	0.476	0.357	0.234
B	127.910	23.223	53.608	22.814	28.600	26.438	15.943	30.428	17.017	14.854
Mo	7.844	0.898	2.717	1.832	1.932	0.683	0.475	0.390	1.792	0.618
Pb	0.229	0.258	0.313	0.247	1.130	2.233	0.175	0.206	0.700	0.189
Cd	0.079	0.011	0.031	0.013	0.051	0.050	0.014	0.019	0.035	0.024
Cl	7.508	0.877	3.957	0.686	0.551	0.584	0.965	0.692	0.866	0.544
SO4	80.705	2.456	29.829	7.421	2.263	1.671	3.275	3.073	1.188	1.717
NO3	0.376	0.217	0.289	0.576	0.105	0.174	0.102	0.328	0.518	0.373
Available P	2.738	2.186	3.294	1.675	4.342	3.954	3.412	4.363	4.165	4.293
CaCO3 %	5.698	3.837	5.661	4.358	3.837	3.167	3.781	6.377	5.233	6.210
Inorganic C %	0.684	0.460	0.679	0.523	0.460	0.380	0.454	0.765	0.628	0.745
Organic C %	0.197	0.084	0.096	0.130	0.065	0.058	0.011	0.044	0.061	0.038
Total C %	0.880	0.545	0.776	0.653	0.525	0.438	0.465	0.809	0.689	0.783
Total N %	0.012	0.004	0.011	0.005	0.009	0.008	0.009	0.010	0.005	0.010
Clay %	1.011	0.212	1.883	1.089	1.261	1.728	0.637	1.298	0.979	2.014
Silt %	10.726	5.284	14.234	7.065	2.242	4.475	6.168	8.231	4.537	7.011
Sand %	88.263	94.504	83.883	91.846	96.497	93.798	93.195	90.471	94.484	90.975
Moisture %	0.798	0.053	1.845	1.712	0.299	0.372	0.176	0.140	0.785	0.970
Bulk Density%	1.255	1.122	1.293	1.205	1.238	1.119	1.090	0.984	0.991	1.148

Table 17. Las Vegas bear poppy Literature Review Matrix

	Meyer S.E. 1987, Meyer S.E. 1980	Thompson S.K. and Smith S.D. 1997	Drojan P.J. and Buck B.J. 2006. Drojan P.J. and Merkler D.J. 2009	Boettinger J.L. 2010	MSHCP 609
Location	Numerous sites within and East of the Las Vegas Valley	2 Locations near Overton Beach Nv. and one near Temple Bar Az. All within Lake Mead NRA	Tule Springs (North Las Vegas)	Upper Las Vegas Wash including Tule Springs (North Las Vegas)	Sites East of Las Vegas Valley in the vicinity of Lake Mead
Methodology	Compares soil samples and vegetation data on gypsum soils and alluvial (control) plots. PCA on all data and regression analysis for ARCA. Surface soil was analyzed (0-8cm).	Compares soil samples (surface 1-5cm and 6-15cm depth) between ARCA present and not present within gypsum outcrop and not present outside of gypsum outcrop. Pearson's product-moment coefficient.	Compares soils samples between ARCA present, ARCA present and ARCA/ARCA absent plots within soil series. Horizons sampled were surface (A Horizon) and lower (B Horizon) samples averaged for <40cm measurement. Chi Square and t-test.	Compares soils samples within ARCA presence/absence plots and between ARCA presence and shrub presence plots. Refined maps were created and descriptive differences in ARCA present/absent sites were discussed.	Compares soils samples from ARCA present and ARCA absent plots. T test, regression analysis, NMS ordination.
Sample size	n = 380	n = 21	n = 50	n = 658	n = 58
pH		pH was consistently lower on ARCA sites compared to off site and slightly lower pH on ARCA present compared to within soil type ARCA absent sites for both soil levels.		Surface soil measurements not different within ARCA sites but was higher on ARCA compared to shrub sites.	Layer 2: Significantly lower pH on ARCA plots.
EC		Total salts were 4 fold higher on ARCA site than off site. No difference within site.		Surface soil measurements not different	Layer 1: Significantly higher EC in ARCA plots. Layer 2: Significantly higher EC in ARCA plots.
Na	No difference		A Horizon: Significantly lower Na on ARCA sites compared to unoccupied sites.		Layer 1: Significantly lower Na in ARCA plots. Layer 2: Significantly lower Na on ARCA plots.
K			A Horizon: Significantly higher K on unoccupied sites compared to ARCA sites.		Layer 1: Significantly lower K in ARCA plots. Layer 2: Significantly lower K on ARCA plots.
Mg	High Mg /Ca ratios were found in ARCA sites	Lower Mg on ARCA sites than off site.	A Horizon: Significantly lower Mg on ARCA sites compared to unoccupied sites. No difference in Mg/Ca ratio.		

Ca	High Mg /Ca ratios were found in ARCA sites	Total Ca was 3 fold higher than off site and C average measurements were higher within site.	No difference in Mg/Ca ratio. <40cm: Ca was significantly higher on ARCA sites than unoccupied and ARCA sites.		Layer 1: Significantly higher Ca in ARCA plots. Layer 2: Significantly higher Ca in ARCA plots.
Mn	No difference				
Fe	No difference				Layer 1: Significantly higher Fe in ARCA plots. Layer 2: Significantly higher Fe in ARCA plots.
Ni					Layer 1: Significantly higher Ni in ARCA plots. Layer 2: Significantly higher EC in ARCA plots.
Cu	No difference		<40cm: Significantly less Cu on ARCA sites.		
Zn	No difference		<40cm: Zn was significantly lower on ARCA sites.		
Co					Layer 1: Significantly higher Co in ARCA plots. Layer 2: Significantly higher Co in ARCA plots.
B	Unusually high concentrations found in ARCA sites		A Horizon: Significantly higher B on unoccupied sites compared to ARCA sites.		Layer 1: Significantly lower B in ARCA plots. Layer 2: Significantly lower B on ARCA plots.
Mo			<40cm: Mo was significantly higher on ARCA sites.		Layer 1: Significantly lower Mo in ARCA plots. Layer 2: Significantly lower Mo on ARCA plots.
Pb					
Cd			<40cm: Cd was significantly lower on ARCA sites.		Layer 2: Significantly higher Cd in ARCA plots.
Cl	Gypsum sites with high concentration of Cl do not support ARCA				Layer 1: Significantly lower Cl in ARCA plots. Layer 2: Significantly lower Cl on ARCA plots.
SO4		Total S was 10 fold higher on ARCA sites than with off site. No difference within site. Higher soluble salt content on ARCA sites than off site.	A Horizon: No difference in SO4 was found. <40cm: SO4 was higher on ARCA occupied sites than unoccupied (not significant).		Layer 1: Significantly higher SO4 in ARCA plots. Layer 2: Significantly higher SO4 in ARCA plots.

NO3	Unusually high concentrations found in highest density ARCA site	Higher soluble salt content on ARCA sites than off site.			
Available **P**		Total P 9 fold higher on off site compared to on site and also slightly lower on ARCA present sites than within site.	Soil P was half as much on ARCA sites compared with unoccupied sites (not significant).		Layer 2: Significantly lower Available P on ARCA plots.
CaCO3					Layer 1: Significantly higher CaCO3 in ARCA plots.
C					Layer 1: Significantly higher total C in ARCA plots.
N	Unusually high concentrations found in ARCA sites				
Clay			A Horizon: No difference. <40cm : No difference.	Surface soil measurements not different	Layer 2: Significantly lower Clay on ARCA plots.
Silt			A Horizon: Significantly lower on unoccupied sites. <40cm: Percent silt was significantly lower on unoccupied sites.		
Sand			A Horizon: Significantly higher on unoccupied sites. Significantly larger percentage of very course and course sand. <40cm : Percent sand higher in unoccupied sites.		
Total energy			Lower surface crust strength in ARCA sites (not significant)		
Bulk Density			A Horizon: Bulk density was lower in ARCA sites compared to ERCO sites (not significant). 2 ARCA sites had very low bulk densities.	Surface soil measurements not different within ARCA sites but was lower on ARCA compared to shrub sites.	Layer 1: Significantly lower Bulk Density in ARCA plots. Layer 2: Significantly lower Bilk Density on ARCA plots.

DISCUSSION

Our research indicates that concentration of soil components influence distribution and abundance of Las Vegas bearpoppy even within visually distinct habitat islands occupied by the species. The models created for detection of Las Vegas bearpoppy presence and prediction of Las Vegas bearpoppy abundance demonstrate the potential utility of soil sample data for informing management actions related to conservation of this species. Previous research has approached the comparison of soil samples from Las Vegas bearpoppy present and absent soils similarly. A literature review matrix (Table 17) of four publications compares Las Vegas bearpoppy soils created using our variables for a comparison of results. Many opposed t-test results occurred due to the variety or extremity of Las Vegas bearpoppy habitat types surveyed. Consensus was achieved for several variables, notably Ca, SO4, available P and the physical measure of Bulk Density.

These and other studies have largely concluded that soil surficial qualities are more descriptive of Las Vegas bearpoppy distribution than chemical. The effects of physical processes of surface soils are more implicit as affecting Las Vegas bearpoppy distribution on barren soil types but soil chemistry effects remain vague. Research has suggested topographic position such as slopes can ameliorate extremes of crust strength and extreme concentrations of soil components (Meyer Garcia-Moya, 1992). Boettinger (2010) concluded that on a landscape scale, geomorphic surface and soil map units are better indicators of potentially occupied Las Vegas bearpoppy habitat than surface soil chemistry. We agree with this, but include that soil component concentration is a good indicator of Las Vegas bearpoppy presence within the map units containing ecological site descriptions of gypsum barren and badland (NRCS, 2006).

Our research has the advantage of sampling from a broad spectrum of Las Vegas bearpoppy habitat in Eastern Clark County (Figure 2). The National Park Service has recorded 24 different soil series containing Las Vegas bearpoppy populations within Lake Mead and adjacent BLM lands (Powell 2003). A limitation of previous research was the sampling of Las Vegas bearpoppy soils from similar origins within a comparably small region, but unfortunately not all Las Vegas bearpoppy habitat is created equal. We distinguish Las Vegas bearpoppy habitat as visually distinct islands containing Las Vegas bear poppy. The habitat is described broadly in literature as having distinctly sparse vegetation cover, high crust cover and spongy, mineral rich soils (Mistretta, 1996). Meyer (1986) ecologically refers to the habitat as gypsum barren vegetation and refers to the collection of these various communities as the gypsum milieu. However, recent research has revealed highly variable amounts of actual gypsum content within the soils of these isolated habitats (Drojan and Merkler 2009; Boettinger et al, 2010).

Varying amounts of gypsum and other compounds are due to differences in age and mode of deposition and contribution of materials from nearby sources (Meyer 1986). Differences with off site and on site soil chemistry has been well studied with the finding that apart from SO4, C and bulk density, soils component concentrations tend to be similar (Meyer, 1986; Thompson and Smith, 1997). Some research has suggested that Las Vegas bearpoppy can grow without gypsum (Drojan and Merkler, 2009; Boettinger, 2010). However, our results also indicate SO4, C and bulk density are significantly higher on Las Vegas bearpoppy present sites. Both of these variables are loosely correlated with gypsum content. Las Vegas bearpoppy shared distribution with other labeled gypsoclines, primarily desert sunray.

Due to the variability within gypsum milieu, we warn against generalizations about this genetically diverse species based upon surveys on a single soil series or site. Also high genetic variability between isolated populations of Las Vegas bearpoppy (Hickerson et al. 1998) could lead to ecotypes with differing tolerance to soil chemistry. This could lead to inference of broad soil tolerances which do not reflect the actual tolerance of specific populations.

Soil heterogeneity e.g. varying amounts of gypsum affect the presence and abundance of Las Vegas bearpoppy within visually coherent habitat islands. Soil component concentrations in this study were highly heterogeneous within transects. The Valley of Fire transects, characterized by the presence of halophytic vegetation, contained samples from presumed water table seeps with extreme concentrations of Na, B and soluble salts. These outlying, Las Vegas bearpoppy absent plots were removed from final analysis. Las Vegas bearpoppy present plots had significantly lower Na and thus occupied the less extreme plots of these high salinity transects (Figure 13 and Tables 1 and 4). At the opposite extreme, transects such as Gold Butte and Road 100 are high in clay content with high pH. Las Vegas bearpoppy present plots within these transects contained lower pH and higher concentration of soluble salts. Las Vegas bearpoppy occupies plots which have soil component concentrations intermediary of extreme conditions present within habitat islands. We do not address nutrient thresholds or toxicity in this research and suggest future experimental research to ascertain these parameters.

Knowledge of soil chemistry requirements for Las Vegas bearpoppy distribution have direct impact on future horticultural endeavors and ongoing restoration efforts such as those on gypsum soils at Lake Mead NRA’s Stewart’s Point restoration efforts and Northshore Road construction impacts. We have collected strong evidence to support soil chemistry parameters within habitat islands described vegetatively as gypsum barren communities. This finding could potentially modify previous estimates of habitat suitability reported by Mistretta et al. 1996. Furthermore, limited conservation efforts should focus on areas that support large populations rather than where Las Vegas bearpoppy may occur but habitat is marginal or near the edges of extremes. The models created could be used to define population boundaries more precisely for future monitoring efforts. With these soil survey and data analysis efforts from a broad spectrum of the gypsum milieu in Eastern Clark County, we have helped reduce known parameters defining Las Vegas bearpoppy distribution.

This is the only known research on soil characteristics associated with ringstem. This species is more widespread geographically occupying gypsum islands scattered from Clark County to West Texas. However, in Clark County the species is much less abundant with a narrower range than Las Vegas bearpoppy. Ringstem occurs on transects with high salinity and high sand content such as Valley of Fire and high salinity plots within diverse transects such as Road 100. It was expected that variables with significantly higher concentrations within transect tests would correspond to results between transect tests. However, many variables found to be higher within transect comparison were significantly lower between transect comparison. For example, clay and silt were significantly lower ($p<0.05$) and sand significantly higher between transect results and the opposite within transect results. We interpret this finding as ringstem occurring in the less extreme plots within extreme transects. This is possibly due to occupying a habitat with less competition but more environmental extremes. Ringstem is also labeled a gypsophile and is associated with higher SO_4 content. Ringstem does not share a distribution with Las Vegas bearpoppy (Figure 14).

Recommendations and further research needed

One strength of this study is that soil samples were taken across a wide range of gypsum containing soils instead of isolated areas. Further understanding may be gained from sampling more gypsum soil series across an even wider range of rare plant locations. Furthermore, these methods could be expanded to include other gypsophile and gypsocline species. Compared distributions of other labeled gypsophiles and gypsoclines may be informative for developing models for habitat requirements and conditions for specific rare plant species.

Unfortunately, too few sandy site samples were obtained to run valid statistical analyses. In addition to ensuring an adequate number of samples for statistical analysis, all future soil chemistry investigations should include the topographic position (slope, aspect, etc) of the sample. This could help determine how physical attributes drive soil chemistry, and also help in developing models for rare plant species that depend on sandy soils.

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APPENDIX

(SEE ATTACHED PDF)

Appendix 1. Correlation matrix Las Vegas bearpoppy layer 1

Simple Statistics						
Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
arca	57	1.17698	1.31338	67.08784	0	3.98898
pH	57	7.50351	0.20609	427.7	7.05	8.05
EC	57	37.84844	13.54519	2157	10.77961	57.23635
Na	57	1.6786	1.30197	95.68011	0.4947	5.67057
K	57	2.10449	0.56843	119.95593	0.93216	3.45411
Mg	57	1.84497	0.82164	105.16304	0.57661	4.15025
Ca	57	5.79378	1.56946	330.24572	2.40153	6.96686
Mn	57	2.11176	0.80082	120.37033	0.61519	3.81419
Fe	57	6.95934	1.07662	396.68233	4.40733	7.98124
Ni	57	2.60589	0.89285	148.53597	0.76547	3.53106
Cu	57	2.30363	0.91707	131.30668	0.62594	4.18905
Zn	57	2.86944	3.52807	163.55818	0.44721	22.89607
Co	57	0.53895	0.19851	30.71995	0.157	0.82855
B	57	9.41216	5.86689	536.49311	2.53969	30.19934
Mo	57	1.35806	1.04364	77.40921	0.24495	4.91528
Pb	57	0.03846	0.04963	2.19242	0	0.28518
Cd	57	0.13088	0.09099	7.45991	0	0.3873
Cl	57	2.40982	3.38792	137.35965	0.56569	17.76936
SO4	57	6.31749	2.15059	360.09676	1.13462	7.75731
NO3	57	0.50059	0.38668	28.53352	0.00995	1.72811
Available_P	57	1.55407	0.643	88.58191	0.45108	2.76064
CaCO3	57	2.52989	1.03196	144.20346	0.32208	4.1452
Inorganic_C	57	2.25228	2.09272	128.38	0.05	7.46
Organic_C	57	0.26474	0.36491	15.09	0	2.34
Total_C	57	2.51754	2.19201	143.5	0.21	7.46
Total_N	57	0.01666	0.00946	0.94949	0	0.03922
Clay	57	3.56772	2.53747	203.36	0.62	11.09
Silt	57	26.84404	12.17445	1530	7.31	53.27
Sand	57	69.58825	14.42117	3967	39.3	92.03
Total_Energy	57	274.55702	205.26783	15650	0	860.99
Bulk_Density	57	0.74491	0.23092	42.46	0.18	1.37

Pearson Correlation Coefficients, N = 57
Prob > |r| under H0: Rho=0

	arca	pH	EC	Na	K	Mg	Ca	Mn	Fe	Ni	Cu
arca	1	-0.17397	0.26262	-0.38359	-0.406	-0.12615	0.39956	0.11879	0.36201	0.41595	-0.12724
arca		0.1956	0.0484	0.0032	0.0017	0.3498	0.0021	0.3788	0.0057	0.0013	0.3456
pH	-0.17397	1	-0.52419	-0.21296	-0.02907	-0.2289	-0.52225	-0.52089	-0.44255	-0.43048	-0.14949
pH	0.1956		<.0001	0.1117	0.83	0.0868	<.0001	<.0001	0.0006	0.0008	0.2671
EC	0.26262	-0.52419	1	0.37357	0.00071	0.53027	0.95592	0.329	0.92796	0.93068	-0.48935
EC	0.0484	<.0001		0.0042	0.9958	<.0001	<.0001	0.0125	<.0001	<.0001	0.0001
Na	-0.38359	-0.21296	0.37357	1	0.62827	0.84927	0.1786	0.00549	0.18429	0.10045	-0.21424
Na	0.0032	0.1117	0.0042		<.0001	<.0001	0.1838	0.9677	0.17	0.4572	0.1095
K	-0.406	-0.02907	0.00071	0.62827	1	0.62539	-0.14879	-0.17771	-0.1837	-0.24224	0.078
K	0.0017	0.83	0.9958	<.0001		<.0001	0.2693	0.186	0.1713	0.0694	0.5641
Mg	-0.12615	-0.2289	0.53027	0.84927	0.62539	1	0.3911	-0.14031	0.34665	0.30921	-0.39193
Mg	0.3498	0.0868	<.0001	<.0001	<.0001		0.0026	0.2979	0.0082	0.0193	0.0026
Ca	0.39956	-0.52225	0.95592	0.1786	-0.14879	0.3911	1	0.33356	0.95558	0.96451	-0.48763
Ca	0.0021	<.0001	<.0001	0.1838	0.2693	0.0026		0.0112	<.0001	<.0001	0.0001
Mn	0.11879	-0.52089	0.329	0.00549	-0.17771	-0.14031	0.33356	1	0.42465	0.3259	0.35774
Mn	0.3788	<.0001	0.0125	0.9677	0.186	0.2979	0.0112		0.001	0.0134	0.0063
Fe	0.36201	-0.44255	0.92796	0.18429	-0.1837	0.34665	0.95558	0.42465	1	0.96069	-0.48388
Fe	0.0057	0.0006	<.0001	0.17	0.1713	0.0082	<.0001	0.001		<.0001	0.0001
Ni	0.41595	-0.43048	0.93068	0.10045	-0.24224	0.30921	0.96451	0.3259	0.96069	1	-0.538
Ni	0.0013	0.0008	<.0001	0.4572	0.0694	0.0193	<.0001	0.0134	<.0001		<.0001
Cu	-0.12724	-0.14949	-0.48935	-0.21424	0.078	-0.39193	-0.48763	0.35774	-0.48388	-0.538	1
Cu	0.3456	0.2671	0.0001	0.1095	0.5641	0.0026	0.0001	0.0063	0.0001	<.0001	
Zn	0.22567	-0.2987	0.16514	-0.15078	-0.13797	-0.14299	0.19328	0.39263	0.19282	0.15229	0.42293
Zn	0.0914	0.024	0.2196	0.2629	0.3061	0.2887	0.1497	0.0025	0.1507	0.2581	0.001
Co	0.38203	-0.41017	0.84923	0.02143	-0.2394	0.20523	0.87979	0.44956	0.9172	0.95172	-0.38871
Co	0.0034	0.0015	<.0001	0.8743	0.0729	0.1257	<.0001	0.0005	<.0001	<.0001	0.0028
B	-0.38344	-0.17276	0.27561	0.88066	0.78409	0.78703	0.08012	-0.09175	0.04125	0.00765	-0.1363
B	0.0032	0.1987	0.038	<.0001	<.0001	<.0001	0.5535	0.4973	0.7606	0.9549	0.312
Mo	-0.33358	-0.19245	0.31194	0.90961	0.74195	0.81283	0.14372	-0.0602	0.12235	0.0694	-0.18018
Mo	0.0112	0.1515	0.0182	<.0001	<.0001	<.0001	0.2862	0.6564	0.3646	0.608	0.1799
Pb	-0.17524	0.56929	-0.52992	-0.14114	-0.11424	-0.25836	-0.52064	-0.14498	-0.33519	-0.42069	0.0409
Pb	0.1923	<.0001	<.0001	0.295	0.3975	0.0523	<.0001	0.2819	0.0108	0.0011	0.7626
Cd	0.01555	-0.24515	0.22885	0.29616	0.13043	0.235	0.14965	0.33156	0.13499	0.14463	0.15947
Cd	0.9086	0.0661	0.0868	0.0253	0.3335	0.0785	0.2665	0.0118	0.3167	0.2831	0.236
Cl	-0.29868	-0.29194	0.43565	0.938	0.57607	0.842	0.22876	0.03561	0.20731	0.15719	-0.21543
Cl	0.024	0.0276	0.0007	<.0001	<.0001	<.0001	0.087	0.7926	0.1218	0.2429	0.1075
SO4	0.41556	-0.53271	0.95268	0.18133	-0.11304	0.3979	0.98818	0.30582	0.92557	0.9443	-0.47384
SO4	0.0013	<.0001	<.0001	0.177	0.4025	0.0022	<.0001	0.0207	<.0001	<.0001	0.0002
NO3	0.29321	0.0987	0.21064	-0.03785	0.08146	0.22433	0.22582	-0.09926	0.20345	0.27896	-0.19735
NO3	0.0269	0.4651	0.1158	0.7798	0.5469	0.0934	0.0912	0.4626	0.129	0.0356	0.1412
Available_P	-0.05165	0.34679	-0.63175	-0.20809	0.10209	-0.20555	-0.59535	-0.28113	-0.60618	-0.53676	0.2853
Available_P	0.7028	0.0082	<.0001	0.1204	0.4499	0.1251	<.0001	0.0341	<.0001	<.0001	0.0315
CaCO3	0.36327	0.51265	-0.42465	-0.45854	-0.23068	-0.23295	-0.3218	-0.37438	-0.32731	-0.22318	-0.17029
CaCO3	0.0055	<.0001	0.001	0.0003	0.0843	0.0812	0.0146	0.0041	0.0129	0.0952	0.2054
Inorganic_C	0.46178	0.42972	-0.23015	-0.39094	-0.3016	-0.12928	-0.12899	-0.38857	-0.14546	-0.02408	-0.32413
Inorganic_C	0.0003	0.0009	0.085	0.0026	0.0226	0.3378	0.3389	0.0028	0.2803	0.8589	0.0139
Organic_C	-0.1303	0.32966	-0.41502	-0.21599	0.04634	-0.19607	-0.38186	-0.18428	-0.41226	-0.35192	0.17612
Organic_C	0.334	0.0123	0.0013	0.1066	0.7321	0.1438	0.0034	0.17	0.0014	0.0073	0.19
Total_C	0.41867	0.46556	-0.28872	-0.40875	-0.27996	-0.15569	-0.18675	-0.40178	-0.20743	-0.0816	-0.28071
Total_C	0.0012	0.0003	0.0294	0.0016	0.0349	0.2475	0.1642	0.0019	0.1216	0.5462	0.0344
Total_N	0.01557	0.07319	-0.29276	-0.21454	0.21087	-0.18719	-0.24496	0.20595	-0.26655	-0.24093	0.42308
Total_N	0.9085	0.5884	0.0271	0.109	0.1154	0.1632	0.0663	0.1243	0.045	0.071	0.001
Clay	0.02189	0.51667	-0.76876	-0.31894	0.10665	-0.33556	-0.74917	-0.37518	-0.74176	-0.71024	0.29359
Clay	0.8716	<.0001	<.0001	0.0156	0.4298	0.0107	<.0001	0.004	<.0001	<.0001	0.0267
Silt	0.20902	0.49855	-0.64817	-0.45047	0.02477	-0.32362	-0.57716	-0.27058	-0.55861	-0.5211	0.20486
Silt	0.1187	<.0001	<.0001	0.0004	0.8549	0.0141	<.0001	0.0418	<.0001	<.0001	0.1263
Sand	-0.18039	-0.51184	0.68247	0.43644	-0.0397	0.33227	0.61909	0.29448	0.60213	0.56492	-0.22464
Sand	0.1793	<.0001	<.0001	0.0007	0.7693	0.0116	<.0001	0.0262	<.0001	<.0001	0.093
Total_Energy	-0.19072	0.0153	-0.34819	-0.09727	0.03163	-0.12324	-0.37536	-0.03658	-0.38499	-0.40517	0.44638
Total_Energy	0.1553	0.91	0.008	0.4717	0.8153	0.3611	0.004	0.787	0.0031	0.0018	0.0005
Bulk_Density	-0.30645	0.47366	-0.70475	-0.13572	0.06416	-0.25197	-0.67053	-0.37907	-0.6781	-0.71199	0.25051
Bulk_Density	0.0204	0.0002	<.0001	0.3141	0.6354	0.0586	<.0001	0.0036	<.0001	<.0001	0.0602

	Zn	Co	B	Mo	Pb	Cd	Cl	SO4	NO3	Available_P	CaCO3
arca	0.22567	0.38203	-0.38344	-0.33358	-0.17524	0.01555	-0.29868	0.41556	0.29321	-0.05165	0.36327
arca	0.0914	0.0034	0.0032	0.0112	0.1923	0.9086	0.024	0.0013	0.0269	0.7028	0.0055
pH	-0.2987	-0.41017	-0.17276	-0.19245	0.56929	-0.24515	-0.29194	-0.53271	0.0987	0.34679	0.51265
pH	0.024	0.0015	0.1987	0.1515	<.0001	0.0661	0.0276	<.0001	0.4651	0.0082	<.0001
EC	0.16514	0.84923	0.27561	0.31194	-0.52992	0.22885	0.43565	0.95268	0.21064	-0.63175	-0.42465
EC	0.2196	<.0001	0.038	0.0182	<.0001	0.0868	0.0007	<.0001	0.1158	<.0001	0.001
Na	-0.15078	0.02143	0.88066	0.90961	-0.14114	0.29616	0.938	0.18133	-0.03785	-0.20809	-0.45854
Na	0.2629	0.8743	<.0001	<.0001	0.295	0.0253	<.0001	0.177	0.7798	0.1204	0.0003
K	-0.13797	-0.2394	0.78409	0.74195	-0.11424	0.13043	0.57607	-0.11304	0.08146	0.10209	-0.23068
K	0.3061	0.0729	<.0001	<.0001	0.3975	0.3335	<.0001	0.4025	0.5469	0.4499	0.0843
Mg	-0.14299	0.20523	0.78703	0.81283	-0.25836	0.235	0.842	0.3979	0.22433	-0.20555	-0.23295
Mg	0.2887	0.1257	<.0001	<.0001	0.0523	0.0785	<.0001	0.0022	0.0934	0.1251	0.0812
Ca	0.19328	0.87979	0.08012	0.14372	-0.52064	0.14965	0.22876	0.98818	0.22582	-0.59535	-0.3218
Ca	0.1497	<.0001	0.5535	0.2862	<.0001	0.2665	0.087	<.0001	0.0912	<.0001	0.0146
Mn	0.39263	0.44956	-0.09175	-0.0602	-0.14498	0.33156	0.03561	0.30582	-0.09926	-0.28113	-0.37438
Mn	0.0025	0.0005	0.4973	0.6564	0.2819	0.0118	0.7926	0.0207	0.4626	0.0341	0.0041
Fe	0.19282	0.9172	0.04125	0.12235	-0.33519	0.13499	0.20731	0.92557	0.20345	-0.60618	-0.32731
Fe	0.1507	<.0001	0.7606	0.3646	0.0108	0.3167	0.1218	<.0001	0.129	<.0001	0.0129
Ni	0.15229	0.95172	0.00765	0.0694	-0.42069	0.14463	0.15719	0.9443	0.27896	-0.53676	-0.22318
Ni	0.2581	<.0001	0.9549	0.608	0.0011	0.2831	0.2429	<.0001	0.0356	<.0001	0.0952
Cu	0.42293	-0.38871	-0.1363	-0.18018	0.0409	0.15947	-0.21543	-0.47384	-0.19735	0.2853	-0.17029
Cu	0.001	0.0028	0.312	0.1799	0.7626	0.236	0.1075	0.0002	0.1412	0.0315	0.2054
Zn	1	0.20651	-0.16049	-0.1924	-0.03675	0.20419	-0.10622	0.19172	-0.10267	-0.09338	-0.27457
Zn		0.1233	0.233	0.1516	0.7861	0.1276	0.4316	0.1531	0.4473	0.4896	0.0387
Co	0.20651	1	-0.06759	0.01384	-0.35225	0.1911	0.05929	0.84565	0.27487	-0.47376	-0.21382
Co	0.1233		0.6174	0.9186	0.0072	0.1545	0.6613	<.0001	0.0385	0.0002	0.1102
B	-0.16049	-0.06759	1	0.85092	-0.21527	0.24711	0.86475	0.10638	0.07714	-0.07827	-0.41236
B	0.233	0.6174		<.0001	0.1078	0.0639	<.0001	0.4309	0.5685	0.5628	0.0014
Mo	-0.1924	0.01384	0.85092	1	-0.17131	0.20612	0.8504	0.15038	-0.01896	-0.14179	-0.36977
Mo	0.1516	0.9186	<.0001		0.2026	0.124	<.0001	0.2642	0.8887	0.2927	0.0046
Pb	-0.03675	-0.35225	-0.21527	-0.17131	1	-0.14864	-0.2224	-0.5797	-0.03651	0.41027	0.40086
Pb	0.7861	0.0072	0.1078	0.2026		0.2698	0.0963	<.0001	0.7874	0.0015	0.002
Cd	0.20419	0.1911	0.24711	0.20612	-0.14864	1	0.39193	0.17251	0.15178	-0.15196	-0.15275
Cd	0.1276	0.1545	0.0639	0.124	0.2698		0.0026	0.1994	0.2597	0.2591	0.2566
Cl	-0.10622	0.05929	0.86475	0.8504	-0.2224	0.39193	1	0.24235	0.00081	-0.2201	-0.44544
Cl	0.4316	0.6613	<.0001	<.0001	0.0963	0.0026		0.0693	0.9952	0.0999	0.0005
SO4	0.19172	0.84565	0.10638	0.15038	-0.5797	0.17251	0.24235	1	0.22704	-0.61673	-0.31917
SO4	0.1531	<.0001	0.4309	0.2642	<.0001	0.1994	0.0693		0.0894	<.0001	0.0155
NO3	-0.10267	0.27487	0.07714	-0.01896	-0.03651	0.15178	0.00081	0.22704	1	0.05313	0.31805
NO3	0.4473	0.0385	0.5685	0.8887	0.7874	0.2597	0.9952	0.0894		0.6947	0.0159
Available_P	-0.09338	-0.47376	-0.07827	-0.14179	0.41027	-0.15196	-0.2201	-0.61673	0.05313	1	0.55359
Available_P	0.4896	0.0002	0.5628	0.2927	0.0015	0.2591	0.0999	<.0001	0.6947		<.0001
CaCO3	-0.27457	-0.21382	-0.41236	-0.36977	0.40086	-0.15275	-0.44544	-0.31917	0.31805	0.55359	1
CaCO3	0.0387	0.1102	0.0014	0.0046	0.002	0.2566	0.0005	0.0155	0.0159	<.0001	
Inorganic_C	-0.25717	-0.06241	-0.3691	-0.33649	0.30482	-0.1074	-0.3589	-0.13021	0.44863	0.43351	0.91622
Inorganic_C	0.0535	0.6446	0.0047	0.0105	0.0211	0.4265	0.0061	0.3343	0.0005	0.0008	<.0001
Organic_C	-0.12665	-0.28942	-0.09679	-0.13387	0.2765	-0.07429	-0.24022	-0.41052	0.23078	0.41707	0.26995
Organic_C	0.3478	0.029	0.4739	0.3208	0.0373	0.5828	0.0719	0.0015	0.0841	0.0012	0.0423
Total_C	-0.26678	-0.10783	-0.36813	-0.34307	0.33739	-0.11525	-0.38223	-0.19274	0.46646	0.48309	0.91948
Total_C	0.0449	0.4247	0.0048	0.009	0.0103	0.3933	0.0033	0.1509	0.0003	0.0001	<.0001
Total_N	0.01524	-0.11423	-0.02238	-0.12383	0.07714	0.00239	-0.20317	-0.25656	0.07057	0.49433	0.16275
Total_N	0.9104	0.3975	0.8688	0.3588	0.5685	0.9859	0.1296	0.0541	0.6019	<.0001	0.2264
Clay	-0.2151	-0.65767	-0.18378	-0.22548	0.3553	-0.18764	-0.37316	-0.70434	-0.01495	0.56292	0.62159
Clay	0.1081	<.0001	0.1712	0.0917	0.0067	0.1622	0.0043	<.0001	0.9121	<.0001	<.0001
Silt	-0.21239	-0.45571	-0.32464	-0.33894	0.39174	-0.1575	-0.47174	-0.55436	0.21076	0.58236	0.74574
Silt	0.1127	0.0004	0.0137	0.0099	0.0026	0.242	0.0002	<.0001	0.1156	<.0001	<.0001
Sand	0.21713	0.50048	0.30641	0.32585	-0.3932	0.16602	0.46393	0.59195	-0.17529	-0.5907	-0.73896
Sand	0.1047	<.0001	0.0204	0.0134	0.0025	0.2171	0.0003	<.0001	0.1922	<.0001	<.0001
Total_Energy	0.11914	-0.31554	-0.08394	-0.17171	0.01331	0.01315	-0.10783	-0.37023	-0.23504	0.15531	-0.02102
Total_Energy	0.3774	0.0168	0.5347	0.2015	0.9217	0.9226	0.4247	0.0046	0.0784	0.2487	0.8767
Bulk_Density	-0.03425	-0.72721	-0.06169	-0.20418	0.4374	-0.22355	-0.20578	-0.66563	-0.20338	0.50037	0.25293
Bulk_Density	0.8003	<.0001	0.6485	0.1276	0.0007	0.0946	0.1246	<.0001	0.1292	<.0001	0.0577

	Inorganic_C	Organic_C	Total_C	Total_N	Clay	Silt	Sand	Total_Energy	Bulk_Density
arca	0.46178	-0.1303	0.41867	0.01557	0.02189	0.20902	-0.18039	-0.19072	-0.30645
arca	0.0003	0.334	0.0012	0.9085	0.8716	0.1187	0.1793	0.1553	0.0204
pH	0.42972	0.32966	0.46556	0.07319	0.51667	0.49855	-0.51184	0.0153	0.47366
pH	0.0009	0.0123	0.0003	0.5884	<.0001	<.0001	<.0001	0.91	0.0002
EC	-0.23015	-0.41502	-0.28872	-0.29276	-0.76876	-0.64817	0.68247	-0.34819	-0.70475
EC	0.085	0.0013	0.0294	0.0271	<.0001	<.0001	<.0001	0.008	<.0001
Na	-0.39094	-0.21599	-0.40875	-0.21454	-0.31894	-0.45047	0.43644	-0.09727	-0.13572
Na	0.0026	0.1066	0.0016	0.109	0.0156	0.0004	0.0007	0.4717	0.3141
K	-0.3016	0.04634	-0.27996	0.21087	0.10665	0.02477	-0.0397	0.03163	0.06416
K	0.0226	0.7321	0.0349	0.1154	0.4298	0.8549	0.7693	0.8153	0.6354
Mg	-0.12928	-0.19607	-0.15569	-0.18719	-0.33556	-0.32362	0.33227	-0.12324	-0.25197
Mg	0.3378	0.1438	0.2475	0.1632	0.0107	0.0141	0.0116	0.3611	0.0586
Ca	-0.12899	-0.38186	-0.18675	-0.24496	-0.74917	-0.57716	0.61909	-0.37536	-0.67053
Ca	0.3389	0.0034	0.1642	0.0663	<.0001	<.0001	<.0001	0.004	<.0001
Mn	-0.38857	-0.18428	-0.40178	0.20595	-0.37518	-0.27058	0.29448	-0.03658	-0.37907
Mn	0.0028	0.17	0.0019	0.1243	0.004	0.0418	0.0262	0.787	0.0036
Fe	-0.14546	-0.41226	-0.20743	-0.26655	-0.74176	-0.55861	0.60213	-0.38499	-0.6781
Fe	0.2803	0.0014	0.1216	0.045	<.0001	<.0001	<.0001	0.0031	<.0001
Ni	-0.02408	-0.35192	-0.0816	-0.24093	-0.71024	-0.5211	0.56492	-0.40517	-0.71199
Ni	0.8589	0.0073	0.5462	0.071	<.0001	<.0001	<.0001	0.0018	<.0001
Cu	-0.32413	0.17612	-0.28071	0.42308	0.29359	0.20486	-0.22464	0.44638	0.25051
Cu	0.0139	0.19	0.0344	0.001	0.0267	0.1263	0.093	0.0005	0.0602
Zn	-0.25717	-0.12665	-0.26678	0.01524	-0.2151	-0.21239	0.21713	0.11914	-0.03425
Zn	0.0535	0.3478	0.0449	0.9104	0.1081	0.1127	0.1047	0.3774	0.8003
Co	-0.06241	-0.28942	-0.10783	-0.11423	-0.65767	-0.45571	0.50048	-0.31554	-0.72721
Co	0.6446	0.029	0.4247	0.3975	<.0001	0.0004	<.0001	0.0168	<.0001
B	-0.3691	-0.09679	-0.36813	-0.02238	-0.18378	-0.32464	0.30641	-0.08394	-0.06169
B	0.0047	0.4739	0.0048	0.8688	0.1712	0.0137	0.0204	0.5347	0.6485
Mo	-0.33649	-0.13387	-0.34307	-0.12383	-0.22548	-0.33894	0.32585	-0.17171	-0.20418
Mo	0.0105	0.3208	0.009	0.3588	0.0917	0.0099	0.0134	0.2015	0.1276
Pb	0.30482	0.2765	0.33739	0.07714	0.3553	0.39174	-0.3932	0.01331	0.4374
Pb	0.0211	0.0373	0.0103	0.5685	0.0067	0.0026	0.0025	0.9217	0.0007
Cd	-0.1074	-0.07429	-0.11525	0.00239	-0.18764	-0.1575	0.16602	0.01315	-0.22355
Cd	0.4265	0.5828	0.3933	0.9859	0.1622	0.242	0.2171	0.9226	0.0946
Cl	-0.3589	-0.24022	-0.38223	-0.20317	-0.37316	-0.47174	0.46393	-0.10783	-0.20578
Cl	0.0061	0.0719	0.0033	0.1296	0.0043	0.0002	0.0003	0.4247	0.1246
SO4	-0.13021	-0.41052	-0.19274	-0.25656	-0.70434	-0.55436	0.59195	-0.37023	-0.66563
SO4	0.3343	0.0015	0.1509	0.0541	<.0001	<.0001	<.0001	0.0046	<.0001
NO3	0.44863	0.23078	0.46646	0.07057	-0.01495	0.21076	-0.17529	-0.23504	-0.20338
NO3	0.0005	0.0841	0.0003	0.6019	0.9121	0.1156	0.1922	0.0784	0.1292
Available_P	0.43351	0.41707	0.48309	0.49433	0.56292	0.58236	-0.5907	0.15531	0.50037
Available_P	0.0008	0.0012	0.0001	<.0001	<.0001	<.0001	<.0001	0.2487	<.0001
CaCO3	0.91622	0.26995	0.91948	0.16275	0.62159	0.74574	-0.73896	-0.02102	0.25293
CaCO3	<.0001	0.0423	<.0001	0.2264	<.0001	<.0001	<.0001	0.8767	0.0577
Inorganic_C	1	0.19195	0.98643	0.0214	0.49103	0.65897	-0.64271	-0.16199	0.12754
Inorganic_C		0.1526	<.0001	0.8744	0.0001	<.0001	<.0001	0.2286	0.3444
Organic_C	0.19195	1	0.35047	0.40717	0.28274	0.32622	-0.32509	0.16464	0.30143
Organic_C	0.1526		0.0075	0.0017	0.0331	0.0133	0.0136	0.221	0.0227
Total_C	0.98643	0.35047	1	0.08804	0.51564	0.68303	-0.66734	-0.12705	0.17242
Total_C	<.0001	0.0075		0.5149	<.0001	<.0001	<.0001	0.3463	0.1996
Total_N	0.0214	0.40717	0.08804	1	0.19619	0.36916	-0.34622	0.04972	0.06696
Total_N	0.8744	0.0017	0.5149		0.1436	0.0047	0.0083	0.7134	0.6207
Clay	0.49103	0.28274	0.51564	0.19619	1	0.86267	-0.90427	0.308	0.51304
Clay	0.0001	0.0331	<.0001	0.1436		<.0001	<.0001	0.0198	<.0001
Silt	0.65897	0.32622	0.68303	0.36916	0.86267	1	-0.99603	0.18077	0.38533
Silt	<.0001	0.0133	<.0001	0.0047	<.0001		<.0001	0.1784	0.0031
Sand	-0.64271	-0.32509	-0.66734	-0.34622	-0.90427	-0.99603	1	-0.2068	-0.41563
Sand	<.0001	0.0136	<.0001	0.0083	<.0001	<.0001		0.1227	0.0013
Total_Energy	-0.16199	0.16464	-0.12705	0.04972	0.308	0.18077	-0.2068	1	0.34386
Total_Energy	0.2286	0.221	0.3463	0.7134	0.0198	0.1784	0.1227		0.0088
Bulk_Density	0.12754	0.30143	0.17242	0.06696	0.51304	0.38533	-0.41563	0.34386	1
Bulk_Density	0.3444	0.0227	0.1996	0.6207	<.0001	0.0031	0.0013	0.0088	

Appendix 2. Correlation matrix Las Vegas bearpoppy layer 2

Simple Statistics						
Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
pH	58	7.47069	0.2429	433.3	7.095	8.148
EC	58	38.88473	14.01891	2255	10.31988	57.82733
Na	58	1.83464	1.61655	106.40935	0.359	5.53812
K	58	2.08687	0.72055	121.03828	0.97989	3.67054
Mg	58	1.98356	0.97031	115.04638	0.53368	4.12021
Ca	58	5.84099	1.63863	338.77747	2.12495	6.88262
Mn	58	1.41928	0.52591	82.31851	0.43898	2.75565
Fe	58	7.00886	1.09279	406.51372	4.50838	8.00278
Ni	58	2.62852	0.94017	152.45418	0.56568	3.53084
Cu	58	1.80316	0.65712	104.58342	0.71206	3.2293
Zn	58	2.71724	3.04174	157.60002	0.52255	20.47099
Co	58	0.53168	0.20769	30.8377	0.11801	0.8083
B	58	9.41771	7.89818	546.2269	2.4204	30.45031
Mo	58	1.2797	1.01538	74.2225	0.23696	4.18455
Pb	58	0.03259	0.03747	1.89009	0.0000149	0.17911
Cd	58	0.13285	0.09125	7.70516	0.00693	0.44811
Cl	58	2.60774	3.65669	151.24908	0.46152	13.38841
SO4	58	6.37494	2.26268	369.74634	1.14237	7.70462
NO3	58	0.30543	0.26596	17.71496	0.00598	1.70267
Available_P	58	1.26114	0.52621	73.14592	0.49348	2.53892
CaCO3	58	2.51585	0.92029	145.91922	0.81905	4.02699
Inorganic_C	58	2.00463	1.60711	116.2688	0.1522	6.611
Organic_C	58	0.18429	0.23119	10.6886	0.00438	1.24484
Total_C	58	2.18892	1.72463	126.9574	0.16953	6.7521
Total_N	58	0.00953	0.00502	0.55272	0.00224	0.02516
Clay	58	2.91219	2.49751	168.90721	0.16181	9.77146
Silt	58	21.68694	12.1681	1258	4.78889	50.49482
Sand	58	75.40087	14.49955	4373	42.40795	95.0493
Total_Energy	58	271.60397	204.73854	15753	0	860.9888
Bulk_Density	58	0.62977	0.17726	36.52681	0.25166	1.16055

Pearson Correlation Coefficients, N = 58

Prob > |r| under H0: Rho=0

	pH	EC	Na	K	Mg	Ca	Mn	Fe	Ni	Cu	Zn
pH	1	-0.84739	-0.2651	-0.08661	-0.38512	-0.83168	-0.34668	-0.7727	-0.77871	0.19319	-0.22368
pH		<.0001	0.0443	0.518	0.0028	<.0001	0.0077	<.0001	<.0001	0.1462	0.0914
EC	-0.84739	1	0.32552	0.17732	0.54706	0.95795	0.3331	0.9321	0.91156	-0.33734	0.28949
EC	<.0001		0.0127	0.183	<.0001	<.0001	0.0106	<.0001	<.0001	0.0096	0.0275
Na	-0.2651	0.32552	1	0.57914	0.76888	0.11385	0.10285	0.11257	0.03478	0.01745	0.09674
Na	0.0443	0.0127		<.0001	<.0001	0.3948	0.4423	0.4002	0.7955	0.8966	0.47
K	-0.08661	0.17732	0.57914	1	0.74521	0.03849	-0.10685	-0.00258	-0.08266	0.09558	0.14609
K	0.518	0.183	<.0001		<.0001	0.7742	0.4247	0.9847	0.5373	0.4754	0.2738
Mg	-0.38512	0.54706	0.76888	0.74521	1	0.39196	-0.01874	0.36375	0.29467	-0.18061	0.15146
Mg	0.0028	<.0001	<.0001	<.0001		0.0023	0.8889	0.005	0.0247	0.1749	0.2564
Ca	-0.83168	0.95795	0.11385	0.03849	0.39196	1	0.30766	0.96734	0.96621	-0.36988	0.2642
Ca	<.0001	<.0001	0.3948	0.7742	0.0023		0.0188	<.0001	<.0001	0.0043	0.0451
Mn	-0.34668	0.3331	0.10285	-0.10685	-0.01874	0.30766	1	0.38393	0.30228	0.19587	0.43605
Mn	0.0077	0.0106	0.4423	0.4247	0.8889	0.0188		0.0029	0.0211	0.1406	0.0006
Fe	-0.7727	0.9321	0.11257	-0.00258	0.36375	0.96734	0.38393	1	0.96697	-0.37923	0.24452
Fe	<.0001	<.0001	0.4002	0.9847	0.005	<.0001	0.0029		<.0001	0.0033	0.0643
Ni	-0.77871	0.91156	0.03478	-0.08266	0.29467	0.96621	0.30228	0.96697	1	-0.44482	0.1816
Ni	<.0001	<.0001	0.7955	0.5373	0.0247	<.0001	0.0211	<.0001		0.0005	0.1725
Cu	0.19319	-0.33734	0.01745	0.09558	-0.18061	-0.36988	0.19587	-0.37923	-0.44482	1	0.41477
Cu	0.1462	0.0096	0.8966	0.4754	0.1749	0.0043	0.1406	0.0033	0.0005		0.0012
Zn	-0.22368	0.28949	0.09674	0.14609	0.15146	0.2642	0.43605	0.24452	0.1816	0.41477	1
Zn	0.0914	0.0275	0.47	0.2738	0.2564	0.0451	0.0006	0.0643	0.1725	0.0012	
Co	-0.7347	0.84928	0.00326	-0.13198	0.21834	0.90298	0.40776	0.93808	0.96653	-0.3774	0.17719
Co	<.0001	<.0001	0.9806	0.3233	0.0996	<.0001	0.0015	<.0001	<.0001	0.0035	0.1833
B	-0.20448	0.32549	0.80907	0.76486	0.7931	0.1269	0.00831	0.10123	0.06767	-0.02889	0.09958
B	0.1236	0.0127	<.0001	<.0001	<.0001	0.3425	0.9506	0.4496	0.6137	0.8296	0.4571
Mo	-0.26647	0.41023	0.86275	0.65542	0.83237	0.22235	0.12194	0.22975	0.16885	-0.08944	0.1532
Mo	0.0432	0.0014	<.0001	<.0001	<.0001	0.0934	0.3618	0.0828	0.2051	0.5043	0.2509
Pb	0.36432	-0.33026	-0.01337	-0.07382	-0.10572	-0.32815	-0.10428	-0.22782	-0.28417	0.06423	-0.08793
Pb	0.0049	0.0113	0.9207	0.5818	0.4296	0.0119	0.436	0.0854	0.0306	0.6319	0.5116
Cd	-0.34347	0.38359	0.16866	-0.08416	0.20738	0.36439	0.15581	0.37469	0.37232	-0.18687	0.04841
Cd	0.0083	0.003	0.2057	0.5299	0.1183	0.0049	0.2428	0.0038	0.004	0.1601	0.7182
Cl	-0.39284	0.47332	0.93404	0.54809	0.7857	0.25825	0.14051	0.23319	0.17086	-0.03297	0.17096
Cl	0.0023	0.0002	<.0001	<.0001	<.0001	0.0503	0.2928	0.0781	0.1997	0.8059	0.1994
SO4	-0.81711	0.95736	0.12111	0.07728	0.40607	0.99194	0.27223	0.9554	0.95123	-0.36818	0.26728
SO4	<.0001	<.0001	0.3651	0.5642	0.0016	<.0001	0.0387	<.0001	<.0001	0.0045	0.0425
NO3	-0.12716	0.17373	0.07204	0.0309	0.10318	0.1667	-0.07745	0.15737	0.17359	-0.18205	-0.04111
NO3	0.3415	0.1922	0.591	0.8179	0.4408	0.2111	0.5634	0.2381	0.1925	0.1714	0.7593
Available_P	0.56681	-0.62484	-0.19554	0.05018	-0.1649	-0.59808	-0.40502	-0.62112	-0.5546	0.10905	-0.20723
Available_P	<.0001	<.0001	0.1413	0.7084	0.2161	<.0001	0.0016	<.0001	<.0001	0.4152	0.1186
CaCO3	0.5589	-0.48228	-0.34661	-0.25553	-0.21308	-0.40788	-0.41237	-0.38682	-0.30654	-0.24084	-0.33623
CaCO3	<.0001	0.0001	0.0077	0.0529	0.1083	0.0015	0.0013	0.0027	0.0193	0.0686	0.0099
Inorganic_C	0.45984	-0.42087	-0.36464	-0.31914	-0.23817	-0.3229	-0.41497	-0.30762	-0.21532	-0.29042	-0.30125
Inorganic_C	0.0003	0.001	0.0049	0.0146	0.0718	0.0134	0.0012	0.0188	0.1045	0.027	0.0216
Organic_C	0.38033	-0.33847	-0.24948	0.08798	-0.06823	-0.30644	-0.39107	-0.33513	-0.24899	-0.1566	-0.22799
Organic_C	0.0032	0.0094	0.0589	0.5114	0.6108	0.0193	0.0024	0.0101	0.0595	0.2404	0.0852
Total_C	0.47949	-0.43756	-0.37324	-0.2856	-0.23109	-0.34197	-0.43912	-0.33159	-0.23403	-0.29163	-0.31129
Total_C	0.0001	0.0006	0.0039	0.0298	0.0809	0.0086	0.0006	0.011	0.077	0.0263	0.0174
Total_N	0.41506	-0.4318	-0.11409	0.31367	-0.03068	-0.44749	-0.20312	-0.54666	-0.50803	0.29431	0.03037
Total_N	0.0012	0.0007	0.3938	0.0165	0.8192	0.0004	0.1262	<.0001	<.0001	0.0249	0.8209
Clay	0.83935	-0.84744	-0.31778	0.02273	-0.34655	-0.82504	-0.40132	-0.78818	-0.77691	0.14504	-0.27545
Clay	<.0001	<.0001	0.0151	0.8655	0.0077	<.0001	0.0018	<.0001	<.0001	0.2773	0.0364
Silt	0.77532	-0.7787	-0.42807	-0.00045	-0.34358	-0.71301	-0.415	-0.69616	-0.68198	0.11707	-0.22834
Silt	<.0001	<.0001	0.0008	0.9973	0.0083	<.0001	0.0012	<.0001	<.0001	0.3815	0.0847
Sand	-0.79523	0.79946	0.41398	-0.00354	0.34803	0.74048	0.4174	0.71998	0.70615	-0.12323	0.23907
Sand	<.0001	<.0001	0.0012	0.979	0.0074	<.0001	0.0011	<.0001	<.0001	0.3567	0.0707
Total_Energy	0.26384	-0.37148	-0.06229	-0.00632	-0.10741	-0.40141	-0.05259	-0.38053	-0.45661	0.33618	-0.0174
Total_Energy	0.0454	0.0041	0.6423	0.9624	0.4222	0.0018	0.695	0.0032	0.0003	0.0099	0.8969
Bulk_Density	0.17286	-0.27219	0.03914	0.27093	0.13146	-0.29379	-0.13245	-0.32958	-0.35865	0.12057	0.27002
Bulk_Density	0.1944	0.0387	0.7705	0.0397	0.3253	0.0252	0.3216	0.0115	0.0057	0.3673	0.0404

	Co	B	Mo	Pb	Cd	Cl	SO4	NO3	Available_P	CaCO3	Inorganic_C
pH	-0.7347	-0.20448	-0.26647	0.36432	-0.34347	-0.39284	-0.81711	-0.12716	0.56681	0.5589	0.45984
pH	<.0001	0.1236	0.0432	0.0049	0.0083	0.0023	<.0001	0.3415	<.0001	<.0001	0.0003
EC	0.84928	0.32549	0.41023	-0.33026	0.38359	0.47332	0.95736	0.17373	-0.62484	-0.48228	-0.42087
EC	<.0001	0.0127	0.0014	0.0113	0.003	0.0002	<.0001	0.1922	<.0001	0.0001	0.001
Na	0.00326	0.80907	0.86275	-0.01337	0.16866	0.93404	0.12111	0.07204	-0.19554	-0.34661	-0.36464
Na	0.9806	<.0001	<.0001	0.9207	0.2057	<.0001	0.3651	0.591	0.1413	0.0077	0.0049
K	-0.13198	0.76486	0.65542	-0.07382	-0.08416	0.54809	0.07728	0.0309	0.05018	-0.25553	-0.31914
K	0.3233	<.0001	<.0001	0.5818	0.5299	<.0001	0.5642	0.8179	0.7084	0.0529	0.0146
Mg	0.21834	0.7931	0.83237	-0.10572	0.20738	0.7857	0.40607	0.10318	-0.1649	-0.21308	-0.23817
Mg	0.0996	<.0001	<.0001	0.4296	0.1183	<.0001	0.0016	0.4408	0.2161	0.1083	0.0718
Ca	0.90298	0.1269	0.22235	-0.32815	0.36439	0.25825	0.99194	0.1667	-0.59808	-0.40788	-0.3229
Ca	<.0001	0.3425	0.0934	0.0119	0.0049	0.0503	<.0001	0.2111	<.0001	0.0015	0.0134
Mn	0.40776	0.00831	0.12194	-0.10428	0.15581	0.14051	0.27223	-0.07745	-0.40502	-0.41237	-0.41497
Mn	0.0015	0.9506	0.3618	0.436	0.2428	0.2928	0.0387	0.5634	0.0016	0.0013	0.0012
Fe	0.93808	0.10123	0.22975	-0.22782	0.37469	0.23319	0.9554	0.15737	-0.62112	-0.38682	-0.30762
Fe	<.0001	0.4496	0.0828	0.0854	0.0038	0.0781	<.0001	0.2381	<.0001	0.0027	0.0188
Ni	0.96653	0.06767	0.16885	-0.28417	0.37232	0.17086	0.95123	0.17359	-0.5546	-0.30654	-0.21532
Ni	<.0001	0.6137	0.2051	0.0306	0.004	0.1997	<.0001	0.1925	<.0001	0.0193	0.1045
Cu	-0.3774	-0.02889	-0.08944	0.06423	-0.18687	-0.03297	-0.36818	-0.18205	0.10905	-0.24084	-0.29042
Cu	0.0035	0.8296	0.5043	0.6319	0.1601	0.8059	0.0045	0.1714	0.4152	0.0686	0.027
Zn	0.17719	0.09958	0.1532	-0.08793	0.04841	0.17096	0.26728	-0.04111	-0.20723	-0.33623	-0.30125
Zn	0.1833	0.4571	0.2509	0.5116	0.7182	0.1994	0.0425	0.7593	0.1186	0.0099	0.0216
Co	1	0.02806	0.16163	-0.2447	0.41447	0.11594	0.87781	0.20568	-0.53539	-0.2844	-0.19866
Co		0.8344	0.2255	0.0641	0.0012	0.3861	<.0001	0.1214	<.0001	0.0305	0.1349
B	0.02806	1	0.8362	-0.08903	0.06474	0.81401	0.14487	0.20393	-0.00111	-0.31604	-0.35549
B	0.8344		<.0001	0.5063	0.6292	<.0001	0.2779	0.1247	0.9934	0.0157	0.0062
Mo	0.16163	0.8362	1	0.0399	0.15645	0.8768	0.22931	0.10691	-0.14252	-0.21035	-0.25348
Mo	0.2255	<.0001		0.7662	0.2409	<.0001	0.0834	0.4244	0.2859	0.113	0.0549
Pb	-0.2447	-0.08903	0.0399	1	-0.12749	-0.10088	-0.34271	0.08639	0.14911	0.30668	0.37946
Pb	0.0641	0.5063	0.7662		0.3402	0.4512	0.0085	0.5191	0.2639	0.0192	0.0033
Cd	0.41447	0.06474	0.15645	-0.12749	1	0.2251	0.36129	0.38388	-0.34981	-0.02414	0.04334
Cd	0.0012	0.6292	0.2409	0.3402		0.0893	0.0053	0.0029	0.0071	0.8572	0.7466
Cl	0.11594	0.81401	0.8768	-0.10088	0.2251	1	0.26587	0.09195	-0.29617	-0.39729	-0.41619
Cl	0.3861	<.0001	<.0001	0.4512	0.0893		0.0437	0.4924	0.024	0.002	0.0012
SO4	0.87781	0.14487	0.22931	-0.34271	0.36129	0.26587	1	0.15423	-0.59481	-0.40222	-0.32313
SO4	<.0001	0.2779	0.0834	0.0085	0.0053	0.0437		0.2477	<.0001	0.0017	0.0134
NO3	0.20568	0.20393	0.10691	0.08639	0.38388	0.09195	0.15423	1	-0.04229	0.00142	0.09483
NO3	0.1214	0.1247	0.4244	0.5191	0.0029	0.4924	0.2477		0.7526	0.9916	0.4789
Available_P	-0.53539	-0.00111	-0.14252	0.14911	-0.34981	-0.29617	-0.59481	-0.04229	1	0.57211	0.52799
Available_P	<.0001	0.9934	0.2859	0.2639	0.0071	0.024	<.0001	0.7526		<.0001	<.0001
CaCO3	-0.2844	-0.31604	-0.21035	0.30668	-0.02414	-0.39729	-0.40222	0.00142	0.57211	1	0.94211
CaCO3	0.0305	0.0157	0.113	0.0192	0.8572	0.002	0.0017	0.9916	<.0001		<.0001
Inorganic_C	-0.19866	-0.35549	-0.25348	0.37946	0.04334	-0.41619	-0.32313	0.09483	0.52799	0.94211	1
Inorganic_C	0.1349	0.0062	0.0549	0.0033	0.7466	0.0012	0.0134	0.4789	<.0001	<.0001	
Organic_C	-0.22747	0.06842	-0.07464	0.01584	-0.06751	-0.26463	-0.29333	0.27886	0.6079	0.45636	0.45498
Organic_C	0.0859	0.6098	0.5777	0.9061	0.6146	0.0447	0.0254	0.034	<.0001	0.0003	0.0003
Total_C	-0.21561	-0.32209	-0.24621	0.35572	0.03134	-0.42331	-0.34044	0.12575	0.5735	0.93909	0.99285
Total_C	0.1041	0.0137	0.0625	0.0061	0.8153	0.0009	0.0089	0.3469	<.0001	<.0001	<.0001
Total_N	-0.51305	0.13297	-0.12325	0.0471	-0.2006	-0.13297	-0.44647	-0.04172	0.4559	0.15972	0.11256
Total_N	<.0001	0.3197	0.3566	0.7255	0.1311	0.3197	0.0004	0.7559	0.0003	0.2311	0.4002
Clay	-0.74421	-0.19098	-0.29753	0.26462	-0.37734	-0.45144	-0.80526	-0.1803	0.68987	0.62648	0.52316
Clay	<.0001	0.151	0.0233	0.0447	0.0035	0.0004	<.0001	0.1756	<.0001	<.0001	<.0001
Silt	-0.67285	-0.31112	-0.37407	0.22856	-0.32885	-0.53359	-0.698	-0.18139	0.68243	0.6584	0.57648
Silt	<.0001	0.0174	0.0038	0.0844	0.0117	<.0001	<.0001	0.173	<.0001	<.0001	<.0001
Sand	0.69285	0.29399	0.36517	-0.23739	0.34097	0.52555	0.72447	0.18328	-0.69153	-0.66044	-0.5739
Sand	<.0001	0.0251	0.0048	0.0728	0.0088	<.0001	<.0001	0.1685	<.0001	<.0001	<.0001
Total_Energy	-0.39843	-0.0809	-0.18951	0.09392	-0.1406	-0.18181	-0.39286	-0.02998	0.36266	0.05572	-0.02649
Total_Energy	0.002	0.546	0.1542	0.4832	0.2925	0.172	0.0023	0.8232	0.0051	0.6778	0.8435
Bulk_Density	-0.38529	0.09803	0.06427	0.14374	-0.28214	0.01139	-0.31047	-0.04805	0.21129	-0.03694	-0.0205
Bulk_Density	0.0028	0.4641	0.6317	0.2817	0.0319	0.9324	0.0177	0.7202	0.1113	0.7831	0.8786

	Organic_C	Total_C	Total_N	Clay	Silt	Sand	Total_Energy	Bulk_Density
pH	0.38033	0.47949	0.41506	0.83935	0.77532	-0.79523	0.26384	0.17286
pH	0.0032	0.0001	0.0012	<.0001	<.0001	<.0001	0.0454	0.1944
EC	-0.33847	-0.43756	-0.4318	-0.84744	-0.7787	0.79946	-0.37148	-0.27219
EC	0.0094	0.0006	0.0007	<.0001	<.0001	<.0001	0.0041	0.0387
Na	-0.24948	-0.37324	-0.11409	-0.31778	-0.42807	0.41398	-0.06229	0.03914
Na	0.0589	0.0039	0.3938	0.0151	0.0008	0.0012	0.6423	0.7705
K	0.08798	-0.2856	0.31367	0.02273	-0.00045	-0.00354	-0.00632	0.27093
K	0.5114	0.0298	0.0165	0.8655	0.9973	0.979	0.9624	0.0397
Mg	-0.06823	-0.23109	-0.03068	-0.34655	-0.34358	0.34803	-0.10741	0.13146
Mg	0.6108	0.0809	0.8192	0.0077	0.0083	0.0074	0.4222	0.3253
Ca	-0.30644	-0.34197	-0.44749	-0.82504	-0.71301	0.74048	-0.40141	-0.29379
Ca	0.0193	0.0086	0.0004	<.0001	<.0001	<.0001	0.0018	0.0252
Mn	-0.39107	-0.43912	-0.20312	-0.40132	-0.415	0.4174	-0.05259	-0.13245
Mn	0.0024	0.0006	0.1262	0.0018	0.0012	0.0011	0.695	0.3216
Fe	-0.33513	-0.33159	-0.54666	-0.78818	-0.69616	0.71998	-0.38053	-0.32958
Fe	0.0101	0.011	<.0001	<.0001	<.0001	<.0001	0.0032	0.0115
Ni	-0.24899	-0.23403	-0.50803	-0.77691	-0.68198	0.70615	-0.45661	-0.35865
Ni	0.0595	0.077	<.0001	<.0001	<.0001	<.0001	0.0003	0.0057
Cu	-0.1566	-0.29163	0.29431	0.14504	0.11707	-0.12323	0.33618	0.12057
Cu	0.2404	0.0263	0.0249	0.2773	0.3815	0.3567	0.0099	0.3673
Zn	-0.22799	-0.31129	0.03037	-0.27545	-0.22834	0.23907	-0.0174	0.27002
Zn	0.0852	0.0174	0.8209	0.0364	0.0847	0.0707	0.8969	0.0404
Co	-0.22747	-0.21561	-0.51305	-0.74421	-0.67285	0.69285	-0.39843	-0.38529
Co	0.0859	0.1041	<.0001	<.0001	<.0001	<.0001	0.002	0.0028
B	0.06842	-0.32209	0.13297	-0.19098	-0.31112	0.29399	-0.0809	0.09803
B	0.6098	0.0137	0.3197	0.151	0.0174	0.0251	0.546	0.4641
Mo	-0.07464	-0.24621	-0.12325	-0.29753	-0.37407	0.36517	-0.18951	0.06427
Mo	0.5777	0.0625	0.3566	0.0233	0.0038	0.0048	0.1542	0.6317
Pb	0.01584	0.35572	0.0471	0.26462	0.22856	-0.23739	0.09392	0.14374
Pb	0.9061	0.0061	0.7255	0.0447	0.0844	0.0728	0.4832	0.2817
Cd	-0.06751	0.03134	-0.2006	-0.37734	-0.32885	0.34097	-0.1406	-0.28214
Cd	0.6146	0.8153	0.1311	0.0035	0.0117	0.0088	0.2925	0.0319
Cl	-0.26463	-0.42331	-0.13297	-0.45144	-0.53359	0.52555	-0.18181	0.01139
Cl	0.0447	0.0009	0.3197	0.0004	<.0001	<.0001	0.172	0.9324
SO4	-0.29333	-0.34044	-0.44647	-0.80526	-0.698	0.72447	-0.39286	-0.31047
SO4	0.0254	0.0089	0.0004	<.0001	<.0001	<.0001	0.0023	0.0177
NO3	0.27886	0.12575	-0.04172	-0.1803	-0.18139	0.18328	-0.02998	-0.04805
NO3	0.034	0.3469	0.7559	0.1756	0.173	0.1685	0.8232	0.7202
Available_P	0.6079	0.5735	0.4559	0.68987	0.68243	-0.69153	0.36266	0.21129
Available_P	<.0001	<.0001	0.0003	<.0001	<.0001	<.0001	0.0051	0.1113
CaCO3	0.45636	0.93909	0.15972	0.62648	0.6584	-0.66044	0.05572	-0.03694
CaCO3	0.0003	<.0001	0.2311	<.0001	<.0001	<.0001	0.6778	0.7831
Inorganic_C	0.45498	0.99285	0.11256	0.52316	0.57648	-0.5739	-0.02649	-0.0205
Inorganic_C	0.0003	<.0001	0.4002	<.0001	<.0001	<.0001	0.8435	0.8786
Organic_C	1	0.55803	0.40029	0.45577	0.5197	-0.51464	0.12871	0.08147
Organic_C		<.0001	0.0018	0.0003	<.0001	<.0001	0.3356	0.5432
Total_C	0.55803	1	0.15855	0.5486	0.60687	-0.60378	-0.00743	-0.00818
Total_C	<.0001		0.2345	<.0001	<.0001	<.0001	0.9558	0.9514
Total_N	0.40029	0.15855	1	0.45529	0.51725	-0.5125	0.2392	0.18506
Total_N	0.0018	0.2345		0.0003	<.0001	<.0001	0.0705	0.1643
Clay	0.45577	0.5486	0.45529	1	0.92031	-0.94458	0.28484	0.17265
Clay	0.0003	<.0001	0.0003		<.0001	<.0001	0.0302	0.195
Silt	0.5197	0.60687	0.51725	0.92031	1	-0.99773	0.27271	0.14793
Silt	<.0001	<.0001	<.0001	<.0001		<.0001	0.0383	0.2678
Sand	-0.51464	-0.60378	-0.5125	-0.94458	-0.99773	1	-0.27793	-0.15388
Sand	<.0001	<.0001	<.0001	<.0001	<.0001		0.0347	0.2488
Total_Energy	0.12871	-0.00743	0.2392	0.28484	0.27271	-0.27793	1	0.12609
Total_Energy	0.3356	0.9558	0.0705	0.0302	0.0383	0.0347		0.3456
Bulk_Density	0.08147	-0.00818	0.18506	0.17265	0.14793	-0.15388	0.12609	1
Bulk_Density	0.5432	0.9514	0.1643	0.195	0.2678	0.2488	0.3456	

Appendix 3. Correlation matrix ringstem layer 1 within sites

Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
anle1	33	0.48485	0.50752	16	0	1
ANLE	33	0.59135	0.70603	19.51461	0	2.19722
pH	33	7.51473	0.19727	247.986	7.191	7.866
EC	33	41.44248	14.3406	1368	11.23833	80.85172
Na	33	2.22709	1.7	73.49407	0.49716	5.81973
K	33	2.23055	0.8339	73.60799	0.93233	4.94065
Mg	33	2.18679	1.18854	72.16392	0.57707	5.84095
Ca	33	6.0412	1.36217	199.35959	2.68826	6.96843
Mn	33	1.89711	0.79014	62.60462	0.61369	3.36762
Fe	33	7.1008	0.93807	234.32639	4.65065	8.05278
Ni	33	2.76971	0.77662	91.40057	1.00234	3.53115
Cu	33	1.91954	0.73836	63.34467	0.62677	3.97275
Zn	33	2.57409	4.00545	84.94505	0.44199	22.8961
Co	33	0.55717	0.17835	18.38665	0.16687	0.85934
B	33	12.22752	8.34207	403.50803	2.54017	38.76066
Mo	33	1.90523	1.94816	62.87264	0.23633	10.17366
Pb	33	0.04671	0.05667	1.54153	0.0001733	0.2862
Cd	33	0.14517	0.1169	4.79059	0.01549	0.56011
Cl	33	4.06841	5.58074	134.25746	0.56125	24.57615
SO4	33	6.61654	1.87734	218.34593	1.67777	8.06512
NO3	33	0.47764	0.37397	15.7622	0.00717	1.69124
Available_P	33	1.62344	0.57348	53.57368	0.50078	2.7576
CaCO3	33	2.48438	1.14712	81.98451	0.91295	4.14514
Inorganic_C	33	2.41599	2.40766	79.7276	0.179	7.4552
Organic_C	33	0.25761	0.44268	8.50119	0.00444	2.34318
Total_C	33	2.6736	2.55016	88.22879	0.22691	7.46032
Total_N	33	0.01569	0.00829	0.51788	0.00474	0.03919
Clay	33	3.02659	2.32549	99.87748	0.39501	11.09212
Silt	33	23.47695	12.73044	774.73926	7.03936	49.38436
Sand	33	73.49646	14.87727	2425	39.72384	92.56562
Total_Energy	33	224.07195	154.57024	7394	0	557.1104
Bulk_Density	33	0.76793	0.22125	25.34163	0.47793	1.37164

Pearson Correlation Coefficients, N = 33
Prob > |r| under H0: Rho=0

	anle1	ANLE	pH	EC	Na	K	Mg	Ca	Mn	Fe	Ni
anle1	1	0.87674	-0.36695	0.31609	0.01075	-0.23677	0.01951	0.43104	0.14584	0.39056	0.44228
anle1		<.0001	0.0357	0.0731	0.9526	0.1846	0.9142	0.0123	0.418	0.0246	0.01
ANLE	0.87674	1	-0.18963	0.19894	-0.08803	-0.31337	-0.00559	0.35294	-0.10881	0.30409	0.37017
ANLE	<.0001		0.2905	0.2671	0.6262	0.0758	0.9754	0.0439	0.5467	0.0853	0.034
pH	-0.36695	-0.18963	1	-0.79213	-0.47114	-0.02458	-0.36228	-0.78848	-0.59534	-0.78348	-0.71575
pH	0.0357	0.2905		<.0001	0.0056	0.892	0.0383	<.0001	0.0003	<.0001	<.0001
EC	0.31609	0.19894	-0.79213	1	0.60058	0.32302	0.68019	0.8645	0.278	0.85112	0.82734
EC	0.0731	0.2671	<.0001		0.0002	0.0667	<.0001	<.0001	0.1172	<.0001	<.0001
Na	0.01075	-0.08803	-0.47114	0.60058	1	0.75958	0.89053	0.28059	0.15792	0.31538	0.14316
Na	0.9526	0.6262	0.0056	0.0002		<.0001	<.0001	0.1137	0.3801	0.0738	0.4267
K	-0.23677	-0.31337	-0.02458	0.32302	0.75958	1	0.79823	-0.08423	-0.12595	-0.05835	-0.16741
K	0.1846	0.0758	0.892	0.0667	<.0001		<.0001	0.6412	0.4849	0.747	0.3517
Mg	0.01951	-0.00559	-0.36228	0.68019	0.89053	0.79823	1	0.37545	-0.09002	0.38178	0.27651
Mg	0.9142	0.9754	0.0383	<.0001	<.0001	<.0001		0.0313	0.6183	0.0283	0.1193
Ca	0.43104	0.35294	-0.78848	0.8645	0.28059	-0.08423	0.37545	1	0.28513	0.94361	0.95562
Ca	0.0123	0.0439	<.0001	<.0001	0.1137	0.6412	0.0313		0.1078	<.0001	<.0001
Mn	0.14584	-0.10881	-0.59534	0.278	0.15792	-0.12595	-0.09002	0.28513	1	0.38814	0.26298
Mn	0.418	0.5467	0.0003	0.1172	0.3801	0.4849	0.6183	0.1078		0.0256	0.1392
Fe	0.39056	0.30409	-0.78348	0.85112	0.31538	-0.05835	0.38178	0.94361	0.38814	1	0.94092
Fe	0.0246	0.0853	<.0001	<.0001	0.0738	0.747	0.0283	<.0001	0.0256		<.0001
Ni	0.44228	0.37017	-0.71575	0.82734	0.14316	-0.16741	0.27651	0.95562	0.26298	0.94092	1
Ni	0.01	0.034	<.0001	<.0001	0.4267	0.3517	0.1193	<.0001	0.1392	<.0001	
Cu	-0.31074	-0.48982	-0.15719	-0.04256	0.062	0.25664	-0.07194	-0.18266	0.51284	-0.15675	-0.21995
Cu	0.0784	0.0038	0.3823	0.8141	0.7318	0.1494	0.6907	0.3089	0.0023	0.3837	0.2187
Zn	0.14471	-0.02211	-0.37506	0.17207	-0.09844	-0.12299	-0.14344	0.23026	0.4898	0.25781	0.21335
Zn	0.4217	0.9028	0.0315	0.3383	0.5857	0.4953	0.4258	0.1974	0.0038	0.1475	0.2332
Co	0.31589	0.19634	-0.67552	0.8057	0.14618	-0.0336	0.29127	0.85523	0.346	0.89218	0.93483
Co	0.0733	0.2735	<.0001	<.0001	0.417	0.8527	0.1001	<.0001	0.0486	<.0001	<.0001
B	0.00644	-0.11821	-0.34953	0.56189	0.89177	0.88496	0.87479	0.16276	0.06032	0.17315	0.0702
B	0.9716	0.5123	0.0462	0.0007	<.0001	<.0001	<.0001	0.3655	0.7388	0.3352	0.6979
Mo	-0.07561	-0.14477	-0.32641	0.62723	0.84325	0.8619	0.88285	0.2232	0.00962	0.25965	0.15033
Mo	0.6758	0.4215	0.0637	<.0001	<.0001	<.0001	<.0001	0.2118	0.9576	0.1445	0.4037
Pb	-0.3579	-0.28477	0.47651	-0.33896	-0.11755	0.10301	-0.08796	-0.48701	-0.05981	-0.24202	-0.38874
Pb	0.0409	0.1082	0.0051	0.0537	0.5147	0.5684	0.6264	0.004	0.7409	0.1748	0.0254
Cd	-0.12493	-0.28447	-0.43869	0.62215	0.60778	0.53514	0.60656	0.28546	0.37187	0.33003	0.26752
Cd	0.4885	0.1086	0.0107	0.0001	0.0002	0.0013	0.0002	0.1073	0.0331	0.0607	0.1323
Cl	0.02513	-0.08474	-0.43574	0.68838	0.90683	0.78617	0.89927	0.27866	0.10919	0.31441	0.20568
Cl	0.8896	0.6392	0.0113	<.0001	<.0001	<.0001	<.0001	0.1163	0.5452	0.0747	0.2508
SO4	0.42642	0.34832	-0.77914	0.88066	0.30024	-0.05224	0.39678	0.9904	0.24818	0.92085	0.94937
SO4	0.0133	0.047	<.0001	<.0001	0.0896	0.7728	0.0222	<.0001	0.1637	<.0001	<.0001
NO3	-0.0255	0.0322	0.23893	0.03168	0.02732	0.19302	0.21826	0.01626	-0.28382	-0.0313	0.02166
NO3	0.888	0.8588	0.1805	0.8611	0.8801	0.2818	0.2224	0.9284	0.1094	0.8627	0.9048
Available_P	-0.3662	-0.24858	0.74306	-0.73259	-0.48795	-0.10208	-0.42324	-0.67622	-0.2699	-0.65375	-0.59104
Available_P	0.0361	0.163	<.0001	<.0001	0.004	0.5719	0.0141	<.0001	0.1288	<.0001	0.0003
CaCO3	-0.08801	0.1625	0.77584	-0.54032	-0.64403	-0.35029	-0.39691	-0.38897	-0.55796	-0.39726	-0.25595
CaCO3	0.6262	0.3662	<.0001	0.0012	<.0001	0.0457	0.0222	0.0253	0.0007	0.0221	0.1505
Inorganic_C	0.02878	0.27452	0.62477	-0.3794	-0.5813	-0.38486	-0.31724	-0.22286	-0.47881	-0.23418	-0.08828
Inorganic_C	0.8737	0.1221	0.0001	0.0294	0.0004	0.027	0.072	0.2125	0.0048	0.1896	0.6252
Organic_C	-0.15249	-0.10202	0.48943	-0.45803	-0.27365	-0.02356	-0.21284	-0.4228	-0.23158	-0.49244	-0.4286
Organic_C	0.3969	0.5721	0.0038	0.0074	0.1233	0.8964	0.2344	0.0142	0.1947	0.0036	0.0128
Total_C	0.0007	0.24147	0.67482	-0.43771	-0.59632	-0.36745	-0.33646	-0.2838	-0.49225	-0.30658	-0.15775
Total_C	0.9969	0.1758	<.0001	0.0109	0.0002	0.0354	0.0556	0.1095	0.0036	0.0827	0.3806
Total_N	-0.42191	-0.43471	0.49707	-0.57512	-0.30354	0.11738	-0.30232	-0.61051	-0.11013	-0.65021	-0.55877
Total_N	0.0145	0.0115	0.0033	0.0005	0.0859	0.5153	0.0873	0.0002	0.5418	<.0001	0.0007
Clay	-0.25106	-0.08842	0.84849	-0.71509	-0.5108	-0.08382	-0.41812	-0.70116	-0.47288	-0.69786	-0.60601
Clay	0.1587	0.6246	<.0001	<.0001	0.0024	0.6428	0.0155	<.0001	0.0055	<.0001	0.0002
Silt	-0.30556	-0.13451	0.86663	-0.73598	-0.57143	-0.15943	-0.42261	-0.66592	-0.44009	-0.65019	-0.54884
Silt	0.0838	0.4555	<.0001	<.0001	0.0005	0.3755	0.0143	<.0001	0.0104	<.0001	0.0009
Sand	0.30071	0.12892	-0.8742	0.74155	0.56881	0.14953	0.42698	0.67942	0.4505	0.66545	0.56437
Sand	0.089	0.4746	<.0001	<.0001	0.0006	0.4062	0.0132	<.0001	0.0085	<.0001	0.0006
Total_Energy	-0.03607	-0.18917	-0.06281	0.04106	-0.08736	0.00797	-0.01943	0.15749	0.09024	0.10674	0.11305
Total_Energy	0.842	0.2917	0.7284	0.8205	0.6288	0.9649	0.9145	0.3814	0.6175	0.5544	0.5311
Bulk_Density	-0.29794	-0.20165	0.71155	-0.77947	-0.29921	0.0719	-0.33776	-0.80123	-0.24202	-0.74104	-0.81217
Bulk_Density	0.0922	0.2604	<.0001	<.0001	0.0907	0.6909	0.0546	<.0001	0.1748	<.0001	<.0001

	Cu	Zn	Co	B	Mo	Pb	Cd	Cl	SO4	NO3	Available_P
anle1	-0.31074	0.14471	0.31589	0.00644	-0.07561	-0.3579	-0.12493	0.02513	0.42642	-0.0255	-0.3662
anle1	0.0784	0.4217	0.0733	0.9716	0.6758	0.0409	0.4885	0.8896	0.0133	0.888	0.0361
ANLE	-0.48982	-0.02211	0.19634	-0.11821	-0.14477	-0.28477	-0.28447	-0.08474	0.34832	0.0322	-0.24858
ANLE	0.0038	0.9028	0.2735	0.5123	0.4215	0.1082	0.1086	0.6392	0.047	0.8588	0.163
pH	-0.15719	-0.37506	-0.67552	-0.34953	-0.32641	0.47651	-0.43869	-0.43574	-0.77914	0.23893	0.74306
pH	0.3823	0.0315	<.0001	0.0462	0.0637	0.0051	0.0107	0.0113	<.0001	0.1805	<.0001
EC	-0.04256	0.17207	0.8057	0.56189	0.62723	-0.33896	0.62215	0.68838	0.88066	0.03168	-0.73259
EC	0.8141	0.3383	<.0001	0.0007	<.0001	0.0537	0.0001	<.0001	<.0001	0.8611	<.0001
Na	0.062	-0.09844	0.14618	0.89177	0.84325	-0.11755	0.60778	0.90683	0.30024	0.02732	-0.48795
Na	0.7318	0.5857	0.417	<.0001	<.0001	0.5147	0.0002	<.0001	0.0896	0.8801	0.004
K	0.25664	-0.12299	-0.0336	0.88496	0.8619	0.10301	0.53514	0.78617	-0.05224	0.19302	-0.10208
K	0.1494	0.4953	0.8527	<.0001	<.0001	0.5684	0.0013	<.0001	0.7728	0.2818	0.5719
Mg	-0.07194	-0.14344	0.29127	0.87479	0.88285	-0.08796	0.60656	0.89927	0.39678	0.21826	-0.42324
Mg	0.6907	0.4258	0.1001	<.0001	<.0001	0.6264	0.0002	<.0001	0.0222	0.2224	0.0141
Ca	-0.18266	0.23026	0.85523	0.16276	0.2232	-0.48701	0.28546	0.27866	0.9904	0.01626	-0.67622
Ca	0.3089	0.1974	<.0001	0.3655	0.2118	0.004	0.1073	0.1163	<.0001	0.9284	<.0001
Mn	0.51284	0.4898	0.346	0.06032	0.00962	-0.05981	0.37187	0.10919	0.24818	-0.28382	-0.2699
Mn	0.0023	0.0038	0.0486	0.7388	0.9576	0.7409	0.0331	0.5452	0.1637	0.1094	0.1288
Fe	-0.15675	0.25781	0.89218	0.17315	0.25965	-0.24202	0.33003	0.31441	0.92085	-0.0313	-0.65375
Fe	0.3837	0.1475	<.0001	0.3352	0.1445	0.1748	0.0607	0.0747	<.0001	0.8627	<.0001
Ni	-0.21995	0.21335	0.93483	0.0702	0.15033	-0.38874	0.26752	0.20568	0.94937	0.02166	-0.59104
Ni	0.2187	0.2332	<.0001	0.6979	0.4037	0.0254	0.1323	0.2508	<.0001	0.9048	0.0003
Cu	1	0.59304	-0.02649	0.19106	0.16407	0.06802	0.33964	0.10978	-0.17882	-0.02114	0.18876
Cu		0.0003	0.8837	0.2868	0.3616	0.7068	0.0531	0.5431	0.3194	0.907	0.2928
Zn	0.59304	1	0.31374	-0.10082	-0.08508	-0.0286	0.19946	-0.05791	0.21552	-0.14608	-0.0253
Zn	0.0003		0.0754	0.5767	0.6378	0.8744	0.2658	0.7489	0.2284	0.4173	0.8889
Co	-0.02649	0.31374	1	0.12996	0.24568	-0.22977	0.37629	0.24835	0.83677	-0.05556	-0.49884
Co	0.8837	0.0754		0.471	0.1682	0.1983	0.0309	0.1634	<.0001	0.7588	0.0031
B	0.19106	-0.10082	0.12996	1	0.88549	-0.09203	0.65553	0.92554	0.20276	0.18626	-0.37365
B	0.2868	0.5767	0.471		<.0001	0.6105	<.0001	<.0001	0.2578	0.2994	0.0322
Mo	0.16407	-0.08508	0.24568	0.88549	1	0.07718	0.66712	0.92541	0.24245	0.05335	-0.40447
Mo	0.3616	0.6378	0.1682	<.0001		0.6694	<.0001	<.0001	0.174	0.7681	0.0196
Pb	0.06802	-0.0286	-0.22977	-0.09203	0.07718	1	0.01978	-0.01579	-0.52681	0.00748	0.32357
Pb	0.7068	0.8744	0.1983	0.6105	0.6694		0.913	0.9305	0.0016	0.967	0.0662
Cd	0.33964	0.19946	0.37629	0.65553	0.66712	0.01978	1	0.77833	0.32962	-0.00142	-0.3571
Cd	0.0531	0.2658	0.0309	<.0001	<.0001	0.913		<.0001	0.061	0.9937	0.0413
Cl	0.10978	-0.05791	0.24835	0.92554	0.92541	-0.01579	0.77833	1	0.31263	0.08287	-0.46713
Cl	0.5431	0.7489	0.1634	<.0001	<.0001	0.9305	<.0001		0.0765	0.6466	0.0061
SO4	-0.17882	0.21552	0.83677	0.20276	0.24245	-0.52681	0.32962	0.31263	1	0.04827	-0.69225
SO4	0.3194	0.2284	<.0001	0.2578	0.174	0.0016	0.061	0.0765		0.7896	<.0001
NO3	-0.02114	-0.14608	-0.05556	0.18626	0.05335	0.00748	-0.00142	0.08287	0.04827	1	0.17975
NO3	0.907	0.4173	0.7588	0.2994	0.7681	0.967	0.9937	0.6466	0.7896		0.3168
Available_P	0.18876	-0.0253	-0.49884	-0.37365	-0.40447	0.32357	-0.3571	-0.46713	-0.69225	0.17975	1
Available_P	0.2928	0.8889	0.0031	0.0322	0.0196	0.0662	0.0413	0.0061	<.0001	0.3168	
CaCO3	-0.41871	-0.31138	-0.2905	-0.57934	-0.4943	0.29414	-0.46342	-0.56826	-0.38401	0.33183	0.57428
CaCO3	0.0153	0.0777	0.101	0.0004	0.0035	0.0966	0.0066	0.0006	0.0274	0.0592	0.0005
Inorganic_C	-0.43141	-0.26185	-0.16224	-0.53588	-0.44342	0.19802	-0.39646	-0.48869	-0.21422	0.42452	0.46258
Inorganic_C	0.0122	0.141	0.367	0.0013	0.0097	0.2693	0.0224	0.0039	0.2313	0.0138	0.0067
Organic_C	0.12598	-0.10322	-0.39068	-0.15777	-0.18588	0.24939	-0.19698	-0.26144	-0.43922	0.31078	0.48223
Organic_C	0.4848	0.5676	0.0246	0.3806	0.3004	0.1616	0.2719	0.1417	0.0105	0.0783	0.0045
Total_C	-0.38544	-0.26514	-0.22099	-0.53332	-0.45091	0.23025	-0.4085	-0.50676	-0.2785	0.45475	0.52045
Total_C	0.0267	0.1359	0.2165	0.0014	0.0084	0.1974	0.0183	0.0026	0.1166	0.0078	0.0019
Total_N	0.36705	-0.03492	-0.37452	-0.11129	-0.24532	0.12461	-0.16593	-0.31335	-0.61658	0.04802	0.59897
Total_N	0.0356	0.847	0.0318	0.5375	0.1688	0.4896	0.3561	0.0758	0.0001	0.7907	0.0002
Clay	-0.06418	-0.24846	-0.57427	-0.37531	-0.37996	0.2802	-0.41817	-0.49205	-0.65921	0.16642	0.68172
Clay	0.7227	0.1632	0.0005	0.0314	0.0292	0.1142	0.0154	0.0036	<.0001	0.3546	<.0001
Silt	-0.08744	-0.25468	-0.49719	-0.4616	-0.44602	0.33379	-0.44388	-0.55025	-0.65527	0.30147	0.75581
Silt	0.6285	0.1526	0.0032	0.0069	0.0093	0.0576	0.0097	0.0009	<.0001	0.0882	<.0001
Sand	0.08486	0.25677	0.51521	0.45365	0.44105	-0.32942	0.44519	0.54776	0.66375	-0.28398	-0.7533
Sand	0.6387	0.1492	0.0022	0.008	0.0102	0.0612	0.0094	0.001	<.0001	0.1092	<.0001
Total_Energy	0.06043	0.19605	0.21246	-0.03076	-0.16775	-0.17343	0.10173	-0.1193	0.13144	-0.02825	-0.00114
Total_Energy	0.7383	0.2742	0.2352	0.8651	0.3508	0.3344	0.5732	0.5084	0.4659	0.876	0.995
Bulk_Density	0.21703	-0.10465	-0.72971	-0.15851	-0.22319	0.50217	-0.31405	-0.32359	-0.81887	0.05391	0.65475
Bulk_Density	0.225	0.5622	<.0001	0.3783	0.2118	0.0029	0.0751	0.0662	<.0001	0.7657	<.0001

	CaCO3	Inorganic_C	Organic_C	Total_C	Total_N	Clay	Silt	Sand	Total_Energy	Bulk_Density
anle1	-0.08801	0.02878	-0.15249	0.0007	-0.42191	-0.25106	-0.30556	0.30071	-0.03607	-0.29794
anle1	0.6262	0.8737	0.3969	0.9969	0.0145	0.1587	0.0838	0.089	0.842	0.0922
ANLE	0.1625	0.27452	-0.10202	0.24147	-0.43471	-0.08842	-0.13451	0.12892	-0.18917	-0.20165
ANLE	0.3662	0.1221	0.5721	0.1758	0.0115	0.6246	0.4555	0.4746	0.2917	0.2604
pH	0.77584	0.62477	0.48943	0.67482	0.49707	0.84849	0.86663	-0.8742	-0.06281	0.71155
pH	<.0001	0.0001	0.0038	<.0001	0.0033	<.0001	<.0001	<.0001	0.7284	<.0001
EC	-0.54032	-0.3794	-0.45803	-0.43771	-0.57512	-0.71509	-0.73598	0.74155	0.04106	-0.77947
EC	0.0012	0.0294	0.0074	0.0109	0.0005	<.0001	<.0001	<.0001	0.8205	<.0001
Na	-0.64403	-0.5813	-0.27365	-0.59632	-0.30354	-0.5108	-0.57143	0.56881	-0.08736	-0.29921
Na	<.0001	0.0004	0.1233	0.0002	0.0859	0.0024	0.0005	0.0006	0.6288	0.0907
K	-0.35029	-0.38486	-0.02356	-0.36745	0.11738	-0.08382	-0.15943	0.14953	0.00797	0.0719
K	0.0457	0.027	0.8964	0.0354	0.5153	0.6428	0.3755	0.4062	0.9649	0.6909
Mg	-0.39691	-0.31724	-0.21284	-0.33646	-0.30232	-0.41812	-0.42261	0.42698	-0.01943	-0.33776
Mg	0.0222	0.072	0.2344	0.0556	0.0873	0.0155	0.0143	0.0132	0.9145	0.0546
Ca	-0.38897	-0.22286	-0.4228	-0.2838	-0.61051	-0.70116	-0.66592	0.67942	0.15749	-0.80123
Ca	0.0253	0.2125	0.0142	0.1095	0.0002	<.0001	<.0001	<.0001	0.3814	<.0001
Mn	-0.55796	-0.47881	-0.23158	-0.49225	-0.11013	-0.47288	-0.44009	0.4505	0.09024	-0.24202
Mn	0.0007	0.0048	0.1947	0.0036	0.5418	0.0055	0.0104	0.0085	0.6175	0.1748
Fe	-0.39726	-0.23418	-0.49244	-0.30658	-0.65021	-0.69786	-0.65019	0.66545	0.10674	-0.74104
Fe	0.0221	0.1896	0.0036	0.0827	<.0001	<.0001	<.0001	<.0001	0.5544	<.0001
Ni	-0.25595	-0.08828	-0.4286	-0.15775	-0.55877	-0.60601	-0.54884	0.56437	0.11305	-0.81217
Ni	0.1505	0.6252	0.0128	0.3806	0.0007	0.0002	0.0009	0.0006	0.5311	<.0001
Cu	-0.41871	-0.43141	0.12598	-0.38544	0.36705	-0.06418	-0.08744	0.08486	0.06043	0.21703
Cu	0.0153	0.0122	0.4848	0.0267	0.0356	0.7227	0.6285	0.6387	0.7383	0.225
Zn	-0.31138	-0.26185	-0.10322	-0.26514	-0.03492	-0.24846	-0.25468	0.25677	0.19605	-0.10465
Zn	0.0777	0.141	0.5676	0.1359	0.847	0.1632	0.1526	0.1492	0.2742	0.5622
Co	-0.2905	-0.16224	-0.39068	-0.22099	-0.37452	-0.57427	-0.49719	0.51521	0.21246	-0.72971
Co	0.101	0.367	0.0246	0.2165	0.0318	0.0005	0.0032	0.0022	0.2352	<.0001
B	-0.57934	-0.53588	-0.15777	-0.53332	-0.11129	-0.37531	-0.4616	0.45365	-0.03076	-0.15851
B	0.0004	0.0013	0.3806	0.0014	0.5375	0.0314	0.0069	0.008	0.8651	0.3783
Mo	-0.4943	-0.44342	-0.18588	-0.45091	-0.24532	-0.37996	-0.44602	0.44105	-0.16775	-0.22319
Mo	0.0035	0.0097	0.3004	0.0084	0.1688	0.0292	0.0093	0.0102	0.3508	0.2118
Pb	0.29414	0.19802	0.24939	0.23025	0.12461	0.2802	0.33379	-0.32942	-0.17343	0.50217
Pb	0.0966	0.2693	0.1616	0.1974	0.4896	0.1142	0.0576	0.0612	0.3344	0.0029
Cd	-0.46342	-0.39646	-0.19698	-0.4085	-0.16593	-0.41817	-0.44388	0.44519	0.10173	-0.31405
Cd	0.0066	0.0224	0.2719	0.0183	0.3561	0.0154	0.0097	0.0094	0.5732	0.0751
Cl	-0.56826	-0.48869	-0.26144	-0.50676	-0.31335	-0.49205	-0.55025	0.54776	-0.1193	-0.32359
Cl	0.0006	0.0039	0.1417	0.0026	0.0758	0.0036	0.0009	0.001	0.5084	0.0662
SO4	-0.38401	-0.21422	-0.43922	-0.2785	-0.61658	-0.65921	-0.65527	0.66375	0.13144	-0.81887
SO4	0.0274	0.2313	0.0105	0.1166	0.0001	<.0001	<.0001	<.0001	0.4659	<.0001
NO3	0.33183	0.42452	0.31078	0.45475	0.04802	0.16642	0.30147	-0.28398	-0.02825	0.05391
NO3	0.0592	0.0138	0.0783	0.0078	0.7907	0.3546	0.0882	0.1092	0.876	0.7657
Available_P	0.57428	0.46258	0.48223	0.52045	0.59897	0.68172	0.75581	-0.7533	-0.00114	0.65475
Available_P	0.0005	0.0067	0.0045	0.0019	0.0002	<.0001	<.0001	<.0001	0.995	<.0001
CaCO3	1	0.94962	0.34214	0.95595	0.23048	0.7628	0.85636	-0.85202	-0.10601	0.3156
CaCO3		<.0001	0.0513	<.0001	0.1969	<.0001	<.0001	<.0001	0.5571	0.0736
Inorganic_C	0.94962	1	0.23949	0.9857	0.05048	0.66878	0.77811	-0.77037	-0.18761	0.14584
Inorganic_C	<.0001		0.1795	<.0001	0.7802	<.0001	<.0001	<.0001	0.2958	0.418
Organic_C	0.34214	0.23949	1	0.3997	0.55904	0.34269	0.40877	-0.40335	0.16261	0.49222
Organic_C	0.0513	0.1795		0.0212	0.0007	0.0509	0.0182	0.0199	0.3659	0.0036
Total_C	0.95595	0.9857	0.3997	1	0.14471	0.69089	0.80559	-0.79734	-0.1489	0.22314
Total_C	<.0001	<.0001	0.0212		0.4217	<.0001	<.0001	<.0001	0.4082	0.212
Total_N	0.23048	0.05048	0.55904	0.14471	1	0.43277	0.49752	-0.49338	0.29303	0.46911
Total_N	0.1969	0.7802	0.0007	0.4217		0.0119	0.0032	0.0035	0.0979	0.0059
Clay	0.7628	0.66878	0.34269	0.69089	0.43277	1	0.90968	-0.93472	-0.16868	0.55307
Clay	<.0001	<.0001	0.0509	<.0001	0.0119		<.0001	<.0001	0.348	0.0008
Silt	0.85636	0.77811	0.40877	0.80559	0.49752	0.90968	1	-0.99789	-0.0474	0.553
Silt	<.0001	<.0001	0.0182	<.0001	0.0032	<.0001		<.0001	0.7934	0.0008
Sand	-0.85202	-0.77037	-0.40335	-0.79734	-0.49338	-0.93472	-0.99789	1	0.06693	-0.55965
Sand	<.0001	<.0001	0.0199	<.0001	0.0035	<.0001	<.0001		0.7113	0.0007
Total_Energy	-0.10601	-0.18761	0.16261	-0.1489	0.29303	-0.16868	-0.0474	0.06693	1	0.06288
Total_Energy	0.5571	0.2958	0.3659	0.4082	0.0979	0.348	0.7934	0.7113		0.7281
Bulk_Density	0.3156	0.14584	0.49222	0.22314	0.46911	0.55307	0.553	-0.55965	0.06288	1
Bulk_Density	0.0736	0.418	0.0036	0.212	0.0059	0.0008	0.0008	0.0007	0.7281	

Appendix 4. Correlation matrix ringstem layer 1 between sites

	Simple Statistics					
Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
anle	62	0.53226	0.50303	33	0	1
ANLE1	62	0.31475	0.59159	19.51461	0	2.19722
pH	62	7.51215	0.25921	465.753	7.095	8.148
EC	62	36.88243	15.09475	2287	10.31988	57.82733
Na	62	1.78834	1.57351	110.8772	0.359	5.53812
K	62	2.12808	0.69213	131.94126	0.97989	3.67054
Mg	62	1.95826	0.95993	121.41226	0.53368	4.12021
Ca	62	5.61271	1.77688	347.98796	2.12495	6.88262
Mn	62	1.39306	0.52198	86.36969	0.43898	2.75565
Fe	62	6.84744	1.19149	424.54125	4.50838	8.00278
Ni	62	2.49485	0.99522	154.68091	0.56568	3.53084
Cu	62	1.83513	0.6154	113.77782	0.71206	3.2293
Zn	62	2.5759	2.98806	159.70575	0.52255	20.47099
Co	62	0.50093	0.2202	31.05773	0.11801	0.8083
B	62	9.45675	7.67803	586.31837	2.4204	30.45031
Mo	62	1.25764	0.99004	77.9738	0.23696	4.18455
Pb	62	0.03324	0.03561	2.06058	0.0000149	0.17911
Cd	62	0.11805	0.07816	7.31898	0.00693	0.30789
Cl	62	2.47817	3.56941	153.6468	0.46152	13.38841
SO4	62	6.06103	2.46433	375.78401	1.14237	7.70462
NO3	62	0.26794	0.19287	16.61204	0.00598	0.94398
Available_P	62	1.31881	0.53306	81.76641	0.49348	2.53892
CaCO3	62	2.55152	0.89227	158.19447	0.81905	3.68638
Inorganic_C	62	2.00724	1.4488	124.4486	0.1522	4.668
Organic_C	62	0.19892	0.23381	12.33319	0.00438	1.24484
Total_C	62	2.20616	1.57771	136.78179	0.16953	5.09875
Total_N	62	0.01054	0.0056	0.6536	0.00224	0.02516
Clay	62	3.33986	2.754	207.07121	0.16181	9.77146
Silt	62	23.93402	13.40942	1484	4.78889	50.49482
Sand	62	72.72612	15.99128	4509	42.40795	95.0493
Total_Energy	62	276.9537	199.18595	17171	0	860.9888
Bulk_Density	62	0.63456	0.18186	39.34254	0.25166	1.16055

Pearson Correlation Coefficients, N = 58
Prob > |r| under H0: Rho=0

	anle2	ANLE	pH	EC	Na	K	Mg	Ca	Mn	Fe	Ni
anle2	1	0.37455	0.11897	0.28187	0.27628	0.13995	0.18979	0.26117	-0.29795	0.15389	0.33589
anle2		0.0038	0.3738	0.0321	0.0358	0.2947	0.1536	0.0477	0.0231	0.2488	0.0099
ANLE	0.37455	1	-0.02156	0.10712	-0.01999	-0.10301	-0.03852	0.17765	-0.22441	0.0763	0.20776
ANLE	0.0038		0.8724	0.4235	0.8816	0.4416	0.774	0.1821	0.0904	0.5692	0.1176
pH	0.11897	-0.02156	1	-0.4651	-0.22624	-0.11385	-0.15037	-0.50052	-0.46072	-0.40694	-0.31787
pH	0.3738	0.8724		0.0002	0.0877	0.3948	0.2599	<.0001	0.0003	0.0015	0.015
EC	0.28187	0.10712	-0.4651	1	0.68709	0.60897	0.70712	0.81471	0.19395	0.80002	0.71611
EC	0.0321	0.4235	0.0002		<.0001	<.0001	<.0001	<.0001	0.1446	<.0001	<.0001
Na	0.27628	-0.01999	-0.22624	0.68709	1	0.76433	0.81366	0.24577	-0.11199	0.25229	0.12935
Na	0.0358	0.8816	0.0877	<.0001		<.0001	<.0001	0.0629	0.4026	0.0561	0.3332
K	0.13995	-0.10301	-0.11385	0.60897	0.76433	1	0.96477	0.12754	-0.1409	0.19222	0.06786
K	0.2947	0.4416	0.3948	<.0001	<.0001		<.0001	0.34	0.2914	0.1483	0.6128
Mg	0.18979	-0.03852	-0.15037	0.70712	0.81366	0.96477	1	0.2435	-0.11745	0.29168	0.18631
Mg	0.1536	0.774	0.2599	<.0001	<.0001	<.0001		0.0655	0.3799	0.0263	0.1614
Ca	0.26117	0.17765	-0.50052	0.81471	0.24577	0.12754	0.2435	1	0.35947	0.92616	0.90187
Ca	0.0477	0.1821	<.0001	<.0001	0.0629	0.34	0.0655		0.0056	<.0001	<.0001
Mn	-0.29795	-0.22441	-0.46072	0.19395	-0.11199	-0.1409	-0.11745	0.35947	1	0.45728	0.2791
Mn	0.0231	0.0904	0.0003	0.1446	0.4026	0.2914	0.3799	0.0056		0.0003	0.0339
Fe	0.15389	0.0763	-0.40694	0.80002	0.25229	0.19222	0.29168	0.92616	0.45728	1	0.90391
Fe	0.2488	0.5692	0.0015	<.0001	0.0561	0.1483	0.0263	<.0001	0.0003		<.0001
Ni	0.33589	0.20776	-0.31787	0.71611	0.12935	0.06786	0.18631	0.90187	0.2791	0.90391	1
Ni	0.0099	0.1176	0.015	<.0001	0.3332	0.6128	0.1614	<.0001	0.0339	<.0001	
Cu	-0.5169	-0.30922	-0.16627	-0.38106	-0.13565	-0.0157	-0.05576	-0.43705	0.21895	-0.42335	-0.48704
Cu	<.0001	0.0182	0.2122	0.0032	0.31	0.9069	0.6776	0.0006	0.0987	0.0009	0.0001
Zn	0.00533	-0.03699	-0.16361	0.0741	-0.07293	-0.06027	-0.04702	0.17359	0.32239	0.15255	0.09592
Zn	0.9683	0.7828	0.2197	0.5804	0.5864	0.6531	0.726	0.1925	0.0136	0.253	0.4738
Co	0.20051	0.05699	-0.3889	0.74606	0.15858	0.14737	0.24952	0.91094	0.43534	0.95335	0.95695
Co	0.1313	0.6709	0.0026	<.0001	0.2345	0.2696	0.0589	<.0001	0.0006	<.0001	<.0001
B	0.29436	0.01252	-0.20018	0.67744	0.93476	0.8754	0.87984	0.20502	-0.1401	0.21989	0.1087
B	0.0249	0.9257	0.1319	<.0001	<.0001	<.0001	<.0001	0.1226	0.2942	0.0972	0.4167
Mo	0.19679	-0.04159	-0.15746	0.69221	0.8168	0.96867	0.98869	0.23743	-0.11856	0.29149	0.16425
Mo	0.1387	0.7566	0.2378	<.0001	<.0001	<.0001	<.0001	0.0727	0.3754	0.0264	0.2179
Pb	0.14677	-0.12511	0.50422	-0.21236	0.04996	0.20086	0.20762	-0.37092	-0.19586	-0.25449	-0.25169
Pb	0.2716	0.3494	<.0001	0.1095	0.7096	0.1306	0.1178	0.0042	0.1406	0.0539	0.0567
Cd	0.17078	-0.15658	-0.20118	0.6593	0.75932	0.75953	0.81345	0.29142	0.03392	0.34173	0.26619
Cd	0.1999	0.2405	0.13	<.0001	<.0001	<.0001	<.0001	0.0265	0.8005	0.0087	0.0434
Cl	0.22202	-0.02735	-0.19225	0.71763	0.93501	0.89916	0.94849	0.23325	-0.10337	0.26439	0.16473
Cl	0.0939	0.8385	0.1482	<.0001	<.0001	<.0001	<.0001	0.0781	0.44	0.0449	0.2166
SO4	0.19442	0.12398	-0.50864	0.89561	0.38722	0.25157	0.37284	0.95286	0.35584	0.89648	0.86258
SO4	0.1436	0.3538	<.0001	<.0001	0.0027	0.0568	0.0039	<.0001	0.0061	<.0001	<.0001
NO3	0.22527	-0.02984	0.14237	0.09777	-0.00615	0.01051	0.02325	0.09928	-0.11548	0.12244	0.27209
NO3	0.0891	0.824	0.2864	0.4653	0.9634	0.9376	0.8625	0.4584	0.388	0.3599	0.0388
Available_P	0.0726	-0.10607	0.37616	-0.60475	-0.23393	-0.10036	-0.18011	-0.6399	-0.16786	-0.63315	-0.51794
Available_P	0.5881	0.4281	0.0036	<.0001	0.0772	0.4535	0.1761	<.0001	0.2078	<.0001	<.0001
CaCO3	0.26304	0.3382	0.43692	-0.29816	-0.32093	-0.21147	-0.1922	-0.2055	-0.30551	-0.21477	0.05762
CaCO3	0.0461	0.0094	0.0006	0.023	0.014	0.111	0.1483	0.1217	0.0197	0.1055	0.6675
Inorganic_C	0.26304	0.3382	0.43692	-0.29816	-0.32093	-0.21147	-0.1922	-0.2055	-0.30551	-0.21477	0.05762
Inorganic_C	0.0461	0.0094	0.0006	0.023	0.014	0.111	0.1483	0.1217	0.0197	0.1055	0.6675
Organic_C	0.01114	-0.06898	0.33241	-0.38045	-0.19853	-0.08697	-0.14024	-0.40159	-0.13654	-0.34761	-0.29571
Organic_C	0.9338	0.6069	0.0108	0.0032	0.1352	0.5163	0.2937	0.0018	0.3068	0.0075	0.0242
Total_C	0.25268	0.31106	0.47179	-0.34745	-0.33898	-0.21609	-0.20655	-0.2626	-0.31398	-0.26247	0.00587
Total_C	0.0557	0.0175	0.0002	0.0075	0.0092	0.1033	0.1198	0.0464	0.0164	0.0465	0.9651
Total_N	-0.18478	-0.31243	0.07241	-0.32723	-0.24093	-0.07316	-0.17303	-0.28393	0.3138	-0.23263	-0.25894
Total_N	0.165	0.017	0.5891	0.0122	0.0685	0.5852	0.194	0.0308	0.0165	0.0789	0.0497
Clay	-0.21527	-0.09508	0.52255	-0.70518	-0.34175	-0.11953	-0.25231	-0.76122	-0.28129	-0.70689	-0.61235
Clay	0.1046	0.4777	<.0001	<.0001	0.0086	0.3715	0.056	<.0001	0.0324	<.0001	<.0001
Silt	-0.19967	-0.14079	0.50428	-0.65308	-0.43574	-0.20657	-0.3126	-0.62977	-0.16593	-0.55657	-0.43741
Silt	0.1329	0.2918	<.0001	<.0001	0.0006	0.1198	0.0169	<.0001	0.2132	<.0001	0.0006
Sand	0.20628	0.13556	-0.51731	0.67492	0.42784	0.19541	0.30818	0.665	0.1893	0.59366	0.47647
Sand	0.1203	0.3103	<.0001	<.0001	0.0008	0.1416	0.0186	<.0001	0.1547	<.0001	0.0002
Total_Energy	-0.37273	-0.23725	0.02156	-0.31316	-0.12377	-0.12678	-0.13916	-0.31986	-0.00696	-0.35525	-0.35885
Total_Energy	0.004	0.0729	0.8724	0.0167	0.3546	0.343	0.2975	0.0144	0.9586	0.0062	0.0057
Bulk_Density	0.02237	-0.03916	0.47366	-0.57532	-0.17111	-0.03568	-0.09665	-0.68291	-0.38193	-0.7316	-0.6994
Bulk_Density	0.8676	0.7704	0.0002	<.0001	0.1991	0.7903	0.4705	<.0001	0.0031	<.0001	<.0001

	Cu	Zn	Co	B	Mo	Pb	Cd	Cl	SO4	NO3	Available_P
anle2	-0.5169	0.00533	0.20051	0.29436	0.19679	0.14677	0.17078	0.22202	0.19442	0.22527	0.0726
anle2	<.0001	0.9683	0.1313	0.0249	0.1387	0.2716	0.1999	0.0939	0.1436	0.0891	0.5881
ANLE	-0.30922	-0.03699	0.05699	0.01252	-0.04159	-0.12511	-0.15658	-0.02735	0.12398	-0.02984	-0.10607
ANLE	0.0182	0.7828	0.6709	0.9257	0.7566	0.3494	0.2405	0.8385	0.3538	0.824	0.4281
pH	-0.16627	-0.16361	-0.3889	-0.20018	-0.15746	0.50422	-0.20118	-0.19225	-0.50864	0.14237	0.37616
pH	0.2122	0.2197	0.0026	0.1319	0.2378	<.0001	0.13	0.1482	<.0001	0.2864	0.0036
EC	-0.38106	0.0741	0.74606	0.67744	0.69221	-0.21236	0.6593	0.71763	0.89561	0.09777	-0.60475
EC	0.0032	0.5804	<.0001	<.0001	<.0001	0.1095	<.0001	<.0001	<.0001	0.4653	<.0001
Na	-0.13565	-0.07293	0.15858	0.93476	0.8168	0.04996	0.75932	0.93501	0.38722	-0.00615	-0.23393
Na	0.31	0.5864	0.2345	<.0001	<.0001	0.7096	<.0001	<.0001	0.0027	0.9634	0.0772
K	-0.0157	-0.06027	0.14737	0.8754	0.96867	0.20086	0.75953	0.89916	0.25157	0.01051	-0.10036
K	0.9069	0.6531	0.2696	<.0001	<.0001	0.1306	<.0001	<.0001	0.0568	0.9376	0.4535
Mg	-0.05576	-0.04702	0.24952	0.87984	0.98869	0.20762	0.81345	0.94849	0.37284	0.02325	-0.18011
Mg	0.6776	0.726	0.0589	<.0001	<.0001	0.1178	<.0001	<.0001	0.0039	0.8625	0.1761
Ca	-0.43705	0.17359	0.91094	0.20502	0.23743	-0.37092	0.29142	0.23325	0.95286	0.09928	-0.6399
Ca	0.0006	0.1925	<.0001	0.1226	0.0727	0.0042	0.0265	0.0781	<.0001	0.4584	<.0001
Mn	0.21895	0.32239	0.43534	-0.1401	-0.11856	-0.19586	0.03392	-0.10337	0.35584	-0.11548	-0.16786
Mn	0.0987	0.0136	0.0006	0.2942	0.3754	0.1406	0.8005	0.44	0.0061	0.388	0.2078
Fe	-0.42335	0.15255	0.95335	0.21989	0.29149	-0.25449	0.34173	0.26439	0.89648	0.12244	-0.63315
Fe	0.0009	0.253	<.0001	0.0972	0.0264	0.0539	0.0087	0.0449	<.0001	0.3599	<.0001
Ni	-0.48704	0.09592	0.95695	0.1087	0.16425	-0.25169	0.26619	0.16473	0.86258	0.27209	-0.51794
Ni	0.0001	0.4738	<.0001	0.4167	0.2179	0.0567	0.0434	0.2166	<.0001	0.0388	<.0001
Cu	1	0.2759	-0.36949	-0.12546	-0.05526	0.09958	0.01184	-0.07633	-0.40741	-0.17984	0.40146
Cu		0.0361	0.0043	0.3481	0.6803	0.457	0.9297	0.569	0.0015	0.1767	0.0018
Zn	0.2759	1	0.17155	-0.08872	-0.05809	0.03017	0.05649	-0.05575	0.17462	-0.09032	-0.04523
Zn	0.0361		0.1979	0.5078	0.6649	0.8221	0.6736	0.6777	0.1898	0.5001	0.736
Co	-0.36949	0.17155	1	0.14773	0.23063	-0.2447	0.33828	0.20885	0.87759	0.23916	-0.51084
Co	0.0043	0.1979		0.2684	0.0816	0.0641	0.0094	0.1156	<.0001	0.0706	<.0001
B	-0.12546	-0.08872	0.14773	1	0.88432	0.06174	0.7646	0.94937	0.34221	0.02401	-0.19064
B	0.3481	0.5078	0.2684		<.0001	0.6452	<.0001	<.0001	0.0086	0.858	0.1517
Mo	-0.05526	-0.05809	0.23063	0.88432	1	0.20537	0.77808	0.93473	0.34505	-0.01226	-0.18159
Mo	0.6803	0.6649	0.0816	<.0001		0.122	<.0001	<.0001	0.008	0.9272	0.1725
Pb	0.09958	0.03017	-0.2447	0.06174	0.20537	1	0.12891	0.13861	-0.35169	0.00826	0.36974
Pb	0.457	0.8221	0.0641	0.6452	0.122		0.3348	0.2994	0.0068	0.9509	0.0043
Cd	0.01184	0.05649	0.33828	0.7646	0.77808	0.12891	1	0.84853	0.43879	0.09066	-0.22837
Cd	0.9297	0.6736	0.0094	<.0001	<.0001	0.3348		<.0001	0.0006	0.4985	0.0847
Cl	-0.07633	-0.05575	0.20885	0.94937	0.93473	0.13861	0.84853	1	0.394	0.01103	-0.2002
Cl	0.569	0.6777	0.1156	<.0001	<.0001	0.2994	<.0001		0.0022	0.9345	0.1319
SO4	-0.40741	0.17462	0.87759	0.34221	0.34505	-0.35169	0.43879	0.394	1	0.07329	-0.68704
SO4	0.0015	0.1898	<.0001	0.0086	0.008	0.0068	0.0006	0.0022		0.5846	<.0001
NO3	-0.17984	-0.09032	0.23916	0.02401	-0.01226	0.00826	0.09066	0.01103	0.07329	1	0.12491
NO3	0.1767	0.5001	0.0706	0.858	0.9272	0.9509	0.4985	0.9345	0.5846		0.3502
Available_P	0.40146	-0.04523	-0.51084	-0.19064	-0.18159	0.36974	-0.22837	-0.2002	-0.68704	0.12491	1
Available_P	0.0018	0.736	<.0001	0.1517	0.1725	0.0043	0.0847	0.1319	<.0001	0.3502	
CaCO3	-0.19069	-0.17129	-0.07661	-0.31642	-0.23167	0.22993	-0.17183	-0.26101	-0.25101	0.45048	0.35846
CaCO3	0.1516	0.1986	0.5676	0.0155	0.0801	0.0825	0.1971	0.0478	0.0574	0.0004	0.0057
Inorganic_C	-0.19069	-0.17129	-0.07661	-0.31642	-0.23167	0.22993	-0.17183	-0.26101	-0.25101	0.45048	0.35846
Inorganic_C	0.1516	0.1986	0.5676	0.0155	0.0801	0.0825	0.1971	0.0478	0.0574	0.0004	0.0057
Organic_C	0.18898	-0.09616	-0.27894	-0.15014	-0.14003	0.22187	-0.15972	-0.1706	-0.42507	0.27155	0.53102
Organic_C	0.1554	0.4727	0.034	0.2606	0.2945	0.0942	0.2311	0.2004	0.0009	0.0392	<.0001
Total_C	-0.15048	-0.1793	-0.11934	-0.32664	-0.24415	0.25607	-0.19035	-0.2772	-0.30989	0.47462	0.42993
Total_C	0.2595	0.1781	0.3723	0.0123	0.0648	0.0524	0.1524	0.0351	0.0179	0.0002	0.0008
Total_N	0.29001	-0.04099	-0.13082	-0.16321	-0.17635	0.02616	-0.22605	-0.20904	-0.30413	0.05355	0.60107
Total_N	0.0272	0.76	0.3277	0.2209	0.1854	0.8454	0.088	0.1153	0.0203	0.6897	<.0001
Clay	0.2956	-0.14287	-0.63875	-0.27103	-0.24689	0.28708	-0.30493	-0.3021	-0.76506	0.0209	0.51681
Clay	0.0243	0.2847	<.0001	0.0396	0.0617	0.0289	0.0199	0.0212	<.0001	0.8763	<.0001
Silt	0.17653	-0.157	-0.4512	-0.39044	-0.32605	0.30016	-0.33779	-0.38682	-0.65031	0.25083	0.56191
Silt	0.185	0.2392	0.0004	0.0024	0.0125	0.0221	0.0095	0.0027	<.0001	0.0575	<.0001
Sand	-0.20076	0.1576	0.49273	0.37722	0.3186	-0.30374	0.33864	0.37958	0.68302	-0.2156	-0.565
Sand	0.1308	0.2374	<.0001	0.0035	0.0148	0.0205	0.0093	0.0033	<.0001	0.1041	<.0001
Total_Energy	0.46329	0.09354	-0.31357	-0.1461	-0.16949	-0.0161	-0.13416	-0.14058	-0.30019	-0.21467	0.18617
Total_Energy	0.0002	0.4849	0.0165	0.2738	0.2034	0.9045	0.3154	0.2925	0.0221	0.1056	0.1617
Bulk_Density	0.22379	0.00652	-0.70948	-0.10073	-0.10415	0.42429	-0.18023	-0.13076	-0.69169	-0.14477	0.53339
Bulk_Density	0.0913	0.9612	<.0001	0.4518	0.4365	0.0009	0.1758	0.3279	<.0001	0.2782	<.0001

	CaCO3	Inorganic_C	Organic_C	Total_C	Total_N	Clay	Silt	Sand	Total_Energy	Bulk_Density
anle2	0.26304	0.26304	0.01114	0.25268	-0.18478	-0.21527	-0.19967	0.20628	-0.37273	0.02237
anle2	0.0461	0.0461	0.9338	0.0557	0.165	0.1046	0.1329	0.1203	0.004	0.8676
ANLE	0.3382	0.3382	-0.06898	0.31106	-0.31243	-0.09508	-0.14079	0.13556	-0.23725	-0.03916
ANLE	0.0094	0.0094	0.6069	0.0175	0.017	0.4777	0.2918	0.3103	0.0729	0.7704
pH	0.43692	0.43692	0.33241	0.47179	0.07241	0.52255	0.50428	-0.51731	0.02156	0.47366
pH	0.0006	0.0006	0.0108	0.0002	0.5891	<.0001	<.0001	<.0001	0.8724	0.0002
EC	-0.29816	-0.29816	-0.38045	-0.34745	-0.32723	-0.70518	-0.65308	0.67492	-0.31316	-0.57532
EC	0.023	0.023	0.0032	0.0075	0.0122	<.0001	<.0001	<.0001	0.0167	<.0001
Na	-0.32093	-0.32093	-0.19853	-0.33898	-0.24093	-0.34175	-0.43574	0.42784	-0.12377	-0.17111
Na	0.014	0.014	0.1352	0.0092	0.0685	0.0086	0.0006	0.0008	0.3546	0.1991
K	-0.21147	-0.21147	-0.08697	-0.21609	-0.07316	-0.11953	-0.20657	0.19541	-0.12678	-0.03568
K	0.111	0.111	0.5163	0.1033	0.5852	0.3715	0.1198	0.1416	0.343	0.7903
Mg	-0.1922	-0.1922	-0.14024	-0.20655	-0.17303	-0.25231	-0.3126	0.30818	-0.13916	-0.09665
Mg	0.1483	0.1483	0.2937	0.1198	0.194	0.056	0.0169	0.0186	0.2975	0.4705
Ca	-0.2055	-0.2055	-0.40159	-0.2626	-0.28393	-0.76122	-0.62977	0.665	-0.31986	-0.68291
Ca	0.1217	0.1217	0.0018	0.0464	0.0308	<.0001	<.0001	<.0001	0.0144	<.0001
Mn	-0.30551	-0.30551	-0.13654	-0.31398	0.3138	-0.28129	-0.16593	0.1893	-0.00696	-0.38193
Mn	0.0197	0.0197	0.3068	0.0164	0.0165	0.0324	0.2132	0.1547	0.9586	0.0031
Fe	-0.21477	-0.21477	-0.34761	-0.26247	-0.23263	-0.70689	-0.55657	0.59366	-0.35525	-0.7316
Fe	0.1055	0.1055	0.0075	0.0465	0.0789	<.0001	<.0001	<.0001	0.0062	<.0001
Ni	0.05762	0.05762	-0.29571	0.00587	-0.25894	-0.61235	-0.43741	0.47647	-0.35885	-0.6994
Ni	0.6675	0.6675	0.0242	0.9651	0.0497	<.0001	0.0006	0.0002	0.0057	<.0001
Cu	-0.19069	-0.19069	0.18898	-0.15048	0.29001	0.2956	0.17653	-0.20076	0.46329	0.22379
Cu	0.1516	0.1516	0.1554	0.2595	0.0272	0.0243	0.185	0.1308	0.0002	0.0913
Zn	-0.17129	-0.17129	-0.09616	-0.1793	-0.04099	-0.14287	-0.157	0.1576	0.09354	0.00652
Zn	0.1986	0.1986	0.4727	0.1781	0.76	0.2847	0.2392	0.2374	0.4849	0.9612
Co	-0.07661	-0.07661	-0.27894	-0.11934	-0.13082	-0.63875	-0.4512	0.49273	-0.31357	-0.70948
Co	0.5676	0.5676	0.034	0.3723	0.3277	<.0001	0.0004	<.0001	0.0165	<.0001
B	-0.31642	-0.31642	-0.15014	-0.32664	-0.16321	-0.27103	-0.39044	0.37722	-0.1461	-0.10073
B	0.0155	0.0155	0.2606	0.0123	0.2209	0.0396	0.0024	0.0035	0.2738	0.4518
Mo	-0.23167	-0.23167	-0.14003	-0.24415	-0.17635	-0.24689	-0.32605	0.3186	-0.16949	-0.10415
Mo	0.0801	0.0801	0.2945	0.0648	0.1854	0.0617	0.0125	0.0148	0.2034	0.4365
Pb	0.22993	0.22993	0.22187	0.25607	0.02616	0.28708	0.30016	-0.30374	-0.0161	0.42429
Pb	0.0825	0.0825	0.0942	0.0524	0.8454	0.0289	0.0221	0.0205	0.9045	0.0009
Cd	-0.17183	-0.17183	-0.15972	-0.19035	-0.22605	-0.30493	-0.33779	0.33864	-0.13416	-0.18023
Cd	0.1971	0.1971	0.2311	0.1524	0.088	0.0199	0.0095	0.0093	0.3154	0.1758
Cl	-0.26101	-0.26101	-0.1706	-0.2772	-0.20904	-0.3021	-0.38682	0.37958	-0.14058	-0.13076
Cl	0.0478	0.0478	0.2004	0.0351	0.1153	0.0212	0.0027	0.0033	0.2925	0.3279
SO4	-0.25101	-0.25101	-0.42507	-0.30989	-0.30413	-0.76506	-0.65031	0.68302	-0.30019	-0.69169
SO4	0.0574	0.0574	0.0009	0.0179	0.0203	<.0001	<.0001	<.0001	0.0221	<.0001
NO3	0.45048	0.45048	0.27155	0.47462	0.05355	0.0209	0.25083	-0.2156	-0.21467	-0.14477
NO3	0.0004	0.0004	0.0392	0.0002	0.6897	0.8763	0.0575	0.1041	0.1056	0.2782
Available_P	0.35846	0.35846	0.53102	0.42993	0.60107	0.51681	0.56191	-0.565	0.18617	0.53339
Available_P	0.0057	0.0057	<.0001	0.0008	<.0001	<.0001	<.0001	<.0001	0.1617	<.0001
CaCO3	1	1	0.19958	0.98669	0.01921	0.50077	0.66498	-0.6493	-0.14616	0.13058
CaCO3		<.0001	0.1331	<.0001	0.8862	<.0001	<.0001	<.0001	0.2736	0.3285
Inorganic_C	1	1	0.19958	0.98669	0.01921	0.50077	0.66498	-0.6493	-0.14616	0.13058
Inorganic_C	<.0001		0.1331	<.0001	0.8862	<.0001	<.0001	<.0001	0.2736	0.3285
Organic_C	0.19958	0.19958	1	0.35624	0.41737	0.29212	0.33548	-0.33446	0.1734	0.30537
Organic_C	0.1331	0.1331		0.0061	0.0011	0.0261	0.01	0.0103	0.193	0.0198
Total_C	0.98669	0.98669	0.35624	1	0.08757	0.52599	0.68977	-0.67465	-0.11061	0.17519
Total_C	<.0001	<.0001	0.0061		0.5133	<.0001	<.0001	<.0001	0.4085	0.1884
Total_N	0.01921	0.01921	0.41737	0.08757	1	0.23638	0.37157	-0.35522	0.11296	0.07454
Total_N	0.8862	0.8862	0.0011	0.5133		0.074	0.0041	0.0062	0.3985	0.5781
Clay	0.50077	0.50077	0.29212	0.52599	0.23638	1	0.86639	-0.90661	0.31992	0.51232
Clay	<.0001	<.0001	0.0261	<.0001	0.074		<.0001	<.0001	0.0144	<.0001
Silt	0.66498	0.66498	0.33548	0.68977	0.37157	0.86639	1	-0.9962	0.19906	0.38411
Silt	<.0001	<.0001	0.01	<.0001	0.0041	<.0001		<.0001	0.1341	0.0029
Sand	-0.6493	-0.6493	-0.33446	-0.67465	-0.35522	-0.90661	-0.9962	1	-0.22404	-0.41398
Sand	<.0001	<.0001	0.0103	<.0001	0.0062	<.0001	<.0001		0.0909	0.0012
Total_Energy	-0.14616	-0.14616	0.1734	-0.11061	0.11296	0.31992	0.19906	-0.22404	1	0.34647
Total_Energy	0.2736	0.2736	0.193	0.4085	0.3985	0.0144	0.1341	0.0909		0.0077
Bulk_Density	0.13058	0.13058	0.30537	0.17519	0.07454	0.51232	0.38411	-0.41398	0.34647	1
Bulk_Density	0.3285	0.3285	0.0198	0.1884	0.5781	<.0001	0.0029	0.0012	0.0077	

Appendix 5. Correlation matrix ringstem layer 2 within sites

Simple Statistics						
Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
ANLE	33	0.59135	0.70603	19.51461	0	2.19722
pH	33	7.448	0.24688	245.784	7.095	8.028
EC	33	41.34513	13.5129	1364	10.63015	57.82733
Na	33	2.36101	1.87896	77.91328	0.359	5.53812
K	33	2.17954	0.77021	71.92495	0.97989	3.62986
Mg	33	2.24398	1.12445	74.05133	0.53368	4.12021
Ca	33	6.03989	1.42337	199.31647	2.4552	6.88262
Mn	33	1.37702	0.50999	45.44182	0.43898	2.66385
Fe	33	7.10403	1.015	234.43312	4.57766	8.00278
Ni	33	2.7662	0.8394	91.28473	0.8015	3.53084
Cu	33	1.61276	0.55137	53.22095	0.71206	3.2293
Zn	33	2.49674	3.6073	82.39236	0.52255	20.47099
Co	33	0.552	0.20134	18.21585	0.12035	0.8083
B	33	12.45528	9.07445	411.02418	2.4204	30.45031
Mo	33	1.65969	1.20335	54.76989	0.23696	4.18455
Pb	33	0.03287	0.03298	1.08458	0.0000231	0.11188
Cd	33	0.1256	0.09191	4.14464	0.00693	0.30789
Cl	33	3.94366	4.41503	130.14079	0.46152	13.38841
SO4	33	6.62663	1.9645	218.67889	1.2449	7.68213
NO3	33	0.29826	0.22391	9.84249	0.00598	0.94398
Available_P	33	1.29213	0.47433	42.64039	0.5619	2.30877
CaCO3	33	2.48593	0.98085	82.03572	1.0391	3.68638
Inorganic_C	33	2.02333	1.62906	66.7698	0.2192	4.668
Organic_C	33	0.20717	0.26746	6.83657	0.00538	1.24484
Total_C	33	2.2305	1.77158	73.60637	0.24898	5.09875
Total_N	33	0.00993	0.00588	0.32779	0.00224	0.02516
Clay	33	2.69065	2.63271	88.79156	0.16181	9.77146
Silt	33	20.17558	14.195	665.79398	4.78889	50.49482
Sand	33	77.13377	16.69152	2545	42.40795	95.0493
Total_Energy	33	224.10225	154.58647	7395	0	557.1104
Bulk_Density	33	0.61981	0.18863	20.45363	0.25166	1.16055
anle1	33	0.48485	0.50752	16	0	1

Pearson Correlation Coefficients, N = 33
Prob > |r| under H0; Rho=0

	ANLE	pH	EC	Na	K	Mg	Ca	Mn	Fe	Ni	Cu
ANLE	1	-0.24984	0.27575	0.04106	-0.10746	0.13744	0.34264	-0.03504	0.33976	0.37667	-0.38031
ANLE		0.1609	0.1204	0.8205	0.5517	0.4456	0.0509	0.8465	0.053	0.0307	0.029
pH	-0.24984	1	-0.86204	-0.49327	-0.02619	-0.38334	-0.82928	-0.51083	-0.80779	-0.73904	-0.06527
pH	0.1609		<.0001	0.0035	0.885	0.0277	<.0001	0.0024	<.0001	<.0001	0.7182
EC	0.27575	-0.86204	1	0.55409	0.1526	0.58372	0.9357	0.45645	0.919	0.85799	0.00838
EC	0.1204	<.0001		0.0008	0.3965	0.0004	<.0001	0.0076	<.0001	<.0001	0.9631
Na	0.04106	-0.49327	0.55409	1	0.72298	0.87839	0.30534	0.28219	0.28202	0.12975	0.14717
Na	0.8205	0.0035	0.0008		<.0001	<.0001	0.084	0.1116	0.1118	0.4717	0.4138
K	-0.10746	-0.02619	0.1526	0.72298	1	0.75409	-0.08014	-0.02206	-0.10802	-0.23819	0.13782
K	0.5517	0.885	0.3965	<.0001		<.0001	0.6575	0.903	0.5496	0.1819	0.4444
Mg	0.13744	-0.38334	0.58372	0.87839	0.75409	1	0.39159	0.16271	0.38261	0.25253	-0.06385
Mg	0.4456	0.0277	0.0004	<.0001	<.0001		0.0242	0.3656	0.028	0.1562	0.7241
Ca	0.34264	-0.82928	0.9357	0.30534	-0.08014	0.39159	1	0.40573	0.9792	0.95357	-0.08609
Ca	0.0509	<.0001	<.0001	0.084	0.6575	0.0242		0.0191	<.0001	<.0001	0.6338
Mn	-0.03504	-0.51083	0.45645	0.28219	-0.02206	0.16271	0.40573	1	0.45199	0.36799	0.44083
Mn	0.8465	0.0024	0.0076	0.1116	0.903	0.3656	0.0191		0.0083	0.0351	0.0102
Fe	0.33976	-0.80779	0.919	0.28202	-0.10802	0.38261	0.9792	0.45199	1	0.96911	-0.1017
Fe	0.053	<.0001	<.0001	0.1118	0.5496	0.028	<.0001	0.0083		<.0001	0.5733
Ni	0.37667	-0.73904	0.85799	0.12975	-0.23819	0.25253	0.95357	0.36799	0.96911	1	-0.13407
Ni	0.0307	<.0001	<.0001	0.4717	0.1819	0.1562	<.0001	0.0351	<.0001		0.457
Cu	-0.38031	-0.06527	0.00838	0.14717	0.13782	-0.06385	-0.08609	0.44083	-0.1017	-0.13407	1
Cu	0.029	0.7182	0.9631	0.4138	0.4444	0.7241	0.6338	0.0102	0.5733	0.457	
Zn	-0.13297	-0.16666	0.29713	0.21012	0.1388	0.15421	0.24082	0.66597	0.24367	0.18522	0.49119
Zn	0.4607	0.3539	0.0931	0.2405	0.4411	0.3915	0.177	<.0001	0.1718	0.3021	0.0037
Co	0.31372	-0.68493	0.79913	0.08522	-0.22233	0.21106	0.8844	0.47114	0.93382	0.96275	-0.07848
Co	0.0754	<.0001	<.0001	0.6373	0.2137	0.2384	<.0001	0.0056	<.0001	<.0001	0.6642
B	0.02916	-0.27688	0.41097	0.83453	0.8567	0.8068	0.16063	0.13297	0.14284	0.04664	0.14709
B	0.872	0.1188	0.0175	<.0001	<.0001	<.0001	0.3719	0.4607	0.4278	0.7966	0.414
Mo	0.11431	-0.34588	0.53453	0.88996	0.78691	0.89836	0.31148	0.26244	0.31183	0.17631	0.09062
Mo	0.5265	0.0486	0.0014	<.0001	<.0001	<.0001	0.0776	0.1401	0.0773	0.3264	0.616
Pb	-0.02654	0.2833	-0.27868	-0.15127	0.01227	-0.09856	-0.2486	-0.11989	-0.21346	-0.24454	-0.05296
Pb	0.8834	0.1101	0.1163	0.4007	0.946	0.5853	0.163	0.5063	0.233	0.1702	0.7697
Cd	0.04256	-0.37025	0.45838	0.37208	0.14991	0.40746	0.40293	0.38621	0.39624	0.34155	0.0667
Cd	0.8141	0.0339	0.0073	0.033	0.405	0.0186	0.0201	0.0264	0.0224	0.0517	0.7123
Cl	0.03924	-0.4985	0.58699	0.98037	0.66997	0.83546	0.32649	0.27951	0.29138	0.15117	0.18347
Cl	0.8283	0.0032	0.0003	<.0001	<.0001	<.0001	0.0637	0.1152	0.0999	0.401	0.3068
SO4	0.33622	-0.81998	0.9356	0.32576	-0.02708	0.40492	0.98746	0.36533	0.9561	0.93389	-0.07735
SO4	0.0557	<.0001	<.0001	0.0643	0.8811	0.0194	<.0001	0.0366	<.0001	<.0001	0.6688
NO3	0.27412	-0.14187	0.22071	0.19344	0.30776	0.24673	0.20167	-0.03346	0.1786	0.16669	-0.23457
NO3	0.1227	0.431	0.2171	0.2808	0.0814	0.1663	0.2604	0.8534	0.32	0.3539	0.1889
Available_P	-0.23828	0.72494	-0.61762	-0.46998	0.05434	-0.24486	-0.54437	-0.51316	-0.53951	-0.47992	-0.19006
Available_P	0.1817	<.0001	0.0001	0.0058	0.7639	0.1696	0.0011	0.0023	0.0012	0.0047	0.2894
CaCO3	0.05315	0.73001	-0.53334	-0.51592	-0.18394	-0.24413	-0.43071	-0.55291	-0.40449	-0.30903	-0.43986
CaCO3	0.7689	<.0001	0.0014	0.0021	0.3055	0.1709	0.0123	0.0008	0.0196	0.0801	0.0104
Inorganic_C	0.06767	0.70388	-0.55874	-0.5945	-0.28824	-0.33489	-0.42023	-0.50904	-0.39047	-0.29375	-0.45259
Inorganic_C	0.7083	<.0001	0.0007	0.0003	0.1038	0.0568	0.0149	0.0025	0.0247	0.0971	0.0082
Organic_C	0.0464	0.5229	-0.42616	-0.35364	0.21877	-0.08056	-0.3866	-0.45736	-0.38991	-0.30497	-0.16973
Organic_C	0.7976	0.0018	0.0134	0.0435	0.2213	0.6558	0.0263	0.0075	0.0249	0.0844	0.345
Total_C	0.06923	0.7262	-0.57814	-0.60007	-0.23203	-0.32011	-0.4448	-0.53714	-0.41793	-0.31616	-0.4418
Total_C	0.7018	<.0001	0.0004	0.0002	0.1938	0.0693	0.0095	0.0013	0.0155	0.0731	0.0101
Total_N	-0.43799	0.67352	-0.62912	-0.19182	0.29183	-0.13527	-0.70799	-0.25079	-0.72932	-0.71603	0.21262
Total_N	0.0108	<.0001	<.0001	0.2849	0.0994	0.4529	<.0001	0.1592	<.0001	<.0001	0.2349
Clay	-0.19795	0.88864	-0.86713	-0.52955	-0.01645	-0.41426	-0.84622	-0.52496	-0.80515	-0.74834	-0.18513
Clay	0.2695	<.0001	<.0001	0.0015	0.9276	0.0165	<.0001	0.0017	<.0001	<.0001	0.3023
Silt	-0.2117	0.86829	-0.84178	-0.55675	-0.05343	-0.39144	-0.78381	-0.53695	-0.76029	-0.70662	-0.13573
Silt	0.2369	<.0001	<.0001	0.0008	0.7677	0.0243	<.0001	0.0013	<.0001	<.0001	0.4514
Sand	0.21126	-0.87859	0.85265	0.55701	0.04804	0.39823	0.80004	0.53944	0.77357	0.71897	0.14463
Sand	0.2379	<.0001	<.0001	0.0008	0.7907	0.0217	<.0001	0.0012	<.0001	<.0001	0.422
Total_Energy	-0.18912	-0.11424	0.07902	-0.08344	0.11514	0.06161	0.13315	0.02141	0.07646	0.05036	-0.00225
Total_Energy	0.2918	0.5267	0.662	0.6443	0.5234	0.7334	0.4601	0.9059	0.6724	0.7808	0.9901
Bulk_Density	-0.32371	0.16613	-0.24817	0.09023	0.23042	0.0907	-0.27034	0.17705	-0.26276	-0.33435	0.01503
Bulk_Density	0.0661	0.3555	0.1638	0.6175	0.197	0.6157	0.1281	0.3243	0.1396	0.0572	0.9338
anle1	0.87674	-0.36438	0.37714	0.10461	-0.08326	0.10758	0.41189	0.06942	0.4019	0.43495	-0.2003
	<.0001	0.0371	0.0305	0.5623	0.645	0.5512	0.0172	0.7011	0.0204	0.0114	0.2637

	Zn	Co	B	Mo	Pb	Cd	Cl	SO4	NO3	Available_P	CaCO3
ANLE	-0.13297	0.31372	0.02916	0.11431	-0.02654	0.04256	0.03924	0.33622	0.27412	-0.23828	0.05315
ANLE	0.4607	0.0754	0.872	0.5265	0.8834	0.8141	0.8283	0.0557	0.1227	0.1817	0.7689
pH	-0.16666	-0.68493	-0.27688	-0.34588	0.2833	-0.37025	-0.4985	-0.81998	-0.14187	0.72494	0.73001
pH	0.3539	<.0001	0.1188	0.0486	0.1101	0.0339	0.0032	<.0001	0.431	<.0001	<.0001
EC	0.29713	0.79913	0.41097	0.53453	-0.27868	0.45838	0.58699	0.9356	0.22071	-0.61762	-0.53334
EC	0.0931	<.0001	0.0175	0.0014	0.1163	0.0073	0.0003	<.0001	0.2171	0.0001	0.0014
Na	0.21012	0.08522	0.83453	0.88996	-0.15127	0.37208	0.98037	0.32576	0.19344	-0.46998	-0.51592
Na	0.2405	0.6373	<.0001	<.0001	0.4007	0.033	<.0001	0.0643	0.2808	0.0058	0.0021
K	0.1388	-0.22233	0.8567	0.78691	0.01227	0.14991	0.66997	-0.02708	0.30776	0.05434	-0.18394
K	0.4411	0.2137	<.0001	<.0001	0.946	0.405	<.0001	0.8811	0.0814	0.7639	0.3055
Mg	0.15421	0.21106	0.8068	0.89836	-0.09856	0.40746	0.83546	0.40492	0.24673	-0.24486	-0.24413
Mg	0.3915	0.2384	<.0001	<.0001	0.5853	0.0186	<.0001	0.0194	0.1663	0.1696	0.1709
Ca	0.24082	0.8844	0.16063	0.31148	-0.2486	0.40293	0.32649	0.98746	0.20167	-0.54437	-0.43071
Ca	0.177	<.0001	0.3719	0.0776	0.163	0.0201	0.0637	<.0001	0.2604	0.0011	0.0123
Mn	0.66597	0.47114	0.13297	0.26244	-0.11989	0.38621	0.27951	0.36533	-0.03346	-0.51316	-0.55291
Mn	<.0001	0.0056	0.4607	0.1401	0.5063	0.0264	0.1152	0.0366	0.8534	0.0023	0.0008
Fe	0.24367	0.93382	0.14284	0.31183	-0.21346	0.39624	0.29138	0.9561	0.1786	-0.53951	-0.40449
Fe	0.1718	<.0001	0.4278	0.0773	0.233	0.0224	0.0999	<.0001	0.32	0.0012	0.0196
Ni	0.18522	0.96275	0.04664	0.17631	-0.24454	0.34155	0.15117	0.93389	0.16669	-0.47992	-0.30903
Ni	0.3021	<.0001	0.7966	0.3264	0.1702	0.0517	0.401	<.0001	0.3539	0.0047	0.0801
Cu	0.49119	-0.07848	0.14709	0.09062	-0.05296	0.0667	0.18347	-0.07735	-0.23457	-0.19006	-0.43986
Cu	0.0037	0.6642	0.414	0.616	0.7697	0.7123	0.3068	0.6688	0.1889	0.2894	0.0104
Zn	1	0.201	0.16887	0.26603	-0.11467	0.08942	0.2552	0.23795	-0.12318	-0.21571	-0.33534
Zn		0.262	0.3475	0.1345	0.5251	0.6207	0.1518	0.1824	0.4947	0.228	0.0564
Co	0.201	1	0.04061	0.17615	-0.19776	0.38385	0.08861	0.85338	0.18108	-0.44632	-0.28539
Co	0.262		0.8225	0.3268	0.2699	0.0274	0.6239	<.0001	0.3132	0.0092	0.1074
B	0.16887	0.04061	1	0.82881	-0.17326	0.25177	0.80641	0.19633	0.46053	-0.16422	-0.41898
B	0.3475	0.8225		<.0001	0.3349	0.1575	<.0001	0.2735	0.007	0.3611	0.0152
Mo	0.26603	0.17615	0.82881	1	0.04547	0.30217	0.86038	0.33066	0.22955	-0.3369	-0.30054
Mo	0.1345	0.3268	<.0001		0.8016	0.0874	<.0001	0.0602	0.1988	0.0552	0.0892
Pb	-0.11467	-0.19776	-0.17326	0.04547	1	-0.25106	-0.18391	-0.2696	-0.10906	0.1264	0.28074
Pb	0.5251	0.2699	0.3349	0.8016		0.1587	0.3056	0.1292	0.5458	0.4833	0.1135
Cd	0.08942	0.38385	0.25177	0.30217	-0.25106	1	0.37732	0.42121	0.12318	-0.40135	-0.13669
Cd	0.6207	0.0274	0.1575	0.0874	0.1587		0.0304	0.0146	0.4946	0.0206	0.4482
Cl	0.2552	0.08861	0.80641	0.86038	-0.18391	0.37732	1	0.34985	0.17125	-0.51389	-0.51484
Cl	0.1518	0.6239	<.0001	<.0001	0.3056	0.0304		0.046	0.3406	0.0022	0.0022
SO4	0.23795	0.85338	0.19633	0.33066	-0.2696	0.42121	0.34985	1	0.20945	-0.54999	-0.42049
SO4	0.1824	<.0001	0.2735	0.0602	0.1292	0.0146	0.046		0.2421	0.0009	0.0148
NO3	-0.12318	0.18108	0.46053	0.22955	-0.10906	0.12318	0.17125	0.20945	1	0.13338	-0.09833
NO3	0.4947	0.3132	0.007	0.1988	0.5458	0.4946	0.3406	0.2421		0.4593	0.5862
Available_P	-0.21571	-0.44632	-0.16422	-0.3369	0.1264	-0.40135	-0.51389	-0.54999	0.13338	1	0.54805
Available_P	0.228	0.0092	0.3611	0.0552	0.4833	0.0206	0.0022	0.0009	0.4593		0.001
CaCO3	-0.33534	-0.28539	-0.41898	-0.30054	0.28074	-0.13669	-0.51484	-0.42049	-0.09833	0.54805	1
CaCO3	0.0564	0.1074	0.0152	0.0892	0.1135	0.4482	0.0022	0.0148	0.5862	0.001	
Inorganic_C	-0.31967	-0.26498	-0.52367	-0.40784	0.26639	-0.12903	-0.60844	-0.41515	-0.08293	0.54951	0.96939
Inorganic_C	0.0698	0.1361	0.0018	0.0185	0.134	0.4742	0.0002	0.0163	0.6464	0.0009	<.0001
Organic_C	-0.22093	-0.26382	0.04594	-0.17696	-0.0324	-0.22071	-0.39679	-0.36863	0.22538	0.72829	0.48016
Organic_C	0.2166	0.1379	0.7996	0.3245	0.858	0.2171	0.0222	0.0348	0.2073	<.0001	0.0047
Total_C	-0.32731	-0.28349	-0.47461	-0.40175	0.24007	-0.15197	-0.6194	-0.43741	-0.04223	0.61526	0.9639
Total_C	0.063	0.1099	0.0053	0.0205	0.1784	0.3985	0.0001	0.0109	0.8155	0.0001	<.0001
Total_N	-0.08801	-0.62909	0.07963	-0.18184	0.2044	-0.12297	-0.21026	-0.6999	0.04623	0.58759	0.29459
Total_N	0.6262	<.0001	0.6596	0.3111	0.2539	0.4954	0.2402	<.0001	0.7984	0.0003	0.0961
Clay	-0.28263	-0.68629	-0.31443	-0.40813	0.27695	-0.38776	-0.55671	-0.82198	-0.13918	0.69851	0.7228
Clay	0.111	<.0001	0.0747	0.0184	0.1187	0.0258	0.0008	<.0001	0.4398	<.0001	<.0001
Silt	-0.26278	-0.66616	-0.38477	-0.44409	0.28364	-0.35304	-0.58708	-0.77831	-0.16111	0.75333	0.74771
Silt	0.1396	<.0001	0.027	0.0096	0.1097	0.0439	0.0003	<.0001	0.3704	<.0001	<.0001
Sand	0.26806	0.67477	0.37681	0.44204	-0.2849	0.36139	0.58708	0.79155	0.15897	-0.75083	-0.74988
Sand	0.1315	<.0001	0.0307	0.01	0.1081	0.0388	0.0003	<.0001	0.3769	<.0001	<.0001
Total_Energy	-0.03175	0.06212	0.0768	-0.14085	0.01322	0.21713	-0.10723	0.10258	0.3216	0.27133	-0.15332
Total_Energy	0.8608	0.7313	0.671	0.4343	0.9418	0.2248	0.5525	0.57	0.068	0.1267	0.3943
Bulk_Density	0.35994	-0.32049	0.09255	0.15684	0.12334	-0.3281	0.05941	-0.31417	-0.22713	0.21691	-0.04042
Bulk_Density	0.0396	0.069	0.6085	0.3834	0.4941	0.0623	0.7426	0.075	0.2037	0.2253	0.8233
anle1	-0.06104	0.38976	0.14293	0.14088	-0.0307	0.07837	0.11558	0.40143	0.37097	-0.3824	-0.18143
	0.7358	0.0249	0.4275	0.4342	0.8653	0.6646	0.5218	0.0206	0.0336	0.0281	0.3123

	Inorganic_C	Organic_C	Total_C	Total_N	Clay	Silt	Sand	Total_Energy	Bulk_Density	anle1
ANLE	0.06767	0.0464	0.06923	-0.43799	-0.19795	-0.2117	0.21126	-0.18912	-0.32371	0.87674
ANLE	0.7083	0.7976	0.7018	0.0108	0.2695	0.2369	0.2379	0.2918	0.0661	<.0001
pH	0.70388	0.5229	0.7262	0.67352	0.88864	0.86829	-0.87859	-0.11424	0.16613	-0.36438
pH	<.0001	0.0018	<.0001	<.0001	<.0001	<.0001	<.0001	0.5267	0.3555	0.0371
EC	-0.55874	-0.42616	-0.57814	-0.62912	-0.86713	-0.84178	0.85265	0.07902	-0.24817	0.37714
EC	0.0007	0.0134	0.0004	<.0001	<.0001	<.0001	<.0001	0.662	0.1638	0.0305
Na	-0.5945	-0.35364	-0.60007	-0.19182	-0.52955	-0.55675	0.55701	-0.08344	0.09023	0.10461
Na	0.0003	0.0435	0.0002	0.2849	0.0015	0.0008	0.0008	0.6443	0.6175	0.5623
K	-0.28824	0.21877	-0.23203	0.29183	-0.01645	-0.05343	0.04804	0.11514	0.23042	-0.08326
K	0.1038	0.2213	0.1938	0.0994	0.9276	0.7677	0.7907	0.5234	0.197	0.645
Mg	-0.33489	-0.08056	-0.32011	-0.13527	-0.41426	-0.39144	0.39823	0.06161	0.0907	0.10758
Mg	0.0568	0.6558	0.0693	0.4529	0.0165	0.0243	0.0217	0.7334	0.6157	0.5512
Ca	-0.42023	-0.3866	-0.4448	-0.70799	-0.84622	-0.78381	0.80004	0.13315	-0.27034	0.41189
Ca	0.0149	0.0263	0.0095	<.0001	<.0001	<.0001	<.0001	0.4601	0.1281	0.0172
Mn	-0.50904	-0.45736	-0.53714	-0.25079	-0.52496	-0.53695	0.53944	0.02141	0.17705	0.06942
Mn	0.0025	0.0075	0.0013	0.1592	0.0017	0.0013	0.0012	0.9059	0.3243	0.7011
Fe	-0.39047	-0.38991	-0.41793	-0.72932	-0.80515	-0.76029	0.77357	0.07646	-0.26276	0.4019
Fe	0.0247	0.0249	0.0155	<.0001	<.0001	<.0001	<.0001	0.6724	0.1396	0.0204
Ni	-0.29375	-0.30497	-0.31616	-0.71603	-0.74834	-0.70662	0.71897	0.05036	-0.33435	0.43495
Ni	0.0971	0.0844	0.0731	<.0001	<.0001	<.0001	<.0001	0.7808	0.0572	0.0114
Cu	-0.45259	-0.16973	-0.4418	0.21262	-0.18513	-0.13573	0.14463	-0.00225	0.01503	-0.2003
Cu	0.0082	0.345	0.0101	0.2349	0.3023	0.4514	0.422	0.9901	0.9338	0.2637
Zn	-0.31967	-0.22093	-0.32731	-0.08801	-0.28263	-0.26278	0.26806	-0.03175	0.35994	-0.06104
Zn	0.0698	0.2166	0.063	0.6262	0.111	0.1396	0.1315	0.8608	0.0396	0.7358
Co	-0.26498	-0.26382	-0.28349	-0.62909	-0.68629	-0.66616	0.67477	0.06212	-0.32049	0.38976
Co	0.1361	0.1379	0.1099	<.0001	<.0001	<.0001	<.0001	0.7313	0.069	0.0249
B	-0.52367	0.04594	-0.47461	0.07963	-0.31443	-0.38477	0.37681	0.0768	0.09255	0.14293
B	0.0018	0.7996	0.0053	0.6596	0.0747	0.027	0.0307	0.671	0.6085	0.4275
Mo	-0.40784	-0.17696	-0.40175	-0.18184	-0.40813	-0.44409	0.44204	-0.14085	0.15684	0.14088
Mo	0.0185	0.3245	0.0205	0.3111	0.0184	0.0096	0.01	0.4343	0.3834	0.4342
Pb	0.26639	-0.0324	0.24007	0.2044	0.27695	0.28364	-0.2849	0.01322	0.12334	-0.0307
Pb	0.134	0.858	0.1784	0.2539	0.1187	0.1097	0.1081	0.9418	0.4941	0.8653
Cd	-0.12903	-0.22071	-0.15197	-0.12297	-0.38776	-0.35304	0.36139	0.21713	-0.3281	0.07837
Cd	0.4742	0.2171	0.3985	0.4954	0.0258	0.0439	0.0388	0.2248	0.0623	0.6646
Cl	-0.60844	-0.39679	-0.6194	-0.21026	-0.55671	-0.58708	0.58708	-0.10723	0.05941	0.11558
Cl	0.0002	0.0222	0.0001	0.2402	0.0008	0.0003	0.0003	0.5525	0.7426	0.5218
SO4	-0.41515	-0.36863	-0.43741	-0.6999	-0.82198	-0.77831	0.79155	0.10258	-0.31417	0.40143
SO4	0.0163	0.0348	0.0109	<.0001	<.0001	<.0001	<.0001	0.57	0.075	0.0206
NO3	-0.08293	0.22538	-0.04223	0.04623	-0.13918	-0.16111	0.15897	0.3216	-0.22713	0.37097
NO3	0.6464	0.2073	0.8155	0.7984	0.4398	0.3704	0.3769	0.068	0.2037	0.0336
Available_P	0.54951	0.72829	0.61526	0.58759	0.69851	0.75333	-0.75083	0.27133	0.21691	-0.3824
Available_P	0.0009	<.0001	0.0001	0.0003	<.0001	<.0001	<.0001	0.1267	0.2253	0.0281
CaCO3	0.96939	0.48016	0.9639	0.29459	0.7228	0.74771	-0.74988	-0.15332	-0.04042	-0.18143
CaCO3	<.0001	0.0047	<.0001	0.0961	<.0001	<.0001	<.0001	0.3943	0.8233	0.3123
Inorganic_C	1	0.47404	0.99112	0.27473	0.71342	0.76312	-0.7615	-0.12998	-0.06867	-0.17078
Inorganic_C		0.0053	<.0001	0.1218	<.0001	<.0001	<.0001	0.4709	0.7042	0.342
Organic_C	0.47404	1	0.58688	0.5457	0.60415	0.63129	-0.63216	0.1797	0.06532	-0.11725
Organic_C	0.0053		0.0003	0.001	0.0002	<.0001	<.0001	0.317	0.718	0.5158
Total_C	0.99112	0.58688	1	0.33502	0.74724	0.79704	-0.79569	-0.09239	-0.05328	-0.17474
Total_C	<.0001	0.0003		0.0567	<.0001	<.0001	<.0001	0.6091	0.7684	0.3307
Total_N	0.27473	0.5457	0.33502	1	0.61042	0.62401	-0.62695	0.36908	0.13567	-0.41056
Total_N	0.1218	0.001	0.0567		0.0002	0.0001	<.0001	0.0345	0.4516	0.0176
Clay	0.71342	0.60415	0.74724	0.61042	1	0.93892	-0.95622	-0.07584	0.12356	-0.37036
Clay	<.0001	0.0002	<.0001	0.0002		<.0001	<.0001	0.6749	0.4933	0.0339
Silt	0.76312	0.63129	0.79704	0.62401	0.93892	1	-0.99853	0.03711	0.14862	-0.38108
Silt	<.0001	<.0001	<.0001	0.0001	<.0001		<.0001	0.8376	0.4091	0.0287
Sand	-0.7615	-0.63216	-0.79569	-0.62695	-0.95622	-0.99853	1	-0.0196	-0.14588	0.3825
Sand	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		0.9138	0.4179	0.028
Total_Energy	-0.12998	0.1797	-0.09239	0.36908	-0.07584	0.03711	-0.0196	1	-0.02378	-0.03586
Total_Energy	0.4709	0.317	0.6091	0.0345	0.6749	0.8376	0.9138		0.8955	0.8429
Bulk_Density	-0.06867	0.06532	-0.05328	0.13567	0.12356	0.14862	-0.14588	-0.02378	1	-0.41597
Bulk_Density	0.7042	0.718	0.7684	0.4516	0.4933	0.4091	0.4179	0.8955		0.0161
anle1	-0.17078	-0.11725	-0.17474	-0.41056	-0.37036	-0.38108	0.3825	-0.03586	-0.41597	1
	0.342	0.5158	0.3307	0.0176	0.0339	0.0287	0.028	0.8429	0.0161	

Appendix 6. Correlation matrix ringstem layer 2 between sites

Simple Statistics						
Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
anle	62	0.53226	0.50303	33	0	1
ANLE1	62	0.31475	0.59159	19.51461	0	2.19722
pH	62	7.51215	0.25921	465.753	7.095	8.148
EC	62	36.88243	15.09475	2287	10.31988	57.82733
Na	62	1.78834	1.57351	110.8772	0.359	5.53812
K	62	2.12808	0.69213	131.94126	0.97989	3.67054
Mg	62	1.95826	0.95993	121.41226	0.53368	4.12021
Ca	62	5.61271	1.77688	347.98796	2.12495	6.88262
Mn	62	1.39306	0.52198	86.36969	0.43898	2.75565
Fe	62	6.84744	1.19149	424.54125	4.50838	8.00278
Ni	62	2.49485	0.99522	154.68091	0.56568	3.53084
Cu	62	1.83513	0.6154	113.77782	0.71206	3.2293
Zn	62	2.5759	2.98806	159.70575	0.52255	20.47099
Co	62	0.50093	0.2202	31.05773	0.11801	0.8083
B	62	9.45675	7.67803	586.31837	2.4204	30.45031
Mo	62	1.25764	0.99004	77.9738	0.23696	4.18455
Pb	62	0.03324	0.03561	2.06058	0.0000149	0.17911
Cd	62	0.11805	0.07816	7.31898	0.00693	0.30789
Cl	62	2.47817	3.56941	153.6468	0.46152	13.38841
SO4	62	6.06103	2.46433	375.78401	1.14237	7.70462
NO3	62	0.26794	0.19287	16.61204	0.00598	0.94398
Available_P	62	1.31881	0.53306	81.76641	0.49348	2.53892
CaCO3	62	2.55152	0.89227	158.19447	0.81905	3.68638
Inorganic_C	62	2.00724	1.4488	124.4486	0.1522	4.668
Organic_C	62	0.19892	0.23381	12.33319	0.00438	1.24484
Total_C	62	2.20616	1.57771	136.78179	0.16953	5.09875
Total_N	62	0.01054	0.0056	0.6536	0.00224	0.02516
Clay	62	3.33986	2.754	207.07121	0.16181	9.77146
Silt	62	23.93402	13.40942	1484	4.78889	50.49482
Sand	62	72.72612	15.99128	4509	42.40795	95.0493
Total_Energy	62	276.9537	199.18595	17171	0	860.9888
Bulk_Density	62	0.63456	0.18186	39.34254	0.25166	1.16055

Pearson Correlation Coefficients, N = 62

Prob > |r| under H0: Rho=0

	anle	ANLE1	pH	EC	Na	K	Mg	Ca	Mn	Fe	Ni
anle	1	0.50283	-0.26614	0.31795	0.3914	0.07996	0.3201	0.25855	-0.03304	0.2316	0.29323
anle		<.0001	0.0365	0.0118	0.0017	0.5367	0.0112	0.0425	0.7988	0.0701	0.0207
ANLE1	0.50283	1	-0.2828	0.31442	0.2275	-0.03466	0.26175	0.30184	-0.03804	0.29766	0.34634
ANLE1	<.0001		0.0259	0.0128	0.0754	0.7891	0.0399	0.0171	0.7691	0.0188	0.0058
pH	-0.26614	-0.2828	1	-0.86921	-0.31534	-0.08396	-0.43824	-0.84726	-0.41425	-0.80111	-0.79974
pH	0.0365	0.0259		<.0001	0.0125	0.5165	0.0004	<.0001	0.0008	<.0001	<.0001
EC	0.31795	0.31442	-0.86921	1	0.35509	0.15618	0.58159	0.96292	0.38865	0.94206	0.92887
EC	0.0118	0.0128	<.0001		0.0046	0.2254	<.0001	<.0001	0.0018	<.0001	<.0001
Na	0.3914	0.2275	-0.31534	0.35509	1	0.551	0.75896	0.16546	0.1182	0.16539	0.09779
Na	0.0017	0.0754	0.0125	0.0046		<.0001	<.0001	0.1987	0.3602	0.1989	0.4496
K	0.07996	-0.03466	-0.08396	0.15618	0.551	1	0.6929	0.03248	-0.16352	-0.0075	-0.06036
K	0.5367	0.7891	0.5165	0.2254	<.0001		<.0001	0.8021	0.2041	0.9539	0.6412
Mg	0.3201	0.26175	-0.43824	0.58159	0.75896	0.6929	1	0.45576	0.00442	0.42906	0.37489
Mg	0.0112	0.0399	0.0004	<.0001	<.0001	<.0001		0.0002	0.9728	0.0005	0.0027
Ca	0.25855	0.30184	-0.84726	0.96292	0.16546	0.03248	0.45576	1	0.36105	0.97202	0.9726
Ca	0.0425	0.0171	<.0001	<.0001	0.1987	0.8021	0.0002		0.0039	<.0001	<.0001
Mn	-0.03304	-0.03804	-0.41425	0.38865	0.1182	-0.16352	0.00442	0.36105	1	0.4347	0.36527
Mn	0.7988	0.7691	0.0008	0.0018	0.3602	0.2041	0.9728	0.0039		0.0004	0.0035
Fe	0.2316	0.29766	-0.80111	0.94206	0.16539	-0.0075	0.42906	0.97202	0.4347	1	0.97108
Fe	0.0701	0.0188	<.0001	<.0001	0.1989	0.9539	0.0005	<.0001	0.0004		<.0001
Ni	0.29323	0.34634	-0.79974	0.92887	0.09779	-0.06036	0.37489	0.9726	0.36527	0.97108	1
Ni	0.0207	0.0058	<.0001	<.0001	0.4496	0.6412	0.0027	<.0001	0.0035	<.0001	
Cu	-0.3886	-0.40873	0.13448	-0.28313	-0.01472	0.03937	-0.22122	-0.31312	0.16376	-0.31642	-0.36299
Cu	0.0018	0.001	0.2974	0.0258	0.9096	0.7613	0.084	0.0132	0.2034	0.0122	0.0037
Zn	-0.02849	-0.11483	-0.2891	0.33659	0.11536	0.12089	0.17208	0.31143	0.45325	0.29714	0.24334
Zn	0.826	0.3742	0.0227	0.0075	0.372	0.3493	0.1811	0.0137	0.0002	0.019	0.0567
Co	0.24939	0.30499	-0.7615	0.8774	0.0697	-0.10231	0.30263	0.91581	0.46562	0.94392	0.96969
Co	0.0506	0.0159	<.0001	<.0001	0.5904	0.4288	0.0168	<.0001	0.0001	<.0001	<.0001
B	0.42	0.23276	-0.21739	0.30891	0.79656	0.75857	0.74801	0.1242	-0.00593	0.10059	0.08334
B	0.0007	0.0687	0.0897	0.0146	<.0001	<.0001	<.0001	0.3362	0.9635	0.4366	0.5196
Mo	0.43674	0.30659	-0.30845	0.4279	0.86167	0.64408	0.8218	0.26023	0.12598	0.26443	0.2195
Mo	0.0004	0.0154	0.0147	0.0005	<.0001	<.0001	<.0001	0.0411	0.3292	0.0378	0.0865
Pb	-0.01115	-0.021	0.43897	-0.37376	-0.03184	-0.07204	-0.14642	-0.3803	-0.09924	-0.28121	-0.35506
Pb	0.9314	0.8713	0.0004	0.0028	0.8059	0.5779	0.2561	0.0023	0.4429	0.0268	0.0046
Cd	0.10384	0.08354	-0.41176	0.4794	0.29597	0.03389	0.36139	0.45207	0.30747	0.45225	0.42072
Cd	0.4219	0.5186	0.0009	<.0001	0.0195	0.7937	0.0039	0.0002	0.0151	0.0002	0.0007
Cl	0.44154	0.25241	-0.43108	0.4869	0.9348	0.51957	0.77464	0.29176	0.16165	0.27142	0.22012
Cl	0.0003	0.0478	0.0005	<.0001	<.0001	<.0001	<.0001	0.0214	0.2094	0.0329	0.0856
SO4	0.24683	0.29191	-0.83414	0.96026	0.1728	0.08065	0.46445	0.9905	0.32177	0.95828	0.95789
SO4	0.0531	0.0213	<.0001	<.0001	0.1793	0.5332	0.0001	<.0001	0.0108	<.0001	<.0001
NO3	0.16907	0.28425	-0.18116	0.22312	0.19868	0.21732	0.20123	0.1861	0.03443	0.16557	0.16129
NO3	0.189	0.0252	0.1588	0.0813	0.1216	0.0898	0.1168	0.1475	0.7905	0.1984	0.2104
Available_P	-0.05383	-0.15981	0.61661	-0.64242	-0.23923	0.04682	-0.20767	-0.61064	-0.45071	-0.63186	-0.57338
Available_P	0.6778	0.2147	<.0001	<.0001	0.0611	0.7178	0.1053	<.0001	0.0002	<.0001	<.0001
CaCO3	-0.07906	-0.00317	0.66004	-0.55911	-0.36073	-0.1905	-0.23182	-0.49135	-0.43309	-0.47798	-0.41952
CaCO3	0.5413	0.9805	<.0001	<.0001	0.004	0.1381	0.0698	<.0001	0.0004	<.0001	0.0007
Inorganic_C	0.01194	0.05364	0.62211	-0.54532	-0.39014	-0.25687	-0.27427	-0.45909	-0.44549	-0.45146	-0.38438
Inorganic_C	0.9266	0.6788	<.0001	<.0001	0.0017	0.0439	0.031	0.0002	0.0003	0.0002	0.002
Organic_C	0.03793	0.0523	0.4616	-0.42764	-0.26461	0.15967	-0.11856	-0.40766	-0.42438	-0.44627	-0.35348
Organic_C	0.7698	0.6864	0.0002	0.0005	0.0377	0.2151	0.3588	0.001	0.0006	0.0003	0.0048
Total_C	0.01659	0.05701	0.63969	-0.56414	-0.39748	-0.21222	-0.26943	-0.482	-0.47198	-0.48071	-0.40536
Total_C	0.8982	0.6598	<.0001	<.0001	0.0014	0.0977	0.0342	<.0001	0.0001	<.0001	0.0011
Total_N	-0.11687	-0.34672	0.50893	-0.51497	-0.18723	0.23576	-0.13573	-0.52502	-0.27873	-0.60954	-0.55308
Total_N	0.3657	0.0058	<.0001	<.0001	0.1451	0.0651	0.2929	<.0001	0.0283	<.0001	<.0001
Clay	-0.25352	-0.24595	0.86051	-0.87244	-0.34881	0.04238	-0.40711	-0.85084	-0.45729	-0.82213	-0.81005
Clay	0.0468	0.054	<.0001	<.0001	0.0055	0.7437	0.001	<.0001	0.0002	<.0001	<.0001
Silt	-0.30143	-0.29187	0.81491	-0.81557	-0.45034	0.00636	-0.3865	-0.75137	-0.46842	-0.74297	-0.72473
Silt	0.0173	0.0213	<.0001	<.0001	0.0002	0.9608	0.0019	<.0001	0.0001	<.0001	<.0001
Sand	0.29642	0.2871	-0.83153	0.83414	0.43771	-0.01263	0.39421	0.77659	0.47155	0.7646	0.74723
Sand	0.0193	0.0237	<.0001	<.0001	0.0004	0.9224	0.0015	<.0001	0.0001	<.0001	<.0001
Total_Energy	-0.28536	-0.23538	0.1458	-0.23789	-0.07267	-0.08875	-0.06377	-0.24123	-0.04058	-0.21981	-0.29126
Total_Energy	0.0246	0.0655	0.2582	0.0626	0.5746	0.4927	0.6224	0.0589	0.7542	0.086	0.0216
Bulk_Density	-0.08723	-0.25407	0.17469	-0.28982	0.01342	0.20019	0.09225	-0.3013	-0.13052	-0.32366	-0.36089
Bulk_Density	0.5002	0.0463	0.1745	0.0223	0.9176	0.1188	0.4758	0.0173	0.3119	0.0103	0.004

	Cu	Zn	Co	B	Mo	Pb	Cd	Cl	SO4	NO3	Available_P
anle	-0.3886	-0.02849	0.24939	0.42	0.43674	-0.01115	0.10384	0.44154	0.24683	0.16907	-0.05383
anle	0.0018	0.826	0.0506	0.0007	0.0004	0.9314	0.4219	0.0003	0.0531	0.189	0.6778
ANLE1	-0.40873	-0.11483	0.30499	0.23276	0.30659	-0.021	0.08354	0.25241	0.29191	0.28425	-0.15981
ANLE1	0.001	0.3742	0.0159	0.0687	0.0154	0.8713	0.5186	0.0478	0.0213	0.0252	0.2147
pH	0.13448	-0.2891	-0.7615	-0.21739	-0.30845	0.43897	-0.41176	-0.43108	-0.83414	-0.18116	0.61661
pH	0.2974	0.0227	<.0001	0.0897	0.0147	0.0004	0.0009	0.0005	<.0001	0.1588	<.0001
EC	-0.28313	0.33659	0.8774	0.30891	0.4279	-0.37376	0.4794	0.4869	0.96026	0.22312	-0.64242
EC	0.0258	0.0075	<.0001	0.0146	0.0005	0.0028	<.0001	<.0001	<.0001	0.0813	<.0001
Na	-0.01472	0.11536	0.0697	0.79656	0.86167	-0.03184	0.29597	0.9348	0.1728	0.19868	-0.23923
Na	0.9096	0.372	0.5904	<.0001	<.0001	0.8059	0.0195	<.0001	0.1793	0.1216	0.0611
K	0.03937	0.12089	-0.10231	0.75857	0.64408	-0.07204	0.03389	0.51957	0.08065	0.21732	0.04682
K	0.7613	0.3493	0.4288	<.0001	<.0001	0.5779	0.7937	<.0001	0.5332	0.0898	0.7178
Mg	-0.22122	0.17208	0.30263	0.74801	0.8218	-0.14642	0.36139	0.77464	0.46445	0.20123	-0.20767
Mg	0.084	0.1811	0.0168	<.0001	<.0001	0.2561	0.0039	<.0001	0.0001	0.1168	0.1053
Ca	-0.31312	0.31143	0.91581	0.1242	0.26023	-0.3803	0.45207	0.29176	0.9905	0.1861	-0.61064
Ca	0.0132	0.0137	<.0001	0.3362	0.0411	0.0023	0.0002	0.0214	<.0001	0.1475	<.0001
Mn	0.16376	0.45325	0.46562	-0.00593	0.12598	-0.09924	0.30747	0.16165	0.32177	0.03443	-0.45071
Mn	0.2034	0.0002	0.0001	0.9635	0.3292	0.4429	0.0151	0.2094	0.0108	0.7905	0.0002
Fe	-0.31642	0.29714	0.94392	0.10059	0.26443	-0.28121	0.45225	0.27142	0.95828	0.16557	-0.63186
Fe	0.0122	0.019	<.0001	0.4366	0.0378	0.0268	0.0002	0.0329	<.0001	0.1984	<.0001
Ni	-0.36299	0.24334	0.96969	0.08334	0.2195	-0.35506	0.42072	0.22012	0.95789	0.16129	-0.57338
Ni	0.0037	0.0567	<.0001	0.5196	0.0865	0.0046	0.0007	0.0856	<.0001	0.2104	<.0001
Cu	1	0.40926	-0.28448	-0.05978	-0.11341	0.09242	-0.0577	-0.05709	-0.30909	-0.07082	0.09269
Cu		0.001	0.025	0.6444	0.3801	0.475	0.656	0.6594	0.0145	0.5844	0.4737
Zn	0.40926	1	0.24163	0.09693	0.16711	-0.10988	0.13107	0.19071	0.31214	0.0076	-0.25184
Zn	0.001		0.0585	0.4536	0.1942	0.3952	0.3099	0.1376	0.0135	0.9532	0.0483
Co	-0.28448	0.24163	1	0.05188	0.21317	-0.31194	0.44545	0.1725	0.89245	0.17832	-0.55188
Co	0.025	0.0585		0.6888	0.0962	0.0136	0.0003	0.18	<.0001	0.1655	<.0001
B	-0.05978	0.09693	0.05188	1	0.82862	-0.08877	0.16477	0.80137	0.14983	0.40979	-0.02825
B	0.6444	0.4536	0.6888		<.0001	0.4926	0.2006	<.0001	0.2451	0.0009	0.8275
Mo	-0.11341	0.16711	0.21317	0.82862	1	0.01973	0.26528	0.87367	0.27135	0.22845	-0.17666
Mo	0.3801	0.1942	0.0962	<.0001		0.879	0.0372	<.0001	0.0329	0.0741	0.1696
Pb	0.09242	-0.10988	-0.31194	-0.08877	0.01973	1	-0.19434	-0.11442	-0.39494	0.00815	0.18275
Pb	0.475	0.3952	0.0136	0.4926	0.879		0.1301	0.3759	0.0015	0.9499	0.1551
Cd	-0.0577	0.13107	0.44545	0.16477	0.26528	-0.19434	1	0.34333	0.45406	0.15397	-0.40441
Cd	0.656	0.3099	0.0003	0.2006	0.0372	0.1301		0.0063	0.0002	0.2322	0.0011
Cl	-0.05709	0.19071	0.1725	0.80137	0.87367	-0.11442	0.34333	1	0.29753	0.21377	-0.33405
Cl	0.6594	0.1376	0.18	<.0001	<.0001	0.3759	0.0063		0.0188	0.0953	0.008
SO4	-0.30909	0.31214	0.89245	0.14983	0.27135	-0.39494	0.45406	0.29753	1	0.19613	-0.60768
SO4	0.0145	0.0135	<.0001	0.2451	0.0329	0.0015	0.0002	0.0188		0.1266	<.0001
NO3	-0.07082	0.0076	0.17832	0.40979	0.22845	0.00815	0.15397	0.21377	0.19613	1	-0.06046
NO3	0.5844	0.9532	0.1655	0.0009	0.0741	0.9499	0.2322	0.0953	0.1266		0.6406
Available_P	0.09269	-0.25184	-0.55188	-0.02825	-0.17666	0.18275	-0.40441	-0.33405	-0.60768	-0.06046	1
Available_P	0.4737	0.0483	<.0001	0.8275	0.1696	0.1551	0.0011	0.008	<.0001	0.6406	
CaCO3	-0.18096	-0.3673	-0.40424	-0.29594	-0.22083	0.29185	-0.22521	-0.41556	-0.48301	-0.21949	0.63701
CaCO3	0.1593	0.0033	0.0011	0.0195	0.0846	0.0214	0.0784	0.0008	<.0001	0.0865	<.0001
Inorganic_C	-0.21738	-0.345	-0.37344	-0.3401	-0.26878	0.32164	-0.19152	-0.44856	-0.45512	-0.16111	0.62275
Inorganic_C	0.0897	0.006	0.0028	0.0068	0.0347	0.0108	0.1359	0.0003	0.0002	0.211	<.0001
Organic_C	-0.10027	-0.26288	-0.33567	0.09701	-0.08451	0.00561	-0.2745	-0.28258	-0.38326	0.09803	0.65679
Organic_C	0.4381	0.039	0.0076	0.4532	0.5137	0.9655	0.0308	0.0261	0.0021	0.4484	<.0001
Total_C	-0.21448	-0.35577	-0.39268	-0.29793	-0.25934	0.29619	-0.21656	-0.45379	-0.47473	-0.13341	0.6692
Total_C	0.0941	0.0045	0.0016	0.0187	0.0418	0.0194	0.0909	0.0002	<.0001	0.3012	<.0001
Total_N	0.20081	-0.07448	-0.5468	0.07023	-0.18821	0.18199	-0.18473	-0.20077	-0.52958	0.0147	0.51196
Total_N	0.1176	0.5651	<.0001	0.5875	0.1429	0.1569	0.1506	0.1177	<.0001	0.9097	<.0001
Clay	0.09443	-0.33023	-0.78497	-0.17707	-0.32312	0.34616	-0.46908	-0.46806	-0.82545	-0.21925	0.70161
Clay	0.4654	0.0088	<.0001	0.1686	0.0104	0.0059	0.0001	0.0001	<.0001	0.0869	<.0001
Silt	0.06422	-0.29371	-0.72249	-0.30191	-0.39669	0.3148	-0.42381	-0.54573	-0.73733	-0.26691	0.71019
Silt	0.62	0.0205	<.0001	0.0171	0.0014	0.0127	0.0006	<.0001	<.0001	0.036	<.0001
Sand	-0.07011	0.30316	0.74103	0.28366	0.38829	-0.32359	0.43617	0.53822	0.76044	0.26158	-0.71636
Sand	0.5882	0.0166	<.0001	0.0255	0.0018	0.0103	0.0004	<.0001	<.0001	0.04	<.0001
Total_Energy	0.26365	-0.0114	-0.23913	-0.13662	-0.20155	0.17535	0.01926	-0.18808	-0.24375	0.10658	0.31891
Total_Energy	0.0384	0.9299	0.0612	0.2897	0.1162	0.1728	0.8819	0.1432	0.0562	0.4096	0.0115
Bulk_Density	0.08366	0.23666	-0.39037	0.04816	0.0219	0.0902	-0.33848	-0.00586	-0.331	-0.16936	0.19251
Bulk_Density	0.518	0.064	0.0017	0.7101	0.8658	0.4857	0.0071	0.9639	0.0086	0.1882	0.1339

	CaCO3	Inorganic_C	Organic_C	Total_C	Total_N	Clay	Silt	Sand	Total_Energy	Bulk_Density
anle	-0.07906	0.01194	0.03793	0.01659	-0.11687	-0.25352	-0.30143	0.29642	-0.28536	-0.08723
anle	0.5413	0.9266	0.7698	0.8982	0.3657	0.0468	0.0173	0.0193	0.0246	0.5002
ANLE1	-0.00317	0.05364	0.0523	0.05701	-0.34672	-0.24595	-0.29187	0.2871	-0.23538	-0.25407
ANLE1	0.9805	0.6788	0.6864	0.6598	0.0058	0.054	0.0213	0.0237	0.0655	0.0463
pH	0.66004	0.62211	0.4616	0.63969	0.50893	0.86051	0.81491	-0.83153	0.1458	0.17469
pH	<.0001	<.0001	0.0002	<.0001	<.0001	<.0001	<.0001	<.0001	0.2582	0.1745
EC	-0.55911	-0.54532	-0.42764	-0.56414	-0.51497	-0.87244	-0.81557	0.83414	-0.23789	-0.28982
EC	<.0001	<.0001	0.0005	<.0001	<.0001	<.0001	<.0001	<.0001	0.0626	0.0223
Na	-0.36073	-0.39014	-0.26461	-0.39748	-0.18723	-0.34881	-0.45034	0.43771	-0.07267	0.01342
Na	0.004	0.0017	0.0377	0.0014	0.1451	0.0055	0.0002	0.0004	0.5746	0.9176
K	-0.1905	-0.25687	0.15967	-0.21222	0.23576	0.04238	0.00636	-0.01263	-0.08875	0.20019
K	0.1381	0.0439	0.2151	0.0977	0.0651	0.7437	0.9608	0.9224	0.4927	0.1188
Mg	-0.23182	-0.27427	-0.11856	-0.26943	-0.13573	-0.40711	-0.3865	0.39421	-0.06377	0.09225
Mg	0.0698	0.031	0.3588	0.0342	0.2929	0.001	0.0019	0.0015	0.6224	0.4758
Ca	-0.49135	-0.45909	-0.40766	-0.482	-0.52502	-0.85084	-0.75137	0.77659	-0.24123	-0.3013
Ca	<.0001	0.0002	0.001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0589	0.0173
Mn	-0.43309	-0.44549	-0.42438	-0.47198	-0.27873	-0.45729	-0.46842	0.47155	-0.04058	-0.13052
Mn	0.0004	0.0003	0.0006	0.0001	0.0283	0.0002	0.0001	0.0001	0.7542	0.3119
Fe	-0.47798	-0.45146	-0.44627	-0.48071	-0.60954	-0.82213	-0.74297	0.7646	-0.21981	-0.32366
Fe	<.0001	0.0002	0.0003	<.0001	<.0001	<.0001	<.0001	<.0001	0.086	0.0103
Ni	-0.41952	-0.38438	-0.35348	-0.40536	-0.55308	-0.81005	-0.72473	0.74723	-0.29126	-0.36089
Ni	0.0007	0.002	0.0048	0.0011	<.0001	<.0001	<.0001	<.0001	0.0216	0.004
Cu	-0.18096	-0.21738	-0.10027	-0.21448	0.20081	0.09443	0.06422	-0.07011	0.26365	0.08366
Cu	0.1593	0.0897	0.4381	0.0941	0.1176	0.4654	0.62	0.5882	0.0384	0.518
Zn	-0.3673	-0.345	-0.26288	-0.35577	-0.07448	-0.33023	-0.29371	0.30316	-0.0114	0.23666
Zn	0.0033	0.006	0.039	0.0045	0.5651	0.0088	0.0205	0.0166	0.9299	0.064
Co	-0.40424	-0.37344	-0.33567	-0.39268	-0.5468	-0.78497	-0.72249	0.74103	-0.23913	-0.39037
Co	0.0011	0.0028	0.0076	0.0016	<.0001	<.0001	<.0001	<.0001	0.0612	0.0017
B	-0.29594	-0.3401	0.09701	-0.29793	0.07023	-0.17707	-0.30191	0.28366	-0.13662	0.04816
B	0.0195	0.0068	0.4532	0.0187	0.5875	0.1686	0.0171	0.0255	0.2897	0.7101
Mo	-0.22083	-0.26878	-0.08451	-0.25934	-0.18821	-0.32312	-0.39669	0.38829	-0.20155	0.0219
Mo	0.0846	0.0347	0.5137	0.0418	0.1429	0.0104	0.0014	0.0018	0.1162	0.8658
Pb	0.29185	0.32164	0.00561	0.29619	0.18199	0.34616	0.3148	-0.32359	0.17535	0.0902
Pb	0.0214	0.0108	0.9655	0.0194	0.1569	0.0059	0.0127	0.0103	0.1728	0.4857
Cd	-0.22521	-0.19152	-0.2745	-0.21656	-0.18473	-0.46908	-0.42381	0.43617	0.01926	-0.33848
Cd	0.0784	0.1359	0.0308	0.0909	0.1506	0.0001	0.0006	0.0004	0.8819	0.0071
Cl	-0.41556	-0.44856	-0.28258	-0.45379	-0.20077	-0.46806	-0.54573	0.53822	-0.18808	-0.00586
Cl	0.0008	0.0003	0.0261	0.0002	0.1177	0.0001	<.0001	<.0001	0.1432	0.9639
SO4	-0.48301	-0.45512	-0.38326	-0.47473	-0.52958	-0.82545	-0.73733	0.76044	-0.24375	-0.331
SO4	<.0001	0.0002	0.0021	<.0001	<.0001	<.0001	<.0001	<.0001	0.0562	0.0086
NO3	-0.21949	-0.16111	0.09803	-0.13341	0.0147	-0.21925	-0.26691	0.26158	0.10658	-0.16936
NO3	0.0865	0.211	0.4484	0.3012	0.9097	0.0869	0.036	0.04	0.4096	0.1882
Available_P	0.63701	0.62275	0.65679	0.6692	0.51196	0.70161	0.71019	-0.71636	0.31891	0.19251
Available_P	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0115	0.1339
CaCO3	1	0.9568	0.48017	0.94979	0.32521	0.70058	0.7377	-0.73925	0.10751	-0.02223
CaCO3		<.0001	<.0001	<.0001	0.0099	<.0001	<.0001	<.0001	0.4056	0.8638
Inorganic_C	0.9568	1	0.49516	0.99168	0.32974	0.66778	0.72289	-0.72118	0.07469	-0.02675
Inorganic_C	<.0001		<.0001	<.0001	0.0089	<.0001	<.0001	<.0001	0.564	0.8365
Organic_C	0.48017	0.49516	1	0.6029	0.50454	0.52767	0.57423	-0.5724	0.08781	0.05598
Organic_C	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001	<.0001	0.4973	0.6657
Total_C	0.94979	0.99168	0.6029	1	0.37757	0.69142	0.74892	-0.74708	0.0816	-0.01627
Total_C	<.0001	<.0001	<.0001		0.0025	<.0001	<.0001	<.0001	0.5284	0.9001
Total_N	0.32521	0.32974	0.50454	0.37757	1	0.5299	0.60278	-0.59672	0.1248	0.15481
Total_N	0.0099	0.0089	<.0001	0.0025		<.0001	<.0001	<.0001	0.3338	0.2296
Clay	0.70058	0.66778	0.52767	0.69142	0.5299	1	0.92506	-0.94792	0.12892	0.17645
Clay	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	0.318	0.1701
Silt	0.7377	0.72289	0.57423	0.74892	0.60278	0.92506	1	-0.99786	0.15845	0.17531
Silt	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001	0.2187	0.1729
Sand	-0.73925	-0.72118	-0.5724	-0.74708	-0.59672	-0.94792	-0.99786	1	-0.15507	-0.1774
Sand	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		0.2288	0.1678
Total_Energy	0.10751	0.07469	0.08781	0.0816	0.1248	0.12892	0.15845	-0.15507	1	0.12491
Total_Energy	0.4056	0.564	0.4973	0.5284	0.3338	0.318	0.2187	0.2288		0.3334
Bulk_Density	-0.02223	-0.02675	0.05598	-0.01627	0.15481	0.17645	0.17531	-0.1774	0.12491	1
Bulk_Density	0.8638	0.8365	0.6657	0.9001	0.2296	0.1701	0.1729	0.1678	0.3334	

Appendix 7. Perennial vegetation at sandy sites

Scientific Name	Common Name
Ambrosia dumosa	White bursage
Achnatherum hymenoides	Ricegrass
Ephedra sp.	Ephedra
Eriogonum inflatum	Desert trumpet
Krameria erecta	Pima rhatany
Krameria grayii	White rhatany
Larrea tridentata	Creosote bush
Opuntia basilaris	Beavertail cactus
Opuntia echinocarpa	Silver cholla
Pleuraphis rigida	Big galleta grass
Psorothamnus fremontii	Indigobush
Sphaeralcea ambigua	Globemallow
Stephanomeria pauciflora	Wire lettuce
Tamarix ramosissima	Saltcedar

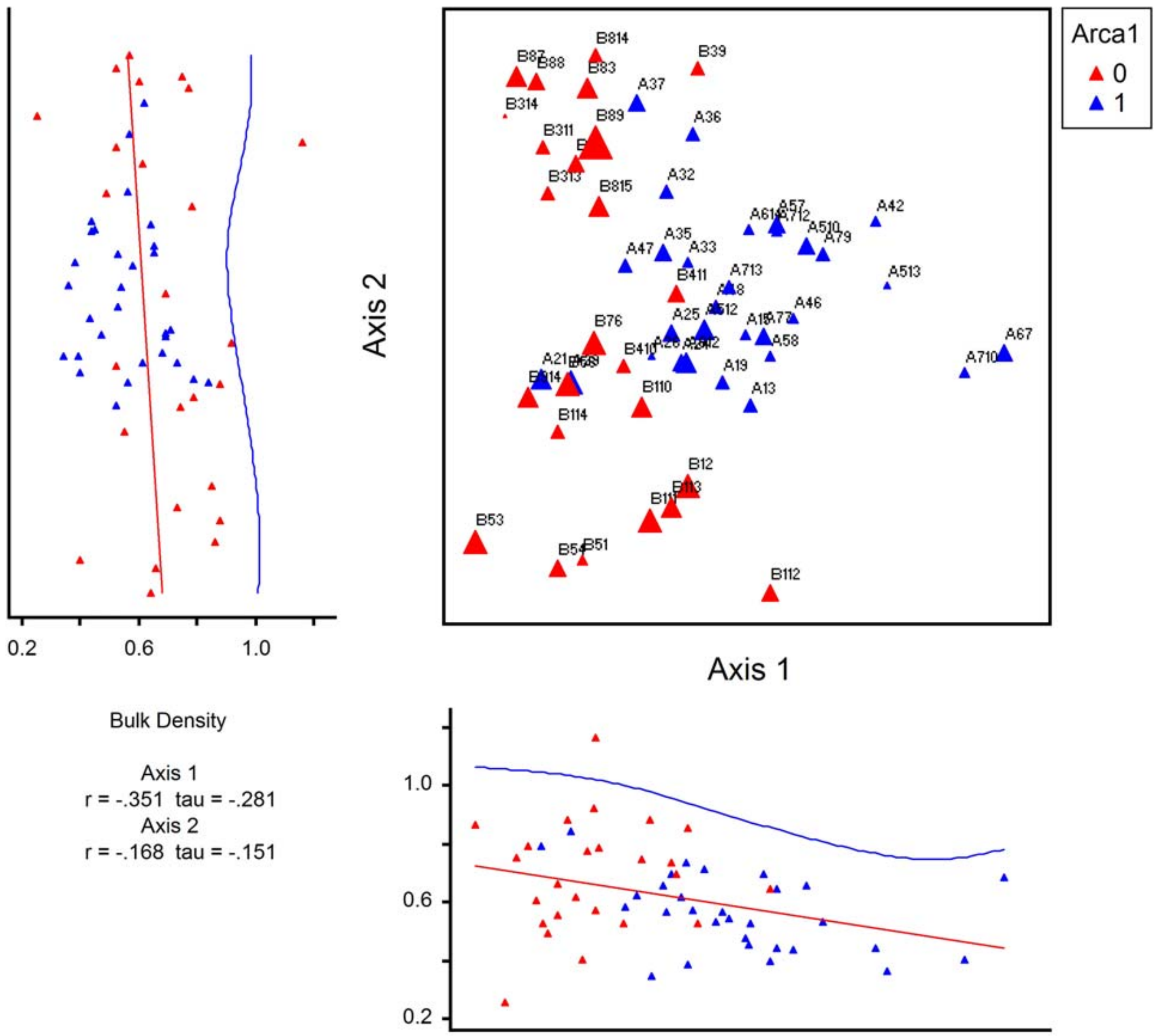
Appendix 8. Perennial vegetation at gypsum sites

Scientific Name	Common Name
Acacia gregii	Catclaw
Allenrolfea occidentalis	Iodinebush
Ambrosia dumosa	White bursage
Amphipappus fremontii	Chaffbush
Anulocaulis leiosolenus var. *leiosolenus*	Ringstem
Arctomecon californica	Las Vegas bearpoppy
Aristida purpurea	Purple threeawn
Atriplex confertifolia	Shadscale
Atriplex hymenoclea	Desert holly
Chamaesyce fendleri	Fendlers sandmat
Distichlis spicata	Saltgrass
Enceliopsis argophylla	Sunray
Encelia farinosa	Brittlebush
Ephedra nevadensis	Nevada ephedra
Ephedra torreyana	Torrey ephedra
Eriogonum inflatum	Desert trumpet
Galium stellatum var. *eremicum*	Crevice bedstraw
Gutierrezia sarothrae	Snakeweed
Hymenoclea salsola var. *salsola*	Cheesebush
Isocoma acradenia	Alkali goldenbush
Krameria erecta	Pima rhatany
Krameria grayii	White rhatany
Krascheninnikovia lanata	Winterfat
Larrea tridentata	Creosote bush
Lepidium fremontii	Desert alyssum
Lycium andersonii	Andersons wolfberry
Opuntia basilaris	Beavertail cactus
Opuntia echinocarpa	Silver cholla
Petalonyx parryi	Parrys sandpaper plant
Peucephyllum schottii	Pygmy cedar
Phacelia palmeri	Palmers phacelia
Pleuraphis rigida	Big galleta grass
Psorothamnus fremontii	Indigobush
Salazaria mexicana	Bladdersage
Sclerocactus johnsonii	Pigmy barrel cactus
Sphaeralcea ambigua	Globemallow
Sporobolus airoides	Alkali sacaton
Stephanomeria pauciflora	Wire lettuce
Suaeda nigra	Seepbush
Tiquilia latior	Matted tiquilia
Yucca utahensis	Utah yucca

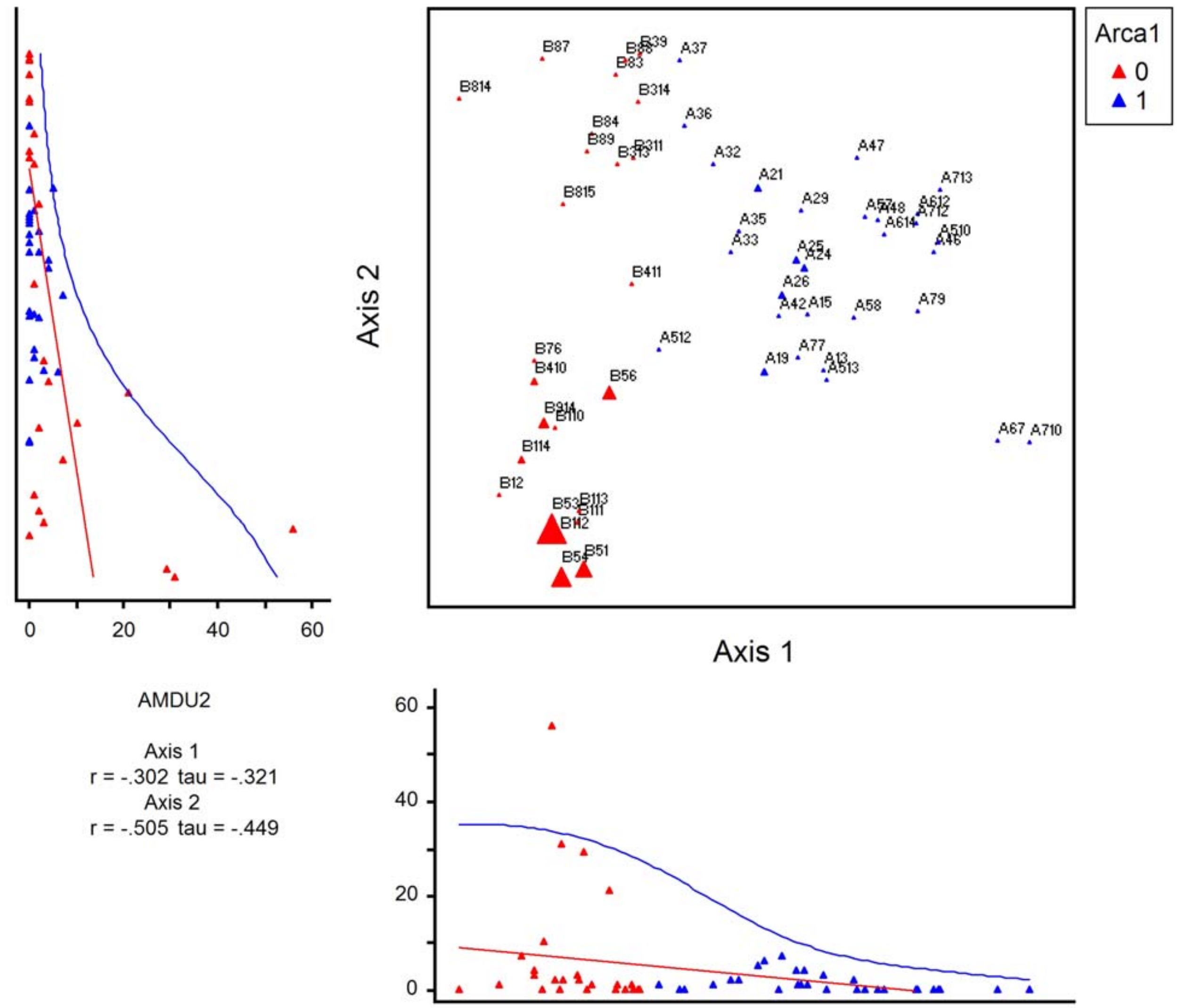
Appendix 9. Analysis of variable in Las Vegas bearpoppy NMS ordination = Las Vegas bear poppy absent. =Las Vegas bearpoppy present.

Plot Name	ARCA	Site	Plot Name	ARCA	Site
A13	present	Gold Butte	B12	absent	Gold Butte
A15	present	Gold Butte	B110	absent	Gold Butte
A19	present	Gold Butte	B111	absent	Gold Butte
A21	present	Blue Point	B112	absent	Gold Butte
A24	present	Blue Point	B113	absent	Gold Butte
A25	present	Blue Point	B114	absent	Gold Butte
A26	present	Blue Point	B39	absent	Valley of Fire
A29	present	Blue Point	B311	absent	Valley of Fire
A32	present	Valley of Fire	B313	absent	Valley of Fire
A33	present	Valley of Fire	B314	absent	Valley of Fire
A35	present	Valley of Fire	B410	absent	Gale Hills
A36	present	Valley of Fire	B411	absent	Gale Hills
A37	present	Valley of Fire	B83	absent	Valley of Fire
A42	present	Gale Hills	B84	absent	Valley of Fire
A46	present	Gale Hills	B87	absent	Valley of Fire
A47	present	Gale Hills	B88	absent	Valley of Fire
A48	present	Gale Hills	B89	absent	Valley of Fire
A57	present	Road 100	B814	absent	Valley of Fire
A58	present	Road 100	B815	absent	Valley of Fire
A510	present	Road 100	B51	absent	Road 100
A512	present	Road 100	B53	absent	Road 100
A513	present	Road 100	B54	absent	Road 100
A67	present	Sunrise Hills	B56	absent	Road 100
A612	present	Sunrise Hills	B914	absent	Road 100
A614	present	Sunrise Hills	B76	absent	Sunrise Hills
A77	present	Sunrise Hills			
A79	present	Sunrise Hills			
A710	present	Sunrise Hills			
A712	present	Sunrise Hills			
A713	present	Sunrise Hills			

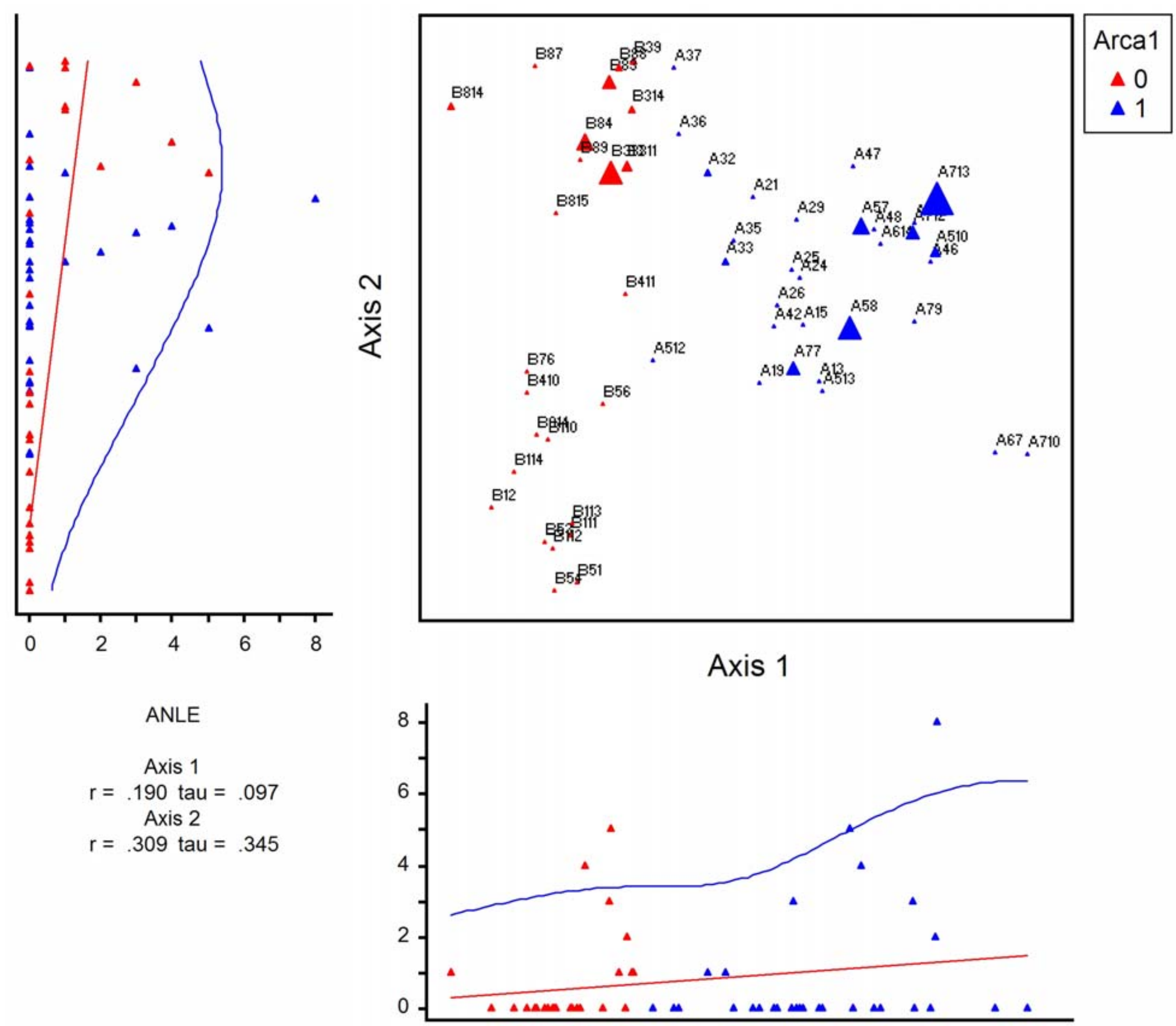
Bulk Density



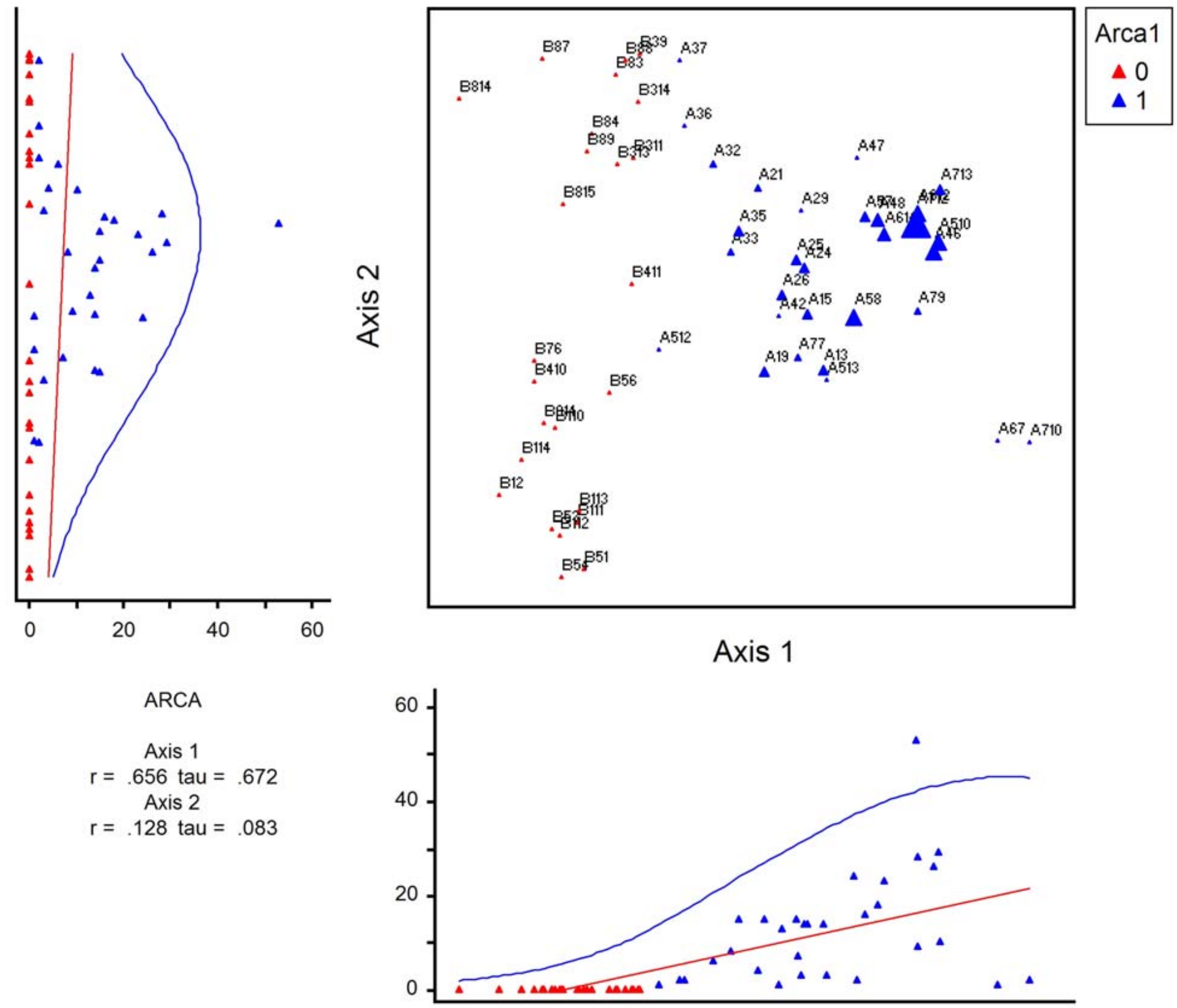
Ambrosia dumosa



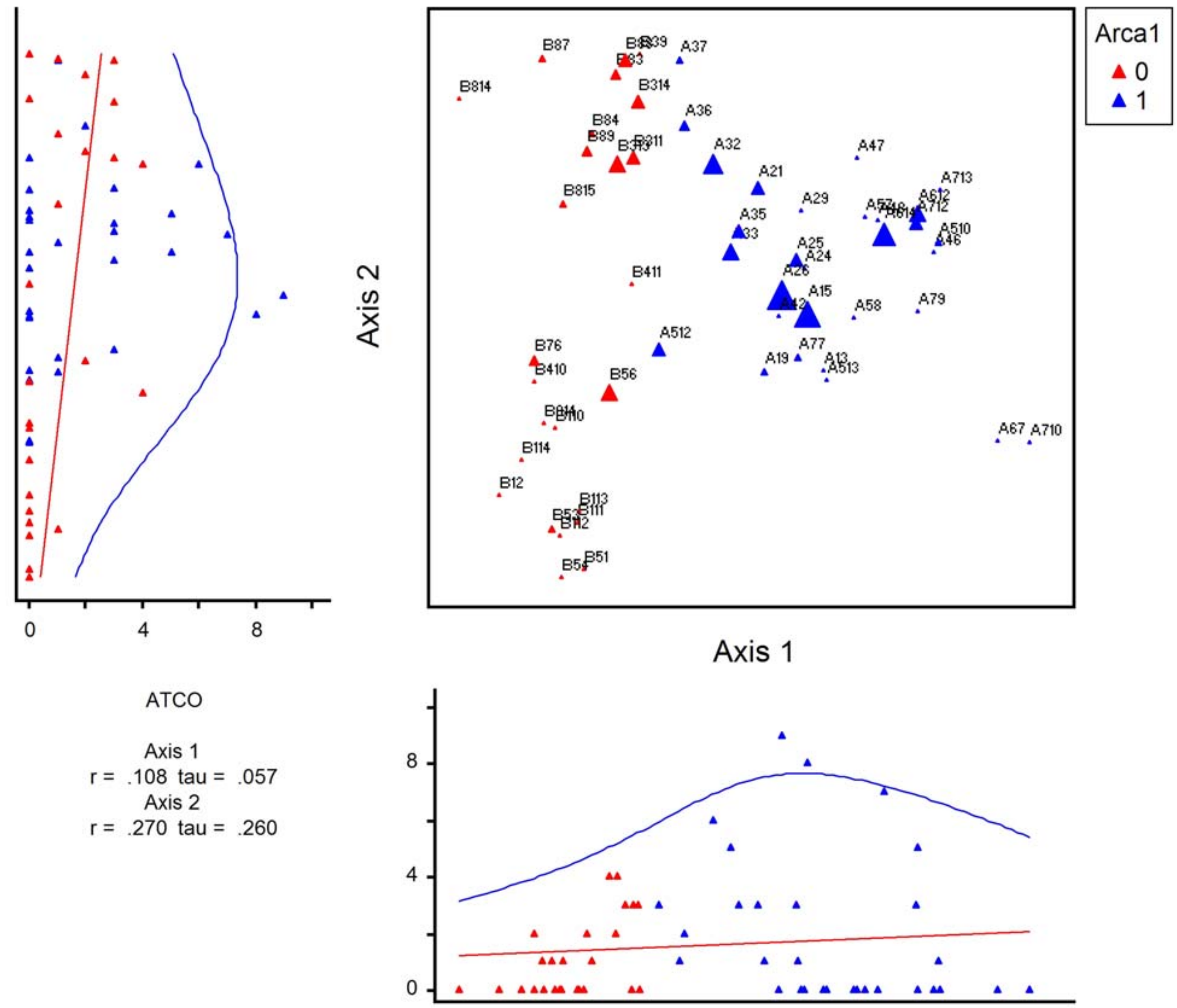
Anulocaulis leiosolenus var. *leiosolenus*



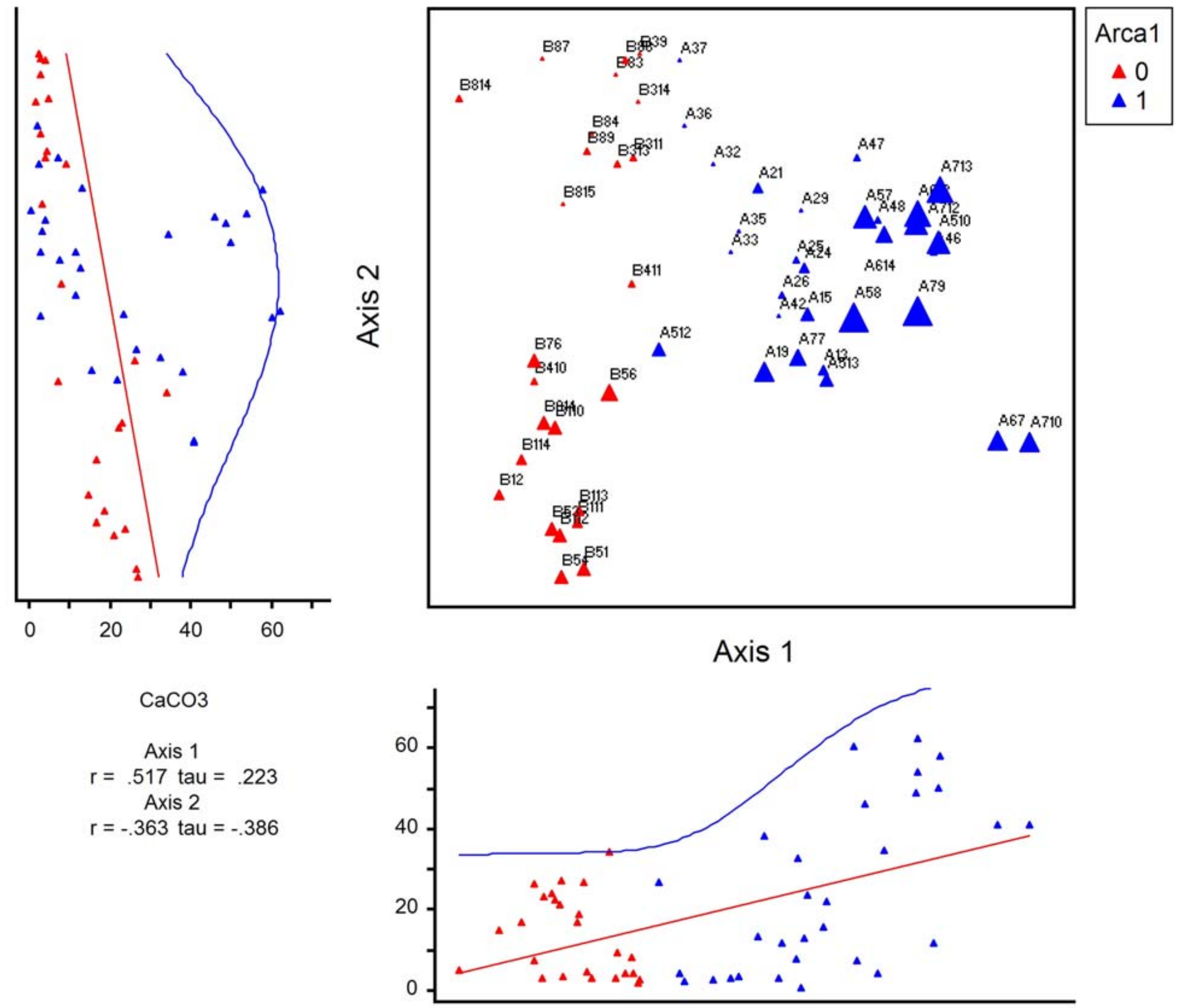
Arctomecon californica



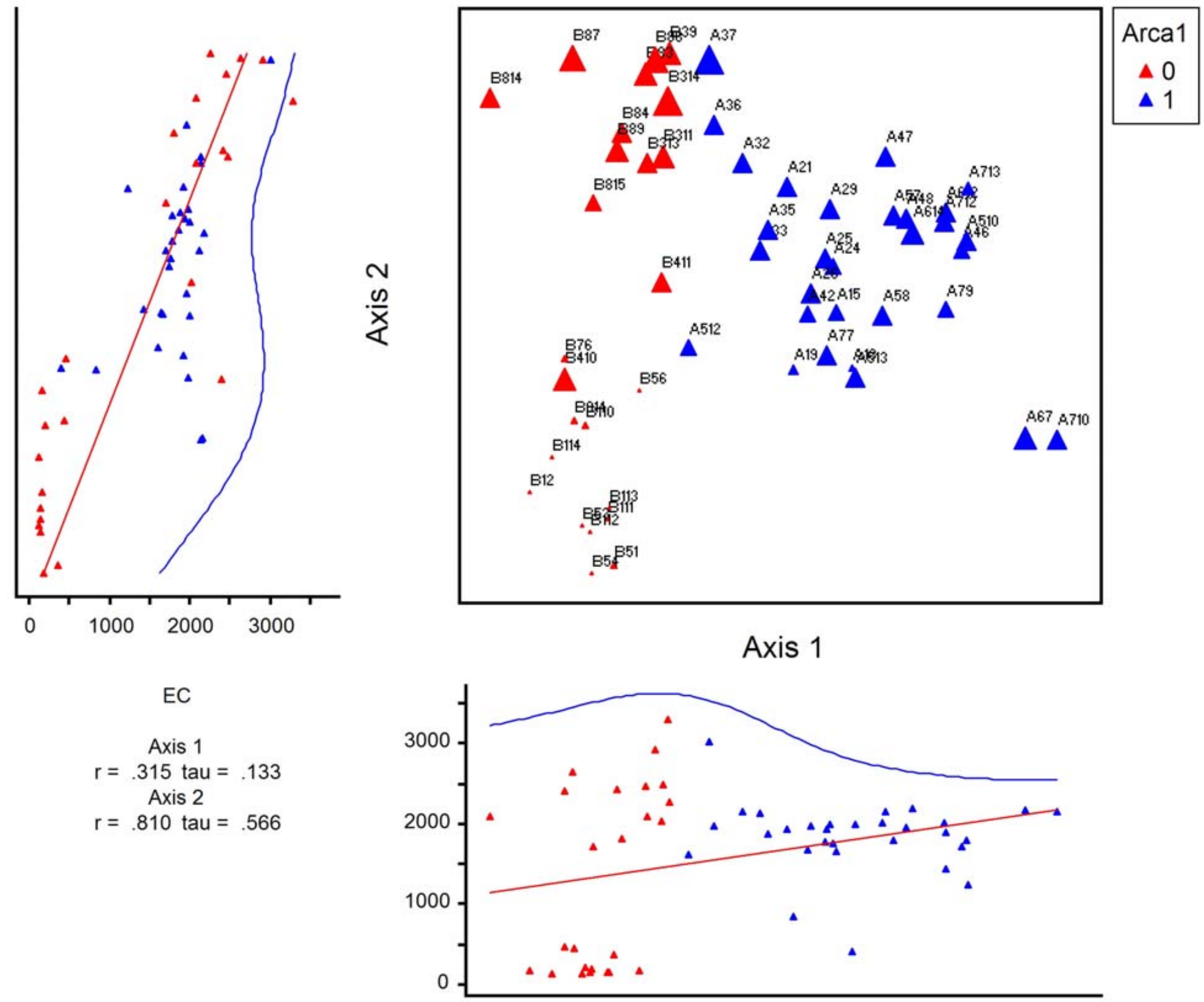
Atriplex confertifolia



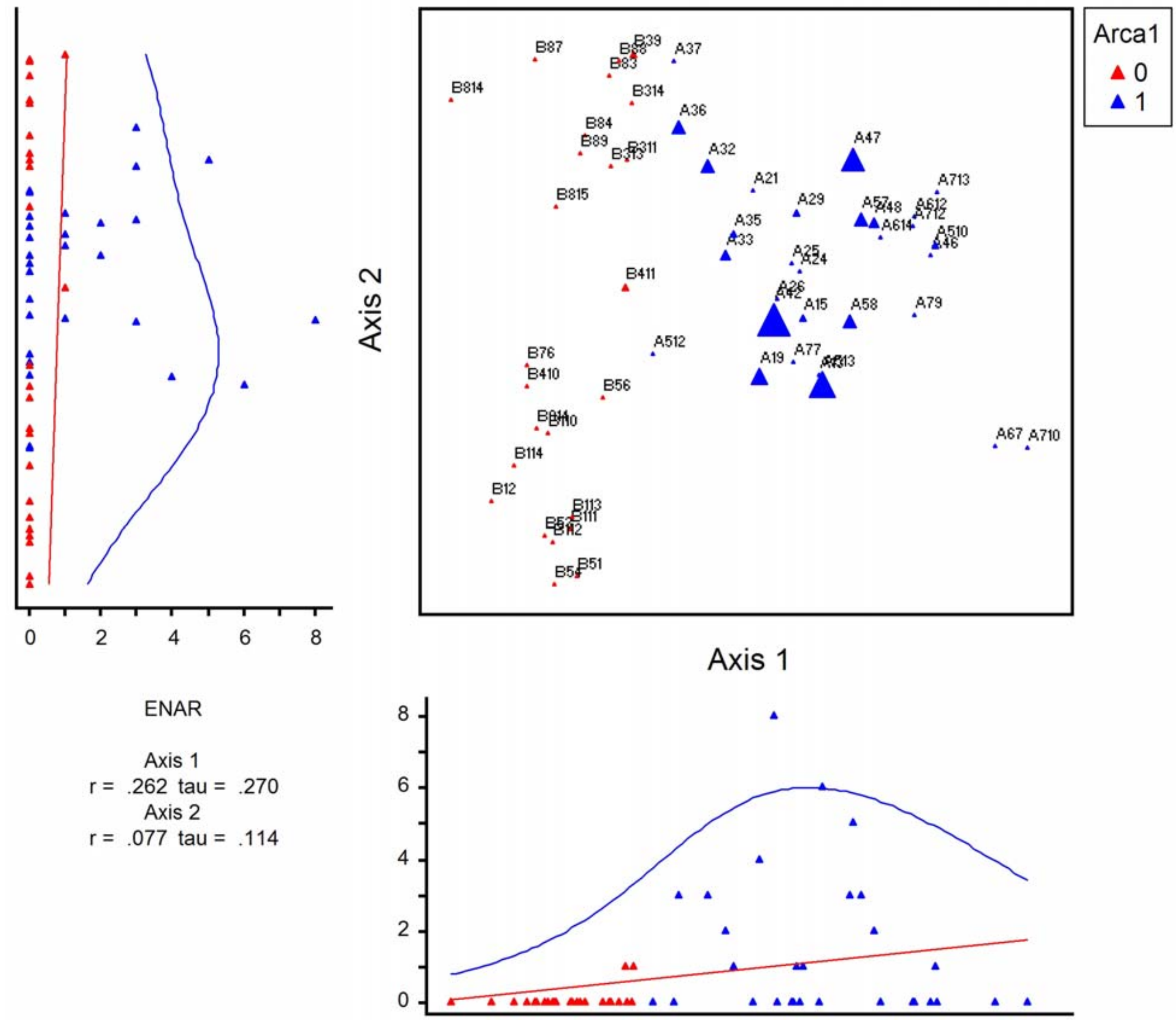
CaCO3


Arca1
0
1
Axis 1
Axis 2
0
20
40
60
CaCO3
Axis 1
r = .517 tau = .223
Axis 2
r = -.363 tau = -.386

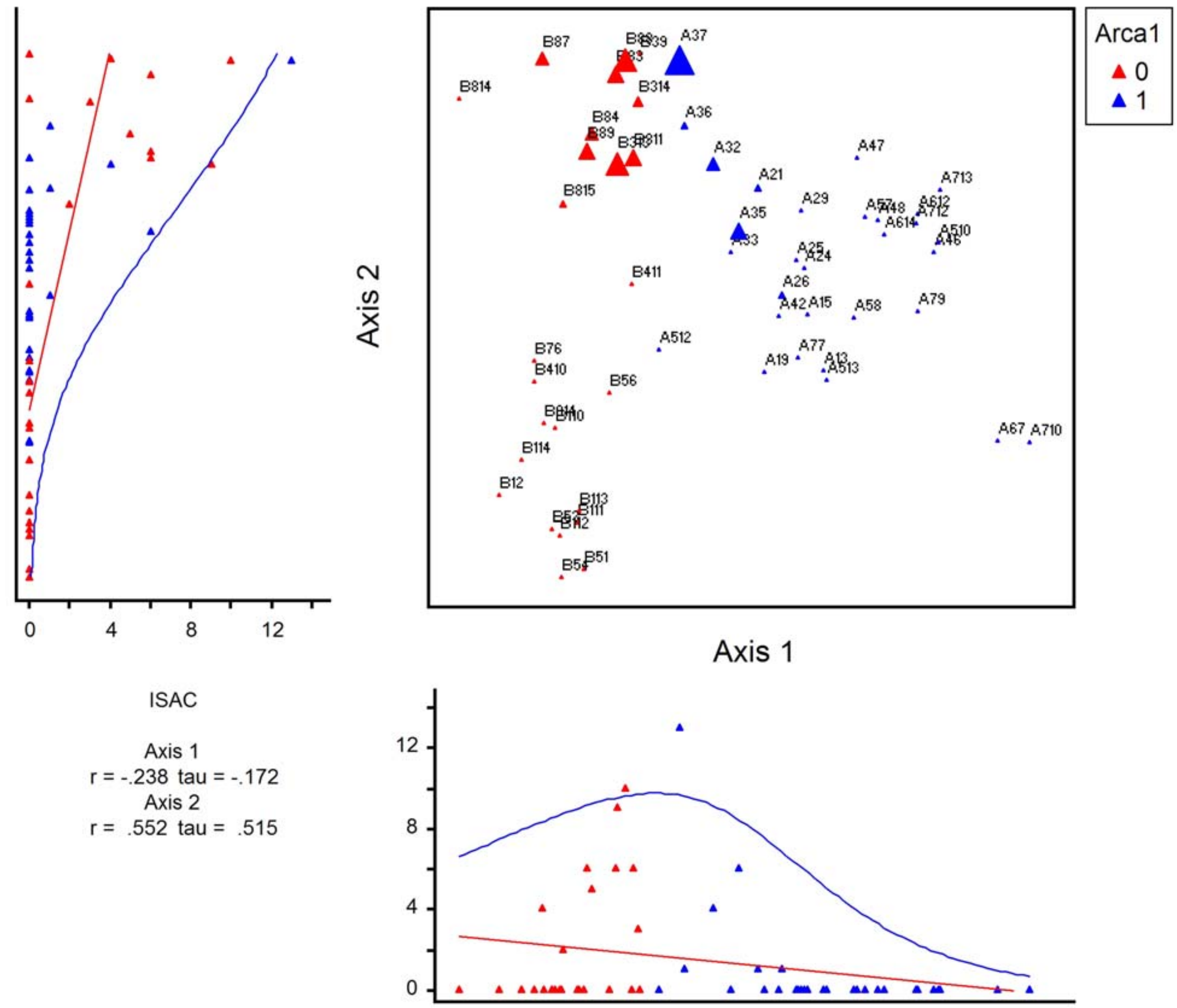
EC


Arca1
0
1
Axis 2
Axis 1
0
1000
2000
3000
EC
Axis 1
r = .315 tau = .133
Axis 2
r = .810 tau = .566

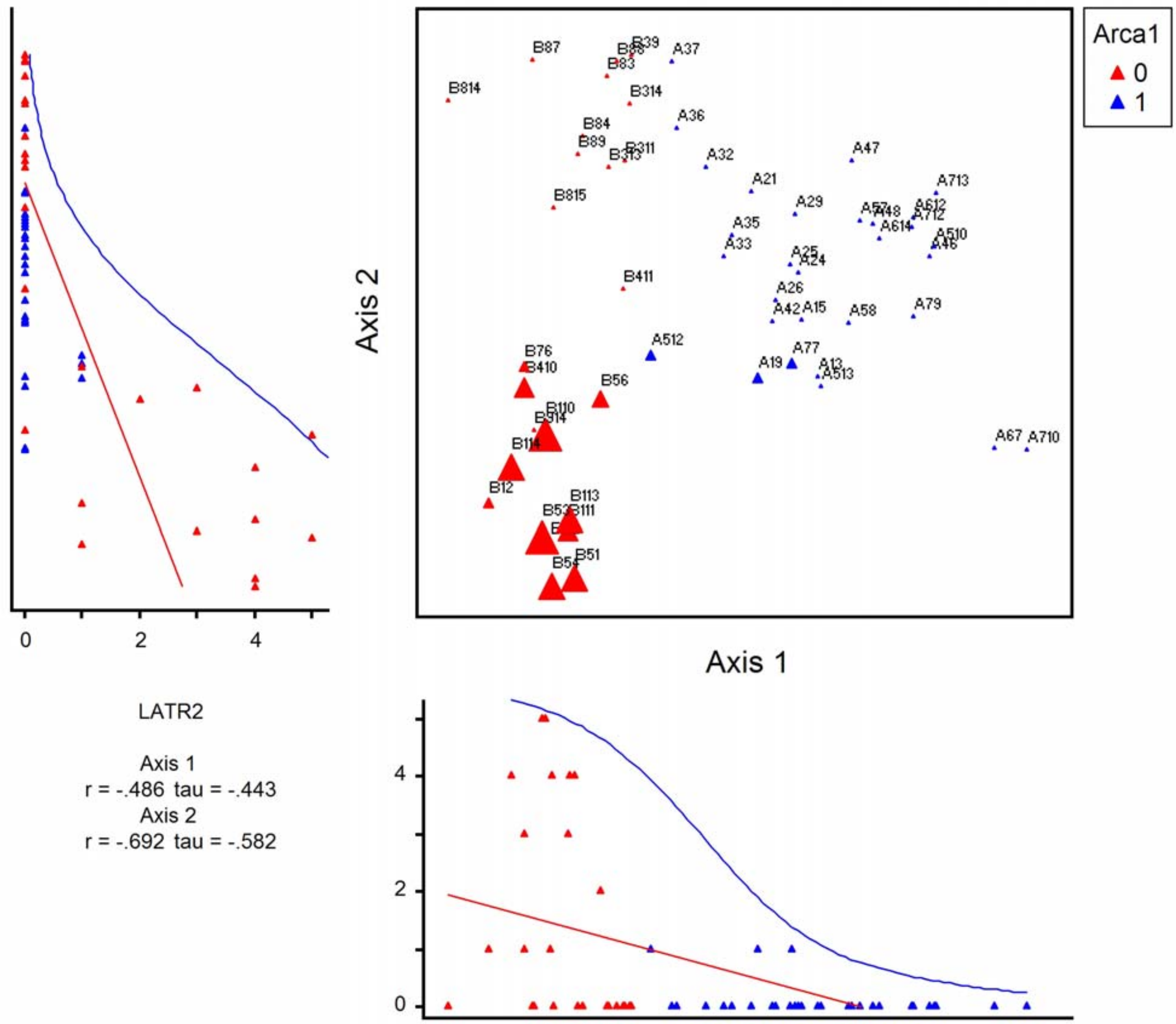
Enceliopsis argophylla



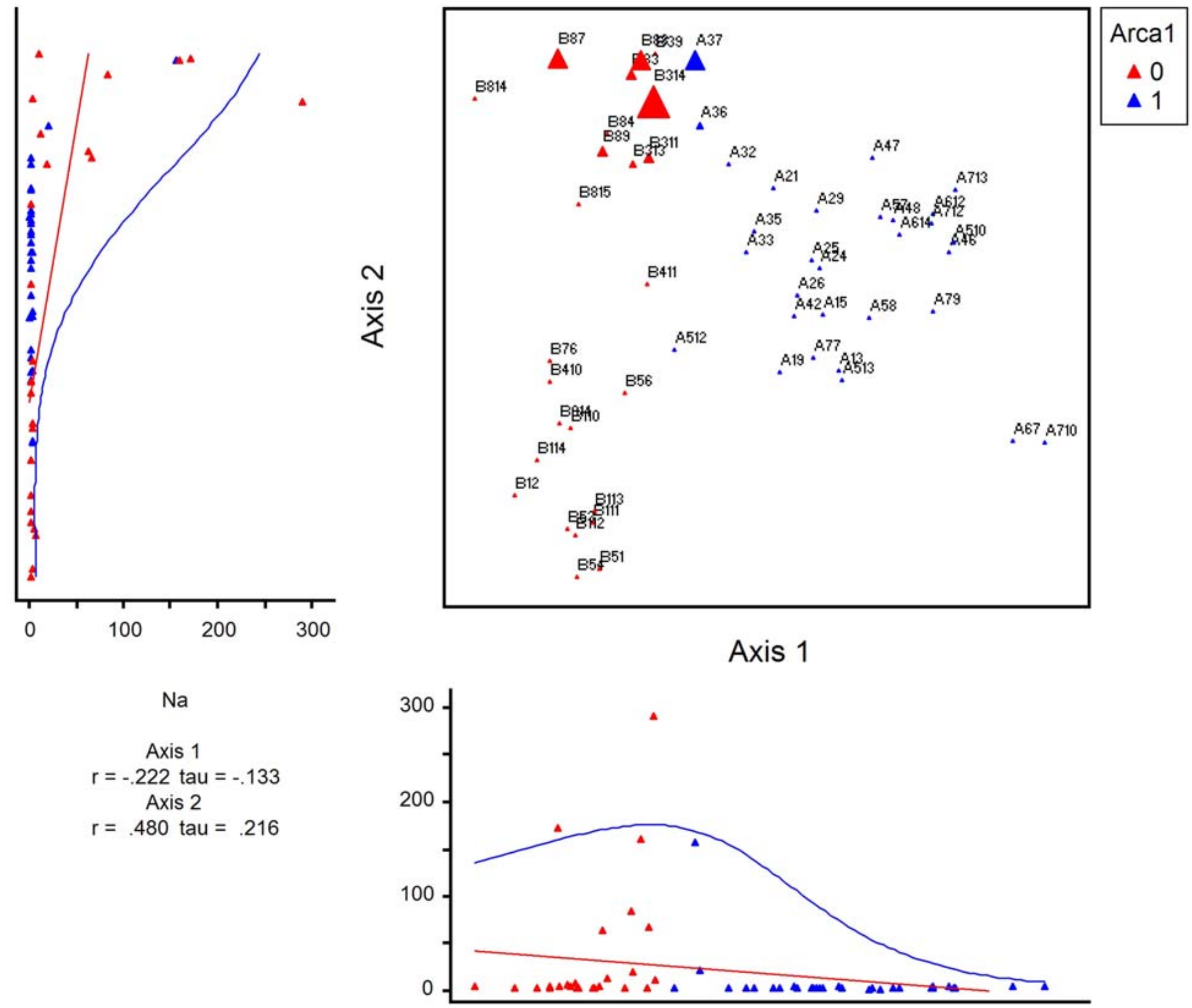
Isocoma acradenia



Larrea tridentata



Na


Arca1
0
1
Axis 2
Axis 1
0
100
200
300
Na
Axis 1
r = -.222 tau = -.133
Axis 2
r = .480 tau = .216

SO4