Soil Data for Desert Tortoise Occupancy Covariate Monitoring
Boulder City Conservation Easement

Final Report

Submitted to:
Clark County Desert Conservation Program

Submitted by:
Logan Simpson Design Inc.
777 North Rainbow Boulevard, Suite 385
Las Vegas, Nevada 89107

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Lead Investigator: Blake Krejci
Project Manager: Bruce Palmer

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Executive Summary

This project is a survey of the geomorphic surfaces present in 80 predetermined plots in the Boulder City Conservation Easement. It is part of a larger study by the Clark County Desert Conservation Program to model habitat occupied by the desert tortoise. A traverse sampling method was used to collect data on the different geomorphic surfaces along three transects in each plot. In addition, soil pits were described to the series level, where series were available, at each of the 15 predetermined locations near active tortoise burrows.

Following data collection, plots were combined into groups with similar characteristics. It was determined whether or not these groups fit with the concept of their associated map unit from the original NRCS soil map. It is recommended that some delineations and map units be changed on the original soil map for Eldorado Valley to reflect the field data. Next, representative plots and pit locations were selected from each group to accurately represent the different types of soils in each group. There are a total of 18 locations recommended for full descriptions (future pits), some of which may also need full characterization (lab analysis) of the horizons. Some acid dissolution experiments are also recommended to determine cementing agents in exposed restrictive feature samples that were collected during this project.

Introduction

Description of the Project

This project is a small scale soil survey conducted by Logan Simpson Design (LSD) in the Boulder City Conservation Easement (BCCE) under contract by the Clark County Desert Conservation Program (DCP). The purpose is to validate the geomorphic surface and evaluate how well the study sites fit with the concept of their associated Map Unit from the original Natural Resource Conservation Service (NRCS) soil survey. A method was developed through collaboration between the Desert Conservation Program (DCP), a NRCS Resource Soil Scientist, and LSD. The LSD field team responsible for data collection consisted of Blake Krejci and Lindsey Chiquoine.

Geomorphic surface data consisting of surface rock fragment abundance, slope class, flooding class, and surface texture was collected on 80 predetermined plots during fall 2013 via traverse sampling method. Additionally, soil pits were described near active desert tortoise burrows located in the plots. The validity of the existing Map Units was evaluated based on surface characteristics. The field data is intended to be used by the DCP as part of a larger model to predict desert tortoise occupancy.

Background and Need for the Project

This project is part of the Desert Tortoise Occupancy Covariate Monitoring Project (2009-CC-801), a larger effort being conducted by the DCP to collect a range of covariates to describe habitat of the desert tortoise in the Upper Eldorado Valley, Clark County, Nevada. The other covariates include perennial and ephemeral vegetation, precipitation, disturbances and habitat alterations, and management actions. The soils data will be used to assist in the interpretation of the results from desert tortoise occupancy sampling and in the development of a fine-scale predictive model of desert tortoise occurrence within the BCCE and other similar ecological systems. The data collected in this project will be used by the DCP staff to produce a soil map of the entire BCCE. For the occupancy sampling project the ultimate goal is to correlate soil series with the presence of tortoises.

The covariate monitoring protocol accompanies a previously developed occupancy sampling monitoring protocol designed to assess the status and long-term spatial trends of the desert tortoise in the BCCE. The covariates will be used to interpret the occupancy sampling data and test for correlations with hypothesized causal factors that influence the presence of desert tortoises. The correlated causal factors will then be used to develop and evaluate management actions intended to increase the presence of the desert tortoise.

Management Actions Addressed

The project occurred on a protected easement where vehicle travel was limited to open roads. Desert tortoises, when observed, were not disturbed in any manner. Rules and regulations pertaining to the easement were followed at all times.

Goals and Objectives

The following project objectives/tasks were completed during the fall of 2013:

1. Estimation of soil series within each plot using traverse sampling method in each of the 80 predetermined plots (e.g., the length of each soil series on each of three traverses and cover estimate by soils series within the plot);

2. Determination of the soil series present at the 16 known active desert tortoise burrows in the 80 plots; and

3. Determination of exposed restrictive layer (i.e., petrocalcic, duripan) locations within each of the 80 plots via visual observation along traverses.

Methods and Materials

The covariate monitoring sample unit size and shape (i.e., plot) were determined by the needs of the Mojave desert tortoise occupancy sampling protocol—a size that is a compromise between desert tortoise home ranges and the ability to sample a plot for tortoise occupancy within two hours. The plot size is a 4-hectare (ha) or 200–meter (m) square area. The randomly established plots are numbered 1 through 80. The locations of the plots are shown in Figure 1.

The sampling of the soil covariates was conducted within each of the 80 established 4-ha plots using a traverse sampling method. There was no specific seasonal timing for this sampling effort.

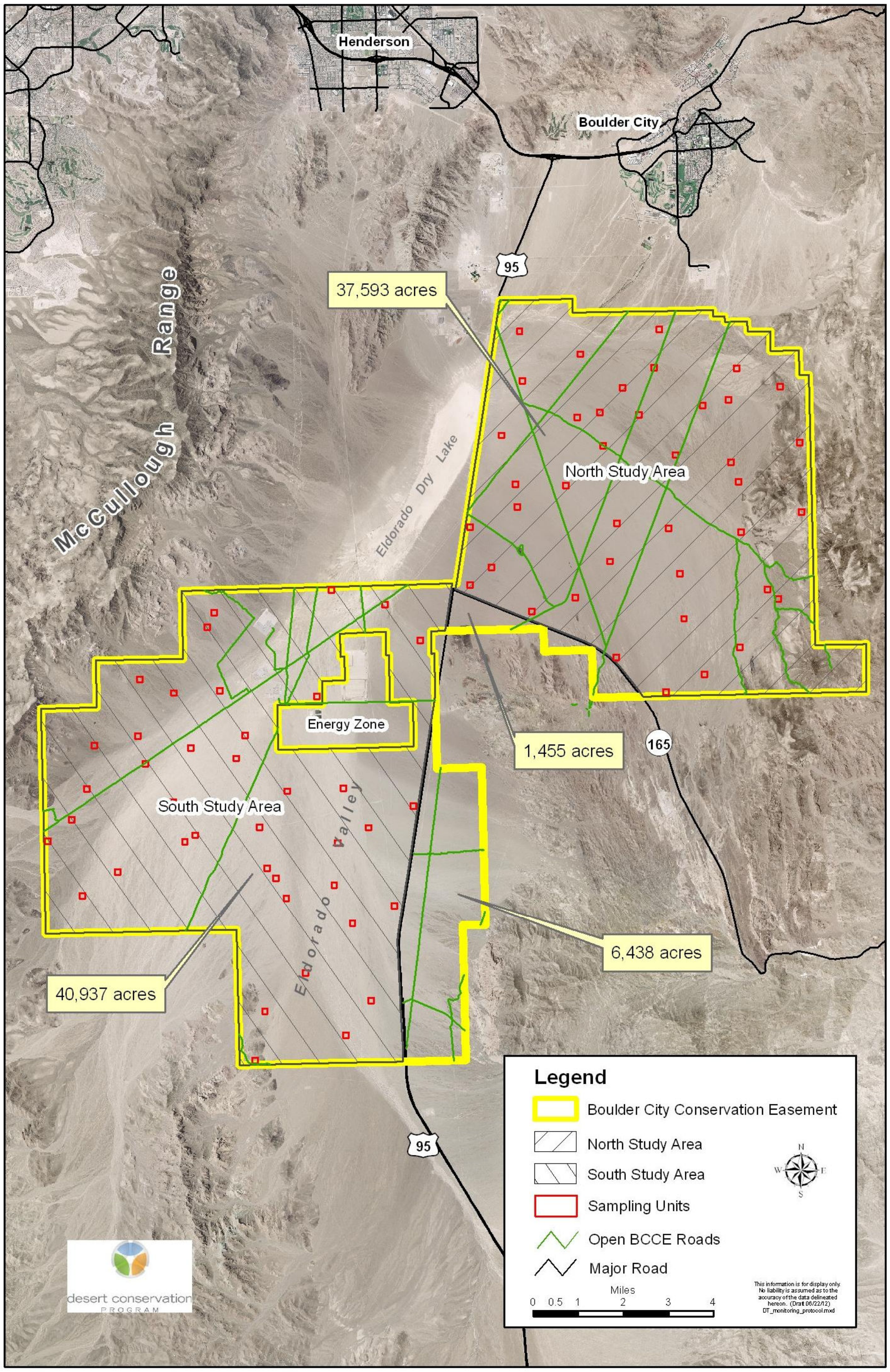

Figure 1: Locations of the 80 4-ha plots in the BCCE.

Task 1: Estimation of soil series changes using traverse sampling method in each of the 80 predetermined plots.

The traverse sampling method included walking three straight traverses at the 50-m, 100-m, and 150-m locations starting on any side of the established 200-m x 200-m plot as selected to maximize capture of the soil variability based on factors such as landform and elevation changes.

While walking a traverse, a global positioning system (GPS) waypoint was captured on each of the representative geomorphic surfaces in the plot. For example, if the plot consisted of fan remnant landforms with desert pavement summits and was transected by a wash system, then several GPS points were taken in the wash and several were taken on the summits of the fan remnants in order to collect data that represents each surface. The different geomorphic surfaces can be correlated to different soil series in a map unit. At each GPS point a photo of ground cover and the landform were collected along with the following observational data: surface rock fragment abundance, slope, flooding class, and surface texture.

Task 2: Determination of the soil series present at the 15 known active desert tortoise burrows in the 80 plots.

The GPS locations of these active tortoise burrows were made available by DCP. Soil pits near burrows were dug at an appropriate distance away from the burrow so as to not disturb the burrow—a distance of 15 or more feet from a surface burrow or 60 feet from a burrow in the side of a wash. Soil pits were dug near each of the 15 active burrow sites and if the soil characteristics matched a known soil series this was identified and associated with a confidence rating. The confidence rating intervals are described in Table 1.

If no known soil series matched the pit, the series was indicated as “Other.” In this case, a soil pit description is provided. This includes depth, texture, rock fragment modifier, and effervescence class data for each horizon along with additional descriptive notes. Effervescence classes are described in Table 2.

Task 3: Determination of exposed restrictive feature (e.g., petrocalcic, duripan) locations within each of the 80 plots by visual observation along traverses.

Desert tortoise habitat may be limited by restrictive soil features such as petrocalcic layers, duripans or other restrictive features. Locations and photos of exposed restrictive features were identified during the traverse sampling in Task 1. Additionally, any exposed restrictive features found while walking between plots were noted as well.

Materials

Juno Trimble Unit
LaMotte Soil pH kit
Munsell Color Book
Clinometer
Sharp shooter shovel
Plot maps
3M half mask respirator and P100 filter
Sampling bags
Spray bottle with water
2mm (#10) Sieve
Hand lens
Camera
200 mL of 1M Hydrochloric acid

Results and Evidence

The three stated objectives of this project were successfully completed by the LSD field team. In the field, data was collected using a Trimble Juno device. Additionally, field notes were written on individual plot maps generated by LSD based on aerial imagery provided by the DCP and Soil Map layers provided by the NRCS.

Four types of points were recorded using the Trimble Juno GPS device: SoilSeries, SoilPit, ExpRest, and OtherFeat. SoilSeries points were selected along the traverses to represent the geomorphic surface of a particular landform in the plot. These geo-referenced locations are useful in comparing similar soils across a landscape and were used to create groups of similar plots. This data set supports Task 1 in the Objectives section of this report.

SoilPit points were collected whenever a soil pit was excavated. This occurred at each of the active desert tortoise burrows sites provided by the DCP. In some cases, more than one tortoise burrow were close enough together that they were located on the same landform and therefore most likely the same soil series. When this occurred only one pit was excavated to represent all of the associated burrows. A total of 9 soil pits were excavated near active tortoise burrow sites and 4 “quick pits” were excavated during the course of traverse sampling. This data set supports Task 2 in the Objectives section of this report.

ExpRest points documented any exposed restrictive features that were found by the field team. This includes petrocalcic and duripan layers that were found in the plots while walking the traverses or in between plots while walking or driving to points. This data set supports Task 3 in the Objectives section of this report.

OtherFeat points are incidental to the goals of the project. This data point was used to geo-reference any type of interesting feature and associate it with photographs. Usually, this was used for tagging burrows, dens, or refuse.

The plot maps used in the field and soil pit description sheets are included in a binder of deliverables for this project. Photo documentation is also provided as per the Data Management Plan and is included in the deliverables as JPEG files on a DVD. At the request of DCP staff, incidental photos of interesting plants and wildlife were taken and are included in the deliverables for supplemental purposes only.All paper data sheets were scanned and provided as PDF files on a DVD.

A summary of pit results are provided in Table 3. However, the soil descriptions with horizon data are provided in the hand written field notes in the deliverable binder. The notes on the “quick pits” can be found on the back of the plot map associated with that pit. A description of Field Note Abbreviations used in handwritten notes is provided in Table 4. Some samples of exposed restrictive features were taken in the field and were properly labeled. Collection of these samples was not required but will be mention later in this report.

Table 1. Confidence Intervals	
Rating	**Meaning**
1	Very Confident
2	Confident
3	Somewhat Confident
4	Not Confident

Table 2. Effervescence Classes	
Rating	**Meaning**
NE	Non-effervescent
SE	Slightly effervescent
ST	Strongly effervescent
VE	Violently effervescent

Table 3. Pit Summary

Plot #	Type	Burrow #	Series	Confidence	Notes
BC_N_006	Active burrow	a0290	Other	1	Petrocalcid
BC_N_010	Active burrow	a0312	Tonopah	3[1]	Live tortoise in burrow
BC_N_010	Active burrow	a0173	Arizo	3[2]	
BC_S_045	Active burrow	b0083	Arizo	1	
BC_S_072	Active burrow	b0391	Arizo, frequently flooded	2	
BC_S_072	Active burrow	b0392, b0182	Other	2	There was only one burrow found
BC_S_075	Active burrow	b0174	Other	1	Duripan in bottom possibly
BC_S_075	Active burrow	b0079, b0172, b0385	Arizo	1	Could not find all three burrows
BC_S_079	Active burrow	b0452, b0215, b0120, b0213	Arizo	1	All burrows in same series
BC_N_029	Quick pit	NA	Searchlight	2	See plot map
BC_N_028	Quick pit	NA	Searchlight	2	See plot map
BC_N_024	Quick pit	NA	Searchlight	2	See plot map
BC_N_021	Quick pit	NA	Searchlight	2	See plot map

Soil had a low confidence rating of 3 for the following reasons:

[1]Tonopah soils are very to extremely gravelly throughout the profile. This pit was not and was also missing the 45% stone of boulder cover as described in the MU.

[2]Arizo soils have sand/coarse sand from 2-60 inches, but this pit had sandy loams and loamy sands. Also did not have 50% stone or boulder cover as called for in the MU description.

Table 4. Field Note Abbreviations	
MU	Map Unit
DP	Desert pavement: >65% rock cover (Graham et al.)
DP (Wk)	weak development, few vesicular pores, poor sorting, spaces between rocks, crushes under weight of foot
DP (Mod)	moderate development, common vesicular pores, not much space between rocks
DP (Str)	strong development, tightly packed rock fragments, will not crush under weight of foot, many vesicular pores
Av	vesicular horizon
Unk	Unknown
Btw	Between
Conf.	Confidence rating on a scale of 1 to 4, 1 is the highest
Eff	Effervescent
Texture Classes	Refer to the Field Book for Describing and Sampling Soils, pages 2-37
Apron, skirt, etc.	For landform definitions, refer to Peterson's "Landforms of the Basin and Range"

Evaluation/Discussion of Results

Plot Groupings

The North and South Sections of the BCCE were evaluated separately and should generally be regarded as separate from a soil genesis perspective. The soils in the South Section are primarily influenced by the material originating in the mountains on the west and south side of Eldorado Valley, while the soils in the North Section are influenced by the material in the mountains to the east of the easement. There is a small area of the South section that is influenced by alluvial fan material originating from the mountains east of US Highway 95.

Plots with similar geomorphic surface characteristics were combined into groups. This was done by reviewing the following for each plot: aerial imagery, the SoilSeries point data, handwritten field notes and the field photographs. Each group can therefore be described by its dominant characteristics (see descriptions next to each group). It is accurate to say that each plot in a group is made of the same association or complex of soils as the next plot in that group with the exception of the group called "Individuals." Landform and vegetation notes aided this process since they can be key factors in identifying a large scale change between Map Units. A summary of the Plot Groups is provided later in this report.

It was found that 26.25% of the plots fit well with their original Map Units, 13.75% do not fit with the original Map Units and the remaining 60% of the plots cannot be determined in this study. Both the North and South Sections of the BCCE had plots that did not fit with any other groups and therefore where placed in a group labeled "Individuals." Plots were designated as "Individuals" if 1) they were the only plot in a particular Map Unit; 2) they were transitional between two Map Units and reflect characteristics of multiple groups; or 3) the plot was unique and was unable to be associated with any one group. In this case, normal conclusions about the similarities between plots in a group do not apply since the "Individuals" are a grouping of dissimilar plots. Plots in the "Individual" group must be evaluated separately or ignored as outliers in further discussions.

Grouping the plots allows for identification of a single plot that represents that entire group. A representative plot was picked for each group by looking for a plot in a central location of a group and avoiding plots near the transition zones between groups. A representative plot may also have been chosen because of good accessibility. The representative plots encompass the characteristics of the type of soils across all the plots in the groups. If further series validation occurs in a representative plot then the results will reflect conclusions that can be applied to all similar landforms and geomorphic surfaces in all the plots in that group. These representative plots are listed in Table 5. This table also includes waypoint locations that best represent the main geomorphic surface in that plot. In some cases, two waypoint locations are identified because there are two main geomorphic surfaces that likely represent two different soil series.

Plot Delineations

In addition to grouping the plots, there are some small scale soil series delineations drawn on the plot maps that were used in the field. These lines were drawn by looking at the aerial imagery after walking the traverses to confirm what was found on the ground. These delineations represent an initial estimation of the boundaries between soil series based on evaluation of surface soil features and pertain only to that plot. If no delineations were needed and the plot was deemed to be all one series, a note was included on the plot map. If there are no notes about the delineations, then the plot is too complicated to delineate without further work.

While delineating the field maps, the minimum map unit considered for 4-ha plots was 2.5 acres as advised by a NRCS Resource Soil Scientist. Estimated soil series with areas smaller than 2.5 acres were considered too small to map. If delineated accurately at a series level this would create a soil survey map with a scale of 1:12,000. These delineations would benefit from additional data collection and will need to be reevaluated if any additional work is done.

Soil Pit Descriptions

Soil pits near active tortoise burrows provided the most useful information when they were able to be associated with a known soil series with a high confidence rating. It should be noted that in plot BC_N_010 there were two pits that were associated with a known series and were given a low confidence rating of 3. A low rating means the characteristics of the soil deviates from the acceptable limits of the expected soil series description for that location. The specific reason for these low ratings is described in a foot note below Table 3. If desired, these sites could be revisited in order to better associate that soil with a known series.

There were 15 active burrow locations provided by DCP but not all 15 were found. In two cases (plots BC_S_072 and BC_S_075), multiple burrows were supposed to exist at almost the same geo-referenced location but not all could be found. It is hypothesized that some burrows may have been sampled twice during tortoise surveys which were conducted during two separate periods prior to this soils project.

In addition to the soil pits near active tortoise burrows, four “quick pits” were excavated at the beginning of the project. A quick pit was dug to a depth of 40 inches or shallower if a series could be determined before that depth. The “quick pits” help confirm the similarity in soil type between plots in which they were dug. However, the use of quick pits slowed down the field sampling considerably and therefore were only used four times. It was originally thought that a quick pit location in a plot could be identified before sampling by studying aerial imagery. However, after doing four quick pits that turned out to represent the same soil, it became clear that it would be more useful to collect the geomorphic surface data, group plots and then decide on just a few pit locations rather than digging unnecessarily. If a quick pit location was identified and could easily be sampled after the plot grouping then it would have been more efficient to return later. However, time and budget constraints limited the field team.

Exposed Restrictive Features

The field data shows a large number of exposed restrictive features found in several areas of the BCCE. Most of the exposures are petrocalcic (Ca_2CO_3 cemented) and indicate that Petrocalcid soils should exist in the locations throughout the BCCE where these features were found. A Petrocalcid soil is defined at the Great Group level as a soil with a petrocalcic horizon within 100 cm of the soil surface (Keys to Soil Taxonomy, p. 105). However, based on the original soil map of Eldorado Valley, there are no known Petrocalcid soils. This is the primary discrepancy between the original soil map and the field data.

The restrictive features found in the field were tested with drops of 1 M Hydrochloric acid for effervescence. All samples reacted violently, indicating a high presence of Ca_2CO_3. However, another cementing agent, silica, can also be present at the same time. Silica cementation can be seen under a hand lens and is usually toffee colored but does not effervesce. Evidence of silica cementation is found in the restrictive exposures in the South Section of the BCCE in plots BC_S_041 and BC_S_042. When two cementing agents are present, the one that makes up greater than 50% of the restrictive horizon influences the series description.

As mentioned before, samples of several key exposed restrictive features were collected during this project and could assist in identifying the cementing agent and therefore the series of an unmapped soil. This is achieved by performing an acid dissolution of these samples in a lab with proper safety measures.

The presence of an exposed restrictive feature also affects the soil pit description. For example, plot BC_N_006 had an active tortoise burrow pit that was described as “Other” because it did not fit any of the known series in the area. However, the soil profile showed a petrocalcic horizon starting at 5 inches below the soil surface which keys out as a Petrocalcid at the Great Group level (Keys to Soil Taxonomy, p 105). This pit must be revisited in order to map it at the Series level and to prove that the cementing agent is in fact 50% or more Ca_2CO_3 and not silica.

Summary of Groups

Plot Groups: South Section

Group 1: This is fan apron material with little to no stones on the surface. These are mostly Arizo soils as determined at pits near the active tortoise burrows. Within this group are many tortoise burrows in sides of washes and under shrubs. Dominant vegetation was *Larrea tridentata* and *Ambrosia dumosa*. Some plots show very active channels with flooding evidence from this year. No exposed restrictive features present. There is a high confidence level that this group reflects the concept of Map Unit 450.

BC_S_045	BC_S_068	BC_S_074	BC_S_076	BC_S_079
BC_S_059	BC_S_072	BC_S_075	BC_S_077	

Group 2: This is fan apron material with some fan remnant summits and desert pavement areas. There is a high percentage of stone cover across all plots. Vegetation was diverse including dominant shrubs, various cacti, and annual grass cover. No exposed restrictive features present. There is a moderate confidence level that this group reflects the concept of Map Unit 450.

BC_S_065	BC_S_069	BC_S_080b	BC_S_056
BC_S_067	BC_S_073	BC_S_060	

Group 3: This is fan remnant material with greater slopes than elsewhere in the BCCE. Exposed restrictive layers (petrocalcic) were found in deep washes. There are healthier plants, greater recent growth due to more moisture and greater water input from hills. Grass component is present (*Pleuraphis rigida*). There is a moderate confidence level that this group reflects the concept of Map Unit 400.

BC_S_043	BC_S_047	BC_S_053
BC_S_044	BC_S_048	BC_S_066

Group 4: This is fan skirt material and is most likely Hypoint Series because it is very sandy. No exposed restrictive features present. There is a high confidence level that this group reflects the concept of Map Unit 150.

BC_S_049	BC_S_052	BC_S_055
BC_S_050	BC_S_054	BC_S_058

Group 5: This is a transition zone between Group 2 and Group 4. There is a loss of stone cover that characterized Group 2 but this group reflects the sand component of Group 4. No exposed restrictive features present.

BC_S_063	BC_S_070	BC_S_071

Group 6: Dominant vegetation is *Larrea tridentata* and *Ambrosia dumosa*. There is little topographic relief between fan remnant surfaces. Some desert pavement areas exist. No stone component is present on the surface. No exposed restrictive features present. There is a moderate confidence level that this group reflects the concept of Map Unit 380.

BC_S_046	BC_S_061	BC_S_064

Group 7: Exposed restrictive layers are both petrocalcic and silica cemented. There is a high confidence level that this group does *not* reflect the concept of Map Unit 430.

BC_S_041	BC_S_042

Individuals: Plot lies on a transition zone or is not associated with any other group.

BC_S_051	Transition Zone
BC_S_057	Transition Zone
BC_S_062	Transition Zone
BC_S_078	Moderate confidence level that this plot reflects the concept of MU 380

Plot Groups: North Section

Group 8: This is apron material. No strongly developed desert pavement areas exist. Vegetation is dominated by *Larrea tridentata* and *Ambrosia dumosa*. Topographic relief between channels is small. No exposed restrictive features present. The Searchlight series in the plots is missing an argillic horizon. There is a moderate confidence level that this group reflects the concept of Map Unit 760.

BC_N_001	BC_N_018*	BC_N_024	BC_N_029*
BC_N_009	BC_N_019	BC_N_025	BC_N_031
BC_N_012	BC_N_021*	BC_N_027	BC_N_033
BC_N_015	BC_N_023	BC_N_028*	BC_N_039

* indicates active channels on lower part of fan apron

Group 9: This is fan remnant material incised by washes. Exposed restrictive (petrocalcic) features were found. A large number of tortoise carcasses were found. Burrows were found in petrocalcic wash exposures. There is a high confidence level that this group does *not* reflect the concept of Map Unit 380.

BC_N_022b	BC_N_036	BC_N_038	BC_N_030
BC_N_034	BC_N_037	BC_N_040	

Group 10: This is fan skirt and alluvial flat material. Sandy soils are present. No exposed restrictive features present. There is a high confidence level that this group reflects the concept of Map Unit 390.

BC_N_003	BC_N_004	BC_N_007	BC_N_014

Group 11: This is fan remnant material. A dendritic pattern to the stone distribution indicates a possible basaltic mudflow. Very stony surface with petrocalcic fragments and Ca_2CO_3 coatings on rocks are found in most areas. There is a moderate confidence level that this group reflects the concept of Map Unit 380.

BC_N_035	BC_N_017	BC_N_020	BC_N_026

Individuals: Plot lies on a transition zone or is not associated with any other group.

BC_N_010	Transition Zone
BC_N_011	Transition Zone
BC_N_013	Transition Zone
BC_N_032	Transition Zone
BC_N_005	There is a high confidence level that this plot does *not* reflect the concept of MU 760
BC_N_006	There is a high confidence level that this plot does *not* reflect the concept of MU 211
BC_N_002	There is a high confidence level that this plot reflects the concept of MU 150
BC_N_008	There is a moderate confidence level that this plot reflects the concept of MU 211
BC_N_016	There is a high confidence level that this plot reflects the concept of MU 750

Table 5. Representative Plots			
Plot	**Group**	**SoilSeries Waypoint # for Pit**	**Notes**
BC_S_041	7	4	
BC_S_056	Individuals	2	
BC_S_061	6	3	
BC_S_063	5	6+5	
BC_S_054	4	4	Not to 60 in, just to validate
BC_S_044	3	7	
BC_S_067	2	7	
BC_S_065	2	3	
BC_S_072	1	11	
BC_N_035	11	9	
BC_N_007	10	5	
BC_N_005	Individuals	3	
BC_N_036	9	5	
BC_N_019	8	2	
BC_N_006	Individuals	8	Previous pit location
BC_N_010	Individuals	6	Previous pit location
BC_N_032	Individuals	9	

Conclusion

This project serves as a validation of the geomorphic surfaces present in each of the 80 predetermined plots and acts as a review of the original soil map. After combining the plots into appropriate groups and comparing them to the original Map Unit descriptions for Eldorado Valley, it is clear that there are some discrepancies between the data and the original soil map. Each group was evaluated in a manner that works to validate or reject the current soil map. Based on the results, some new objectives can be suggested in order to make better use of this data.

The large scale delineations on the current soil map of Eldorado Valley could be modified to reflect some of the new information collected in this study. In some cases, the original map unit boundaries could be moved to exclude plots that showed similarities with a neighboring map unit. These types of boundary changes can be made without further collection of data unless they also fall into the category of plots that do not match their map unit concepts.

In some cases, an entire group of plots do not match the concept of the original Map Unit. These are areas of high concern that need to be reevaluated and associated with new series information. In the cases where the data does not match the concept of the current Map Unit more soils data will need to be collected.

Finally, care must be given while evaluating the series delineations drawn on the individual plot maps. These are estimations in a single plot and may not necessarily be applied over the entire study area. Extrapolating these small scale delineations over the BCCE may be useful in some models but may not be accurate without verification in each delineated series. This may be an unnecessary amount of work for the overall goal of predicting tortoise occupancy.

Management and data use objectives should be evaluated before proceeding. For the purposes of this project, individual plot delineations were not completely feasible. Outlining all the intricate washes by hand or developing a model for the landforms at that scale was not possible due to time and budget constraints.

Recommendations

Further data could be collected to make the corrective changes to the soil map of Eldorado Valley and to validate the series in each group. If possible, a full pit to a depth of 60 inches should be described in each of the 18 representative plots in Table 4. This list provides a pit in each of the Plot Groups so that all soils in those groups can be associated with the resulting data. It also provides pit locations for some of the pits in the "Individuals" Group so that they can be properly mapped as well. Some of the "Individual" plots are on transition zones or are outliers that do not provide representative information about any of the soils and therefore do not require full pit descriptions.

The suggested pit locations have already been identified in Table 4 to overlap with a SoilSeries data point and waypoint number from this study. In addition to a full description at each of the pit locations, some pits will need full characterization. Full characterization includes sampling each horizon in a pit and running a suite of National Cooperative Soil Survey standard lab analyses in order to provide the information needed to key out a soil to the series level. Not all 18 pits will need full characterization. However, determining which pits and how many pits may depend on the data from the full pit descriptions. When keying out a soil to the series level, the full pit descriptions may sometimes provide only some of the information and the lab data provides the rest.

Additionally, analysis of the samples of exposed restrictive features that were collected during this project would be useful in determining some of the unmapped soil series. An acid dissolution experiment is necessary to determine whether the cementing agent in the collected samples is Ca_2CO_3 or silica. This experiment requires access to a lab with a fume hood and high concentration (37%) hydrochloric acid. After the reaction goes to completion, the mass of undissolved material represents the fraction that is silica cemented.

The information from the 18 full descriptions and additional characterizations may help identify new series and confirm or reject previously mapped series in the easement. The data from the collected restrictive features will assist in interpreting the 18 full descriptions and may be used to associate new series for the soil map. It will also help create the fine scale series delineations in the plot if those are determined to be useful in the tortoise occupancy model.

Acknowledgements

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