Spatial Analysis of Baseline Data of Surface Soil and Landcover Classes of the North Etiwanda Preserve after Five Years of Drought Stress (2011-2015) in a Mediterranean Climate Region of Southern California.

by
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1. Executive Summary

North Etiwanda Preserve (NEP) – a conservation area located west of the deserts in the southern portion of San Bernardino County, Southern California, which is in a hot, dry summer and cool, wet winter Mediterranean Climate.

The objectives of this study were to construct a baseline inventory for vegetation types, surface soil conditions, and vegetation distributions after five years of drought stress as well as to anticipate changes in ecological processes, such as surface soil run-off volume, non-native plant invasion, and multiple-succession stages in disturbed and non-disturbed areas of the NEP.

The study was conducted to produce up-to-date Geographic Information Systems (GIS) vegetation maps created from 2015 aerial photo that had higher than 85% accuracy and can be used as a reference to complete vegetation spatial analysis of the NEP. Furthermore, comparisons of soil parameter attributes were measured, which enhanced the descriptions of the soil conditions with respect to landcover classes. In addition, validation of the successional stages between naturally disturbed areas, riparian and human disturbed areas were completed for the NEP.

This study used enhanced aerial images, digitized major habitat types and areas, classified light energy signature of each landcover class within finer defined areas to produce GIS vegetation maps. A geodatabase was created to map the landcover maps. The design of the field survey method was a combination of protocols gathered from USFWS, USFS, NRCS, and USDA to form the vegetation survey, soil sample collections, and laboratory procedures.

Quality control of the maps was completed by equating the mapped classes with field surveys and soil lab results. The user's accuracy of the produced landcover classes maps was determined to be 86%. The maps were then used to calculate the canopy percentage coverage of plant communities and for identification of dominant plants. The surface soil run-off volume of each surveyed location was calculated using The Universal Soil Loss Equation: $A = RKLSCP$

The landcover, species distribution, and soil erosion volume maps show a 2015 baseline condition of the NEP. A graphic representation was created to illustrate the various surface and subterranean parameters of the preserve along the west to east cross-section of ten sections of the preserve along the 34.471° north.

The surface soil condition of the NEP was strongly influenced by vegetation types and the litter/wood cover. The soil organic layers were shallow with low CEC. Areas of soil erosion appeared greatest along the fire break areas and within areas of previous wildfire events. The greatest soil stability was located along the eastern portion of the preserve where most of plant communities were at their mature successional stage. Soil disturbance, such as foot traffic or mechanical manipulation enhanced non-native plant species growth in the NEP. The presence of non-native annual plants have shallow root systems that effects soil structure, chemicals, and water retention in impacted areas.

It was normal for this coastal sage shrub habitat to have soil pH value around 7.4, while the bog area has pH = 7.2 due to higher organic matter in the soil. Changes of pH in a habitat promote non-native species growth, which could lead to the primary species demise by outcompeting the native species for nutrients. Changes can also occur by microbial succession due to the water availability and temperature change.

The canopy percentage coverage of coastal sage shrub was determined to be low after five years of drought stress. The distribution of vegetation communities within the early successional stages were pioneer species such as annual grasses, deer weed, and white sage that generally dominate disturbed areas. Disturbed areas are susceptible to soil erosion and changes in existing native plant species which could lead to a change of habitat type not only for native plants, but also for endemic invertebrate and vertebrate species in this Mediterranean climate region.

2. Abstract

The North Etiwanda Preserve (NEP) is a conservation area in a Mediterranean climate located in Southern California. This study focused on surface soil characteristics at the NEP to understand the soil stability and to find the erosion rate as well as the surface soil condition and the coverage of vegetation communities of the preserve area after five years of drought stress. Digitized main habitat types and areas as well as enhanced raster images were used to create landcover maps to display the vegetation composition of each habitat.

A geodatabase was created to map the landcover maps. The vegetation was identified and data was collected using the point intercept method. Soil samples from 36 sampling sites were collected and were tested for soil parameters (soil structure, texture, temperature, pH value, soil water % weight, bulk density, CEC, etc.). Quality control of the maps was done by comparing the mapped classes with field surveys and soil lab results. The user's accuracy of the produced landcover class maps was 86.4 %. The canopy percentage coverage of plant communities and of dominant species was calculated. The surface soil run-off volume of each surveyed location was calculated using the Universal Soil Loss Equation: $A = RKLSCP$.

The NEP had shallow soil organic layers and low CEC. Hot spots of soil erosion were located along the fire break area. Soil erosion rate was higher within the burned area when compared to the east side of the preserve where vegetation communities were at the mature successional stage. The surface soil conditions of the NEP are strongly influenced by vegetation types and the litter/wood cover. The pioneer vegetation communities mainly grew within the disturbed areas, which were vulnerable to soil erosion and changes of successional stages.

3. Acknowledgements

The author extends her gratitude to Jerry L. Burgess, the Program Director and Sr. Lecturer for the Environmental Sciences and Policy Program at Johns Hopkins University for his insightful knowledge and instruction in the method used in conducting studies for soils in natural ecosystems; Daniel S. Zachary, the Program Director and Sr. Lecturer for the Energy Policy and Climate Program at Johns Hopkins University for his guidance in producing the capstone project report; and Robert McKernan, Chairman of the biology committee of the San Bernardino County Special Districts Department (SBC-SDD) for his mentoring on the survey site criteria and his in-depth knowledge of the Coastal Sage Scrub habitats. Also, special thanks go to Erin Opliger and Tim Millington, management team of the SBC-SDD, for permission to do this research and supplying helpful volunteers; to Robin Ikeda of the Chaffey Community College Biology Department for the use of her lab; to the students who worked so hard in the field; to James des Lauriers, Emeritus Professor of Biology, Chaffey Community College, for his support in refining my research plan; and to Josephine Quici for assisting in the editing of this paper. Finally, the author wishes to acknowledge the many family members and friends for their endless support.

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4. Introduction

4.1. Background

The North Etiwanda Preserve (NEP) is located west of the deserts in the southern portion of San Bernardino County, Southern California, which is in a hot, dry summer and cool, wet winter Mediterranean climate. According to the North Etiwanda Preserve Management plan (USFWS and CDFG, 2010), the NEP was established in1998 as a single parcel of open space, high quality, and sensitive habitat to address the issues of habitat loss and habitat fragmentation of the Coastal Sage Scrub habitat (CSS). (USFWS and CDFG, 2010) This preserve is a conservation easement managed by the North Etiwanda Board of Directors of the San Bernardino County Special Districts Department (SBC-SDD) with the intent of permanently protecting the riversiden alluvial fan scrub and other endemic native communities and species that occupy the land. (San Bernardino County Museum, 2005)

4.2. Previous Studies

The Inland Empire region of Southern California is vulnerable to earthquakes, wildfires, and landslides. (Marshak, 2012) Previous studies in the region include vegetative characteristics of CSS (Beyers and Wirtz II, 1995), post-fire recovery in CSS (Conlisk et al., 2016); effects of climate change and urban development within the distribution of vegetation in a Mediterranean-ecosystem (Beltrán et al., 2014). Coates et al. (2015) mapped and monitored drought impacts on Southern California chaparral species using hyperspectral and thermal infrared imagery and found that among chaparral species, *Ceanothus* species were resilient to long-term drought stress. Witztum and Stow (2004) analyzed the reliability of the GIS mappings, which were created to assess the direct impacts of hiking trails on coastal sage scrub habitat, although the authors provided limited discussion of the vegetation communities. The landcover map in the North Etiwanda Preserve Management Plan was produced by USFWS and CDFG in 2010 using 1994 baseline survey data. This vector map clearly classifies sixteen classes in the preserve, but is very limited relative to vegetation composition of each plant community type.

Turner and Gardner (2015d, 2015e) pointed out that, when under environmental stress, the threshold of resilience of an ecosystem depends on the factors that would change over different time scales, such as seasonal, annual, or millenniums, etc. Those factors include the levels of redundancy –numbers of species that perform the same function in the food-web/energy web of the system (Bardgett 2005; Molles 2005a, 2005b; Rosenfeld 2002), environmental stress – climate change, water availability (Ward and Trimble, 2004a, 2004b, 2004c), and degree of disturbance – Santa Ana winds (Fovell 2002), wild fires (Blank et al. 1995; Beyers and Wirtz II 1997; Verkaik et al., 2013), spatial context or fragmentation (Syphard et al., 2013), and human activities (Cain et al. 2014a; Davis 2005; Syphard et al., 2009;Tilman and Lehman 2001). There are also studies that show the role (mechanisms) of the architectural characteristics of roots in terms of shallow slope stabilization and erosion control (Reubens et al. 2007; Brady and Weil 2010), which often are affected by the change of landuse type (Bardgett 2005; Blank et al. 1995; Turner and Gardner, 2015a, 2015b, 2015c) in the highly-specialized plant communities of Mediterranean-climate zone in southern California.

Between the years of 2011 and 2015, California experienced one of the most severe droughts on record drought stress. (California Water Science Center, 2017) Several other studies at the regional and national levels utilized multi-spectral imagery, ArcGIS mapping software and geodatabases to study the interaction among various habitats, ecosystems and vegetation successions (Arctur and Zeiler, 2004; Barlow 2016; Dai and Ratick, 2014; Harris et al. 2011; Stella et al., 2013; the Center for Geographical Studies, 2015; Cain et al., 2014b). Since water is one of the major limiting factors that affects plant growth, it was important to delineate landscape patterns of the NEP after the severe drought. Baseline information is critical regarding surface soil conditions and the landcover classes of the NEP, and could be benefical to evaluate consequences of management options, policies, and conservation practices that could provide insight into frequency and intensity of stochastic perturbations.

4.3. Objectives and Actions

The objectives of this study were to construct a baseline inventory for vegetation types, surface soil conditions, and vegetation distributions after five years of drought stress as well as to changes in ecologic processes, such as surface soil run-off volume, non-native plant invasion, and multiple-succession stages in disturbed and non-disturbed areas of the NEP.

This study focused on the following actions:

1. To produce an up-to-date Geographic Information System (GIS) vegetation map created from 2015 aerial photos that had higher than 85% accuracy and could be used as a reference to complete vegetation spatial analysis of the NEP,

2. To compare soil parameters, such as hydrological run off rate, soil water, pH value, bulk density, cation exchange capacity (CEC), and depth of organic (O) horizon of surface soil, which overall defined the soil conditions with respect to landcover classes in the NEP
3. To identify the successional stages between naturally disturbed areas, riparian and human disturbed areas in the NEP.

5. Method

5.1. Study Area

The North Etiwanda Preserve of San Bernardino Country, California

This nature preserve, which is an open space/habitat preservation for riversiden alluvial fan scrub, is one of the conservation easements managed by the Special District Department of San Bernardino County. (San Bernardino County Museum 2005; USFWS and CDFG 2010) Results of the intense north-south compression when the Pacific Ocean plate is being subducted beneath the North American continental plate, the great thicknesses of Cenozoic petroleum-rich sedimentary rocks have been folded and faulted and created a rapidly rising landscape of east-west structured Transverse Ranges, which are perpendicular to all other mountain ranges in California. (Marshak 2012)

Both climate and geological characteristics of the Transverse Range have profound effect on NEP. Interior Southern California is influenced by a warm summer Mediterranean climate which means frequent dry years interspersed with rare high precipitation years. Intense summer and early fall subtropical storms are brief, often causing the bulk of precipitation and runoff.

Typically during autumn, southern California experiences strong extremely dry down-slope Santa Ana winds (> 60 mph) originating in the Great Basin. These prevailing north winds are strongest in the canyons and passes where they blow though an opening of the Transverse Range. These winds occur across the deserts and through coastal southern California far out over the Pacific Ocean for 2-3 weeks, which often coincide with the normal rainy season. These Santa Ana winds decrease the amount of precipitation of the first 2-3 weeks of the rainy season. (Fovell, 2002) To adapt to such weather, most of native plants shed their leaves in the autumn and have little capacity to intercept precipitation during early November to late February. (Charters, 2016)

5.2. Software Requirement

ESRI's ArcGIS 10.4 ArcMap, ArcCatalog, Microsoft Word, and Microsoft Excel.

5.3. Research Plan

A geodatabase was created using ArcGIS 10.4 mapping software to structure relationships between digital data and references from various sources as well as to interpret and analyze the ecological condition of the North Etiwanda Preserve.

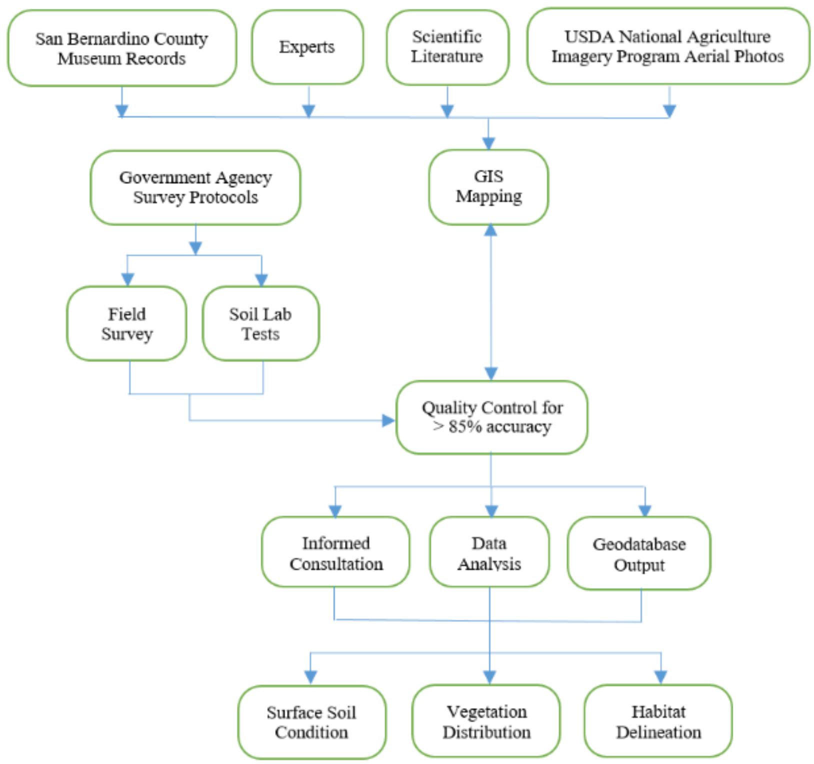

Figure 1 The flow chart depicts the research steps to identify and construct a baseline-spatial-analysis of vegetation types and surface soil conditions of the NEP after a five years of drought in a Mediterranean climate region of Southern California.

The GIS mapping utilized enhanced 2015 aerial Image from USDA National Agriculture Imagery Program (NAIP); the digitized landform, dominate habitat types, and classified light energy signature of landcover classes were protayed in a finer resolution (Figure 2), which was integrated into the 2015 Geographic Information Systems (GIS) vegetation maps (Figures 1, and 2, Appendix E).

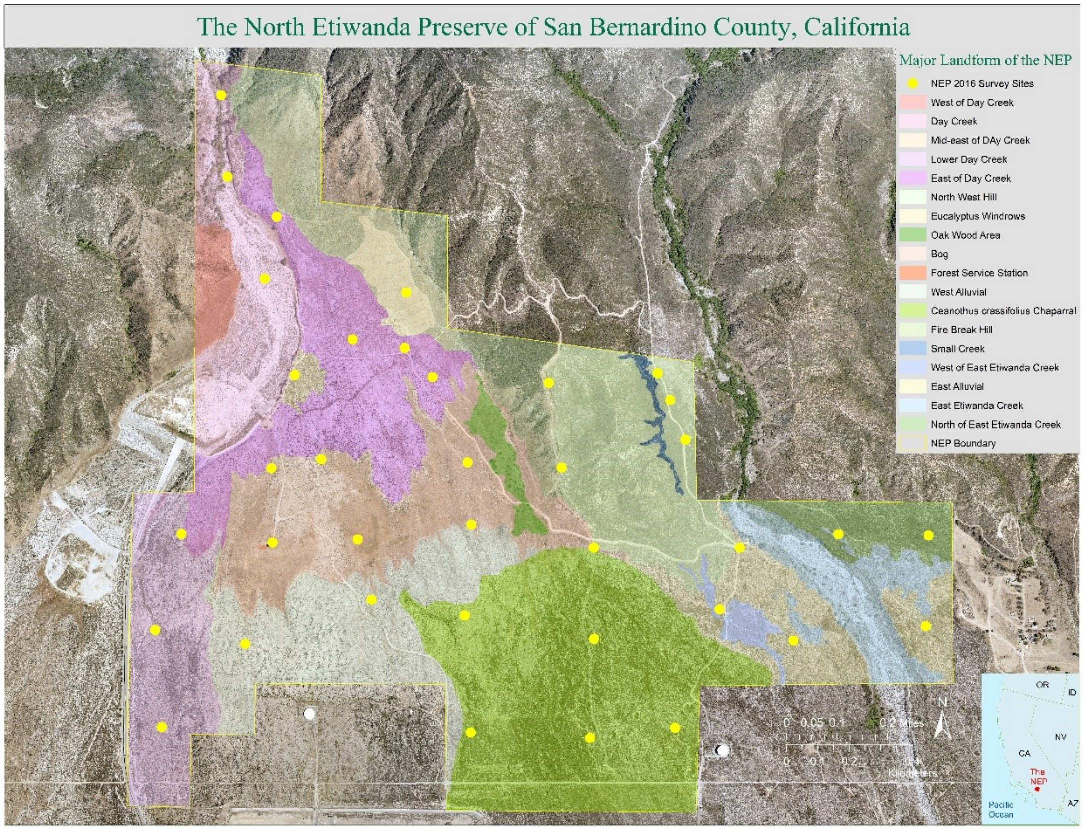

Figure 2 The map of digitized landform areas, enhanced raster images, and soil-vegetation sampling sites. This figure represents the natural color of the preserve in the later summer of 2015, which is approximately at the end of five years drought.

5.4. Field survey

Because landscapes are unique, one set of protocols often will not satisfy the detailed record collection procedures required for this soil-vegetation study. The design of this ecological survey was adapted from a combination of US Fish and Wildlife Service's How to Develop Survey Protocols handbook (2013), US Forest Service's *Ecological Monitoring Tools and Methods*, and NRCS' Sampling Vegetation Attributes (1999). The soil sample collection and Laboratory procedures were adapted from USDA Soil Survey Field and Laboratory Methods Manual (2014), "NRCS Soil Health Card Template" from the Guidelines for Soil Quality Assessment in Conservation Planning in Conservation Planning (2001), and the "Agronomic Library – Cation exchange capacity (CEC)" video (Spectrum Analytic Inc. OH). A simplified dichotomous key for dominant plant species was adapted from Conrad's *Common shrubs of chaparral and associated* *ecosystems of southern California* (1987) and from Charters's *Southern California plant communities* (2016).

5.4.1. Sampling Sites

There were thirty-six NEP soil-vegetation sampling sites, which were varied in terms of vegetative cover and observable soil physical characteristics. Those roughly evenly distributed areas served as a base survey unit for the NEP. (Figure 2) The ecological survey was done to collect baseline vegetation data, landcover class, and surface soil parameters of sampling sites.

5.4.2. Survey Team

The field survey was accomplished with the aid of fourteen undergraduate students from Chaffey Community College and two volunteers (Appendix F).

5.4.3. Survey Equipment

A digital camera, a GPS, a Munsell soil color chart, safety equipment (first-aid kit, gloves, dust masks, goggles), hand lens, a yellow measuring tape, shovels (small and long ones), a box of plastic bags (Zip-locked plastic freezer bags), a pH meter, five 500ml water bottles, and a five-gallon bucket for carrying all of the above items and the soil samples.

5.4.4. Field Survey Procedure

The point intercept method was used for soil-vegetation survey/ground truth

1. Measure 12 meters in north-south direction and 12 meters in east-west direction using soil sampling pit as the center point (crossing point)
2. Use line intercept at 1 meter interval for semiarid bunchgrass-shrub vegetation types for foliar and basal cover and composition. (USFS, 2013)
3. Mark the species present and record aerial and basal point intercepts by live foliar vegetation species, litter, rock, lichen, or bare ground. Note: "litter" does not include standing dead vegetation from current year's growth (Appendix G)
4. Estimate of both basal, canopy cover, and the maximum height of each species

For shrubs, live and dead branches touching the pole were recorded separately in order to monitor shrub mortality. The maximum height of live and dead branches were also recorded separately. If the pole did not touch anything, the location was recorded as "bare".

No plant vouchers were archived for this study, however digital photographs were collected for phenological data of the plan at the intercepted point. Those phenological data included height, percentage of canopy with functioning leaves, and vegetation community of the survey site (Appendixes G H, and I). Data collection also included GPS point (atitude and longitude), elevation, slope, aspect of each point, and a photograph of the species at intercepted point, which could be used as the reference to identify unknowns. More photos were take both close-up and general view as “the portrayal of resource values and conditions and provides visual documentation of vegetation and soil changes over time.” (NRCS, 1999)

5.4.4.1. List of Vegetation Communities

- Woodland
  - White Alder Riparian Forest
  - OAK Woodland
  - Sycamore Alluvial Woodland (RIP)
  - California Walnut Woodland
  - Eucalyptus Windrows
- Chaparral
  - Chamise Chaparral or Chaparral
  - *Ceanothus crassifolius* Chaparral
- Alluvial
  - CC/ Alluvial Scrub or Alluvial Chaparral
  - Riversidean Alluvial Fan Sage Scrub
  - Mulefat Scrub
  - Spare
  - Freshwater Cienega (Cienega)
- Freshwater Marsh Wet Meadow
- Grassland
  - Native
  - Non-native
- Bare Ground with litter

Bare Ground

Rock

Shadow

Other

5.4.4.2. Dominant Species Coastal Sage Scrub Species

Dominant Coastal Sage Scrub Species at the NEP:

Artemisia californica (California Sage),

Salvia apiana (White Sage),

Eriogonum fasciculatum (BuckWheat),

Acmispon glaber (Deer Weed),

Eriodictyon trichocalyx (Yerba Santa),

Ceanothus crassifolius,

Salvia mellifera (Black Sage),

Ericameria laricifolia (Turpentine Bush), and

Yucca whipplei percusa

5.4.5. Soil quality assessment

The on-site tests: color test and ribbon test for wet sample, soil horizon measurement. Soil data collection included photos of the surface area, sampling pit, soil horizon, on-site tests, and one cup of soil sample form each testing site for soil lab (Appendixes H and M).

5.4.5.1. On-site Soil Test Procedure

1. Dig a small hole, about 12 inches deep and approximately 8 inches wide.
2. From the inside of the pit, take sample while pushing the shovel down from the surface to about four inches in depth.
3. Take good care to keep samples intact so that observation can be made for what the color and structure are all the way from the top to the bottom.
4. Place the sample into zip-loc bag along with soils collected from two ends of each transect on site. Mark with the site number for lab text later.

5. Preform two on-site tests:

   (1) Color value test – Compare color value of soil for an unspecified water state to color value from Munsell soil color chart (2009 revision)

   (2) Ribbon test – Smear soil material out between thumb and first finger to form flattened body about 2 mm thick. The minimum length of coherent unit required for recognition of ribbon is 2 cm. If maximum length equals or exceeds 4 cm, ribbon is strong (Appendix M)

5.5. Laboratory Work

5.5.1. Soil pH value

Procedure to determine Soil pH value

1. Remove about one cm^3 of soil from each collected sample and add to an equal amount of distilled water.
2. Stir the soil and water mixture vigorously, then let it sit for five minutes.
3. Calibrate pH meter by placing the electrode in a pH 7 buffer solution. After the reading stabilizes, set the display to read 7, rinse the electrode with distilled water, then let it dry for a few minutes.
4. Submerge the pH sensor completely in the soil solution. Record the reading.

5.5.2. Soil Water % Weight and Bulk Density

Procedure to determine soil water % weight and bulk density

1. Remove 8 cm^3 of soil from each collected soil sample.
2. Record the initial weight (g) of each sample.
3. Dry the soil samples in an oven for four hours and then cool down for an hour.
4. Weigh the soil sample (Appendix J).
5. Subtract the weight of dry soil from initial weight to find the weight of water in each soil sample.
6. Calculate soil water % weight by dividing weight of water with initial weight of soil sample then multiplying 100.
7. Determine bulk density by dividing dry soil weight with soil volume (cm^3).

5.5.3. CEC Lab

Cation exchange capacity (CEC) tested number of exchangeable sites within a soil for cation by using the standard all-purpose ammonium acetate method. Solutions are buffed at pH7. Ammonium ion is a good choice to replace the other cations (Appendix K). (How to chemically measure CEC in the lab: by Virtual Soil Science Learning Resources)

5.5.3.1. Chemical for Each Soil Sample

200 ml of 1M solution of ammonium acetate, 120 ml of isopropanol, 250 ml of 1M solution of potassium chloride solution, distilled water.

5.5.3.2. Equipment

An analytical balance, a small oven, six 100 ml centrifuge tubes with stoppers, an automatic shaker, a 1000 ml vacuum flask, a tube (to connect vacuum flask and vacuum apparatus), vacuum apparatus, a 35 ml Buchner funnel, 35-40 mm filter papers, thirty-eight 60 ml media bottles, a 250 ml volume metric flask with a stopper, a squeeze bottle (for distilled water), a 100 ml graduated cylinder, a 150 or 250 ml beaker.

5.5.3.3. Lab Procedure

1. Record the weight of the soil sample.
2. Place the sample on a tray and bake in an oven at 150 °F for three or more hours.
3. Record the air-dry weight of the entire sample.
4. Weigh an air-dried (2 millimeters) soil sample. The weight of testing samples depends on the organic matter content of the soil:
   a. Low in organic matter => use about 10 grams
   b. High in organic matter soil => 2 to 5 grams

   Note: Samples obtained from sampling sites were generally low in organic matter, so this lab used 7 grams of solid weight for each soil sample.
5. Put the weighed sample into a 100 ml centerfused tube.
6. Add 40 ml of 1st extraction solution - 1 M solution of ammonium acetate. Stopper that up, shake for about five minutes. Line all the samples in a tray and put them on automatic shaker for many soil samples.
7. Let the solution stand overnight.
8. Shake the soil samples up again for 15 minutes.
9. Do 1st filtering (must have all solutions on hand and ready to go) - need 1M ammonium acetate, isopropanol, 1 M potassium chloride solution.

10. Set up the vacuum flask, put the funnel on top, and slant the long tip of the funnel away from vacuum. Hook the vacuum flask up to the vacuum apparatus. Place right-sized filter paper on the funnel (coving all the holes of the funnel).
11. Start the vacuum to suck on the paper and the soil feed underneath.

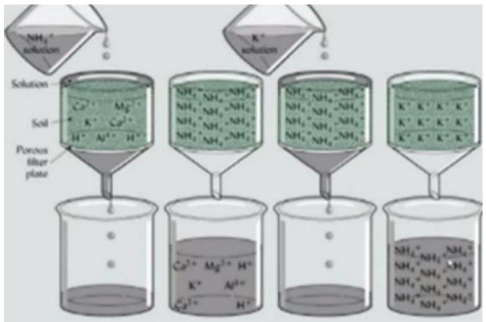

Figure 3 Ammonium ion is replacing the other cations. Ammonium ion has replaced all of the other cations that were originally on the exchange site. Those cations should be released because they have been displaced into the solution Ca++, K+, Mg++ (Russ Briggs from ESFA Academics).

12. Give a little rinse to the “stopper” and “tube” making sure to get all of the soil sample.
13. Do a couple more rinses with ammonium acetate – 4 washes with 30 ml ammonium acetate solution. (a handy dispenser can approximate volumes)
14. Discard the solution at the bottom of vacuum flask, disconnect the flask and dump off what is left in the bottom into a waste container.
15. Do the 2nd filtering and rinse with isopropanol. Wash three times with 40 ml of isopropanol to rinse out the excess ammonium that is not actually adsorbed onto the exchange sites in the soil.
16. Dispose the filtrate again.
17. Do the 3rd rinse. Wash with 50 ml of potassium chloride four times. Do not go over 250 ml, because that is the final volume we are going to work up to. The potassium ions are going to displace all of the ammonium ions that are currently on the site so that we can measure how much ammonium was there.
18. Take the filtrate that contains the ammonia we want to analyze, and pour that into the volume metric flask.
19. Use more KCl solution to take up the volume in the flask just below the line.
20. Grab a squeeze bottle and finish it off so that the bottom of the meniscus is at eye level, just at the line =250ml.
21. Stopper up and mix the solution in the volume metric flask so that the air bubble goes all the way

to the bottom and all the way back up to the top of the neck up to 20 times inverted to thoroughly mix the solutions.

22. Transfer 60 ml (a small amount) into a small media bottle, and that is what will be sent to UC Davis Analytical Lab to do color metric method to analyze ammonium using flow injection analysis (FIA). Label the sample container with sample code and dates so that we are able to track our samples.

Note:

(1) The last step was to determine the concentration of NH4-N in the KCl extract by distillation or colorimetry as well as to determine NH4-N in the original KCl extracting solution (blank) to adjust for possible NH4-N contamination in this reagent. Where NH4-N was reported in mg NH4/L: CEC ($cmol_c$/kg) = [(NH4-Nin extract - NH4-Nin blank) /18] centi-mol per kg.

(2) One tube of KCl blank and liquid sample tubs were then sent out to UC Davis Analytical Lab for ammonium analysis. Since those sample were for a baseline surface soil survey of the costal sage scrub and chaparral habitats of the NEP, no reference sample or lab replicates were available to measure lab precision.

5.6. Analysis Procedure

5.6.1. Accuracy Assessment for 2015 Vegetation Landcover Classes Map

The collected data were utilized as ground truth data for quality control for high thematic accuracy (> 85%) of GIS maps, which were derived from fine resolution aerial photos for the NEP landcover classes. The accuracy assessment was done by "comparing the vegetation [class] shown on the map to the vegetation [class] identified on the ground for a representative sample of evaluation points." Both producer's and user's accuracy were calculated for each vegetation type (Appendix N). (ESRI, 2017; NatureServe 2008)

5.6.2. Canopy Percentage Coverage

The results of land cover maps were then used to calculate the number of pixels of each plant community on the raster map to determine the canopy percentage coverage of plant communities. The same method was use to determine the canopy percentage coverage of dominant species.

5.6.3. Surface Soil Run-off Volume Calculation

The collected survey data were used to calculate the surface soil run-off volume of each surveyed location using The Universal Soil Loss Equation: $A = RKLSCP$, where A is *average annual soil loss* in tons per acre per year (t/a). R is *rainfall and runoff erosivity index* for a given location. K is *soil erodibility factor*, which is the bonding character of a soil type and its resistance to dislodging and transport due to raindrop impact and overland flow. LS is *the topographic factor*, where L is *slope length factor*, and S is *slope steepness factor.* Both result in increased erosion potential, but in a non - linear manner. C is *cover and crop management factor*, and P is *conservation or support practice factor*. Pease see appendixes A, B, and C for reference tables and examples of the Universal Soil Loss Equation from USDA.

6. Results

6.1. Accuracy of 2015 GIS Vegetation Map

The results of this accuracy assessment showed user's accuracy at 86.4 percent and producer's accuracy at 88.1 percent for landcover vegetation map.

6.2. Landcover Classes

6.2.1. Percentage Coverage of Landcover Classes

This table shows that Chaparral had the highest canopy percentage coverage at a 24.71, Alluvial Chaparral and Alluvial Fan Sage Scrub at a 16.86 percent, followed by Bare Grounds and Rocks together at an 18.82 percent. Woodlands only covered 17.25 percent at the NEP. Note that Shadow had a 9.80 percent coverage on this raster vegetation map.

Table 1 Canopy percentage coverage of landcover classes of the NEP

LandCover Class	Canopy Percentage Coverage
White Alder Riparian Forest	17.25
OAK Woodland	
Sycamore Alluvial Woodland (RIP)	
California Walnut Woodland	
Eucalyptus Windrows	
Chamise Chaparral or Chaparral	24.71
Alluvial Chaparral	9.02
Riversidean Alluvial Fan Sage Scrub	7.84
Spare	12.55
Bare Ground with litter	5.88
Bare Ground	7.06
Rock	5.88
Shadow	9.80
Total	100

The 2015 landcover-classes map illustrates the distribution of the vegetation communities among 18 landforms at the NEP. All five woodland classes are presented by Woodlands (Map 2, Appendix D).

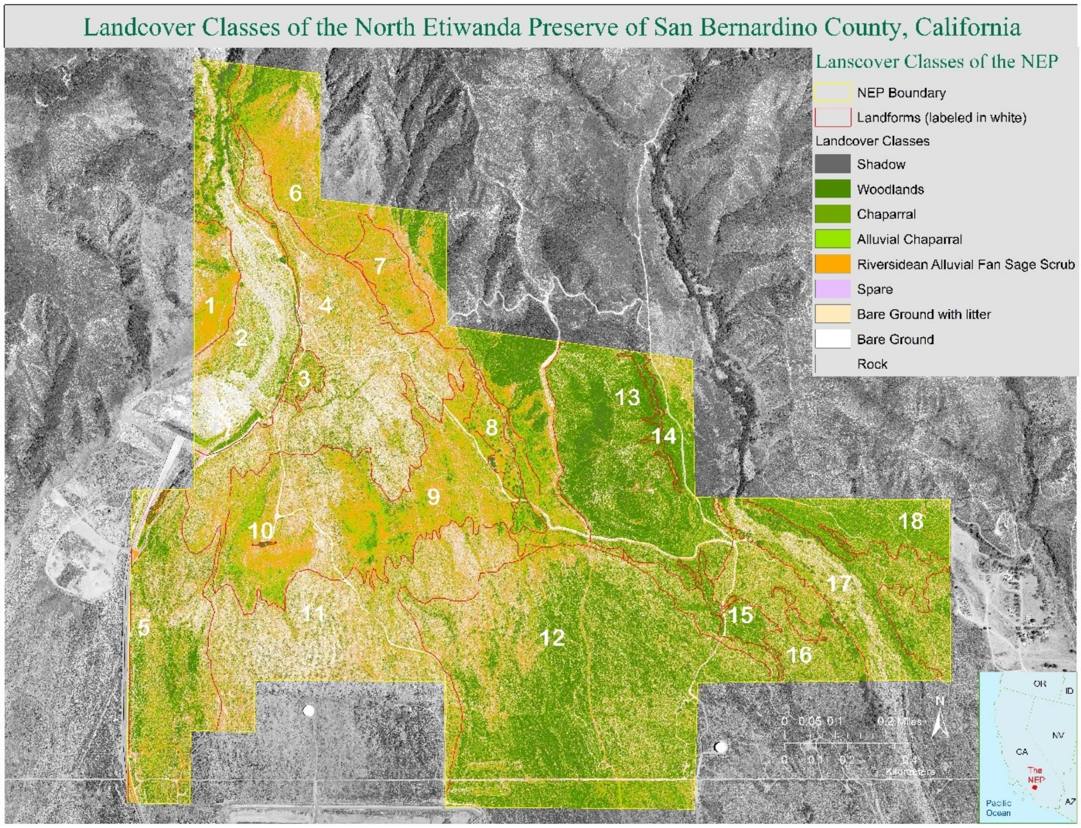

Figure 4 The landcover classes map of the NEP

6.2.2. Dominant landcover class of each landform

1. West of Day Creek – Non-native Grassland
2. Day Creek – White Alder Riparian Forest at the north section, Interior Live Oak Woodland along rocky slopes, and sand bars, and Spare vegetation on rocky stream beds
3. Mid East of Day Creek – dominated by Walnut trees mixed with *Ceanothus* spp.
4. East of Day Creek – Mulefat Scrub dominated on this historical agricultural land
5. Lower Day Creek – CC/ Alluvial Scrub or Alluvial Chaparral, which was a mix of Yerba Santa, White Sage, Deer Weed, and Buck Wheat
6. North Hill – Mainly bare ground with some Alluvial Scrub
7. Eucalyptus Windrows – Three windrows of *Eucalyptus* sp., which is a non-native species, were planted on the north central section of the historical agricultural land at the east alluvial fan of Day Creek
8. Oak Wood Area – Oak Woodland next to the rocky slope of Fire Break Hill

9. Bog Area – Riversidean Alluvial Fan Sage Scrub and non-native grassland
10. Forest Service Station – Oak trees, white Sage, Deer weed, and non-native grasses
11. West Alluvial – Riversidean Alluvial Fan Sage Scrub (Alluvial Scrub), which included White Sage, Yerba Santa, Deer Weed, and other soft-leaved drought deciduous species covered the gentle slope of the alluvial fan area
12. *Ceanothus crassifolius* Chaparral - Ceanothus Chaparral/Riversidean Alluvial Fan Sage Scrub (CC/Alluvial Scrub) or Alluvial Chaparral, which was a mixed shrubland on the south-central section of the preserve
13. Fire Break Hill - Woody evergreen species of Chamise Chaparral at the undisturbed area, Grass and CC/Alluvial vegetation for the fire break areas
14. Small Creek – Mainly Chamise Chaparral, a mix of Black Sage and California Coatal Sagebrush
15. West of East Etiwanda Creek – dominated by California Walnut Woodland mixed with *Ceanothus* and California Coatal Sagebrush
16. East Alluvial - Riversidean Alluvial Fan Sage Scrub and Non-native Grassland along the southern hill
17. East Etiwanda Creek - Sycamore Alluvial Woodland occurred along Etiwanda Creek mixed with some Interior Live Oak Woodland along the west bank of the creek
18. North of East Etiwanda Creek - Chamise Chaparral on south facing mountain slopes

The illustration of the west to east cross-section of the NEP

W ⟶ E at around 34.17344° N

Landcover class	Riversidean Alluvial Fan Sage Scrub	Riversidean alluvial fan sage scrub	Riversidean Alluvial Fan Sage Scrub	Non-native grassland	Sparse CCI Alluvial Scrub	Riversidean Alluvial Fan Sage Scrub	Riversidean Alluvial Fan Sage Scrub	Chamise chaparral	Chamise Chaparral	Chamise Chaparral
% Canopy coverage	20	30	15	5	5	10	40	65	45	45
Succession stage	Secondary pioneer	Secondary pioneer	Secondary pioneer	Secondary pioneer	Secondary pioneer	Secondary intermediate	Primary mature	Primary mature	Primary mature	Primary mature
Direction	← Intense disturbance could reset the community to an earier stage					→ Very few non-native species were found				
Agents of change	Fire	Fire, historical agricultural land	Fire, historical agricultural land	Fire, bog	Fire, soil erosion	Fire	Land use	Structure of the vegetation community	Structure of the vegetation community	Structure of the vegetation community
Key plant species	*Acmispon glaber*, *Salvia apiana*, *Eriogonum fasciculatum*, *Eriodictyon trichocalyx*, and *Piptatherum miliaceum*,	*Acmispon glaber*, *Artemisia californica*, *Salvia apiana*, and *Verbesina encelioides*	*Acmispon glaber* and *Salvia apiana*	*Cirsium* thistle, *Brassica nigra*, and non-native grasses	*Artemisia californica*, *Eriodictyon trichocalyx*, and *Salvia apiana*	*Artemisia californica*, *Salvia apiana*, *Salvia mellifera*, *Eriogonum fasciculatum*, *Cirsium* thistle, and *Piptatherum miliaceum*	*Artemisia californica* , *Salvia apiana*, and *Eriogonum fasciculatum*	*Artemisia californica* , *Salvia apiana*, *Salvia mellifera*, and *Eriogonum fasciculatum*	*Artemisia californica* and *Salvia mellifera*,	*Artemisia californica*, *Salvia mellifera*, and *Eriogonum fasciculatum*

Slope (%)	10.8	15.7	12	10	12	13.7	12	11	14.3	12.2

Soil Texture	Loamy sand	Loamy sand	Loamy sand	Sandy loam	Sandy loam	Sandy loam	Sandy	Sandy loam	Loamy sand	Loam sand
Soil plasticity	None	None	None	Low	Low	Low	None	Low	None	None
Soil permeability	High	High	High	High	High	High	High	High	High	High
Year of soil	2.5	2.5	2.5	2.5	7.5	10	2.5	10	7.5	7.5
pH Value	7.5	7.4	7.5	7.2	7.4	7.4	7.5	7.5	7.4	7.3
Bulk density g/cm^3	1.25	1.10	1.36	0.96	1.18	1.28	1.39	1.20	0.92	1.02
Soil water % weight	4.85	5.42	3.09	2.25	0.90	0.90	1.09	1.03	8.28	6.83
Temperature difference ° C between surface & soil at 8in depth	3.6	5	9.3	3.7	13.9	13.1	10	10.4	6.6	13
Cation exchange capacity (meq100g)	3.43	2.87	3.41	7.2	4.71	3.37	3.17	3.51	5.20	5.06
Average annual soil loss tons/acre/year	0.16	0.05	0.16	0.006	0.20	0.20	0.11	0.08	0.09	0.14
Surveyed area	Day Creek	Near west trail	West trail	Bog area	Center area / gully	Fire break	East trail	Near east trail	East Etiwanda Creek	East end of the NEP

Figure 5 The west to east cross-section of the NEP along the 34.471 degrees north. This graphic representation illustrates the various surface and subterranean parameters of the preserve along the west to east cross-section of ten sections of the preserve along the 34.471° north.

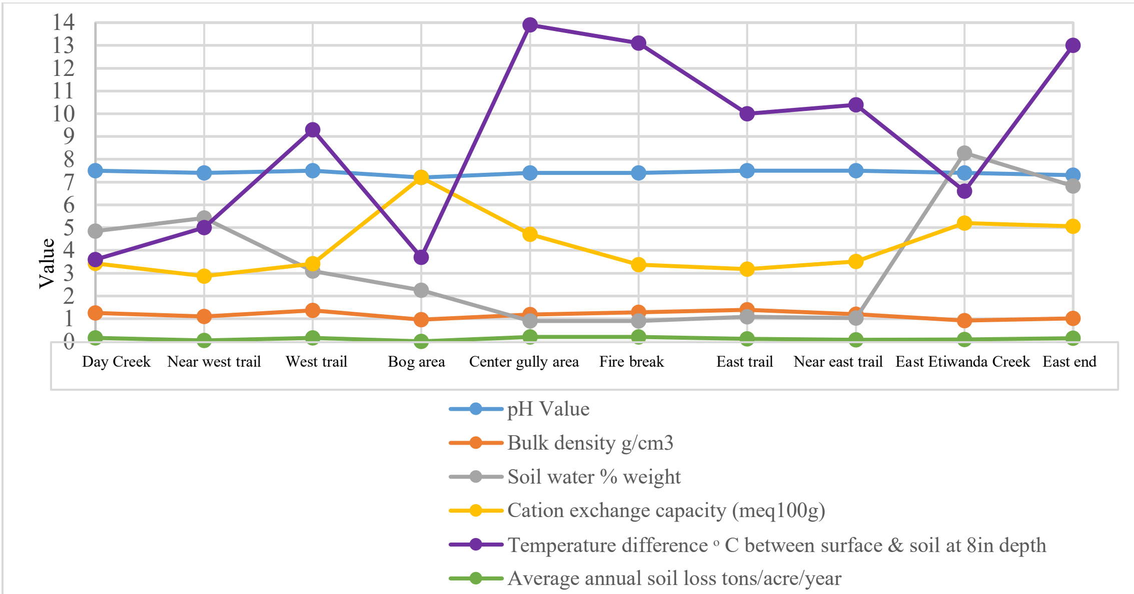

Figure 6 Comparison of soil perimeters. Temperature difference between surface and subterranean soils is the most sensitive parameter that has readings ranging from 3.6º to 13.9º C.

6.3. Surface Soil Condition

Part of the NEP is a steep hill and the rest of the area is slow slope alluvial fan. Watershed soil parent materials include: gravels, sands, alluvial fans, igneous and sedimentary rocks. The major soil type of the NEP was coarse-grained sands upslope near the mountains. Soil pH value ranged from 7.2 to 7.5, and the bulk density ranged from 0.92 to 1.29 g/cm^3 (Figures 5 and 6). Cation exchange capacity had the highest value at the bog area, and the soil water % weight had a peak at the near west trail section. Soil profile of the NEP was mainly Soboba stony loamy sand at around10 percent slope with a very stony loamy sandy O horizon.

California Coastal Sage (*Artemisia californica*), Black Sage (*Salvia mellifera*), and *Ceanothus* spp. grow at chaparral habitat near East Trail on a south facing open slope. The surface was covered by 5 - 18 mm gravel and 40 -150 mm rough edged cobbles. Soil pits showed about 5 cm (2 in.) of Oi, 8 cm (3.15 in.) of Oe followed by Oa below. A horizon started at about 15 cm dept. Soil structure was a loss plate-like structure, gravel sand. Soil ribbon was dull and fell apart at 2.5 cm long and grittiness was prominent feeling sandy loam. The soil had low plasticity and low shrink-swell potential. The greatest soil stability was located along the east side of the preserve where most of plant communities were at their mature succession stage.

White Sage (*Salvia apiana*), Deer Weed (*Acmispon glaber*), dominant coastal sage scrub habitat grew at south facing open slopes. The surface was covered by little twigs, 8 - 20 mm gravel, and 50 -150 mm rough edged cobbles. The pit was about 20 cm deep at very “rocky” locations and showed about a 15 cm (6 in) O horizon followed by A horizon (uncoated sand grains) below it. There was no observable aggregation or soil structural units with large size gravel sand. Soil ribbon test showed no plasticity, no shrink-swell potential.

6.4. Surface Soil Run-off Rate

Areas of soil erosion appeared greatest along the fire break areas and within areas of previous wildfire events (Figure 7).

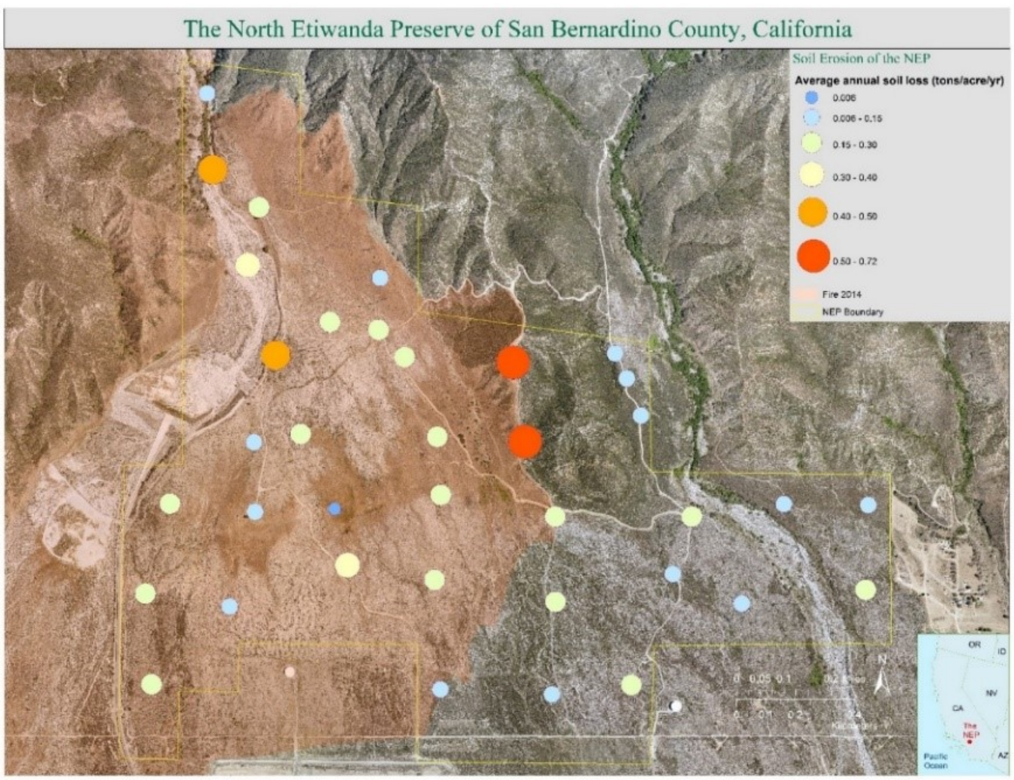

Figure 7 Map of surface soil run-off rate for survey sites at the NEP. Two sites located along the Fire break line of the steep hill appeared to have the highest soil run-off rate.

7. Discussion

7.1. GIS map accuracies

GIS data accuracies included the accuracies of source data and accuracies of the map products. The GPS-error of survey data was about plus-minus 2.5 meters, which means the resolution of survey data could be set at 5m x 5m. According to the USDA, 90 % of points from the 2015 aerial image was tested and had a 98% accuracy within plus- minus of 6 meters on the ground (Appendix E).

This accuracy assessment indicated the user's accuracy at eighty-six percent, which means that the map user would have an 86.4 percent chance (reliability) to encounter correct community types when using the mapped and labeled (classified) vegetation types on raster image. The producer's accuracy at 88.1 percent means that the map maker would have an eighty-eight percent chance to represent the aerial photo interpretation to distinguish ground community types correctly. Both producer's and user's accuracy had high thematic accuracies (> 85%). This means the 2015 GIS vegetation landcover map can be used for several types of spatial analysis regarding the NEP.

7.2. Landcover Class Distributions

The canopy percentage coverage of each land cover class would shift depending on the scale of the map unit used on the map. The percentage of land-cover classes covered in 2015 exhibited a high percentage coverage (31.37 %) of the open area, such as spare, rocky and bare ground from Table 1 (included the trails, most parts of the dam, and dry river beds). This potentially is due to the years of severe drought (2011 -2015) and a wildfire event in 2014. Dark shadow pixels were identified as one of the classes, which is one type of limitation when using an aerial raster image as reference.

The NEP was dominated by CSS, (Alluvial and Chaparral communities at 41.57 canopy percentage coverage, Table 1), which included Ceanothus spp. California Sagebrush, Buck Wheat, Yerba Santa, Black Sage, White Sage, Deer Weed, and Turpentine Bush. According to the *North Etiwanda Preserve Management Plan* (USFWS and CDFG, 2010), "the CDFG'S Natural Diversity Data Base ranks alluvial scrub as S1.1 (very threatened) and a G1 (global level) rare natural community. This is the highest ranking used by CDFG in its inventory of rare natural communities and receives high priority ranking for preservation." Thus, NEP is an important conservation area for such "endangered habitat".

7.3. Succession Stage

Naturally Disturbed Areas

In this Mediterranean climate region, plant community succession stages are often influenced by the frequencies and the intensities of wildfires. The 2014 fire effects can be observed along the alluvial fan at the western portion of the NEP, where the burn-footprint is currently a pioneer successional stage dominated by non-native species.

Human Disturbed Areas

As a result of the 2014 fire, fire breaks were mechanically created generally in a west to east direction along the upper-slopes of the preserve to control the extent of the 2014 fire encroachment in the northern center portion of the NEP. Those deep cuts were approximately six meters wide, and most likely removed the native seed bank in the surface soil layer, which would reduce propagation of native plants. Recent survey indicate that these fire breaks are still bare grounds, with no native species growth when compared to other burned areas of the 2014 fire. Generally non-native species observed at the NEP exploited early succession as a part of their life-history strategies, and are commonly found in riparian and disturbed areas, which also include the recovering areas of historic agricultural lands located at the northern portion of the NEP.

7.4. Soil Properties

The Chaparral communities at the NEP had gritty soil texture, which means soil had large pores, high drainage rate, low water holding capacity, low soil organic matter, and low weathering. Soil permeability was high, and soil separated into coarse sand (1.2 – 0.5 mm). The ribbon test results suggested soil had low plasticity and low shrink-swell potential. The temperature difference between surface and subterranean soils was about 10º C, which might result from dense ground cover at the surface. The root system of plant communities at the mature successional stage are strong and often grow deeper than alluvial scrub, which can reduce the risk of soil run-off.

The Alluvial communities at the NEP had very gritty soil texture, large pores, high drainage rate, low water holding capacity, low soil organic matter, and low weathering. Soil permeability was high, and soil separated into very coarse sand (2.0 - 1.0 mm). Those conditions suggested the area has high soil run-off volume potential. The temperature difference between surface and subterranean soils was generally 4º C, which potentially might caused low vegetation density ground cover.

7.4.1. Organic Matter and Water Availability

General soil condition contains 25% of air, 25 % of water, 45 of % mineral matter, and 5 % of organic matter. Created by microbial transformation of biomolecules in all soil, the 3D non-crystalline polymers of organic colloids (humus) had the highest total surface area per unit mass than any other soil colloids, which means very high water content and very high soil fertility. Soil CEC is related to soil fertility in that the hydrogen ions (H^+), which provides nutrients availability for plants by displacing the cations. Because of the low organic content of organic matter, the soil CEC in the NEP is relatively low (Appendix K). The surface soil condition of the NEP are strongly influenced by vegetation types and the litter/wood cover.

It is normal for this coastal sage shrub habitat to have soil pH value around 7.4, and the bog area has pH = 7.2 due to higher organic matter in the soil. Changes of pH in a habitat promote non-native species growth, which could lead to the primary species demise by outcompeting the native species for nutrients. Changes can also occur by microbial succession due to water availability and temperature change. The high-water permeability of coarse sandy soil also indicates low water availability for vegetation growth. The drought tolerance of native coastal sage scrub could be one of the factors that enables native species to out-compete with non- native species. This strategy could enhance the native vegetation recovering process after disturbances such as wild fires or road cuts.

7.5. Soil Erosion

Soil resilience depends on physical, chemical, and biological processes and effectiveness of chemical and biological conditions under an optimal edaphic environment. Areas of soil erosion appeared greatest along the fire break areas and within areas of previous wildfire events. Soil disturbance, such as foot traffic or mechanical manipulation heightened non-native plant species growth in the NEP. The presence of non-native annual plant species had shallow root systems that affected soil structure, chemicals, and water retention in impacted areas. The greatest soil stability was located along the east side of the preserve where most of plant communities were at their mature successional stage.

With respect to erosive capacity, the two savannahs, represented by the Day Creek section and the near west trail section, underwent much less soil loss compared to the fire break section. The conservation factor (P) and rainfall, runoff erosivity factor (R), and soil texture were the same for all sampling sites. According to the description, the slope length was the same for all three sites, however the slope steepness differed for each site. The fire break section had a slower slope than the near west trail section, but the bare rocky surface from mechanical manipulation was prone to erosion. Although the near west trail section had the steeper slope, making the potential for higher levels of erosion more likely, it displayed the lowest total gross soil loss. This can be attributed to the nature of the setting; there is a high percentage of canopy cover that translates to an extensive plant root network, which serves as the support structure keeping the soil in place, even for a soil with a high sand index.

8. Conclusions

The vegetation communities of this south-east side of the Transverse Ranges include riversidean alluvial fan sage scrub, which is drought-deciduous, soft-leaved, sub-shrubs dominant habitat (CSS). The canopy percentage coverage of chaparral species and nonnative weedy herbaceous species was determined to be low at the NEP after five years of drought stress. The distribution of coastal sage shrub communities within the early successional stages are pioneer species such as annual grasses, deer weed, and white sage that generally dominant disturbed areas. Disturbed areas are susceptible to soil erosion and changes in existing native plant species which can lead to a change of habitat type not only for native plants, but also for endemic invertebrate and vertebrate species in this Mediterranean climate region

Historically, approximately 90% of CSS habitat in the Southern California has been lost to human development. In southern San Bernardino County, CSS occurrence has been reduced to preserves and uninhabitable areas because of development of new urban area in the southern County. Furthermore, potential environmental change agents of the succession stages of CSS habitat include habitat fragmentation, climate condition, wildfire events, and water harvesting.

The Day Creek Canyon watershed in the NEP has been an important local water source since the early 1800s. In the City of Rancho Cucamonga alone, the population was over 171,000 in 2015. Housing developments have occurred at the mouth of the watershed which means more habitat loss, habitat degradation, higher soil erosion, a greater wildland/urban interface, and a decrease in ecological functions. The fast-growing population in the area also means an increasing demand in water usage. The ecosystems of the NEP need to be at their ultimate conditions to support the ecological functions favorable to nearby residents and local wildlife (Appendix L). Now is the most critical time for more in-depth studies of the NEP ecosystem to construct viable management plans to maintain the ecological integrity and functions of the preserve.

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10. Appendices

Appendix A Soil Erosion Factors

Table A1 Cover management, "C" factors for permanent, rangeland, and idle land

Vegetal Canopy		Cover That Contacts the Surface						
Type and Height of Raised Canopy[2]	Canopy Covers[3] %	Type[4]	0	20	Percent Ground Cover 40	60	80	95-100
No appreciable canopy		G	.45	.20	.10	.042	.013	.003
		W	.45	.24	.15	.090	.043	.011
Canopy of tall weeds or short brush, 0.5 m (1.6 ft.) fall ht.	25	G	.36	.17	.09	.038	.012	.003
		W	.36	.20	.13	.082	.041	.011
	50	G	.26	.13	.07	.035	.012	.003
		W	.26	.16	.11	.075	.039	.011
	75	G	.17	.10	.06	.031	.011	.003
		W	.17	.12	.09	.068	.038	.011
Appreciable brush or bushes, 2 m 6.6 ft. fall ht.	25	G	.40	.18	.09	.040	.013	.003
		W	.40	.22	.14	.085	.042	.011
	50	G	.34	.16	.085	.038	.012	.003
		W	.34	.19	.13	.081	.041	.011
	75	G	.28	.14	.08	.036	.012	.003
		W	.28	.17	.12	.077	.040	.011
Trees but no appreciable, low brush , 4 m (13.1 ft.) fall ht.	25	G	.42	.19	.10	.041	.013	.003
		W	.42	.23	.14	.087	.042	.011
	50	G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.085	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.083	.041	.011

[1] All values shown assume: (1) random distribution of mulch or vegetation, and (2) mulch of appreciable depth where it exists. Idle land refers to land with undisturbed profiles for at least a period of three consecutive years.

[2] Average fall height of waterdrops from canopy to soil surface.

[3] Portion of total-area surface that would be hidden from view by canopy in a vertical projection (a birds'-eye view).

[4] G: Cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 2 inches deep.

W: Cover at surface is mostly broadleft herbaceous plants (as weeds with little lateral-root network near the surface, and/or undecayed residue).

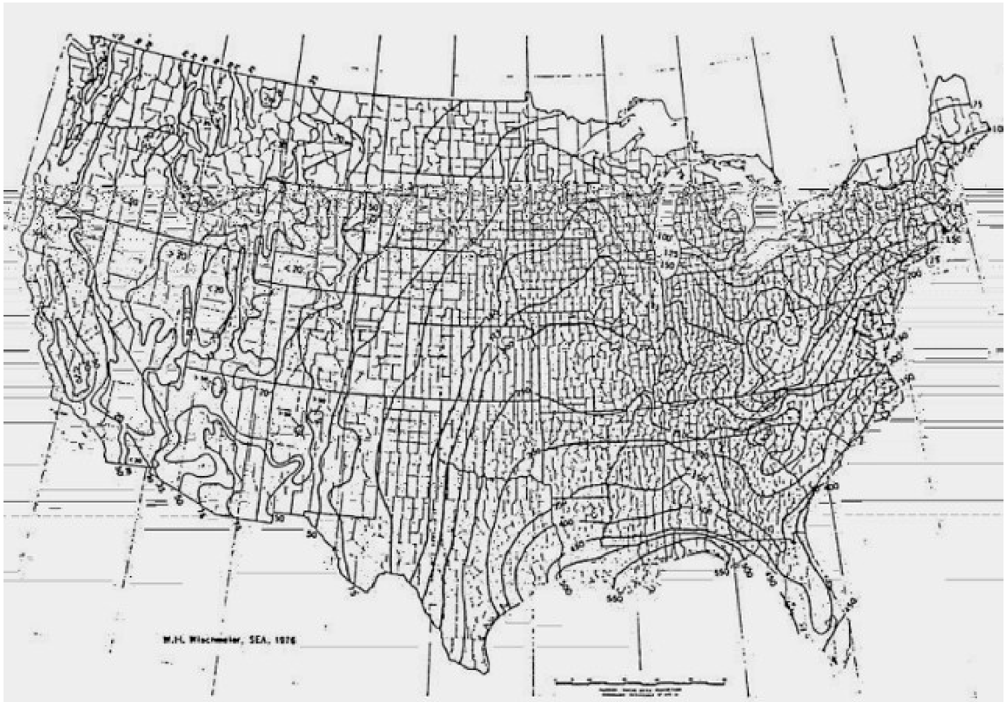

Figure A-1 Average annual values of the rainfall erosion index

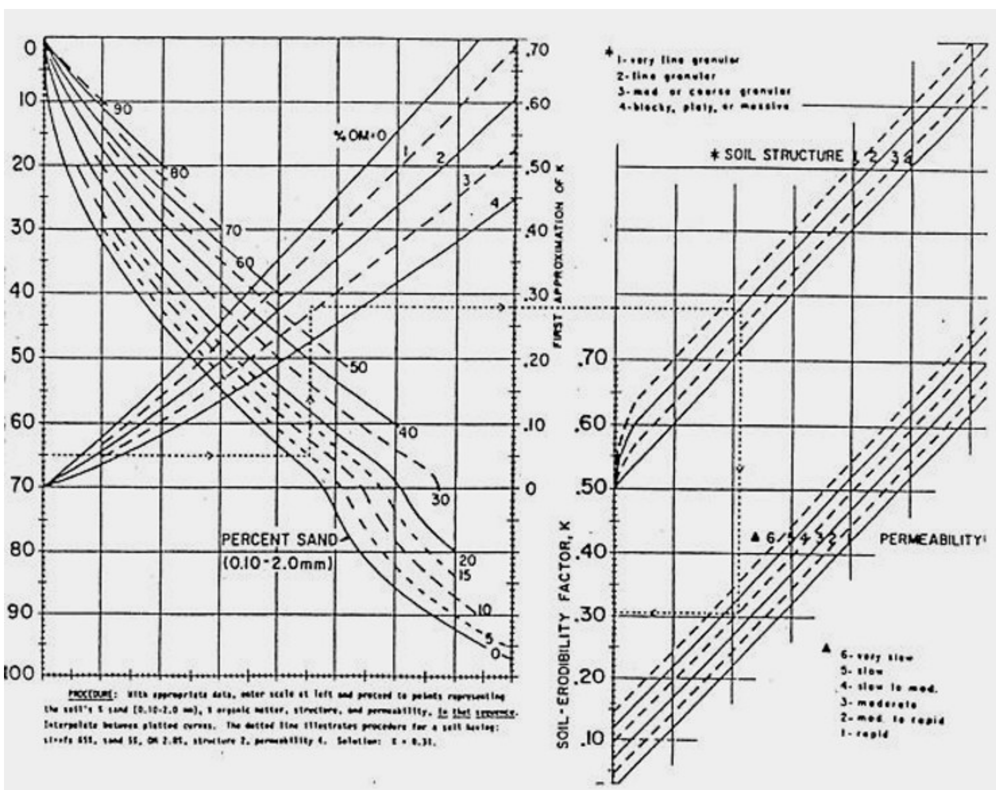

Figure A-2 Soil-erodibility nomograph.

Where the silt fraction does not exceed 70 percent, the equation is:

100 K = 2.1 M1.18 (104) (12 - a) + 3.25 (b - 2) + 2.5 (c - 3) where M = (percent si + vfs) (100-percent c), a = percent organic matter, b = structure code, and c = permeability class.

The nomograph used to determine the K factor for a soil, based on its texture (% silt plus very fine sand, % sand, % organic matter), soil structure, and permeability. *Soil Structure:* 1 friable, 2 fine polyhedral, 3 medium to coarse polyhedral, 4 lamellar or solid column.

Permeability: 6 very slow, 5 slow, 4 slow to moderate, 3 moderate, 2 moderate to fast, 1 fast.

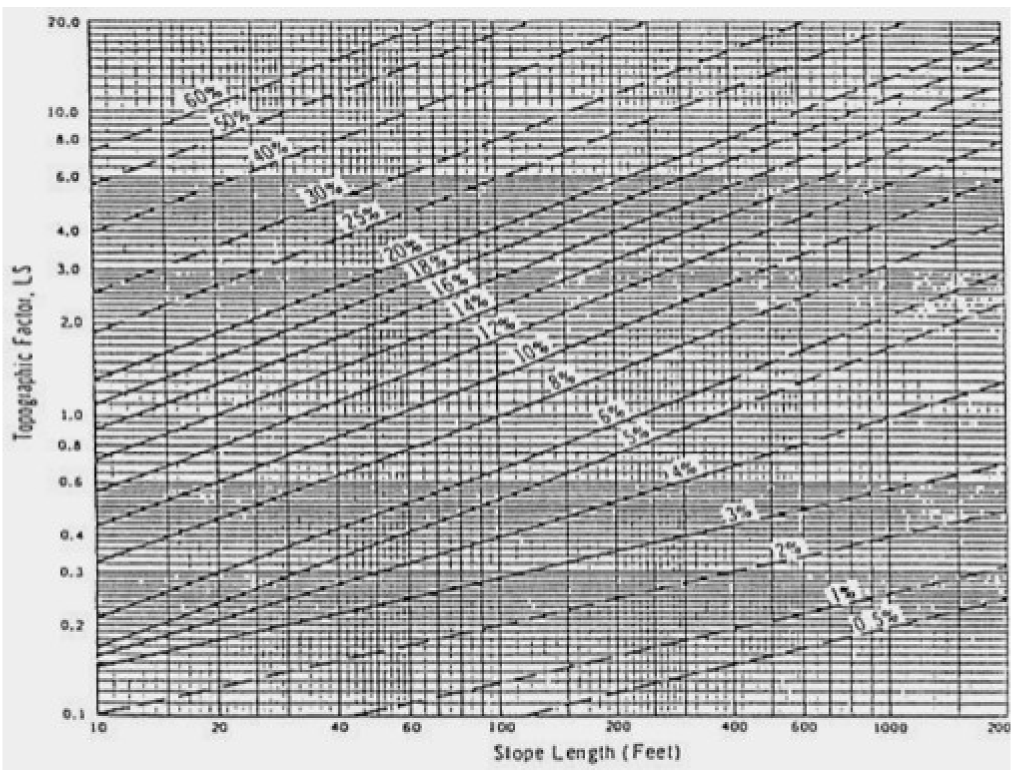

Figure A-3 Topographic LS factor

The conservation practice factor, P, is used to account for the positive impacts of such agricultural management practices as planting on the contour, strip cropping, and use of terraces. Since the NEP lands are not cropped, the primary conservation practice factors of interest will be terraces. Terraces reduce the slope length, and sometimes the slope steepness that, in turn, reduce the L and S factors in the USLE. Thus, the P factor is taken to be 1.0.

Appendix B USDA Textural Classification of Soil Triangle

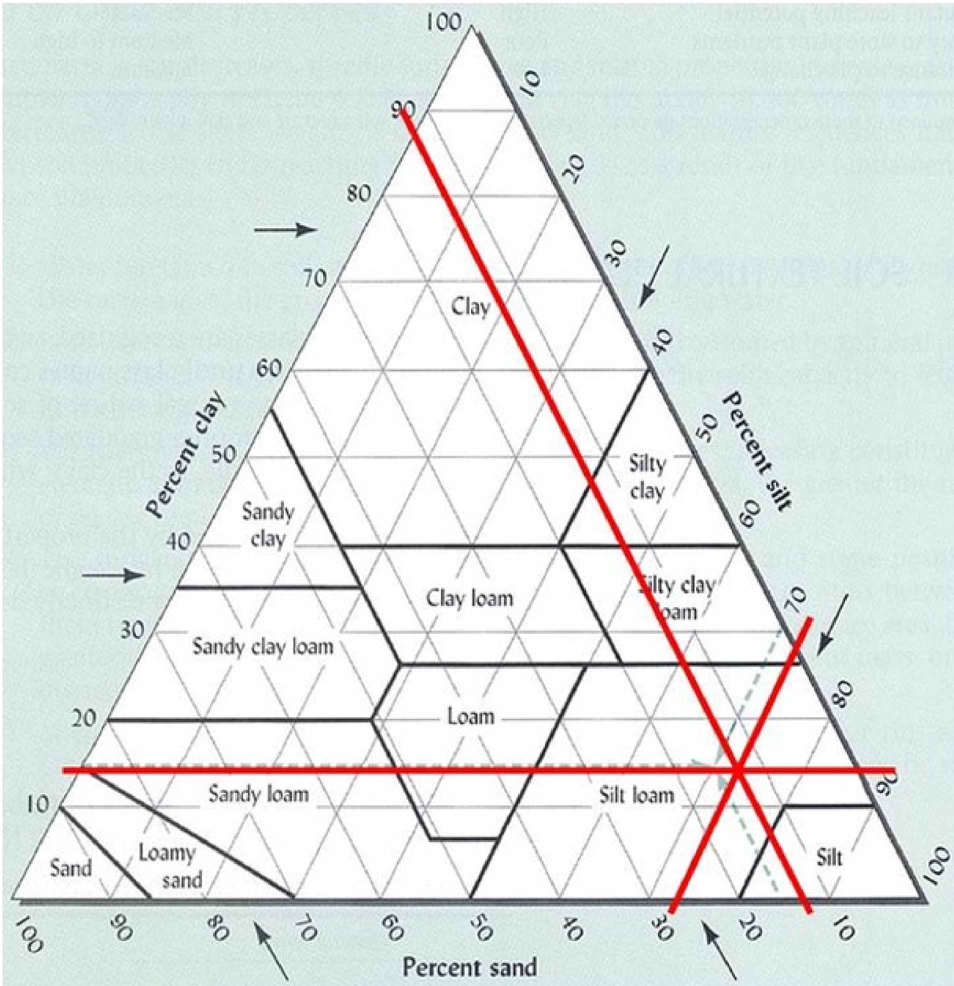

Figure B Weight percentages of sand, silt, and clay for classification in soil families.

The soil texture triangle associates with various combinations of sand, silt and clay. A coarse-textured or sandy soil is one comprised primarily of medium to coarse size sand particles. A fine-textured or clayey soil is one dominanted by tiny clay particles. Due to the strong physical properties of clay, a soil with only 20% clay particles behaves as sticky, gummy clayey soil. The term loam refers to a soil with a combination of sand, silt, and clay sized particles. For example, a soil with 30% clay, 50% sand, and 20% silt is called a sandy clay loam.

Appendix C Examples of Soil Erosion Calculation of the NEP

Part of the NEP is a steep hill and the rest of the area is slow slope alluvial fan. Watershed soil parent materials include: gravels, sands, alluvial fans, igneous and sedimentary rocks. From field observations the following information is obtained for three examples below:

Site 1: Close alluvial fan scrub plant community with 60 % underbrush and undisturbed litter.

Area = 22.24 acres.

Slope length = 1000 feet.

Slope steepness = (144/1000) x 100 = 14.4 %.

Soil texture = very coarse sand (2.0 - 1.0 mm)

Site 3: Bare rocky site, no coverage.

Area = 9.88 acres.

Slope length = 1000 feet.

Slope steepness = (161/1000) x 100 = 16.1%.

Soil texture = Coarse sand (1.0 – 0.5 mm)

Site 6: Open alluvial fan scrub plant community with 20% underbrush and undisturbed litter.

Area = 34.59 acres.

Slope length = 1000 feet.

Slope steepness = (60/1000) x = 6%.

Soil texture = Coarse sand (1.0 – 0.5 mm)

Compute the sediment loss under current land-use conditions

Method: Use the Universal Soil Loss Equation (USLE) as a tool to evaluate soil erosion. USLE was developed to estimate long-term average annual soil loss caused by sheet and rill erosion on agricultural lands. It can not be applied to a specific year or a specific storm.

The Universal Soil Loss Equation is: $A = RKLSCP$, where

A= average annual soil loss in tons per acre per year (t/a).

R= *rainfall and runoff erosivity index* for a given location, which is a statistic calculated from the annual summation of rainfall energy in every storm (correlates with raindrop size) times its maximum 30 - minute intensity.

K= *soil erodibility factor*. This factor quantifies the cohesive, or bonding character of a soil type and its resistance to dislodging and transport due to raindrop impact and overland flow.

LS= *the topographic factor*, where *L*= *slope length factor*, *S* = *slope steepness factor*. L and S are frequently lumped into a single term for convenience. Steeper slopes produce higher overland flow velocities. Longer slopes accumulate runoff from larger areas and also result in higher flow velocities. Both result in increased erosion potential, but in a non - linear manner.

C= *cover and crop management factor*, which is the ratio of soil loss from land cropped under specified conditions to corresponding loss under tilled, continuous fallow conditions. It incorporates effects of: tillage management (dates and types), crops, seasonal erosivity index distribution, cropping history (rotation), and crop yield level (organic matter production potential).

P= *conservation or support practice factor*. Practices included in this term are contouring, strip cropping (alternate crops on a given slope established on the contour), and terracing.

Since the NEP lands generally are not cropped, the primary conservation practice factors of interest will be terraces. Terraces reduce the slope length, and sometimes the slope steepness that, in turn, reduce the L and S factors in the USLE. Thus, the P factor is taken to be 1.0.

Appendix D The Vegetation Landcover of the North Etiwanda Preserve 2015

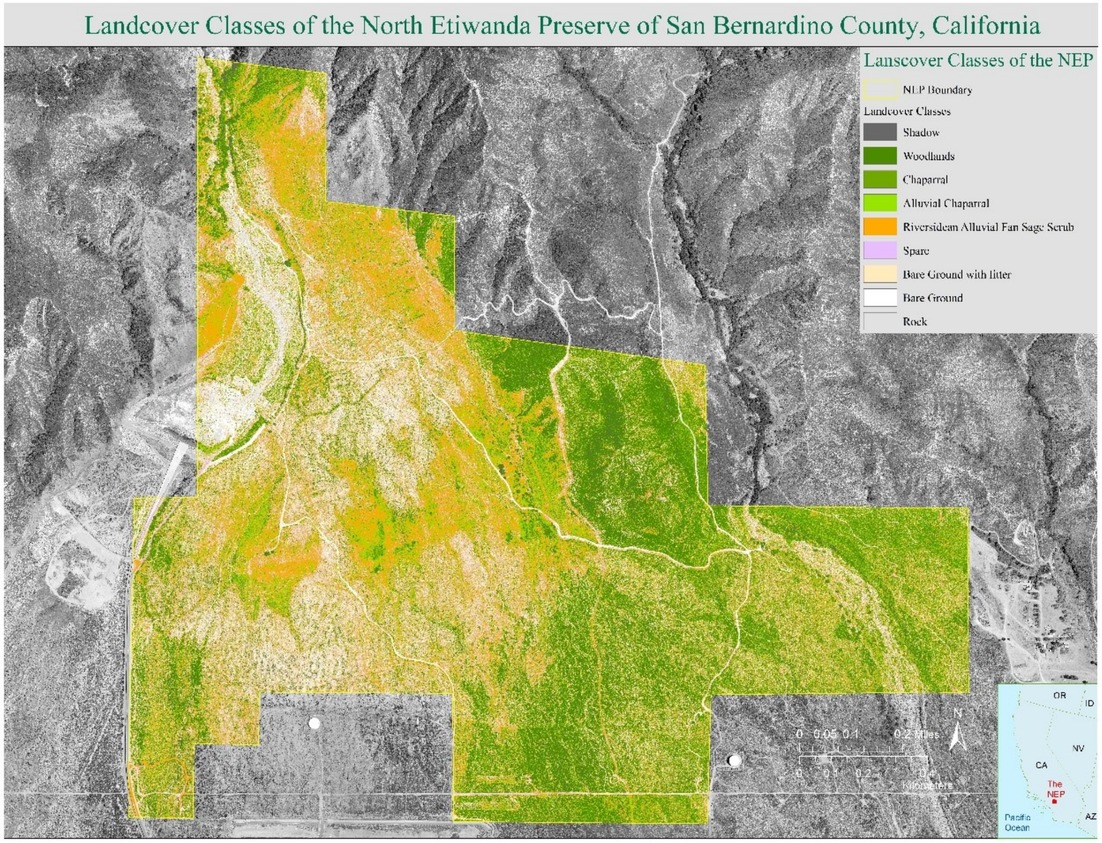

Figure D Map of the vegetation landcover classes of the NEP

Appendix E Conditions and Restrictions of GIS Data

Table E GIS data sources and data restrictions

Feature class/raster	Source	Ranges of valid input	Form of use	Original Coordinate system
CSA120 (NEP) Boundary	SB County	0-99	Polygon feature	NAD_1983_StatePlane_California_V_FIPS_0405_Feet
CSA120 Map Area	Created for map extent	0-99	Polygon feature	NAD_1983_StatePlane_California_V_FIPS_0405_Feet
Plant Diversity Dataset	Generated from survey data	Survey Site ID	Feature classes	NAD_1983_StatePlane_California_V_FIPS_0405_Feet
Hydrography Datasets	NRCS	30700 - 57300	Feature classes	GCS_North_American_1983, NAD_1983_UTM_Zone_11N
Contours	SB County	1160 - 8840		NAD83",SPHEROID
Road	TIGER/Line	MTFCC code	shapefile	GCS_North_American_1983, NAD_1983_UTM_Zone_11N
Fire Polygon	USDA FS Region 5	1911-2120	Polygon feature	NAD_1983_StatePlane_California_V_FIPS_0405_Feet
2015 Aerial Imagery	USDA National Agriculture Imagery Program		Tiff Raster	GCS_North_American_1983
City Boundaries	**SB County**	**0-3**	**Polygon feature**	**NAD_1983_StatePlane_California_V_FIPS_0405_Feet**

Note that “NAD_1983_StatePlane_California_V_FIPS_0405_Feet” is the preferred spatial reference for all feature classes and raster data present in SB County.

Appendix F The NEP 2016 Soil-Vegetation Survey Team

Table F The NEP 2016 soil-vegetation survey team and work hours. Survey team included biology, math and English students from Chaffey College and two registered NEP volunteers (*)

	First Name	Last Name	Sep. 30th, 2016	Oct. 1st, 2016	Oct. 7th, 2016	Oct. 8th, 2016	Oct. 15th, 2016	Oct. 22nd, 2016	Oct.29th, 2016	Mar.10th, 2017	Total hour
1	Esme	Santos	8:00 am - 4:00pm (- 45min lunch) = 7hr	8:30 am - 4:00 pm (- 45min lunch) = 6hr 45	8:00 am - 11:00 am = 3 hr	7:30 am - 1:30 pm = 6 hr	7:00 am - 1:30 pm = 6 hr 30 min	7:00 am - 1:30 pm = 6 hr 30 min	7:00 am - 1:00 pm = 6 hr		42 hr
2	An	Le				7:30 am - 1:30 pm = 6 hr					6 hr
3	Wajeha	mahmoud		8:30 am - 4:00 pm (- 45min lunch) = 6hr 45							6 hr 45 min
4	Rusul	hussein kamal		8:30 am - 4:00 pm (- 45min lunch) = 6hr 45		7:30 am - 1:00 pm = 5 hr 30 min			7:00 am - 1:00 pm = 6 hr		18 hr 15 min
5	Daniel	Zabriskie	8:00 am - 4:00pm (- 45min lunch) = 7hr	8:30 am - 4:00 pm (- 45min lunch) = 6hr 45	8:00 am - 11:00 am = 3 hr			7:00 am - 2:30 pm = 7 hr 30 min	7:00 am - 1:00 pm = 6 hr		30 hr 30 min
6	Michelle	Tristan		8:30 am - 4:00 pm (- 45min lunch) = 6hr 45		7:30 am - 1:00 pm = 5 hr 30 min		7:00 am - 1:00 pm = 6 hr	7:00 am - 1:00 pm = 6 hr		24 hr 15 min
7	Sayra	Velasco				7:30 am - 1:30 pm = 6 hr		7:00 am - 1:30 pm = 6 hr 30 min	7:00 am - 1:00 pm = 6 hr		18 hr 30 min
8	Bilal	Milbes				7:30 am - 1:00 pm = 5 hr 30 min	7:00 am - 1:30 pm = 6 hr 30 min	7:00 am - 2:30 pm = 7 hr 30 min			19 hr 30 min
9	Yuanrong (Rex)	Han							7:00 am - 1:00 pm = 6 hr		6 hr
10	Sergio	Villafenor							7:00 am - 1:00 pm = 6 hr		6 hr
11	Caprice	Depetro								9:00am- 11:30am = 2 hr	2 hr 30 min
12	Connor	Wilson								9:00am- 11:30am = 2 hr	2 hr 30 min
13	Natasha	Walton*					7:00 am - 1:00 pm = 6 hr				6 hr
14	Eunice	Bagwan*					7:00 am - 1:30 pm = 6 hr 30 min				6 hr 30 min

Appendix G The NEP 2016 Field Survey Form

2016 NEP Soil-Vegetation Mapping Ground Form

Plot:	Surveyors:		Date: 10/29/2016	Ecological System name:
GPS used:		WP:	Time:	
Lat:		Elevation (m)	Slope (degrees)	
Long:		Error ±	Aspect (1-360°)	
Camera used:		Photo taken:		Plot size: 12 m x 12 m

Ground cover % Cover	(total=100)	Plant community	Soil	
Litter		OAK Wood Land	Surface Temp	
Wood (> 1cm)		Eucalyptus Windrows	Soil Temperature	
Silt		White Alder Riparian Forest	Structure	
Sand		California Walnut Woodland	Texture	
Small rock (< 7.6 cm)		Sycamore/Willow Alluvial Woodland (RIP)	Ribbon test	
Large rock (> 7.6 cm)		Chaparral	Color	
Bed rock		Chamise Chaparral	pH	
Stems (basal area)		*Ceanothus crassifolius* Chaparral	Soil Water	
Moss		Alluvial		
Lichen		Riversidean Alluvial Fan Sage Scrub		Depth
Water		Mulefat Scrub	Horizon Oi	
Other (describe)		Non-Native Grassland	Horizon Oe	
		Freshwater Cienega (Cienega)	Horizon Oa	
Moisture regime		Freshwater Marsh	Horizon A1	
Dry		Gully	Horizon A2	
Mesic		Barren		
Wet		Disturbed		
Aquatic -FW		Other (describe)		

Landform

NEP Common Plants
Artemisia californica (California sage)
Salvia apiana (white sage)
Eriogonum fasciculatum (buckwheat)
Acmispon glaber (deer weed)
Eriodictyon trichocalyx (yerba santa)
Ceanothus crassifolius
Salvia mellifera (black sage)
Ericameria laricifolia (turpentine bush)
Yucca whipplei percusa

2016-Kuo

2016 NEP point intercept (at 1 meter intervel) Ground Truthing

Surveyors: Camera used: Photo taken:

Plot #	Lat:		Time:	Date: 10/29/2016	
Elevation (m)	Long:		Error ±	Phenology	
Species	Alive / dead	No. of times touching the pole	maximum height of touching point	Height of plant (m)	% of canopy with functioning leaves

Plot #	Lat:		Time:	Date: 10/29/2016	
Elevation (m)	Long:		Error ±	Phenology	
Species	Alive / dead	No. of times touching the pole	maximum height of touching point	Height of plant (m)	% of canopy with functioning leaves

Plot #	Lat:		Time:	Date: 10/29/2016	
Elevation (m)	Long:		Error ±	Phenology	
Species	Alive / dead	No. of times touching the pole	maximum height of touching point	Height of plant (m)	% of canopy with functioning leaves

Plot #	Lat:		Time:	Date: 10/29/2016	
Elevation (m)	Long:		Error ±	Phenology	
Species	Alive / dead	No. of times touching the pole	maximum height of touching point	Height of plant (m)	% of canopy with functioning leaves

Plot #	Lat:		Time:	Date: 10/29/2016	
Elevation (m)	Long:		Error ±	Phenology	
Species	Alive / dead	No. of times touching the pole	maximum height of touching point	Height of plant (m)	% of canopy with functioning leaves

2016-Kuo

G The NEP 2016 field survey form

Appendix H Filed Work Photos

Figure H-1 Example of a survey transect (Oct. 2016)

Figure H-2 Examples of point intercept plots (Oct. 2016)

Figure H-3 Photo Examples of soil on-site tests (Oct. 2016)

Appendix I Photos of Soil Structure of Sampling Sites

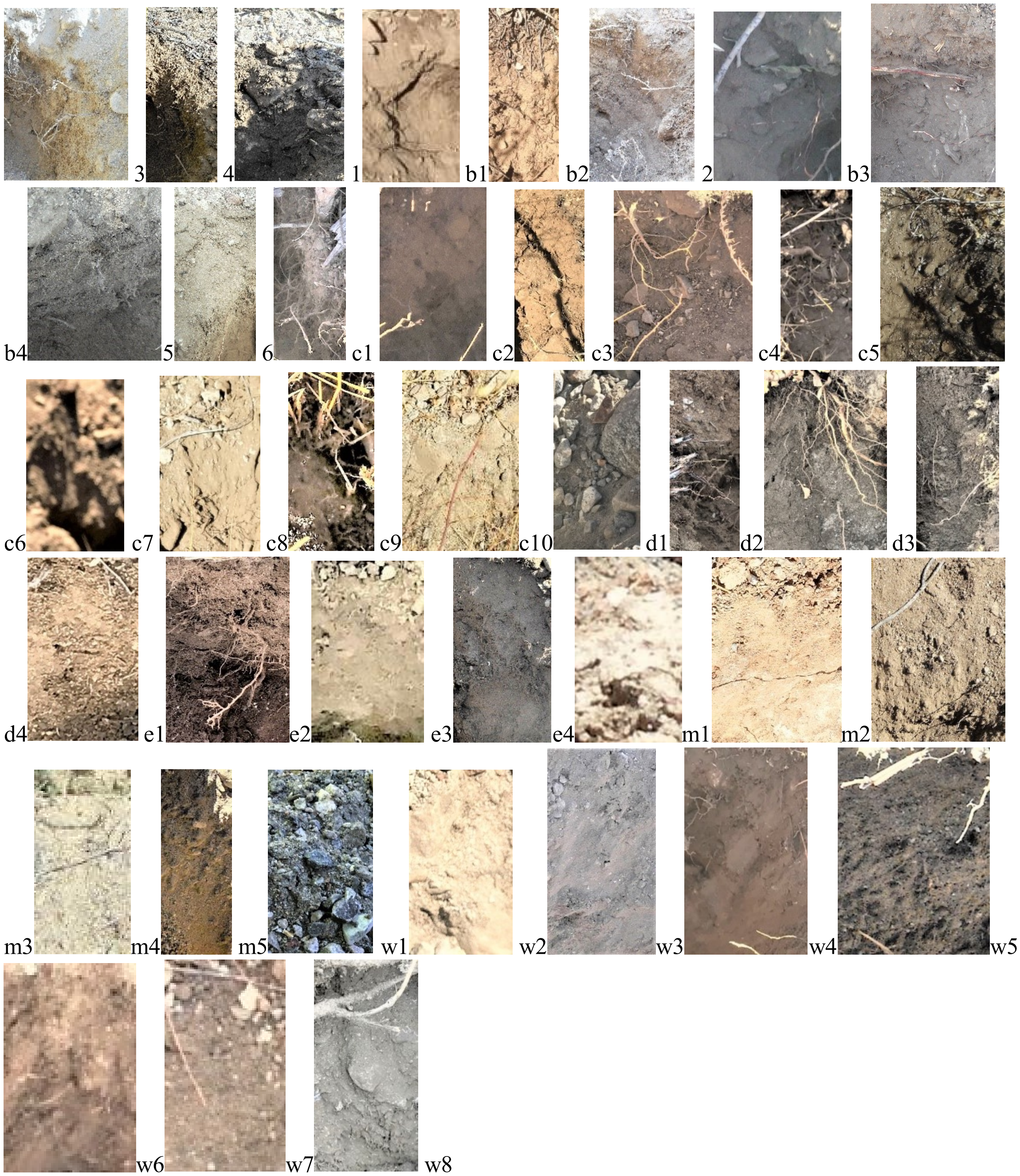

Figure I Photos of soil structure of survey sites

Appendix J Soil Samples

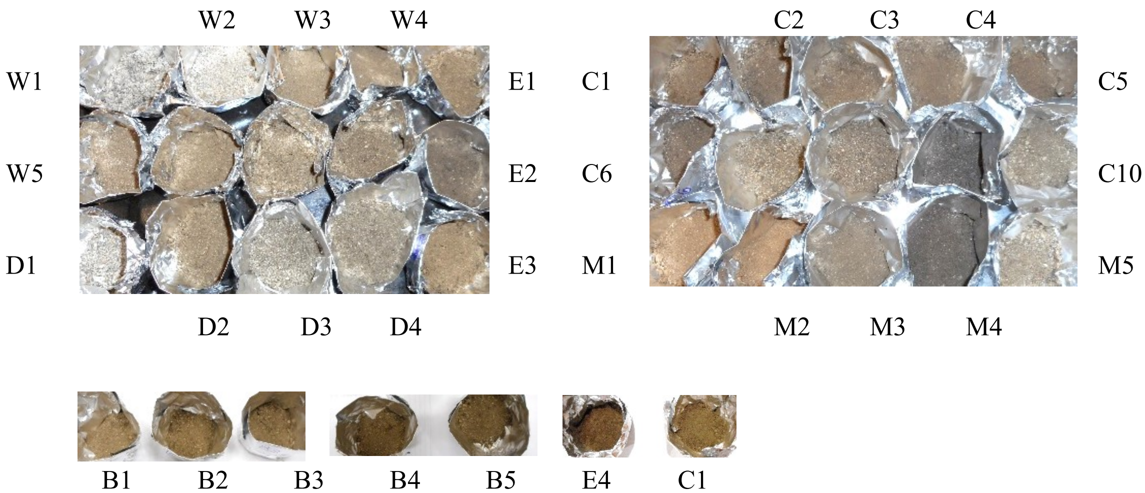

Figure J Dried soil samples labeled with code of survey sites (11/18/2016)

Appendix K Cation Exchange

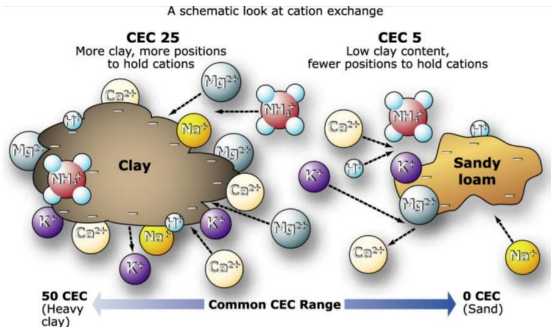

Figure K-1 CEC range

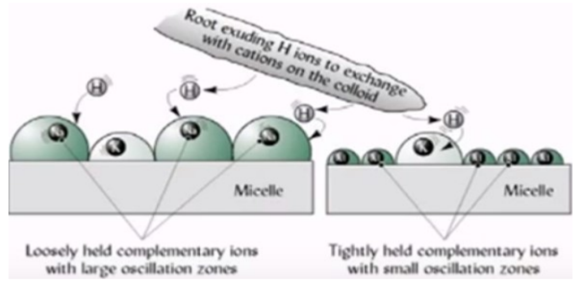

Figure K-2 Size of oscillation zone affecting the cation exchange rates. (Forest Soil Colloids by Russ Briggs from ESFA Academics)

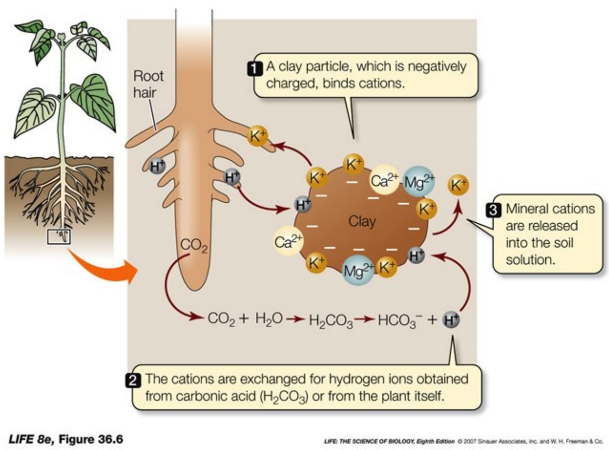

Figure K-3 CEC and plant growth

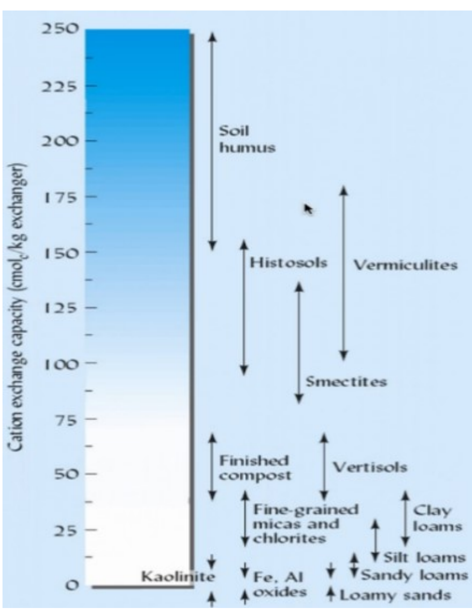

Figure K-4 Cation exchanges (Brady and Weil 2010). The Figure L (Appendix L) shows the vital functions of soil in an ecological system. Nutrients, such as Ca and Mg are supplied to plants from reserves held in the soil colloids (Figure K-3). The ability of soils to store the cations, which is a group of nutrients, is called cation exchange capacity (CEC). Soil colloids, which are minute, have a large surface area per unit mass and also have + and - electrostatic charges that are balanced by cation exchange and anion exchange (Figure O, Appendix O). The highly weathered soil could attract and retain anions (- charged), rather than cations (+ charged). (A & L Canada Laboratories. 2002, Hillel, 2008)

Appendix L Vital Functions of Soil

Soil serve many important ecosystem services, below are a list of five vital functions of soil:

1. Sustaining plant and animal life below and above the surface – biodiversity
2. Regulating and partition water and solute flow – water availability
3. Filtering, buffering, degrading, immobilizing, and detoxifying – water quality & atmospheric CO2 balance
4. Storing and cycling nutrients – steady energy web
5. Providing support to structures – cities built on soil too

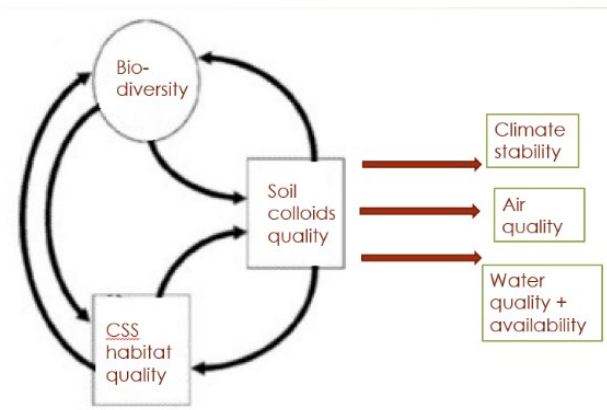

Figure L Ecosystem Service

Appendix M Examples of Soil Survey Description of the NEP

Figure M-1 Soil sampling site 1. (34.17751º N 117.52457º W) 9:00 am 3/4/2016

Photo 1a. A white sage (*Salvia apiana*) dominant coastal sage scrub habitat. It is a south facing open slope at an elevation of 766 m (2513 ft.).

Photo 1b. The surface is covered by little twigs, 8 - 20 mm gravel, and 50 -150 mm rough edged cobbles.

Photo 1c. Soil horizons: the pit is about 26 cm (10 in.) deep of this very "rocky" location. A 15 cm (6 in) O horizon followed by A horizon (uncoated sand grains) below it.

Photo 1d. Soil structure: no observable aggregation or structural units. Large size gravel sand.

Photo 1e. Soil texture: very gritty, has large pores, high drainage rate, low water holding capacity, low soil organic matter, low weathering. Soil permeability is high, and soil separates: very coarse sand (2.0-1.0mm).

Photo 1f. Soil ribbon test: shows no plasticity, no shrink-swell potential. Soil falls apart: sand.

Photo 1g. Soil color: using Munsell soil color chart (2009 revision): 10yr, value (lightness–darkness or white to black) 2/ chroma (color purity or intensity) 2, dominant spectral color is very dark brown.

Soil temperature: 15ºC (59º F) rapidly warms-up under the spring sun.

Figure M-2 Soil sampling site 2. (34.17619º N 117.52437º W) 9:30 am 3/4/2016

Photo 2a. A California Coastal Sagebrush (California Sage, *Artemisia californica*; Yerba Santa, *Eriodictyon trichocalyx*) and chaparral habitat on a south facing open slope at an elevation of 749 m (2457 ft.). Photo 2b. The surface is covered by 5 - 18 mm gravel and 40 -150 mm rough edged cobbles.

Photo 2c. Soil horizons: the pit is about 19 cm (7.5 in.) deep. The pit shows an O horizon: 5 cm (2 in.) of Oi, 8 cm (3.15 in.) of Oe, and followed by Oa below it when we hit a big rock at 19 cm.

Photo 2d. Soil structure: a loss plate-like structure, gravel sand.

Photos 2e and 2f. Soil texture: gritty, has large pores, high drainage rate, low water holding capacity, low soil organic matter, low weathering. Soil permeability is high, and soil separate: coarse sand (1.2 - 0.5 mm).

Photo 2g. Soil ribbon test: soil ribbon is dull and falls apart at 2.5 cm long and grittiness is prominent feel: sandy loam. The soil has low plasticity and low shrink-swell potential.

Photo 2h. Soil color: using Munsell soil color chart: 10yr, value 2/ chroma 2, very dark brown.

Soil temperature: 15.6ºC (60º F) rapidly warms-up under the spring sun.

Figure M-3 Soil sampling site 3. (34.17362ºN 117.52319ºW) 10:00 am 3/4/2016

Photo 3a. A bare rocky site on a west facing open slope at an elevation of 722 m (2369 ft.).

Photo 3b. The surface is covered by 0.5 - 10 mm gravel.

Photo 3c. Soil horizons: the pit is about 23 cm (9.1 in.) deep. The pit shows a12 cm (4.7 in.) of Oi and a root zone, loose sand keeps falling off from weathering down of this rocky wall (heat/cold/water). Below Oi horizon is an A horizon of thin, uncoated sand grains from 12 cm and beyond.

Photo 3d. Soil structure: a loss spheroidal-like structure, gravel sand which has a very weak consistence and a very little force between the particles. It almost feels like quick sand only very much drier.

Photo 3e. Soil texture: gritty, has large pores, very high drainage rate, very low water holding much capacity, low soil organic matter. Soil permeability is high, and soil separates: coarse sand (1.0 – 0.5 mm).

Photo 3f. Soil ribbon test: shows no plasticity, no shrink-swell potential. Soil falls apart: sand.

Photo 3g. Soil color: using Munsell soil color chart: 10yr, value 3/ chroma 4, dark yellowish brown.

Soil temperature: 15ºC (59º F) rapidly warms-up under the spring sun.

Figure M-4 Soil sampling site 4. (34.17237ºN 117.52338ºW) 10:30 am 3/4/2016

Photo 4a. A California Coastal Sagebrush (*Artemisia californica*) and California Buckwheat (*Eriogonum fasciculatum*) dominant costal scrub habitat on an east facing slope at an elevation of 694 m (2277 ft.).

Photo 4b. The surface is covered by very little twigs, 2-20 mm gravel, and 20 -40 mm rough edged cobbles.

Photo 4c. Soil horizons: the pit is about 24 cm (9.5 in.) deep. The pit shows a 3 cm (1.2 in.) of Oi, 6 cm (2.4 in.) of Oe, 12 cm (4.7 in.) of Oa, and followed by an A horizon beyond 21cm.

Photo 4d. Soil structure: a granular-like structure, sand and some organic material.

Photo 4e. Soil texture: soil ped has moderate stickiness and firmness. It still has large pores, high drainage rate, low water holding capacity, and low soil organic matter. Soil permeability is high, and soil separate: coarse sand (1.0 – 0.2 mm).

Photo 4f. Soil ribbon test: is dull and falls apart at 4.0 cm and grittiness is prominent feel: sandy clay loam. The soil has some plasticity and some shrink-swell potential.

Photo 4g. Soil color: using Munsell soil color chart: 10yr, value 3/ chroma 4, dark yellowish brown.

Soil temperature: 16.2ºC (61º F) rapidly warms-up under the spring sun.

Figure M-5 Soil sampling site 5. (34.17047ºN 117.52246ºW) 11:00 am 3/4/2016

Photo 5a. A California Coastal Sagebrush (California Sage, *Artemisia californica*) and chaparral habitat on a north facing slope at an elevation of 673 m (2208ft.).

Photo 5b. The surface is covered by fine twigs, 2 - 20 mm gravel, and 20 -40 mm rough edged cobbles.

Photo 5c. Soil horizons: the pit is about 24 cm (9.5 in.) deep. The pit shows a 5 cm (2 in.) of Oi, 10 cm (4 in.) of Oe, and followed by an Oa beyond 15 cm.

Photo 5d. Soil structure: a granular-like structure, sand and organic material.

Photo 5e. Soil texture: soil ped has moderate stickiness and firmness. It still has large pores, high drainage rate, low water holding capacity, and low soil organic matter. Soil permeability is high, and soil separate: coarse sand (1.0 – 0.2 mm).

Photo 5f. Soil ribbon test: is dull and falls apart at 3.0 cm and grittiness is prominent feel: sandy clay loam. The soil has some plasticity and some shrink-swell potential.

Photo 5g. Soil color: using Munsell soil color chart: 10yr, value 3/ chroma 2, very dark grayish brown.

Soil temperature: 16.1ºC (61º F) warms-up under the spring sun.

Figure M-6 Soil sampling site 6. (34.16776ºN 117.52294ºW) 11:30 am 3/4/2016

Photo 6a. A white sage (*Salvia apiana*) and Remote Blue Ceanothus Bush Lilac (*Ceanothus spp.*) dominant habitat on a south facing open riparian land at an elevation of 656 m (2152 ft.).

Photo 6b. The surface is covered by 5 - 20 mm gravel and 40 -350 mm rough edged cobbles.

Photo 6c. Soil horizons: the pit is about 23 cm (9 in.) deep. The pit shows a 3 cm (7.6 in.) of Oi, 3 cm (7.6 in.) of Oe, 6 cm (15.2 in.) of Oa, and followed by an A horizon below 12 cm.

Photo 6d. Soil structure: a loss plate-like structure, gravel sand.

Photo 6e. Soil texture: gritty, has large pores, high drainage rate, low water holding capacity, low soil organic matter, low weathering. Soil permeability is high, and soil separate: coarse sand (1.2 – 0.5 mm).

Photo 6f. Soil ribbon test: soil ribbon is dull and falls apart at 2.5 cm long and grittiness is prominent feel: sandy loam. The soil has low plasticity and low shrink-swell potential.

Photo 6g. Soil color: using Munsell soil color chart: 10yr, value 2/ chroma 2, very dark brown.

Soil temperature: 16.1ºC (6º F) rapidly warms-up under the spring sun.

11. Writer's Curriculum Vitae

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Career Goal

My career goal has always been to work in a field that concerns natural communities, conservation, invasive animal and plant species, and to assist natural resource managers and others in applying such knowledge effectively. One way I could do this effectively would be through teaching at the college level.

Education

- Master of Science in Environmental Sciences and Policy program with a concentration in Ecological Management May/2017
- Certificate of Geographic Information Systems from the School of Engineering, Department of Geomatics, University of Alaska Anchorage January/2012
- Bachelor of Science from the University of Alaska Anchorage. Major in biological sciences and minors in chemistry and environmental studies March/2010
- K-12 Science Educators Training from Copernicus Project, University of California, Riverside Graduate School of Education August/2007
- Undergraduate Certificate of Geographic Information Systems from Chaffey College in the San Bernardino County city of Rancho Cucamonga, California August/2006
- Associate of Liberal Arts and Sciences from Chaffey Community College in the San Bernardino County city of Rancho Cucamonga, California May/1998

Professional Positions

- Surface soil and baseline vegetation survey and mapping for the North Etiwanda Preserve (NEP) in San Bernardino County, California January/2016 – present

- Volunteer on-site biologist/ecologist/GIS specialist for the NEP in San Bernardino County, California
  January/2015 – present
- Work with students with learning disabilities, Chaffey Community College, California
  January/2015 - present
- Physics and math tutor, the Math Success Center, Chaffey Community College, California
  January/2015 - present
- Ecology/Geographic Information Systems (GIS) Research Technician, Alaska Natural Heritage Program of University of Alaska Anchorage, Alaska January /2010 - January /2014
- Mentor for ecology/botany undergraduate student interns, Alaska Natural Heritage Program of University of Alaska Anchorage, Alaska May/2012 - January/2014
- Ecology/GIS Student intern of Alaska Natural Heritage Program of University of Alaska Anchorage, Alaska November/2007 - January 2010
- The Copernicus Project Science Summer Internships, University of California, Riverside Graduate School of Education, Califotnia June/2007 - August/ 2007
- Chemistry lab assistant of Mathematics and Sciences, Chaffey Community College, California
  August/2003 - December/2005
- Math and chemistry tutor of Mathematics and Sciences, Chaffey Community College, California
  August/2003 - December/2004
- Peer Advisor for Taiwanese international students, Chaffey Community College student club, California August/2000 - August/2006

<u>Research Experience</u>

- Conducting ecological surveys and assisting managing spatial dataset of the North Etiwanda Preserve of San Bernardino County, Southern California for various ecological projects
  January/2015 - present
- Assisting managing spatial datasets for the Bureau of Land Management's Rapid Ecoregional Assessment of Alaska Febrary/2012 - January/2014
- Managing spatial datasets of the Alaska statewide landcover classification maps
  April/2010 - January/2014

- Creating info tables, spatial database, maps, Access database for the Bureau of land Management Alaska: National Petroleum Reserve-Alaska Assessment Inventory and Monitoring project January/2013 - January/2014
- Assisting in mapping the exploration of the occurrences of rare plant species in Alaska January/2013 - December/2013
- Creating Landcover Inventories Map and info tables for analysis for classes: Sitka National Historical Park. Natural Resource Technical Report NPS/SITK/NRTR-2013/773 June/2012
- Creating the digital Plant Association Maps for the Alaska regional ecological exploration and publications in between year 1931 and year 2012 October/2010 - July/2012
- Working with ecological survey data using Microsoft Access for accuracy assessment and multivariate analysis November/2007 - April/2012
- Mapping hunger, poverty and unmet food needs in Alaska and Anchorage for the Food Bank of Alaska August/2009 - December/2009
- Mapping physical characteristic of Cook Inlet basin, Alaska September/2008 - January/2010

Professional Publications

Boggs, K., T.V. Boucher, T.T. Kuo, D. Fehringer, and S. Guyer. 2013. Vegetation map and classification: Southern Alaska. Alaska Natural Heritage Program, University of Alaska Anchorage, Anchorage, Alaska.

Boggs, K., T.V. Boucher, T.T. Kuo, D. Fehringer, and S. Guyer. 2013. Vegetation map and classification: Northern, Western and Interior Alaska. Alaska Natural Heritage Program, University of Alaska Anchorage, Anchorage, Alaska. 88 p.

Boucher, T. V., K. Boggs, B. Koltun, T. T. Kuo, J. McGrath, and C. Lindsay. 2012. Plant associations, vegetation succession, and earth cover classes: Aniakchak National Monument and Preserve. Natural Resource Technical Report NPS/ANIA/NRTR—2012/557. National Park Service, Fort Collins, Colorado.

Boggs, K., T. Kuo, and M.L. McTeague. 2011. Mosaicked Landcover map for the Seward Peninsula - Nulato Hills - Kotzebue Lowlands Rapid Ecoregional Assessment study area. Alaska Natural Heritage Program, University of Alaska Anchorage, Alaska.

Boggs, K., T. Kuo, and M.L. McTeague. 2011. Class descriptions for the mosaicked Landcover map of the Seward Peninsula - Nulato Hills - Kotzebue Lowlands Rapid Ecoregional Assessment. Alaska Natural Heritage Program, University of Alaska Anchorage, Alaska.

Job Related Training

- Investigation of natural resources and ecosystem management and the application of geomantic technologies for their assessment and interpretation. Data gathered from a variety of sources, including remote sensing, ground trusting, global positioning system (GPS), and databases, to be combined into a GIS and evaluated with image analysis software to explore management and land use planning strategies
- Photo interpretation and imaging systems, geometry of tophotogrammetry, theory of electromagnetic spectrum, application of remote sensing in engineering, archaeology, agriculture, and forestry using image analysis software
- Analysis and modeling techniques for theoretical and practical applications of glossarial databases such as: spatial and non-spatial databases, Structured Query Language (SOL), retrieval and indexing, spatial statistics and their application in GIS analysis, basic stream network analysis, surface interpolation and modeling
- Compilation of the data acquired through the knowledge of the ramification of history and philosophy of land, surveying, and land information system in North America, as well as the methods describing and interpreting land descriptions, data acquisition, design, and applications for Land Information Systems (LISP)
- Training in Excel for scientists and engineers, and Visual Basic for Applications (VBS) from the School of Engineering, University of Alaska Anchorage allowed me to modify or adapt standard GIS to meet program needs
- The online Economic and Social Research Institute (ESRI) GIS Analysis training in geographic patterns and relationships, spatial measurements and statistics, modeling suitability, movement, and interaction allowed me to analyze land, mineral, and naturalresource uses of GIS and GPS technology

- Training in Copernicus K-12 Science Educational Project from University of California Riverside (2006) inspired me to display the scientific knowledge with a variety of multidisciplinary individuals

Language Skills

Language	Speak	Write	Read
English	Intermediate	Intermediate	Advanced
Chinese-Mandarin	Advanced	Advanced	Advanced
French	Novice	Novice	Novice

References available upon request