National Cooperative Soil Survey Newsletter

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Editor's Note

Issues of this newsletter are available at http://soils.usda.gov/. Under the Soil Survey tab, click on Partnerships, then on NCSS Newsletters, and then on the desired issue number.

You are invited to submit articles for this newsletter to Jenny Sutherland, National Soil Survey Center, Lincoln, Nebraska. Phone—(402) 437–5326; FAX—(402) 437–5336; email—jenny.sutherland@usda.gov. ■

Explore Idaho Soils StoryMap

By Shawn Nield, Idaho State Soil Scientist.

The University of Idaho and NRCS have had a long relationship based on common interests in soil science and soil survey. Both entities were involved in the creation of something called the "Idaho Soils Atlas" (by R.J. Barker, published in 1983). This publication, now out of print, provides a visually rich tour of Idaho soils and landscapes. I learned a little over a year ago that the soils represented in the publication were sampled but never tested. Furthermore, those samples had been kept in a cool, dry storage area and were still available!

With support from the Soil and Plant Science Division of NRCS (Brian Gardner and David Hoover) and the folks at the University of Idaho (Anita Falen and Dr. Paul McDaniel), I was able to get all the original samples sent to the Kellog Soil Survey Laboratory in Lincoln, Nebraska, for chemical and physical analyses. That data, along with high-quality scans of the soil pit and landscape photos from the "Idaho Soils Atlas," are now viewable in an ArcGIS StoryMap (see link below).

Resource Soil Scientist Shanna Bernal-Fields created the StoryMap, and I provided brief narratives for beginning sections and helped with the layout and graphics. This StoryMap provides a broad overview of the diversity of soils across the State of Idaho. As an interactive learning tool and a way for folks to take a tour of Idaho soils and landscapes, its purpose is outreach and education. It seeks to elevate the public's knowledge of soils and also to introduce them to a variety of NRCS websites and products available to them, with links embedded throughout.

The StoryMap opens with a brief review of the five soil-forming factors, with

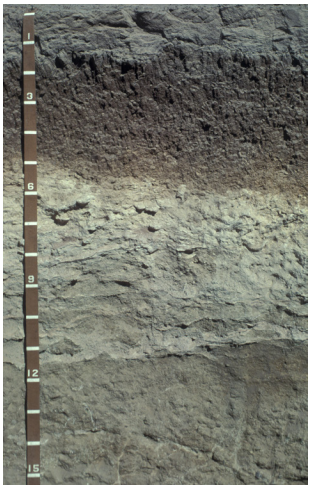


Figure 1.—Every soil in the tour has a profile and landscape photo. Pictured here is the Sebree series. Sebree soils are found in southwest Idaho, and under natural conditions they support rangeland with basin big sagebrush communities. Where used for agriculture, this series produces small grains, corn, alfalfa, and pasture.

links to a variety of sources that expound on each factor, giving preference to those focused on Idaho. From there users are introduced to soil's primary functions. Next is the topic of soil health, with a depiction of a soil food web and an introduction to the four principles of soil health. A collage of images from the Electron and Confocal Microscopy Unit in Maryland is sure to get the reader's attention. Also included is a link to our State's Soil Health webpage.

After the user has been introduced to some foundational soil science principles, they can tour soils across Idaho. The main tour map is interactive—users can zoom in and out and each site has a pop-out point with a landscape photo and a brief narrative on the soil series. Below the map, there is a more technical section for each soil identified that provides landscape and profile photos, taxonomic classification and links to the official series descriptions (OSDs), maps showing series extent, prominent soil features, and lab data. Each soil also has a landscape map with landforms identified. This map is also interactive and allows users to zoom in and out.

One section is on the Kellogg Soil Survey Laboratory and provides a link to the site to query data. An "Idaho Soils Atlas" section follows, highlighting the original reference that inspired the StoryMap and its authors. Web Soil Survey is discussed in a brief section, which provides a live link to the website. The StoryMap concludes with a link to the USDA Service Center Locator site.

StoryMap link: https://storymaps.arcgis.com/stories/97d01af9d4554b9097cb0a477e04fd6f. ■

Nebraska State Conservationist Announces Retirement

Craig Derickson, who has served as the Nebraska State Conservationist for 10 years, is planning to retire on December 31, 2020, after 35 years of Federal service. Derickson said, "I've had a wonderful career with NRCS and have been able to enjoy the rewarding work of conserving our natural resources for more than 40 years. I have had the pleasure of helping people with their conservation needs and working with remarkable conservation partners, like the Nebraska Natural Resources Districts, as well as other State and Federal organizations."

Craig Derickson, retiring Nebraska State Conservationist.

With a background in agricultural research and soil science, Derickson worked 7 years with the University of Nebraska on soil and water conservation research projects in Lincoln and western Nebraska before joining SCS (now NRCS). He joined the agency in 1985 as a field soil scientist in Crawford, Nebraska. He developed soil maps and classification reports for Sioux and Banner Counties. Throughout his career, Derickson held several positions with NRCS in Nebraska, including: District Conservationist, State Resource Conservationist, Assistant State Conservationist, and Regional Technology Coordinator.

In 2002, Derickson began working at the NRCS national office in Washington, D.C., assisting with rulemaking and policy development for conservation programs introduced in the 2002 Farm Bill. After several years in the Programs Division in D.C., Derickson was selected to serve as the State Conservationist in Pennsylvania in 2006. Following his work in Pennsylvania assisting conservation partners with projects to clean up the Chesapeake Bay, Derickson returned to D.C. as the NRCS Deputy Chief for Programs. In 2010, he accepted the position of State Conservationist in Nebraska and returned to Lincoln.

In February 2020, Derickson was recognized as the Outstanding State Conservationist of the Year by the National Association of State Conservation Agencies (NASCA) and other national conservation partners. “As the leading Federal agency that provides technical assistance to farmers and ranchers, we’ve grown tremendously over the span of my career,” he said. “When I began working in the field, we had limited tools to help farmers and ranchers assess the condition of their resources, and we mainly focused on soil erosion. The importance of water quality and how agriculture impacts water quality was just beginning to be investigated. Now, we have the advantage of technology and models to help our employees assist land managers with the planning, design, and installation of crucial conservation practices, including practices to improve water quality and the health of our soils.”

In retirement, Derickson plans to pursue his love for the great outdoors and appreciation of natural resources. He and his wife Kate, who have family in Lincoln and the D.C. area, plan to spend more time enjoying their family and friends and continuing their faith activities. ■

Digital Soil Mapping on the Catahoula Formation in the Pineywoods of East Texas

By Sara Russell and Tyson Hart, NRCS soil scientists.

Digital soil mapping (DSM) has been a focus of soil scientists in recent years as a means of using predictive modeling to provide improved soil maps. NRCS Soil Survey has encouraged its soil survey offices to embrace this technology. The Nacogdoches Soil Survey Office (SSO) in Texas started using DSM techniques to create soil map layers and data for the southern portion of the Western Coastal Plain,

Major Land Resource Area (MLRA) 133B, in the spring of 2020. The soil survey for Jasper and Newton Counties, Texas, was chosen as the focus in improving the current mapping. The survey area is one of the few still mapped at order 3 and is comprised largely of associations and complexes over extremely large polygons. The goal was to use DSM to create a more comprehensive map that would be useful to field offices and the general public.

To begin the assessment process, existing soil series mapped in Jasper and Newton Counties were analyzed. Investigation of each series revealed which soils were suitable for use in the DSM model. Several criteria were taken into consideration to determine best fit, including geographic proximity, geology, taxonomic classification, landform/landscape placement, and MLRA boundaries. During this phase, repetition of taxonomic classifications was discovered among the series present. For example, the Letney and Boykin series are both Arenic Paleudults, are mapped on the same landscape, and have very similar profiles. Based on series extent, the Letney series made more geographical sense for use within this area; the Boykin series was originally mapped several States away.

Underlying geologies were another integral factor during the evaluation. The hope was that the soils or map unit concepts, or both, would occur primarily within their designated geologic boundaries, tying them closely to parent materials and making rough catena classes easier to assign. It is worth noting that, because alluvium and terrace deposits typically yield wide boundaries and are more difficult to categorize within a strict set of parameters, the map units tied closely to them must be scrutinized with greater attention.

The background research into the project area pointed to geologic formations and taxonomically similar soils in the western-adjacent Tyler County. Work on the Tyler Soil Survey Area (SSA) was completed in 2008 and provided a useful template to parallel soil concepts. Countless hours and dollars have been spent in prior mapping, and utilizing previous knowledge pays homage and respect to the preceding soil mappers. Therefore, work began by understanding the concepts of covariates in the Tyler SSA.

The backbone of DSM is Light Detection and Ranging (LiDAR) data (fig. 1). The project utilized data at the 5-meter scale. LiDAR alone provides fine-scale elevation data, so covariate rasters were created by using GIS-software packages. ArcGIS, ArcSIE, SAGA, and RStudio created aspect, planform, profile, slope, and other layers for the Tyler SSA. Satellite imagery was used as well, but not manipulated. In total, 16 covariates were implemented.

The next step required analyzing the intricacies of the mapping concepts. The current Gridded Soil Survey Geographic Database (gSSURGO) for the study area was disaggregated from 10 meter to 5 meter to overlap with the covariate data. The gSSURGO pixels were grouped by mapunit then tabulated by collecting the range of the overlapping covariate data. To visually interpret the data, boxplots were created to graphically show which mapunits had differences by range of covariate data (fig. 1). The boxplots proved useful because the plots show statistics for the minimum (MIN), first quartile (Q1), median (MED), third quartile (Q3), and maximum (MAX).

Results were mixed from the comparisons of the 16 covariates. In an ideal situation, each mapunit would display a concise range within each covariate and have distinct separation between boxes. This did not always happen, and many mapunits had overlapping boxes. The benefit of these results is that they culled out data that had very little variation. Covariates that showed little to no variation included: Aspect, Catch Area, Mid Slope Position, Mod Catch Area, Planform, and Profile. The Landsat and NDVI data distinctly separated the gravel pits and water, but little else. The covariates that showed some level of distinction included: Catch Slope, Lidar, Normal Height, Saga Wetness, Slope, Slope Height, Standard Height, and Valley Depth. The latter data was studied further to find useful combinations to tease apart soils. Lastly, a data

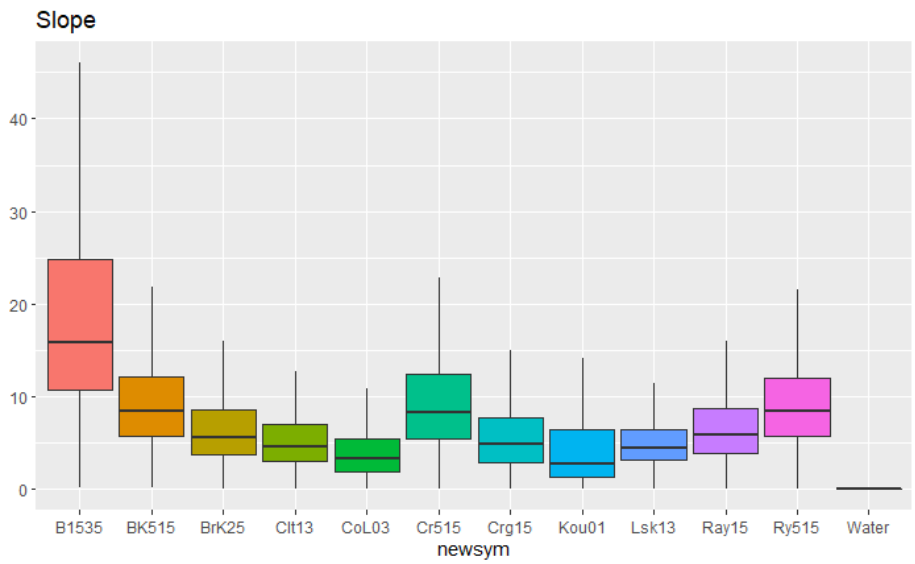


Figure 1.—Boxplot depicting mapunit differences in covariate ranges of slope.

table was created with hard numbers for the desired boxplots to reference for later use as parameters in soil creation.

With the discovery of the most statistically useful covariates in the Tyler SSA, the knowledge was tested on the study area in Jasper and Newton Counties. The testing started with a simple approach by determining if water bodies could be successfully generated. The interquartile range (IQR) from the boxplot statistics was used as the basis. The IQR is the range between Q3 and Q1 and translates to 50 percent of the data. The values above and below Q3 and Q1 trend away from the mapunit concept for that covariate and each represents 25 percent of the data. Remote sensing of the created water bodies by verifying with satellite imagery showed a good fit. The large mass of Sam Rayburn Reservoir was cut evenly between land and water. More impressive, the model found small water bodies the current gSSURGO did not contain.

Proof of concept on a small scale allowed for further development. A catena of 12 soils across roughly 100,000 acres on the Catahoula Formation in the study area was studied. The process used on water bodies was imitated on a large scale. Size of data proved a major setback when working with ArcGIS and ArcSIE. Therefore, the ArcSIE algorithms for optimality of soils based on multiple covariates was converted to RStudio code. To ensure data quality, subsets of small study areas were tested for equivalency between ArcSIE and RStudio. The subset testing resulted in a 99.5 percent equivalency. More importantly, a greater improved efficiency was seen. RStudio performed in 59 seconds a function that took ArcSIE 1 hour and 43 minutes but never finished (the process crashed ArcGIS).

The realization of time savings focused the efforts of DSM on RStudio. The coding was further refined and studied to incorporate the values provided by the boxplots. To make a digital soil map, each mapunit was given the parameters for each covariate with the same soil in Tyler County. Each of the 7 covariates were averaged to find an optimality rating for each pixel on a scale from 0 to 1, with 1 having a higher optimality. The 12 mapunit rasters were stacked, and a function was used to pick each mapunit with the highest score at each pixel.

Finally, after all the research and analysis, a digital soil map was created of 12 mapunits across the Catahoula Formation in Jasper and Newton Counties (fig. 2). A secondary confidence index was created to see where the functions are least certain

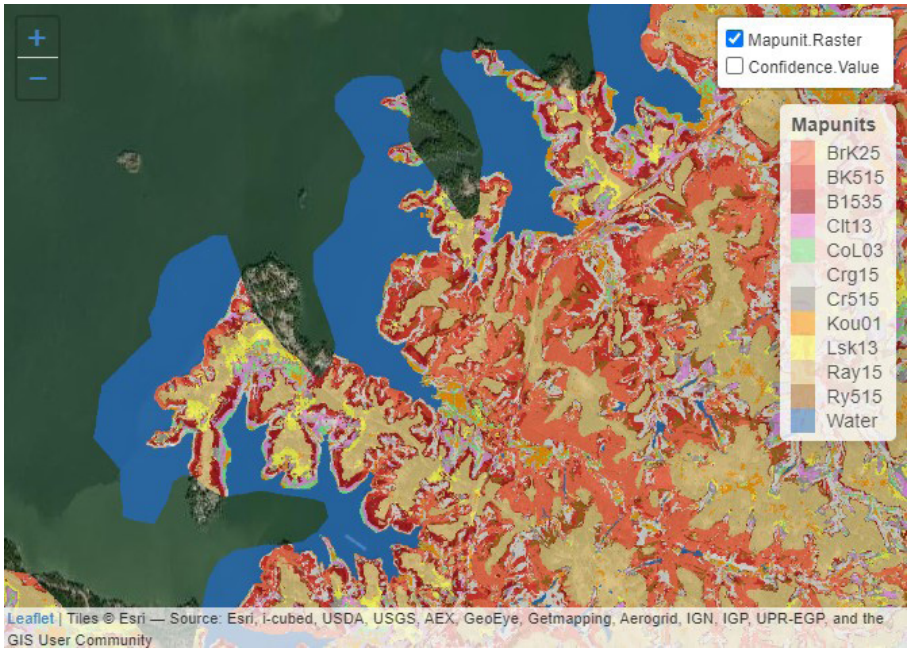


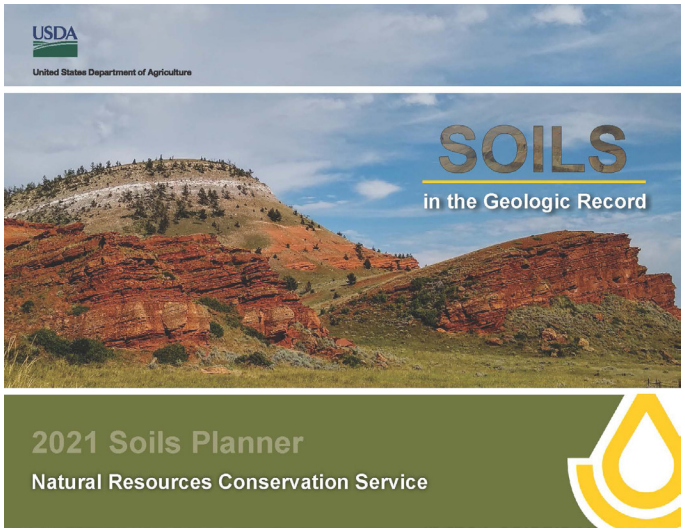
Figure 2.—Digital soil map (DSM) of 12 mapunits on the Catahoula Formation in MLRA 133B.

of a predicted soil. Currently, the Nacogdoches SSO is ground truthing the mapping and the results have been promising. If this method proves fruitful, the goal is to use the process of this study to facilitate further DSM projects. ■

The 2021 Soils Planner Now Available!

By the 2021 Soils Planner Team: Curtis Monger, Marji Patz, Aaron Achen, Kristie Wiley, John Andreoni, and Ann Kinney.

The 2021 Soils Planner is in the traditional (8 ½ x 11 inches) 12-month format and features soils in the geologic record. Different ages of "buried" soils are illustrated, and information is provided on climates, ecosystems, and fossils of the prehistoric past. The planner is highly educational and includes pictures that capture the essence of the Earth's story. Calendar pages provide space for notes and show scheduled meeting dates that have been confirmed for 2021.



Pre-ordered planners were shipped the week of November 9. Paper copies of the planners are in stock, free, and available to everyone, including other agencies,

cooperators, and educators. Ordering is easy through the NRCS Distribution Center and can be done three ways: through the website (https://nrcspad.sc.egov.usda.gov/DistributionCenter/default.aspx), through direct email (commsptctr@ia.usda.gov), or by calling toll-free (888) 526-3227. *Attention international customers:* If your items are to be shipped internationally, please call 1-888-LANDCARE to place your order.

We hope you enjoy the 2021 Soils Planner and would like to extend our thanks to everyone that contributed the beautiful photographs and detailed information—we couldn't have done it without you!!! All submissions were outstanding. We are retaining all submitted photos and information for possible use in future planners or projects.

The theme for next year's planner is "Use of Soils Information," specifically how soils information can be used for non-agricultural purposes. Contributions of high-quality photographs and detailed information are welcome and can be sent to ann.kinney@usda.gov. ■

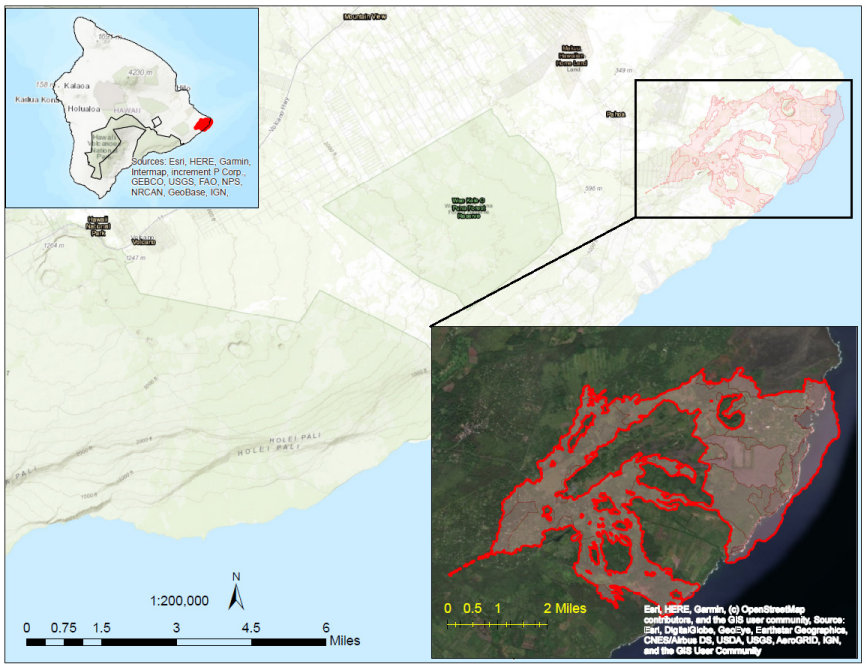


Figure 1.—Map showing the location of Kilauea Volcano on the Island of Hawaii and the area affected by the 2018 Lower East Rift Zone (LERZ) eruption.

Updating the Island of Hawaii Soil Survey after the 2018 Kilauea Eruption

By Jacqueline Vega-Pérez, NRCS resource soil scientist, Red Bluff, California (former MLRA soil scientist, Kealakekua, Hawaii), and Amy Koch, State Soil Scientist - Pacific Islands Area.

Kilauea Volcano, a shield volcano on the Island of Hawaii, has a long history of eruptive activity. Most recently it erupted from May through August 2018 during the 2018 Lower East Rift Zone Eruption and Summit Collapse event (fig. 1). Overall, 13.7 square miles of the Island of Hawaii were covered by lava, as much as 30 to 80 feet thick in some places. About 875 acres of new land were created by the lava flows that entered the ocean and amassed above sea level. Over the course of the event, approximately 1 billion cubic yards of lava erupted (source: U.S. Geological Survey (USGS)).

Figure 2.—Top left: Fissure 8, the most active fissure, in LERZ. Top right: Lava flow from multiples fissures. Bottom: Fissure 8 lava entering Kapoho Bay on June 3, 2018. Hundreds of lower Puna homes were inundated by lava as it advanced to the ocean, later filling the bay and creating new land in the ocean. (USGS photos)

The federally declared natural disaster affected many private landowners and farmers in the Puna Soil and Water Conservation District (SWCD). Lava flows destroyed over 700 dwellings as well as many farms and ranches (fig. 2). Volcanic emissions of sulfur dioxide negatively impacted vegetation on farms and forests in the areas not covered by lava. Though natural, these sudden changes to the landscape drastically affected the use and management of the landscape over a very short time, changing it from shallow, yet productive, organic and volcanic ash soils to cinder and spatter cones, black sand beaches, and `a`a and pahoehoe lava flows (fig. 3). In addition, Kilauea summit was drastically altered by simultaneous activity, including ash explosions, earthquakes, and subsequent collapse of Halema`uma`u crater.

Maintaining soil survey information is an ongoing effort, especially in dynamic areas altered by frequent volcanic activity, such as the Puna district of Hawaii Island. Soil surveys are updated as part of maintenance projects that are conducted for a major land resource area (MLRA) or other region in order to improve the uniformity of the soil survey products in the area. The last update for the Puna area was completed in 2009 and published in the 2012 extensive revision of the soil survey of the Island of Hawaii Area (HI801). In 2019, a MLRA project, MLRA 161A - Lava Flows, was developed to address the southeast area of the Island of Hawaii affected by the 2018 Lower

Figure 3.—Left: The new black sand beach encloses the former boat launch ramp at Pohoiki. Right: The new Pohoiki black sand beach created by the 2018 lava flow.

East Rift Zone eruption. The area of interest was evaluated and edited using remote sensing, ArcGIS, and field observations.

Sixteen map units (7,931 acres) on the HI801 legend were affected by the 2018 lava flows. Only one map unit changed from correlated to additional status (fig. 4) when a unique area of lava flows and tidepools was inundated by new lava flows. All areas that were formerly soil but are now covered by new lava flows were reclassified from MLRA 162 (Humid and Very Humid Organic Soils on Lava Flows) to MLRA 161A (Lava Flows and Rock Outcrops). Three different ecological sites occur in this area as well.

The outcome of this project was to update the HI801 soil spatial and tabular data, providing current, higher-quality soil data for local agricultural and environmental

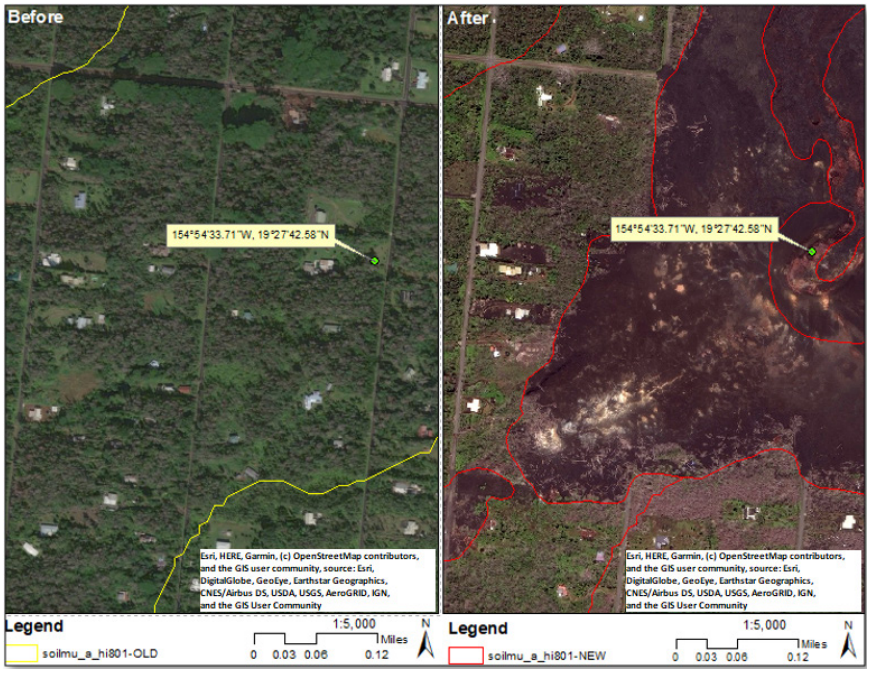


Figure 4.—Before-and-after satellite images of the Fissure 8 area in Leilani Estates, Hawaii. Left: Former soil survey lines; right: updated soil survey lines reflecting landscape changes from soil to lava flows.

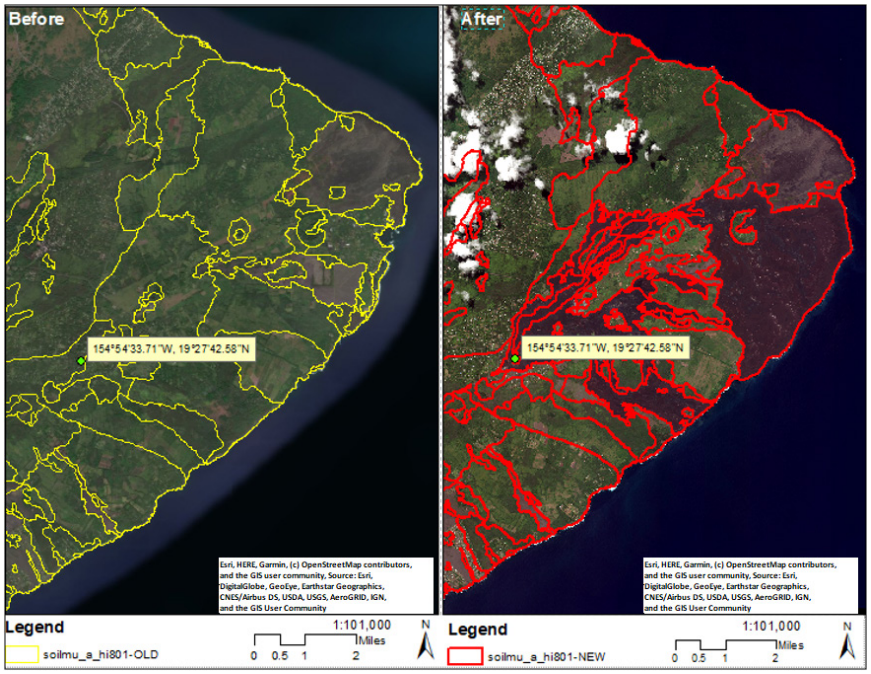


Figure 5.—Before-and-after images of the final product after HI801 legend and maps units were updated. The coordinate (green dot) shows the location of Fissure 8.

management. Deliverables include updated HI801 legend, maps units, and extent as well as updated SSURGO data (fig. 5). The project was a team effort led by Jacqueline Vega (MLRA soil scientist). Vega completed onsite assessment and edited the spatial data. Mike Kolman (MLRA soil survey office leader) and Russell Almaraz (soil scientist and soil survey GIS specialist) in NRCS Soil Survey Region 2 (Pacific Soil Survey Region) conducted quality assurance and quality control on the data and approved the project. Hawaiian Volcano Observatory (USGS) provided digital layers and photographs of the area of interest, as well as informative statistics. State Soil Scientist Amy Koch acquired the updated satellite imagery from Tony Kimmet (National Geospatial Center of Excellence) and facilitated final review and posting of the updated data to the Soil Data Warehouse.

Note: The updated soil survey data are now available on Web Soil Survey, but updated imagery reflecting the area impacted by the 2018 lava flows is not yet loaded for the WSS base map.

For more information on the 2018 Lower East Rift Zone Eruption and Summit Collapse of Kilauea Volcano, visit the USGS webpage: https://volcanoes.usgs.gov/volcanoes/kilauea/geo_hist_2018_lerz_summit.html. ■

MLRA Field Project on Urban Alluvial Soils

By Ralph Tucker, soil scientist, NRCS, Union, Missouri, and Doug Wallace, ecologist, NRCS (ACES Program).

In 2020, the Union Soil Survey Office competed a field project on alluvial map units and hydric classifications within St. Louis. This MLRA field project was the culmination of a long process that began with a string of technical soil service requests from the City of St. Louis and the Missouri Department of Conservation (MDC). The City of St. Louis wants to convert some urban areas to green space, which would be

Figure 1.—Ponding of stormwater runoff in Barbre Park, Webster Groves, Missouri.

managed by MDC. Because many of these urban areas are prone to wetness, flooding, and ponding of stormwater (fig. 1), the soil survey team was asked to provide information on soil properties and potential vegetative communities. While providing this assistance, it was determined that an update to the spatial layer and to the tabular data of some alluvial map units in the St. Louis metro area was needed.

Revisions to the spatial data in the project area were needed to improve the separation of non-flooded uplands from flood plains and to delineate impervious surfaces and disturbed soils from undisturbed soils. These improvements were made using digital elevation models (DEMs) derived from Light Detection and Ranging (LiDAR) and derivatives from terrain analysis of those DEMs (Painted Relief Model, Vertical Distance to Channel Network, Topographic Wetness Index, and Valley Depth), shapefiles containing edits to line work based on field visits, and different vintages of National Agriculture Imagery Program (NAIP) data for the project area. In addition, flooding frequency was evaluated using the Federal Emergency Management Agency's (FEMA) high-resolution flooding frequency map for St. Louis City and County (fig. 2), elevation, available flooding data, and landform position to improve the mapping of different flooding frequency phases.

The most extensive soil in these alluvial areas in the St. Louis area is the Fishpot series. This series was established in 1979. Fishpot soils formed in disturbed materials in urban areas on flood plains and stream terraces. No historical lab data was available, and component data in NASIS only included two horizons. As part of this

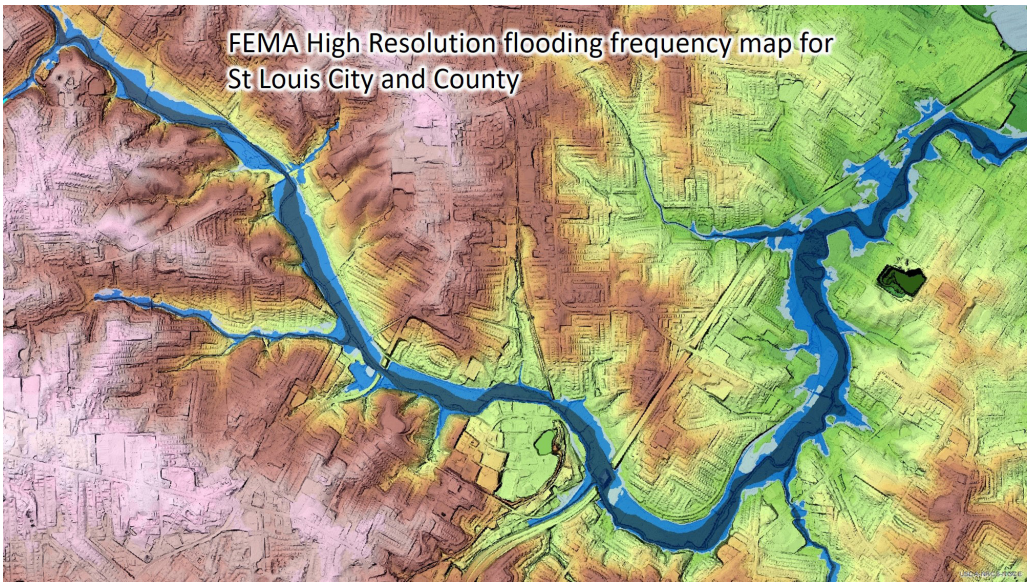


Figure 2.—FEMA map.

project, nine traverses were run and eight pedons were described and sampled for laboratory analysis (fig. 3). Soil health and biological data were also analyzed by the University of Missouri's Soil Health Assessment Center.

As a result of the new field data, the taxonomic class of the Fishpot series was updated to recognize the human-transported materials and presence of artifacts, the range in characteristics was better defined, and two additional horizons were populated with data in NASIS.

Figure 3.—Field data collection in Larson Park, St Louis, Missouri.

Information on vegetative community was a major need identified by the City of St. Louis and the Missouri Department of Conservation. To satisfy this need, a provisional "anthropic" ecological site description was developed. The ecological site information will be used by planners in the metro area to develop green space in areas subject to flooding.

The new soil maps and data were delivered to field offices during the July 1 annual refresh of official NASIS soil survey data (fig. 4). Much needed soil survey and ecological site information will now be available to our urban customers.

Building on the updated soil survey and ecological site information, a new urban ecological site description (ESD) was developed, approved, and placed in the Ecosystem Dynamics Interpretive Tool (EDIT). ■

Figure 4.—New soil lines on painted relief with comparison to aerial photography.

Students at the University of Missouri judge soil cores.

Region 5 Holds Virtual Soil Judging Contest

By Mark Abney, Assistant State Soil Scientist, Clinton, Missouri.

The Region 5 Soil Judging Contest was held October 4 to 10, 2020. The contest was held virtually this year due to COVID-19. This year the University of Missouri sponsored the contest. In preparation, over 200 soil cores in liners were pulled from 10 different sites. NRCS pulled the cores with the assistance of Mark Abney, Gene Campbell, Sheila Staton-Clifton, and J.R. Perkins. Kerry Clark (University of Missouri) directed the contest, set up the rules, and facilitated the distribution of the soil cores to the participating schools. Region 5 was the only region to have a soil judging contest this year. Therefore, one of the schools in Region 5 will not only be the regional contest winner but will be the national contest winner for 2020! Although NRCS was delighted to facilitate the virtual contest this year, we would much rather see the students in open soil pits in face-to-face competition, receiving the best experience in hands-on work and socialization, as well as receiving tacit knowledge from the local professional soil scientist. ■

USFS and NRCS Collaborate on PES Initiative in Western Oregon

By David Rand, NRCS soil scientist, Salem, Oregon.

In September 2020, the U.S. Forest Service (USFS) and NRCS completed work on forested ecological site groups (ESGs) for parts of western Oregon. This cooperative effort was part of the nationwide Provisional Ecological Site (PES) Initiative to link vegetation dynamics to published SSURGO (Soil Survey Geographic Database) information. These ESGs will soon be publicly available through the Ecosystem Dynamics Interpretive Tool (EDIT) and Web Soil Survey.

The Northwest Oregon Ecology Group (U.S. Forest Service, Pacific Northwest Region) created state-and-transition models (STMs) for suites of soils grouped by the Salem MLRA Soil Survey Office. STMs describe vegetative response to disturbance

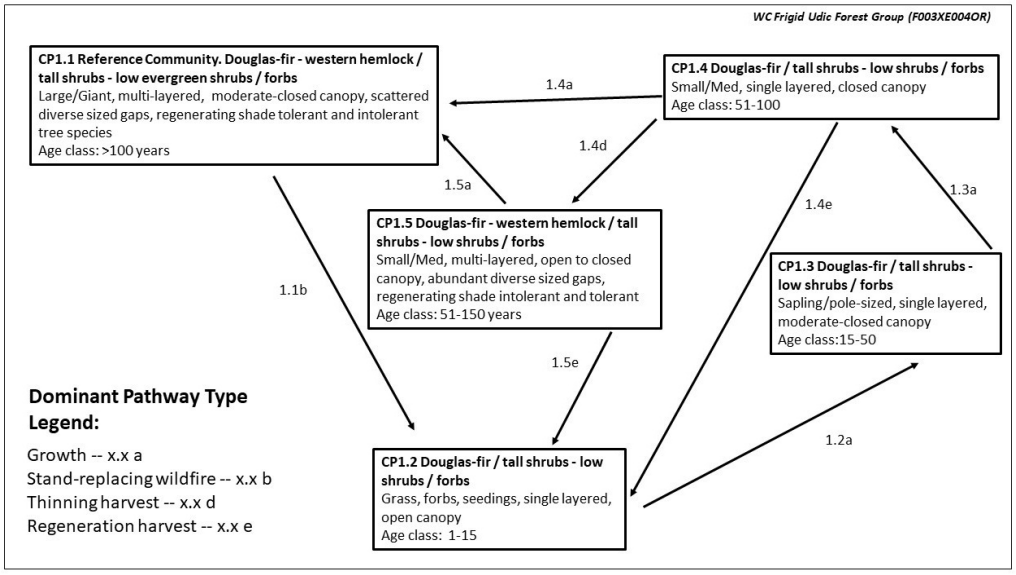


Figure 1.—State-and-transition model for Western Cascades Frigid Udic Forest Group. The model focuses on tree layer structure (note progression from single-layered to multi-layered, from Community Phase 1.2 counterclockwise to Community Phase 1.1). Future ecological sites may be able to expand on understory dynamics, which are not separated at the ESG scale.

(fig. 1). Work focused on the Oregon portion of the Cascade and Olympic Mountains (Major Land Resource Area 3), but the USFS kindly developed an additional model for the Willamette and Puget Sound Valleys (MLRA 2). USFS staff also worked overtime to complete this project despite staff being dispatched to fire assignments. Model contributors included Jane Kertis, Steve Acker, Wendy Peterman, and Pek Wijayratne, a group with many years of experience in Pacific Northwest forests.

This effort grew out of an existing partnership to correlate soils with plant associations on the initial soil survey of the Willamette National Forest. The relationship has developed through biannual office meetings and many days in the field together. Collaboration on PES began in 2019 at the request of MLRA Office Leader Jason Martin. At the time, most of MLRA 3 and all of MLRA 2 in Oregon lacked ecological site correlation. Ecological correlations have now been identified for all published soils in these MLRAs.

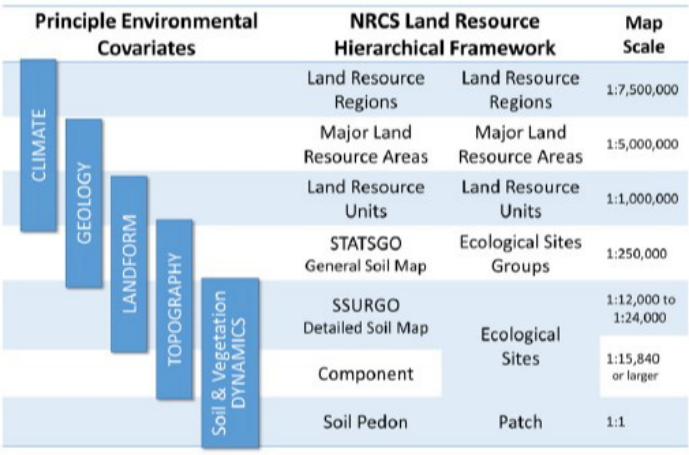


Figure 2.—NRCS Land Resource Hierarchical Framework. From the article "Completing the Land Resource Hierarchy" in *Rangelands* (Salley, Monger, and Brown, 2016). PES Initiative ecological descriptions for Oregon MLRA 3 will be available at the levels of land resource unit and ecological site groups.

The Ecology Group translated vegetation dynamics information

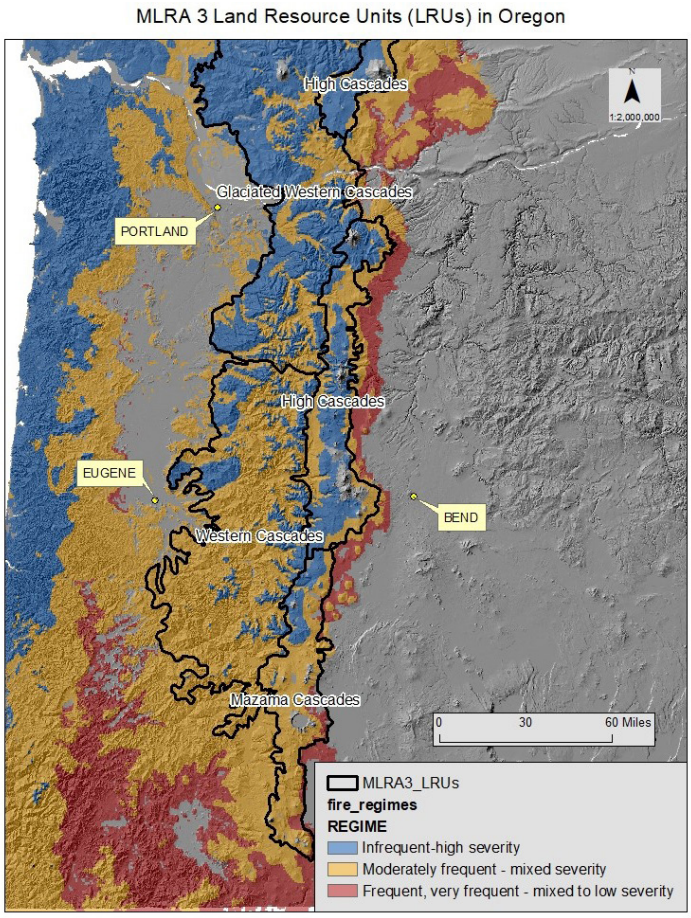


Figure 3.—Land resource units in the Oregon Cascade Mountains. Along the west side of MLRA 3, natural fire frequency and mountain slope morphology (the latter indistinguishable at this scale) change at roughly 44.5 degrees latitude. Generalizations defined at the LRU level reduce the number of characteristics needed to distinguish site concepts at the finer ESG level. Fire regimes are from Northwest Forest Plan, PNW-GTR-966. Map scale is 1:2,000,000.

from ST-Sim (a numerical model) into NRCS's graphical STM format. To learn more about ST-Sim, go to: https://www.fs.usda.gov/rmrs/tools/state-and-transition-simulation-model-st-sim-predicting-landscape-conditions.

Within each STM, all community phases were placed within a single state due to the resilience of these moist forests. Community phases describe forest structures resulting from regeneration harvest, thinning harvest, mixed severity and stand replacing fire. These simple models represent common trends in vegetation development, but do not capture the full range of variability within vegetation groups. Subsequent ecological sites may require additional pathways between phases to describe differences between communities.

The Ecology Group also assembled fire regime studies and wrote a narrative for the disturbance regime common to each ESG. Internal citations and bibliographies guide users to relevant scientific literature.

Before ESGs or the accompanying STMs were developed, the team took time to identify the proper scale for ecological description. It is helpful to think of the PES

Figure 4.—Reference communities developing under mixed-severity fire regimes can be structurally complex due to trees that survive fire events. This stand features two old, fire-tolerant Douglas-fir trees (center and right, background) along with a younger cohort of fire-intolerant western hemlock. Prevalence of mixed-severity fire is a feature shared among upland forested ESGs within the Western Cascades land resource unit.

Figure 5.—Within MLRA 3, soils too wet for conifers usually support a red alder tree canopy. Well drained soils on adjacent uplands support communities that succeed to coniferous forest. Pictured is an area of the ESG Western Cascades Swamp Group. American skunkcabbage and common ladyfern are prominent in the understory.

effort in the context of the NRCS Land Resource Hierarchy (see figure 2). At the beginning of the project only MLRA boundaries were known while lower levels of ecological classification needed development; no land resource units (LRUs), ecological site groups, or ecological sites existed.

To identify the appropriate level of detail for PES, the team first defined LRUs for MLRA 3 (fig. 3). Existing common resource areas (CRAs) were used as a starting point, and the resulting LRUs resemble them with a few changes. Care was taken to split or lump CRA units only on the strength of multiple landscape characteristics. In one case, alignment of boundaries in fire regime and aggregated USFS Landform Associations warranted a mapunit split: stand-replacing fire versus mixed-severity fire regimes have implications for reference community structure (fig. 4); landform associations in this area are a proxy for soil age and texture. In another case, CRAs were lumped into a single LRU. Soil temperature regime was changed to an ESG-level criterion because it could not be represented simply on a small-scale LRU map. This process identified important generalizations, which reduced the number of characteristics needed to distinguish site concepts at the finer ESG level.

Next, ESGs defined by soil moisture and temperature and related to dominant tree species were defined within each LRU. ESGs codify long-standing soil-vegetation correlations within these MLRAs (fig. 5). The ESGs also correspond to Plant Association Series (dominant tree species) or coarse subdivisions, e.g., “warm western hemlock.” This scheme provided coverage for the intensively managed parts of this MLRA, but with a few holes because ESGs were developed only for areas with published SSURGO information.

Ultimately, ESGs, rather than ecological sites, were made the focal point of this project due to the scale of published soil survey information. Associated ecological

interpretations (tree lists, tree site index, and use and vegetation from official soil series descriptions) supported broad distinctions between forest zones but did not resolve fine-scale ecological types equivalent to USFS Plant Associations. Since plant associations represent a scale at which the USFS frequently manages land, it seemed reasonable to reserve ecological sites as the place to describe greater detail later.

The Salem Soil Survey Office and the Ecology Group are eager to continue their collaboration. Communication on this project between the two staffs could have been difficult without their prior working relationship. Fortunately, soil survey office staff had learned the language of USFS Plant Associations and ecologists could decode the jargon of soil temperature and moisture regimes. Soil survey office staff learned about forest vegetation dynamics and disturbance regimes through this project. Much soil-vegetation correlation remains to be done in western Oregon, but this collaboration helps sets future ecological site development and soil survey update on a solid path. ■

Home Soil

By by Drew Kinney, National Leader of Soil Business Systems, National Soil Survey Center, Lincoln, Nebraska.

An old fable claims that wherever you're from you carry a little bit of home soil with you, whether it's under your fingernails or in your soul. Many fables have a biblical origin, and this fable no doubt comes from the burial proverb, "For dust thou art, and unto dust shalt thou return." If you're from Arizona, you no doubt have a little home soil under your fingernails, in your soul, and in your lungs from all the dust storms!

Imagine it's 1933 in Phoenix, Arizona, and 14-year-old George Bertie Jr. is playing ball in a local park with the other neighborhood kids. As if on cue, one of George's closest friends straightens and stiffens with a bewildered and frightened look on his face. George turns to see that his friend is staring at an enormous dust cloud bearing down on them. As George turns back, he sees his friends scatter to the four winds, heading home in a mad race. George sprints to his bicycle, hops on, and begins racing toward his house as fast as he can. He's peddling so hard he can feel the burning in his legs as he cuts through vacant lots and barrels downs the sidewalks. Before George can get halfway home, the storm overtakes him. He tucks his chin down and pulls his T-shirt up over his nose to help keep the dust from burning his lungs.The wind is howling past his ears, and his exposed skin begins to burn as he's literally being sandblasted. He begins coughing, and his eyes are burning from all the dirt, sand, and debris being kicked up by the storm. The earthy smell of dust and creosote fills his lungs—he swears he can taste blood. With his eyes watering and burning and his skin on fire, he peddles faster. He rolls into his front yard, and while the bike is still rolling, he hops off. In one leap he jumps onto the front porch. As the door suddenly swings open, George tumbles through the doorway. His mother slams the door behind him as he falls to the floor.

George knew all too well the dangers of these dust storms. They are as dangerous today as they were in 1933. Many deaths occur on highways due to these all too familiar dust storms that plague the Southwest. There are not only dangers from poor visibility—the potential to spread Valley Fever is ever present. To combat these dust storms, NRCS has partnered with the Agricultural Research Service and the University of Arizona to study them. One of the principal tools used to study the dust storms is the Soil Survey, proving another valuable use for our soils data. Between the soil and ecological site information and the soil health practices, a number of avenues are being scrutinized to help alleviate these dust storms.

You might ask what became of George Bertie Jr. Although the story of George and the dust storm is fictional, George Bertie Jr. from Phoenix, Arizona, is not. He still resides in Arizona. THE Arizona. Seaman Second Class George Allan Bertie Jr. is one of 1,102 sailors and marines that still reside aboard the U.S.S. Arizona, no doubt entombed with a little bit of home soil with him.

Remember Pearl Harbor. ■

Ongoing Collaboration with the Passamaquoddy Nation in Maine

By Nicholas Butler, NRCS soil scientist, Dover-Foxcroft, Maine.

In 2017, the Dover-Foxcroft Soil Survey Office, in collaboration with Maine NRCS, began an ongoing sampling project to assist the Passamaquoddy Indian Nation. The project's primary objective is to evaluate levels of trace metals, specifically mercury, for various positions and cover types across the landscape. Simultaneously, biologists with the Passamaquoddy Nation collected fish specimens within the same watersheds and collected tissue samples to determine mercury concentrations in various fish species. The initial phase of the project spanned 3 years, resulting in 37 full characterization samples for 19 different soil series. The sampling efforts included shallow-to-bedrock soils located at the top of the watershed, very deep lodgment and ablation tills, wooded and open wetlands (including raised acid bogs), and several freshwater subaqueous samples at the stream outlet in the lake at the bottom of the watershed. The red stars on the map in figure 1 show where the initial phase of sampling occurred.

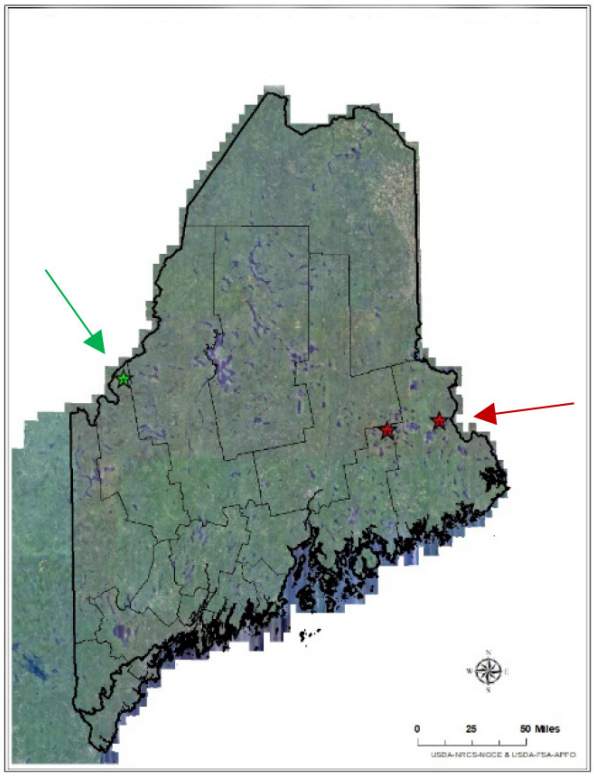


Figure 1.—Passamaquoddy landholdings for watershed analysis of trace metals. The red stars indicate Indian Township and Oqiton Township in eastern Maine, and the green star indicates Prentiss Township in western Maine.

In 2020, phase 2 of the project began on Passamaquoddy landholdings in western Maine (green star on map in figure 1). We followed a sampling approach similar to that applied in phase 1 and used samples ranging from shallow-to-bedrock soils at the top of the watershed to open wetlands at the bottom. These landholdings were more actively managed than those in the east and included a large sugarbush operation (fig. 2).

Many of the same soils that we sampled in eastern Maine were observed and resampled in western Maine. We ended up describing and sampling 20 pedons

Figure 2.—Sugarbush operation on landholdings in Prentiss Township, Maine.

spanning 10 soil series for full characterization analysis. The duplication of soil series sampling under various management types (natural regeneration, pre-commercial thinning, sugarbush operation, etc.) will be evaluated for differences in dynamic soil properties. Furthermore, the trace metal analysis will continue to aid the Passamaquoddy Nation with their ongoing efforts to determine if the mercury levels in the fish they use for food are directly related to the soils within the watersheds of their landholdings.

The last week of the 2020 sampling efforts stretched into late October and provided an excellent learning opportunity for our newly converted pathways hire, Alaina Kresovic (fig. 3). Although temperatures did not get above 32 degrees F and there were snow flurries most of the time, the on-the-job training and learned skillset of proper sampling techniques will be invaluable throughout her career. We look forward to continuing our collaboration with Maine NRCS to assist the Passamaquoddy Nation in their ongoing efforts. ■

Figure 3.—Alaina Kresovic (right) taking notes as Nicholas Butler (left) describes the soil pit.

Staff in Northwest Soil Survey Region Join FEMA Team to Assess and Mitigate Threats from Oregon Wildfires

By Anthony Collora, NRCS soil scientist, Redmond, Oregon Soil Survey Office.

Soil Survey staff as well as Oregon NRCS staff assisted the Federal Emergency Management Agency (FEMA) in a 2-week emergency response to assess erosion-related threats following the historic 2020 wildfire season in the western United States. A combination of severe drought, extreme wind events, and multiple ignitions caused one of the most destructive wildfire seasons in Oregon's history, with approximately 1.07 million acres in the State burned this year. As the fires swept across multiple small towns, at least 11 people were killed and over 3,000 structures were destroyed. In response to these fires, FEMA organized an Erosion Threat Assessment and Reduction Team (ETART) to identify, assess, and model debris flow and mass movement threats that may occur on private and State land.

The ETART response became an interagency effort with partners joining from several agencies including FEMA, Oregon Department of Forestry (ODF), NOAA National Weather Service, Bureau of Land Management (BLM), U.S. Army Corps of Engineers, U.S. Forest Service, and NRCS (fig. 1). The primary objective was to create a landscape-level post-fire risk assessment for private and State lands within the four major wildfires in Oregon: the Beachie Creek, Riverside, Archie Creek, and Holiday Farm Fires. The ETART assessment will be used to support the prioritization of emergency funding for State and locally administered recovery programs and strategize responses.

During the first week, staff were trained on proper assessment criteria to determine soil burn severity (SBS). Field assessments consisted of data validation and identification of critical values at risk. Partners from NRCS and the Forest Service assessed various soil conditions in the field (fig. 2). Soil site assessments included

Figure 1.—Partners working for the Forest Service and BLM, while maintaining social distancing, provided training on how to properly assess field indicators of soil burn severity. From left to right: Bruce Moffatt (NRCS soil conservationist, Eugene, Oregon), Thomas Snyder (NRCS district conservationist, Eugene, Oregon), Megan McGinnis (BLM soil scientist/natural resource specialist), and Mary Young (Forest Service soil scientist). Not pictured: Anthony Collora (NRCS soil scientist, Redmond, Oregon), Amy Kaiser (NRCS district conservationist, Tangent, Oregon), and Nicholle Kovach (NRCS civil engineer, Redmond, Oregon).

Figure 2.—An example of high soil burn severity on the Holiday Farm Fire near Eugene, Oregon. The upper 3 cm of soil has been "cooked" red and has significant loss of soil structure and aggregates. The underlying layer has experienced a moderate degree of charring. At a depth of approximately 8 cm, the native soil characteristics are seen. The surface duff has been recently deposited post-fire from the charred Douglas-fir at this site and will act as a natural defense against erosion.

amount and condition of ground cover, color and depth of ash, soil structure, soil texture, condition of roots, and soil water repellency. Additional site characteristics assessed included surface vegetation conditions, canopy vegetation char, and presence of leaf litter or duff and the degree of char or loss. Pre-fire land management conditions and vegetation were important in judging the soil burn severity as well as potential risks. Since much of these fires affected private industrial forestry land under clear-felling rotations, erosion potential for selective subwatersheds and drainages were taken into close consideration. Table 1 provides a brief overview of field indicators of soil burn severity.

Prior to the ETART effort, partners working for the Forest Service created a SBS map based on pre- and post-fire imagery as well as aerial assessments (fig. 3). The map shows four classes of burn severity: unburned, low SBS, moderate SBS,

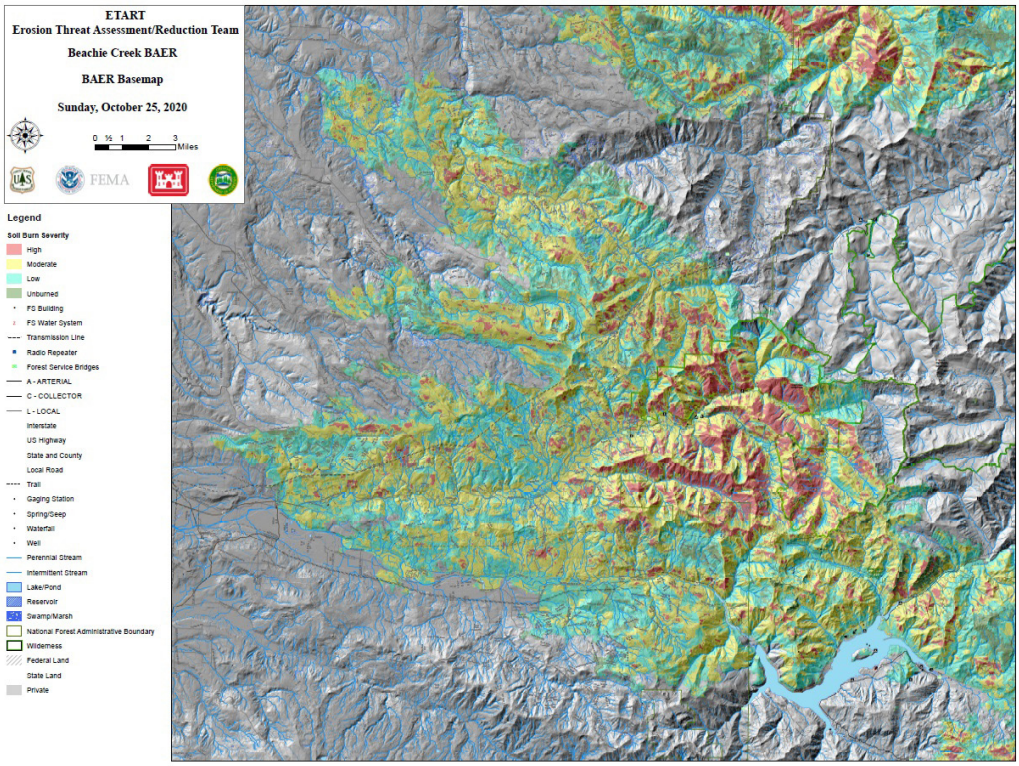


Figure 3.—ETART's soil burn severity map for Beachie Creek.

Table 1.—Field Indicators of Soil Burn Severity

Indicator	Importance	Low	Moderate	High
Ash depth and color	Ash, while nutrient rich, is susceptible to loss through wind and rain.	Ash may be black or gray and is shallow. Natural duff remains.	Ash is dominantly gray and has variable depths. All duff is consumed.	Ash is typically gray and white and there are areas with deep ash. All duff is consumed, and in some places, there may be reddish oxidized soil on the surface. In some cases, ash is lost due to wind erosion during the fire.
Soil char	It indicates consumption of soil organic matter in the upper portions of the soil.	Nonexistent or very thin.	Thin, from 0.5 to 2 cm deep.	Thick or variable, with charred soil extending 2 cm and deeper
Roots	Live roots may indicate speedier vegetation recovery, while loss of live roots may signal slower recovery.	Fine roots are alive, flexible, and intact.	Fine roots are brittle or charred. Deeper and larger roots may remain viable.	Fine roots are entirely consumed. Larger roots may be brittle and charred.
Soil structure	It provides resistance to erosion from raindrop impact and overland flow. Loss of structure increases susceptibility to erosion.	Soil retains natural structure.	Soil structure may be minimally altered at the surface, but not at depth.	Soil structure is lost in the upper surface layer and soil has a powdery texture and appearance.
Hydrophobicity	It reduces water infiltration and increases runoff.	Hydrophobicity is naturally present in volcanic ash soils and persists at depth.	Natural hydrophobic properties are minimally altered by heat. May be interrupted at surface, but alterations are patchy and inconsistent.	Native hydrophobicity is interrupted at soil surface and fire-induced hydrophobicity is at depths to more than 4 cm below the soil surface.

and high SBS. The Forest Service's SBS mapping did not field-validate soil conditions on private or State lands. The ETART soils team validated the SBS map with on-the-ground data collection and visual validation on State and private lands. This was done to ensure that the erosion modeling effort would produce a meaningful output for the watersheds identified.

In addition to the field assessments on soil and site conditions, members of the ETART soils sub-team spent time identifying critical values potentially at risk (fig. 4). Once the SBS maps were field validated and critical values were identified, the modeling effort began.

During the second week, the ETART soils team utilized the erosion modeling tool WEPP, which is hosted by the University of Idaho. WEPP Disturbed is the specific model that was used to assess erosion risk. It uses SSURGO data produced by NRCS as well as data from the National Land Cover Database (NLCD) to parameterize land use for unburned conditions. The SBS map is then fed into the WEPP Disturbed model, resulting in outputs that provide meaningful comparisons between unburned and burned conditions. The soil loss results varied greatly depending on the size and characteristics of each modeled subcatchment and its associated soil burn severity. The output values of hillslope soil loss per year that the WEPP model produced

Table 2.—Summary Breakdown of Modeled Hillslope Erosion for Target Drainages Within the Beachie Creek Fire

Subwatershed	Drainage name	Actual outlet location used in modeling	Unburned		Burned		
			Total hillslope soil loss from outlet (ton/yr)	Total hillslope soil loss per unit area of watershed (lb/acr/yr)	Total hillslope soil loss from outlet (ton/yr)	Total hillslope soil loss per unit area of watershed (lb/acr/yr)	Magnitude in post-fire hillslope soil loss (average)
Middle Butte Creek	Little Coal Creek	-122.556948, 44.993925	200	290	450	660	2.26
	Coal Creek	-122.556547, 44.993212	170	140	490	410	2.91
	Coal Creek Tributary	-122.559063, 44.991007	210	2100	800	7700	3.74
Upper Butte Creek	Upper Butte Creek	-122.445390, 44.906244	800	530	1600	1100	2.04
	Kirk Creek	-122.507017, 44.917941	250	230	1000	940	4.04
Pine Creek - Molalla River	Gawley Creek	-122.458292, 44.954044	2300	800	4100	1400	1.77
Headwaters Molalla	Henry Creek	-122.321868, 44.911915	3400	1900	9100	5100	2.68
	Upper Molalla River (above Henry Creek)	-122.321489, 44.912885	2500	1200	3500	1700	1.41
	Ogle Creek	-122.330127, 44.914142	410	990	1200	3000	2.98
	Copper Creek	-122.338644, 44.923833	820	380	2900	1300	3.48
	Mining Iron Creek	-122.341449, 44.925614	5600	770	18000	2500	3.23
	Minette Creek	-122.364107, 44.935860	100	240	270	640	2.68
Stout Creek - North Santiam River	Stout Creek	-122.614637, 44.800022	450	210	1200	570	2.69

represent a general magnitude of watershed response under average conditions, rather than a precise reflection of total possible erosion. However, the comparison between the pre-fire and post-fire values was determined to be a meaningful and significant judgement of risk based on typical storm event and soil erosion behavior for the area. Table 2 is an example of the results produced after the WEPP Disturbed model was run on selected subcatchments that were identified to have possible critical values at risk.

Once modeling was complete, the ETART soils sub-team used the data to identify the subcatchments in which erosion-related threats pose the greatest risk to critical values on State and private lands. The risk assessment was conducted utilizing the same determination framework as Federal Burned Area Emergency Response

Figure 4.—An area of Mt. Hood National Forest burned by the Riverside Fire. Steep slopes covered in burned vegetation significantly increase the risk of debris flow. The road pictured is currently closed to public traffic and is under extensive review by engineers and road crews with the Oregon Department of Transportation and Mt. Hood National Forest.

Probability of Damage or Loss	Magnitude of Consequences		
	Major	Moderate	Minor
	RISK		
Very Likely	Very High	Very High	Low
Likely	Very High	High	Low
Possible	High	Intermediate	Low
Unlikely	Intermediate	Low	Very Low

Probability of Damage or Loss: The following descriptions provide a framework to estimate the relative probability that damage or loss would occur within 1 to 3 years (depending on the resource):

- Very likely. Nearly certain occurrence (90% - 100%))
- Likely. Likely occurrence (50% - 89%)
- Possible. Possible occurrence (10% - 49%)
- Unlikely. Unlikely occurrence (0% - 9%)

Magnitude of Consequences:

- Major. Loss of life or injury to humans; substantial property damage; irreversible damage to critical natural or cultural resources.
- Moderate. Injury or illness to humans; moderate property damage; damage to critical natural or cultural resources resulting in considerable or long term effects.
- Minor. Property damage is limited in economic value and/or to few investments; damage to critical natural or cultural resources resulting in minimal, recoverable or localized effects.

Figure 5.—BAER Risk Assessment Matrix.

Table 3.—Example of Summary of Critical Values in the Beachie Creek Fire

Value	Probability of damage or loss from hillslope erosion	Magnitude of consequence	Hazard to Value	Treatment recommendation	Treatment justification
OR-22 highway corridor and associated infrastructure, including transmission lines	Possible to likely, depending on location	Moderate to major, depending on location	Intermediate to very high	Road maintenance, storm patrol, debris flow and rockfall signage, hazard tree removal, log erosion barriers. Additional treatments may be necessary.	Highly trafficked highway. Sections of windy road with no shoulder have steep hills abutting highway. Likely occurrence of damage from debris and erosion.
Private property and infrastructure along South Butte Creek Road	Possible	Minor to moderate	Low to intermediate	Inform stakeholders of risk and more detailed assessments of hazards. Engineering teams to inspect culverts and other road infrastructure.	Increased sediment flows could lead to sediment and debris depositing on private property.
Private property and infrastructure in Mill City	Possible	Moderate	Intermediate	Inform stakeholders of risk and more detailed assessments of hazards that may present threats in the drainages above Mill City.	Mosaic of soil burn severity may result in sediment and debris flow towards the northern section of Mill City.
Soil productivity on industrial private lands	Likely	Minor	Low	Natural recovery	Hillslope treatments are not effective enough on steep slopes to be economically viable in impacted areas.

(BAER) teams and is outlined in figure 5. Treatment recommendations were then made based on the WEPP modeling efforts and the scale and scope of the values at risk (fig. 6). Table 3 is an example of hillslope treatment recommendations. It should be noted that the treatments identified serve as broad landscape-level recommendations based on a variety of factors identified on a watershed, including the nature of downstream values at risk, effectiveness of treatment, timeframe for implementation, and cost

Figure 6.—An example of a post-fire hillslope treatment. Cross-felled trees act as log erosion barriers to mitigate the risk of hillslope soil loss and debris flow depositing onto the highway below.

effectiveness, among other factors. Treatments were not meant to serve as property-specific response actions.

One of the main challenges we faced during the completion of this project was balancing in-person and virtual communication. Team members went above and beyond to ensure the safety and respect of each other by maintaining social distance and using masks whenever working face to face. ETART teams used MS Teams throughout the project to maintain communication, share files, and deploy virtual training.

Overall, this project provided NRCS staff with a unique opportunity to work with partners from various Federal, State, and local agencies and organizations while completing a job that was vital in the emergency response to a devastating wildfire season in our beautiful State of Oregon. ■

Colombia and Haiti Soil Survey Projects—A Tale of Two Contrasting DSM Approaches

By Zamir Libohova, NRCS research soil scientist, and Charles Kome, NRCS soil scientist.

The NRCS Soil and Plant Science Division (SPSD) and the International Programs Division (IPD), in cooperation with other Federal government agencies such as USAID (U.S. Agency for International Development) and FAS (Foreign Agricultural Service, USDA), Penn State University, as well as government and non-government institutions and organizations, completed soil surveys in Haiti and Colombia. From the perspective of soil survey, the goals for both projects were similar in that a soil survey product with associated soil maps and interpretations was expected. Other goals were to build soil survey capacities in Haiti and support Cacao for Peace efforts in Colombia. The overall goal and the funding for each project, combined with available data and access to the project areas, shaped the early decisions about the approach to conducting the soil survey in each country.

Digital soil mapping (DSM) approaches and/or DSM elements combined with traditional soil survey mapping and field work were implemented. Some of the DSM aspects were affected by the conditions in each country, most importantly *data availability, site accessibility,* and *in-country expertise*.

Data availability.—The use of a soil landscape model as one of the main criteria for soil mapping required detailed topographic data. The digital elevation model (DEM) was the first and primary data source that provided the first puzzle piece to the design of the soil survey (fig. 1). Haiti was fortunate to have a high-resolution LiDAR DEM at 1m, although it was acquired due to the very unfortunate event following the massive earthquake in January 2010. However, for Colombia the main available DEM was Shuttle Radar Topography Mission (SRTM) at 30m resolution. Another DEM at 12.5m was also available for Colombia; however, the poor quality of the data prevented its use.

Area-wise, the size for the Haiti project was about 3,000 hectares while that for Columbia was 161,000 hectares. DEM resolution and area size combined were suitable for a detailed soil map at about 1:5,000 for Haiti and about 1:24,000 for Colombia. The proposed detailed scales were a significant improvement for both countries. Haiti had no soil maps and relied only on a geomorphology map from 1970 at 1:100,000 scale while Colombia had a general soil map only at 1:100,000 scale generated during the 1980s.

The second puzzle piece was the availability of measured and described soil data from pedons. As expected, such data was not available for both countries. Haiti had no soil data at all, and Colombia had only map unit descriptions and no measured data.

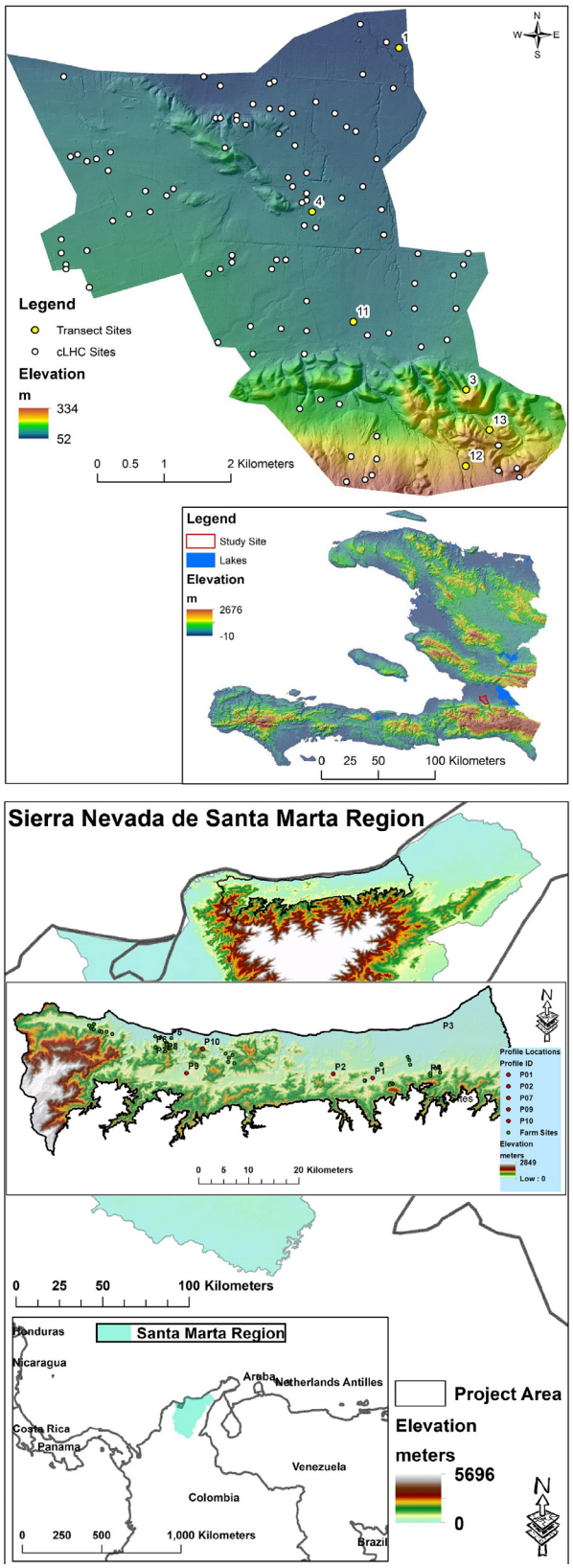


Figure 1.—The location of sampling sites and DEM used for Haiti (top) and Colombia (bottom).

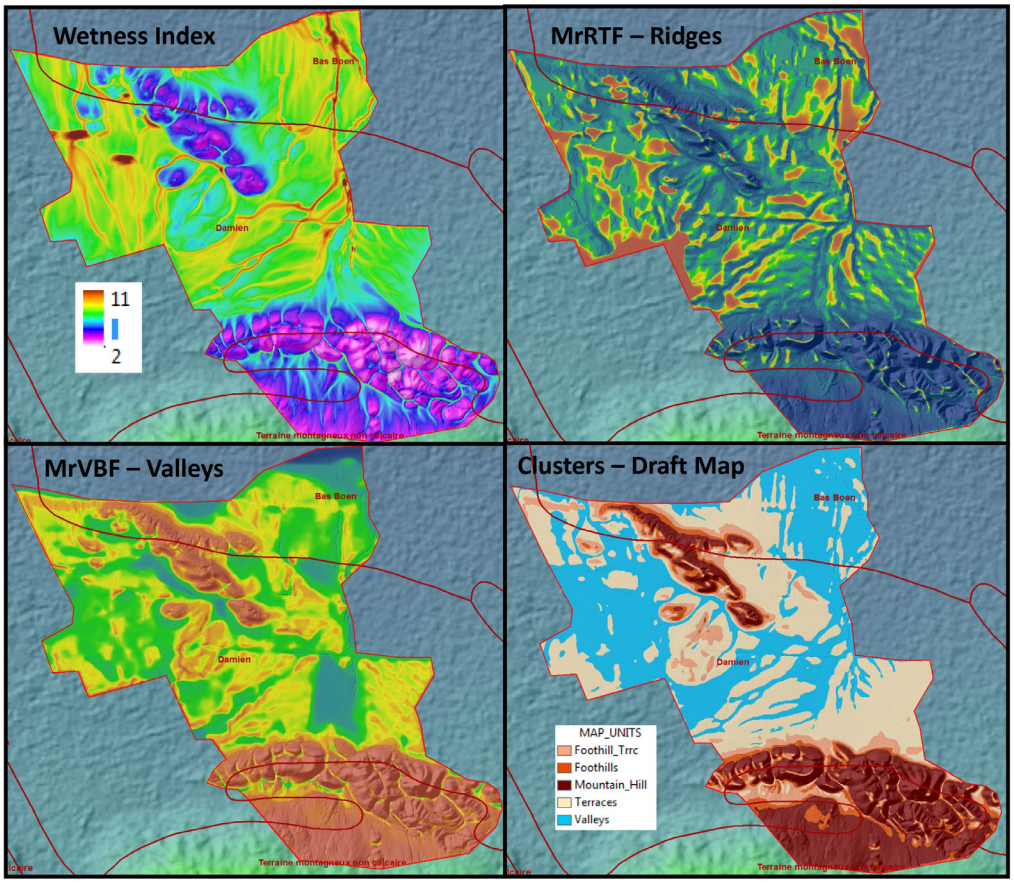


Figure 2.—DEM terrain derivatives used for selecting sampling sites based on cLHC and for the preliminary soil map draft for Haiti.

The description and sampling of pedons was necessary, but other factors, such as cost, site access, and in-country soil expertise, needed to be addressed as well.

Site accessibility.—Because the access to the Haiti project area was unrestricted, a Condition Latin Hypercube (cLHC) sampling design was implemented by selecting approximately 100 points for soil sampling. For this purpose, three DEM terrain derivates were used (Wetness Index; Multiresolution Valley Bottom Flatness, or MrVBF; and Ridge Top Flatness, or MrRTF). The same derivatives were used in a cluster analysis to delineate the first draft of potential soil map units (fig. 2).

The access to the Colombia sites was limited to areas that were predetermined based on the participating farms. Thus, a preliminary soil map was generated based on clustering analysis using six terrain attributes derived from the DEM. Out of the initial 90 to 100 participating farms, between 30 and 35 farms were possible to visit for sampling. Because of the uncertainty of granted access, even for the remaining farms, an analysis was performed to prioritize the sites. Two sets of points (Priority 1 and 2) were created based on the (i) initial soil map units from the cluster analysis (see figure 3), (ii) soil types from the existing 1:100,000 scale map, (iii) geology, (iv) national parks/protected areas, and (v) distance from roads. The target was at least three sites for each of the five initial soil map units from the cluster analysis.

As a result of site accessibility, the density of sample points was 1 per 32 hectares for Haiti and just 1 per 4,600 hectares for Colombia. The high density of sampling points for Haiti allowed for better characterization of soil landscape relationships compared to Colombia (fig. 4).

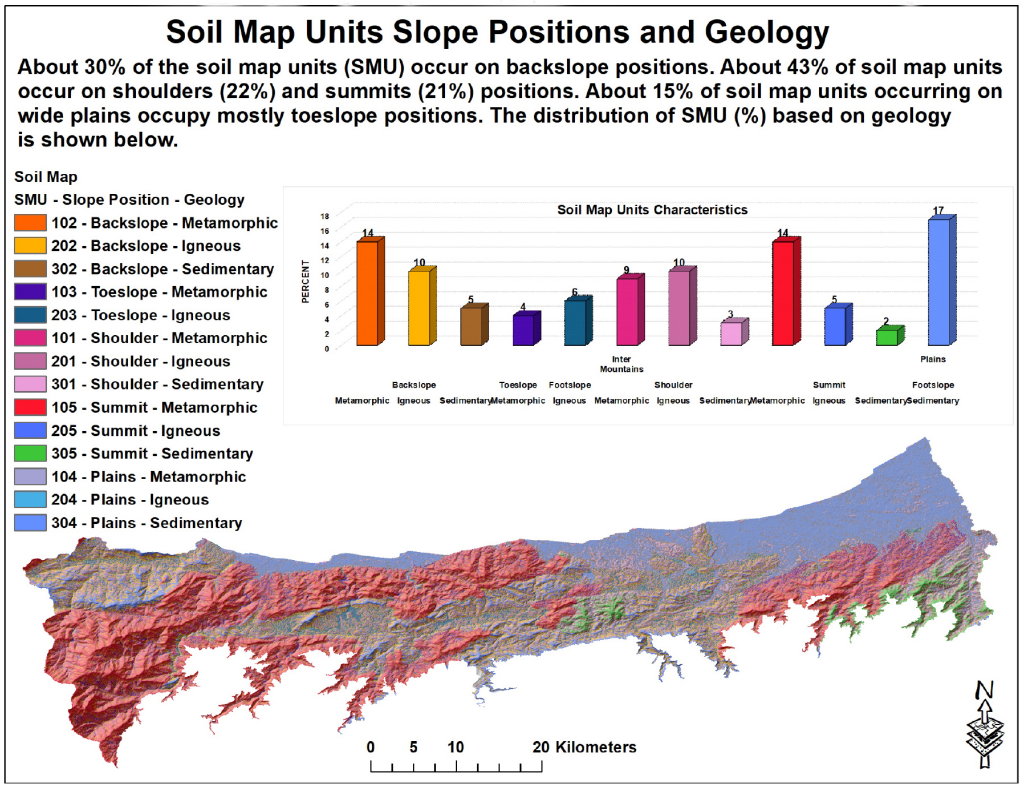


Figure 3.—The draft soil map and the resulting soil map units differentiated by a mixed model of slope positions (summit, shoulder, backslope, footslope/toeslope) and geomorphic units (plains) and stratified by geology.

In-country expertise.—There were no trained or field-experienced soil scientists in Haiti. A small number of project participants had some very limited exposure to soil survey during their visit to the National Soil Survey Center (NSSC) in Lincoln, Nebraska, in August 2013. Building soil survey capacity and expertise in Haiti became one of the major goals of the project. Training new soil scientists and conducting field work to collect samples were combined. Initially, about 30 Haitians participated in the training. The class was full during the first week of training, but attendance dropped after the first field day. The soil survey expertise that once was available in Colombia, in the mid-70s, had eroded due to retirements and discontinuation of soil survey campaigns after the soil survey completion. The only expertise available was at the International Center for Tropical Agriculture (CIAT), and it focused mostly on soil fertility and, to a limited extent, on digital soil mapping.

Due to differences, several aspects of the soil survey and final products were tailored to country conditions. All the sites selected based on cLHC in Haiti were initially described and sampled using augers and the standard 232 forms, which served as templates for training the new soil scientists on reading the landscape, describing soils, and using data and observations to build a soil landscape model. The soil survey activities attracted the attention of local farmers, who were very curious and asked many questions (fig. 5). We answered them through interpreters, aka our new soil scientists, whose sense of humor made these exchanges sometimes very entertaining.

The standard 232 forms translated into Spanish were also used in Colombia. Scientists from CIAT were trained on practices and protocols for describing and sampling soils in the field. A unique feature of the field campaign was the sampling of cacao plants as part of the project to better characterize the plant genetic bank of

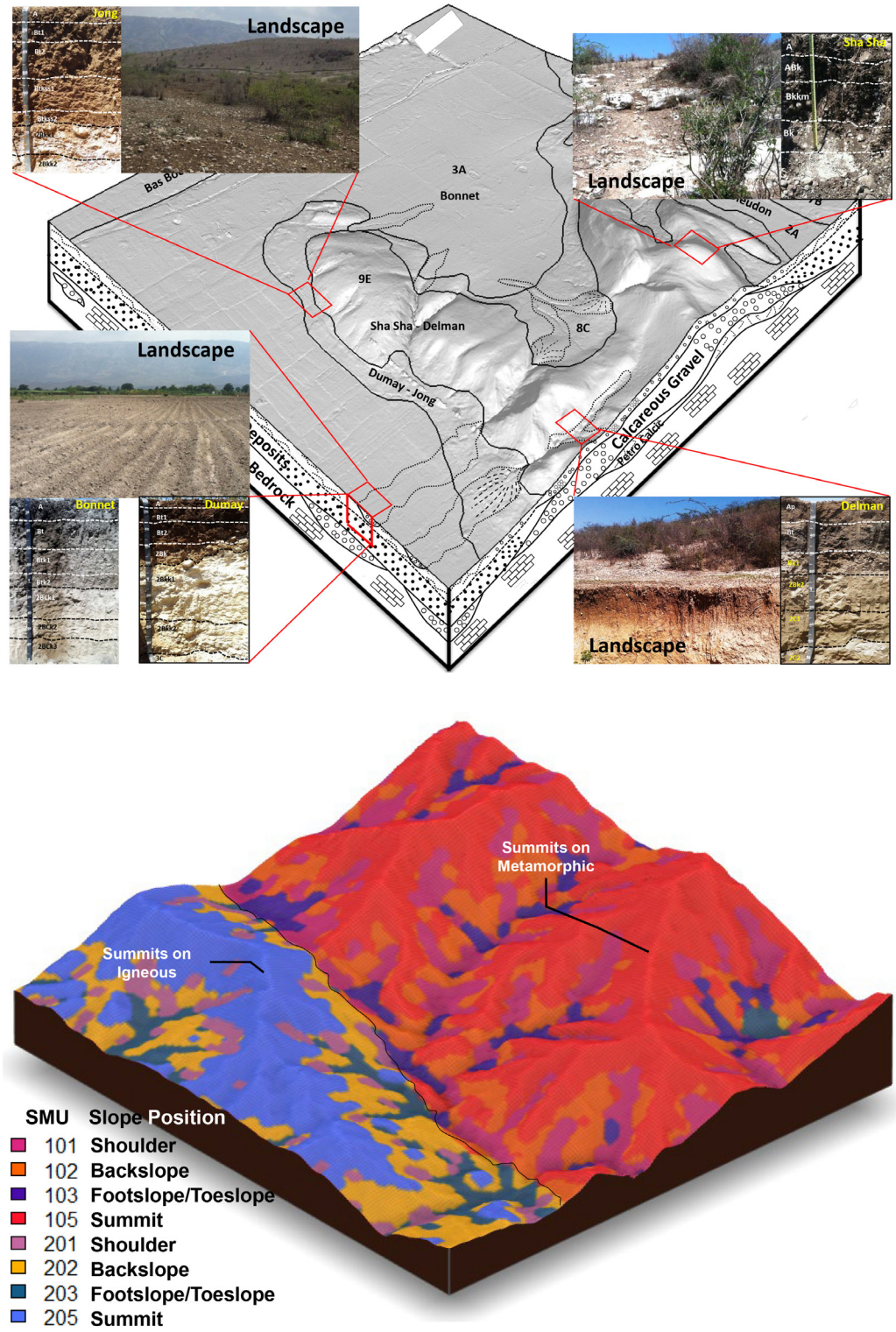


Figure 4.—(Top) Conceptual block diagram derived from LiDAR elevation data detailing links between landscapes and soils in Haiti. (Bottom) Conceptual block diagram derived from SRTM elevation data showing the occurrence of soils on slope positions under two different geologies in Colombia.

Figure 5.—(Top) The field crew describing and discussing soils with three local farmers (the women pictured) in Haiti. (Middle) Siela Maximova from Penn State University collecting samples for the plant genomic study. (Bottom) Local transportation of equipment and soil samples from farms in remote areas in Colombia.

the area. The soil sampling was designed to allow for sampling of trees for the plant genomic study and to help understand the distribution and allocation of cadmium between soils and plants. The soil survey crew in Colombia visited farms located in remote areas, which often required the use of animals to transport equipment and soils (fig. 5).

General Remarks

Irrespective of the differences and challenges of each soil survey, the major products from both projects were soil type and property maps as well as soil interpretation maps. However, the format and delivery platforms for these products differed. The Haiti soil maps were polygon-based at 1:24,000 scale, although the density of the observations permitted a finer scale and supported a raster-based soil map. Because one of the major goals of the project was to build soil survey capacity and because the web-based platforms were not fully developed at that time and considered for the Haiti project, the soil survey products and the laboratory data are hosted by the U.S. Soil Survey database (fig. 6). The data collected during the project in Haiti can be utilized for developing finer resolution, raster-based soil and property maps and for training the local soil scientists not only on traditional soil survey but also on DSM approaches. The achievements of the Haiti soil survey project supported the recent grant from International Development Bank (IDB) to fund a full-scale national soil survey for Haiti. In Colombia, one of the major goals of the soil survey was to support the Cacao for Peace initiative. In order to achieve this goal, the emphasis was on generating soil maps, interpretations, and easy-to-use web-based platforms to support cacao growers. Although the soil maps and interpretations for Colombia are raster-based, unlike the Haiti project, the density of point data for Colombia does not necessarily support maps at 30m resolution. The SRTM 30m resolution selected for soil maps and interpretations was a decision driven by the best available data at the time. Despite differences in the DSM approaches used for the projects, a common thread

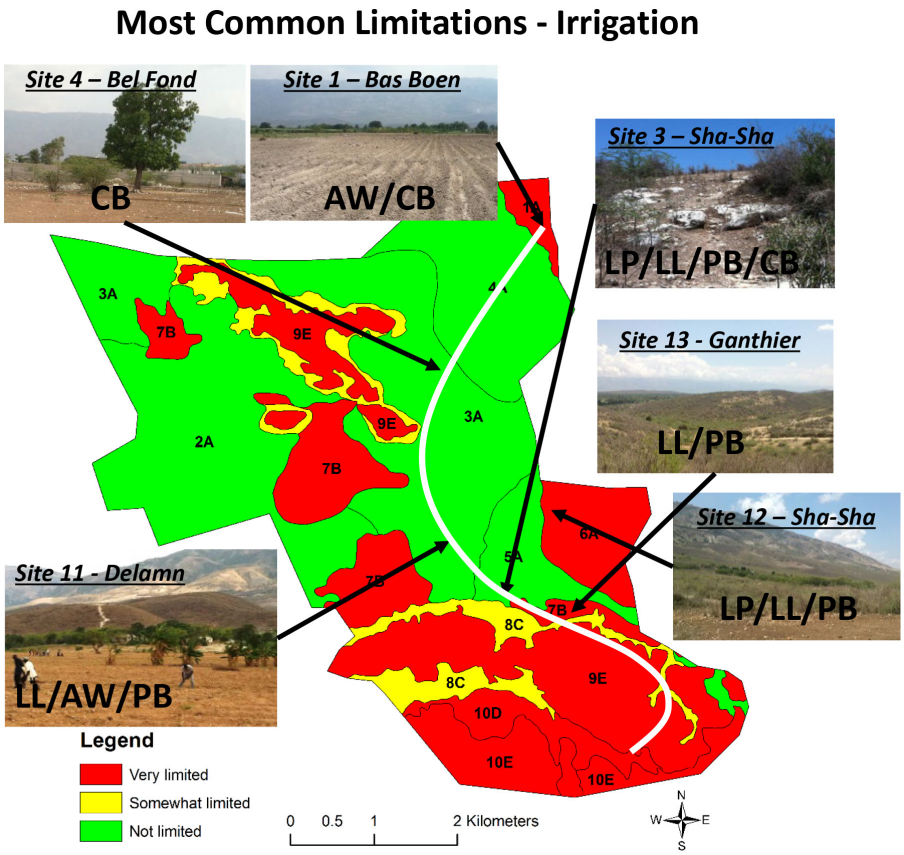


Figure 6.—Interpretation rating for surface irrigation of the project area in Haiti. LP = landscape position; LL = limiting layer; AW = available water; PB = physical barrier; CB = cje,oca; barrier.

Figure 7.—Web-based platform for the data and products from the Cacao for Peace project in Colombia.

was the importance of producing soil information to support decisions at field level. Interpretations were the most sought-after product, highlighting the importance of what is described in the DSM community as functional soil maps. Irrigation suitability in particular is one of the major interpretations. This is no surprise to soil scientists and soil surveyors, who are well versed on the importance of soils in managing water.

Raster-based soil maps and interpretations for cacao suitability were developed and will be freely available to farmers via mobile web-based platforms. Figure 7 shows one of the web-based platforms developed by the SPSD Soil Services and Information Branch. Relevant websites are listed below.

Cacao for Peace Web Map Application: https://arcg.is/1HmGrL

Links to Each Layer

CfP Tree Samples:
https://services.arcgis.com/SXbDpmb7xQkk44JV/arcgis/rest/services/CfP_Tree_Samples/FeatureServer

CfP Soil Samples:
https://services.arcgis.com/SXbDpmb7xQkk44JV/arcgis/rest/services/CfP_Soil_Samples/FeatureServer

CfP Soil Profile Descriptions:
https://services.arcgis.com/SXbDpmb7xQkk44JV/arcgis/rest/services/CfP_Soil_Pro

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