National **C**ooperative **S**oil **S**urvey **Newsletter**

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In This Issue—

Editor's Note

Issues of this newsletter are available on the World Wide Web (http://soils.usda.gov/). Under Quick Access, click on NCSS, then on Newsletters, and then on the desired issue number.

You are invited to submit stories for this newsletter to Stanley Anderson, National Soil Survey Center, Lincoln, Nebraska. Phone—402-437-5357; FAX—402-437-5336; email—stan.anderson@lin.usda.gov.

Synopsis of Soil Survey Division International Detail in Ispra, Italy

By Amy Saunders, Soil Scientist, USDA, NRCS, Hilo, Hawaii, and Fred Young, Soil Scientist, USDA, NRCS, Columbia, Missouri. Pictures courtesy of Julie Youmans.

As part of international details offered by USDA, NRCS, Soil Survey Division, in the summer of 2010, we traveled to the European Commission Joint Research Centre (JRC) in Ispra, Italy, for a 2-week GIS and soil survey technical exchange. The Institute for Environment and Sustainability (IES) is one of five institutes at the JRC's facility located in northern Italy near the small town of Ispra (figs. 1, 2, 3, and 4). We spent 10 working days (August 25 through September 7) with the staff (about 20 scientists) of the IES Land Management and Natural Hazards Unit—Soil Data and Information Systems (SOIL) Action. The exchange was a successful mission in which NRCS and JRC staff shared expert knowledge of their respective soil programs and discussed recent and ongoing research related to soil survey. This exchange also served as a forum for discussing the future of soil survey from a global perspective and identifying potential collaborative projects.

During the first week, Luca Montanarella, Action Leader in SOIL, provided an overview of the structure and purpose of the JRC. He also introduced the researchers of the SOIL group and summarized their current projects. The JRC provides reports to EU political figures in Brussels on the state of European soils as related to key threats (e.g., erosion, contamination, and flooding). Specific tasks include "harmonized" soil maps of Europe (i.e., soil maps that integrate the various national classifications, methods, and scales into a uniform format), soil property maps (e.g., organic carbon), and soil hazard maps (e.g., soil compaction potential).

Discussions with Luca and other researchers revealed some of the significant differences between EU and U.S. soil survey efforts. The EU is in a very different position than the U.S. in regards to soil data availability, which varies from country to country. In Europe, detailed soil survey data are generally proprietary and must be purchased from the soils divisions of individual countries. Once obtained, the data may be in assorted formats, classified in numerous systems, mapped at various scales, and collected via different methods. Compiling and presenting existing soils data uniformly for Europe constitute a major effort for JRC scientists. In response, they have developed expertise in modeling soil properties and interpretations via a combination of terrain attributes and geostatistical interpolation from point data.

Figure 1.—Ispra is in Lombardy, northwest Italy, near Switzerland.

We participated in a training course for Digital Soil Mapping (DSM) for the duration of the second week. This unique opportunity allowed participants to learn from the international DSM experts who taught the course: David Rossiter (University of Twente, The Netherlands), Philippe Lagacherie (University of Montpellier, France), Budiman Minasny and Brendan Malone (University of Sydney, Australia), and Tomislav Hengl (ISRIC, The Netherlands). Bob McMillan (ISRIC, The Netherlands) and Endre Dobos (University of Miskolc, Hungary), visiting scientists active in digital soil mapping, also attended the training. The course provided an overview of key DSM concepts

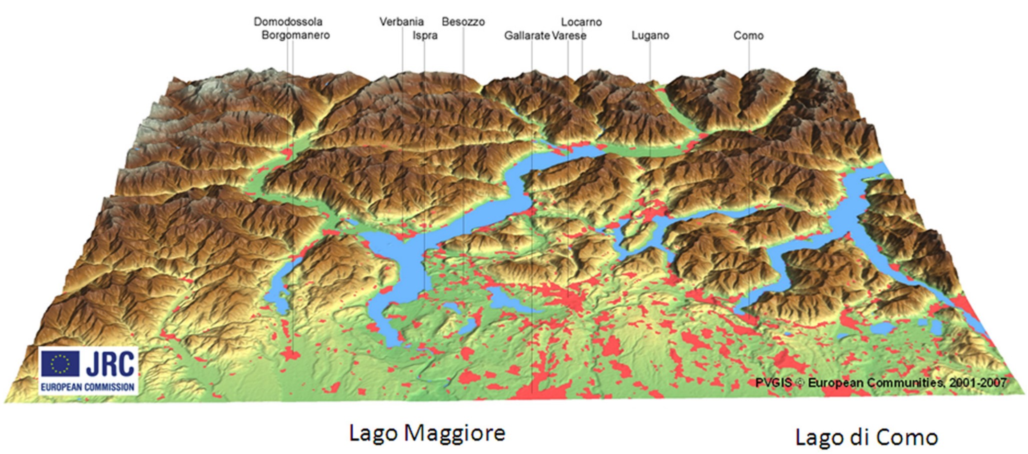


Figure 2.—Lago Maggiore is one of the Italian lakes along the border between Italy and Switzerland.

Figure 3.—Lago Maggiore. We stayed in Angera, beside the lake. The JRC (red star) is in the countryside.

and GlobalSoilMap.net. Again, because of the global problems of data availability and consistency, the course focused on methods of data "harmonization," geostatistical interpolation techniques using pedon data and ancillary data, disaggregation of soil polygons, and use of various open-source software (e.g., R, SAGA) and specialized, proprietary software (e.g., JMP, Vesper, Fuzme, Cubist). Fred presented a module on the Soil Inference Engine (ArcSIE) and its successful application to U.S. soil survey areas. Valuable discussions took place regarding the need to convert digital soil mapping methods into operational soil survey tools that can be applied to multiple levels of soil mapping across diverse landscapes.

The third week we met with Arwyn Jones, Communication Officer and GIS developer, to further discuss JRC activities, including multiple soil atlases (Europe, Northern Circumpolar Region, Soil Biodiversity) the JRC has produced to heighten public awareness of soils. The atlases contain considerable information on soils in general as well as pictures, diagrams, and discussion of soils in the region covered by the atlas. They are excellent tools for communicating the importance of soil and explaining soil-related threats to the general public. Panos Panagos, Web, GIS, and Database Developer, gave us a virtual tour of the European Soil Portal, where publicly available soil survey data and publications are housed online. Amy provided JRC staff with a showcase of Web Soil Survey, Soil Data Mart/Viewer, and the NCSS soil characterization database. The most frequent question from JRC scientists: “Did you say that this is free for users?”

Figure 4.—Angera, with the 17th century Borromeo castle above. This is where we stayed (no, not in the castle).

Figure 5.—Famous (and swanky) hotel in Stresa. We definitely did not stay here.

Figure 6.—Looking out from Isola Bella, one of the Borromean Islands

Happily, it was not all work, work, work. Evenings were generally spent eating. Italian food standards are high, and they are in no hurry to finish dinner. We had two weekends free, but no car. However, Lago Maggiore has an excellent ferry service to many lakeshore towns, including Arona, Stresa (fig. 5), and Locarno, Switzerland, as well as to the Borromean Islands (fig. 6).

Overall, the technical exchange provided an excellent opportunity to learn about soil survey outside of the U.S. and to look at U.S. soil survey in a new light. The extensive, uniform coverage of the U.S. along with its well-populated database (NASIS) is highly coveted by our EU colleagues. The modeling, harmonization, and disaggregation methods developed by JRC scientists have strong potential for application to U.S. soil survey as efforts transition from initial mapping to MLRA updates. This technical exchange will undoubtedly promote future collaboration and research in the years to come.

Find out more about JRC SOIL Action and download copies of publications and atlases at http://eusoils.jrc.ec.europa.eu/. ■

National Leader for Interpretations

From Soil Survey Division, "Weekly Update," January 19, 2011.

Michael Robotham, Assistant Director for Soil Science and Natural Resource Assessments, in Honolulu, Hawaii, started work on January 18 at the National Soil Survey Center (NSSC) as the National Leader for Soil Survey Interpretations. Mike will work cooperatively with all NRCS Divisions on the continued development of interpretative soils information and provide guidance and leadership to the National Cooperative Soil Survey. Mike supervises a staff of eight specialists at the NSSC. The National Leader for Soil Survey Interpretations is the last of the vacant national leader positions to be filled.

National leadership positions at the NSSC include:

- Michael Robotham—National Leader for Soil Survey Interpretations
- Larry West—National Leader for Research and Laboratory
- David Hoover—National Leader for Soil Business Systems
- Susan Andrews—National Leader for Soil Ecology
- Cameron Loerch—National Leader for Soil Survey Standards and Classification ■

Michael Robotham Joins National Soil Survey Center Staff

Michael Robotham joined the NSSC staff in Lincoln on January 18 as the new National Leader for Soil Survey Interpretations. Mike comes to the center from the Pacific Islands Area (Honolulu), where he served as the Assistant Director for Soil Science and Natural Resource Assessments (aka State Soil Scientist) coordinating and managing soil survey, technical soil services, and resource inventory activities in Hawaii, Guam, the Commonwealth of the Northern Mariana Islands, American Samoa, and the Freely Affiliated State (Federated States of Micronesia, Palau, and the Republic of the Marshall Islands). Before becoming State Soil Scientist, Michael was one of two Tropical Technology Specialists with NRCS charged with developing and coordinating cooperative applied research, field testing, and outreach activities in the American tropics.

Michael Robotham demonstrating vetiver grass barrier plantings in Guam.

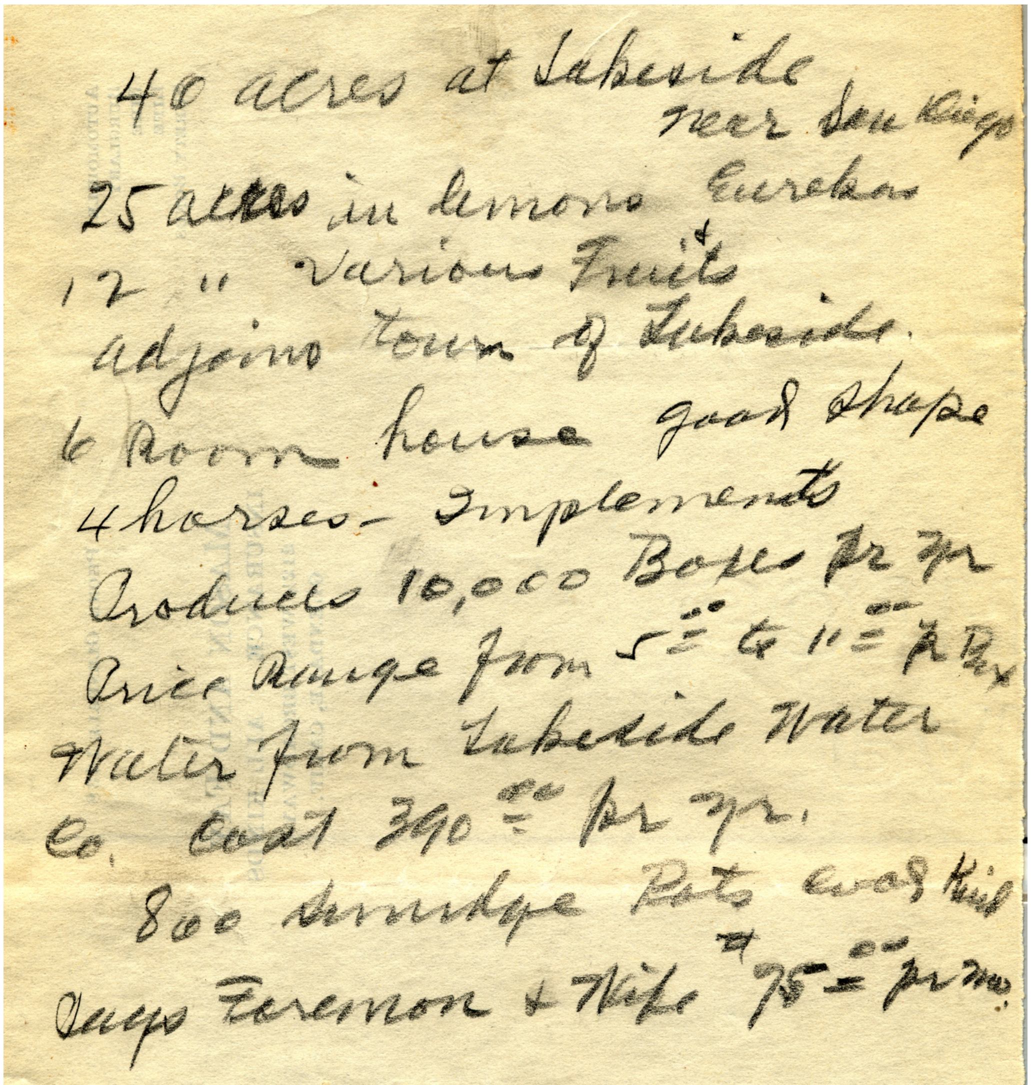
Michael has a Ph.D. in Agronomy and Soil Science from the University of Hawaii at Manoa and an M.S. in Research Development from Michigan State University. Before joining NRCS, he was an Assistant Professor at Oregon State University working with small acreage farmers in the Northern Willamette Valley. He also worked for the University of Hawaii Water Quality Extension program designing non-point source pollution awareness and mitigation outreach materials for home and farm owners. Between his undergraduate studies at Northwestern University and his M.S. work at Michigan State, he served as a Peace Corps volunteer in the Philippines.

Throughout his career, Michael as been interested in how scientific data can be analyzed, synthesized, interpreted, and distributed to help users make better decisions in the United States and throughout the world. Soil Survey Interpretations provide one of the main avenues to make this happen, and there are plenty of great things that can be done. Michael welcomes your input and ideas about how the program can continue to provide the best, most applicable, and most useful information possible. He can be reached at 402-437-4098 or Michael.Robotham@lin.usda.gov. ■

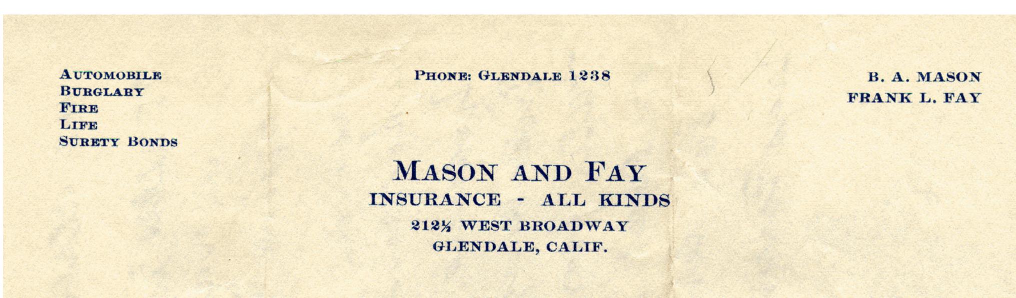
A Found Item

By Stanley P. Anderson, Editor, NRCS, National Soil Survey Center, Lincoln, Nebraska.

As I was preparing a 1918 survey of the San Diego, California, area for scanning, a sheet fell out of the booklet. Following is a scan of the back of the sheet and then a scan of the front. This item is of historical interest.



40 acres at Lakeside
near San Diego
25 acres in lemons Eureka
12 " various Fruits
adjoins town of Lakeside.
6 Room house good shape
4 horses – Implements
Produces 10,000 Boxes pr yr
Price Range from 5.00 to 11.00 pr Box
Water from Lakeside Water
Co. Cost 390.00 pr yr.
800 smudge Pots [illegible]
Pays Foreman & Wife $75.00 pr mo.



AUTOMOBILE
BURGLARY
FIRE
LIFE
SURETY BONDS

PHONE: GLENDALE 1238

B. A. MASON
FRANK L. FAY

MASON AND FAY
INSURANCE - ALL KINDS
212½ WEST BROADWAY
GLENDALE, CALIF.

Soil Survey Division Welcomes Dr. Thomas G. Reinsch

From Soil Survey Division, "Weekly Update," January 5, 2011.

Thomas G. Reinsch recently transferred from the National Soil Survey Center, Lincoln, Nebraska, to the Soil Survey Division staff at Washington, D.C., to fill the position National Leader for World Soil Resources vacated by Dr. Hari Eswaran. Dr. Reinsch received a Ph.D. from Oklahoma State University. He worked at the National Soil Survey Center for nearly 24 years, most recently as the Assistant National Leader for Soil Survey Research and Laboratory. Notable contributions there were the analysis of soil physical properties, completion of nearly 400 investigation projects, and soil survey laboratory information management systems. Dr. Reinsch has worked in at least 25 states and 8 foreign countries. He says that he became a soil scientist because he wanted to understand more about the world under our feet and to promote the wise use of this valuable resource. ■

Dr. Thomas Reisch

Zamir Libohova Joins National Soil Survey Center

Zamir Libohova was hired as a research soil scientist at the National Soil Survey Center in November of 2010. His responsibilities include digital soil mapping and modeling for the creation of continuous raster-based soil maps. From July to November of 2010, Zamir was a postdoctoral fellow at West Virginia University/USDA-NRCS Geospatial Research Unit, where he researched the development of digital soil property maps at regional and continental scales in support of the GlobalSoilMap.net project.

From January 2007 to June 2010, Zamir worked as a soil scientist on an intermittent tour of duty in Indiana, where he conducted soil survey maintenance and update for Howard County based on the Geographic Area/MLRA approach using digital technologies and geospatial analysis. From April 2004 to December 2006, he served as a soil scientist in Alabama, where he conducted initial soil surveys of Bibb County, Lamar County, and Talladega National Forest.

Zamir served as Interim Director of the Project Environmental Management Unit (PEMU), World Bank Forestry Project, in Albania, from February 1999 to May 2000. He was involved with environmental standards of the Forestry Project and conducted Environmental Impact Assessments (EIA) for forest management plans and forest road rehabilitation.

From December 1986 to June 1993, Zamir was Scientific Researcher and Head of the Soil Analytical Laboratory. He conducted soil surveys, prepared fertilization and irrigation guidelines at national and regional levels, and directed and supervised the Soil Analytical Laboratory responsible for soil and plant analysis for scientific experiments and national soil surveys.

Zamir has a Ph.D. in Hydropedology from Purdue University (2010); an M.S. in Watershed Management/Hydrology from Colorado State University (2004); and a Doctor of Science in Soil Fertility and Plant Nutrition from the Agricultural University of Tirana in Albania (2000). He did graduate work in Soil Science on a Fulbright Scholarship at Oregon State University from 1993 to 1996 and received a Bachelor of Science in Agronomy at the Agricultural University of Tirana in 1986. ■

Henry Ferguson Joins National Soil Survey Center

Henry Ferguson, soil scientist, joined the Soil Business Systems Branch of the National Soil Survey Center, Lincoln, Nebraska, in November of 2010.

Henry is a native of Vermont. He earned his B.S. in Plant and Soil Science at the University of Vermont and his Master's in Environmental Engineering through the Civil Engineering Department at the University of Vermont. He managed four soil survey project offices in Vermont and Missouri and served as a Soil Data Quality Specialist in Indiana. While assigned to the National Geospatial Development Center in Morgantown, West Virginia, Henry earned the project management professional status for working on the Soil Resource Inventory Toolbox project. His major duties at the NSSC involve working with universities to assimilate data from many sources into a single National Cooperative Soil Survey Laboratory Database.

Henry's hobbies include sailboarding, contra dancing, and promoting soil health and soil quality. He has developed educational kits and materials to help empower environmental education instructors with innovative visual aids. Some of the visual aids were used by the Smithsonian National Museum of Natural History and the Durham Museum to support the Dig-It exhibit. ■

Steve Monteith Joins NSSC Laboratory Staff

Steve Monteith will be a supervisory soil scientist at the National Soil Survey Center Laboratory working primarily with the soil mineralogy and soil physics sections. Before relocating to Lincoln, Steve worked as Project Leader at the Jackson MLRA Soil Survey Office in western Tennessee and as Project Leader for the Greenville SSO in Greenville, MS. Other experience as a soil scientist includes working for several years as a consulting soil scientist. Some of his major activities in this position included soil mapping and interpretations for wastewater disposal applications and forestry-related soil mapping and interpretations. He also worked on projects with USAID and FAO in Bolivia, which involved soil classification and mapping using Fertility Capability Classification as well as interpretation and extension activities for alternative crops for coca.

Steve started his career in soil science with the SCS and worked in soil survey projects in several locations in Tennessee. He earned his Ph.D. degree in Soil Science at North Carolina State University, completing his research on "Influences of Parent Materials and Time on Soil Properties in a Perudic Area of the Bolivian Amazon," working with Stan Buol. He received his M.S. and B.S. degrees from the University of Tennessee at Knoxville. Some of Steve's early interest in soil science came through FFA land judging in high school and through collegiate soil-judging contests. ■

NASS Launches New CropScape Geospatial Data Service

From Soil Survey Division, "Weekly Update," January 19, 2011.

The National Agricultural Statistics Service (NASS) has launched CropScape, a new cropland exploring service that NRCS employees around the country may find useful. CropScape provides data users access to a variety of new resources and information, including the 2010 Cropland Data Layer (CDL), which was just released. This service offers advanced tools, such as interactive visualization, Web-based data dissemination and geospatial queries, and automated data delivery. There is no need for specialized expertise, GIS software, or high-end computers to use the tool. This information can be used for addressing issues related to agricultural sustainability, land cover monitoring, biodiversity, and extreme events, such as flooding, drought, and hailstorms.

CropScape is operated by NASS's Research and Development Division and hosted and maintained by the Center for Spatial Information Science and Systems at George Mason University. For more information about CropScape and the Cropland Data Layer, visit http://nassgeodata.gmu.edu/CropScape. ■

Report on Antarctic Long-Term Soil-Climate Study

From Soil Survey Division, "Weekly Update," Febuary 2, 2011.

During the period from January 1 to 28, 2011, Dr. Cathy Seybold from the National Soil Survey Center traveled to New Zealand and the McMurdo Sound region of Antarctica. In Antarctica, data were collected from and maintenance carried out on seven long-term soil-climate stations. One new station was installed at an elevation of 700 m in the Wright Valley (fig. 1), and the soil (fig. 2) was described and sampled for standard lab characterization. Each climate station measures atmospheric parameters and soil parameters that extend from the active layer (seasonally thawed layer) into the permafrost. Recorded measurements are made on an hourly basis. For the last 11 years, NRCS personnel have been part of a collaborative effort to better understand the fundamental properties and mechanics of cold and frozen desert soils.

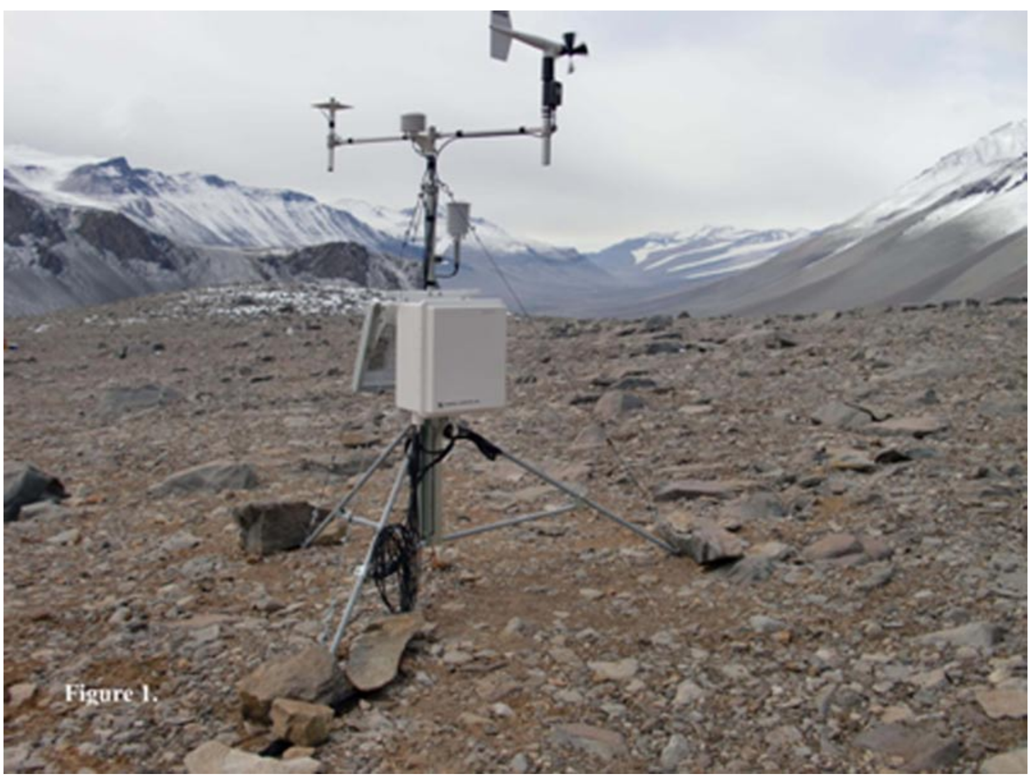


Figure 1.—A new soil-climate station in the Wright Valley.

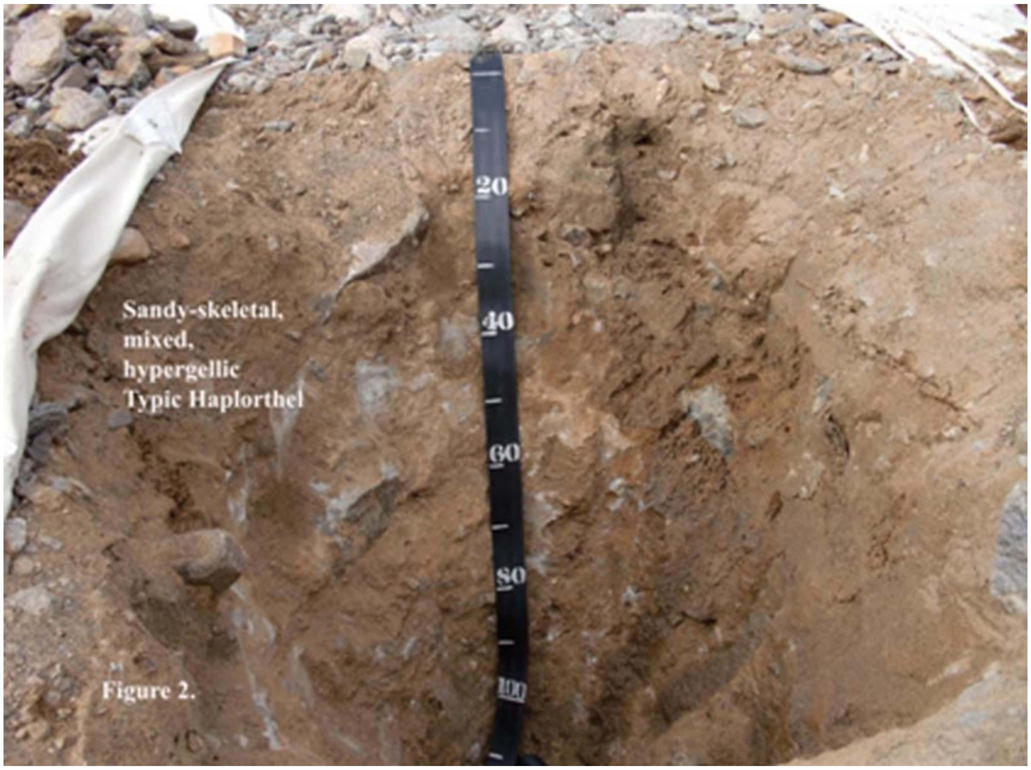


Figure 2.—The soil on the site of the new soil-climate station.

The research being conducted by this project will determine the impacts of climate change on the soil active layer and upper permafrost. The data provide needed baseline information that will help us understand coastal ecosystems and active layer dynamics that exist along the Victoria Land coastline in the McMurdo Sound region. The data also are used in the development of a robust spatial environmental domains classification of this same region. Here in the United States, information resulting from this trip will aid NRCS in understanding cold and dry soils and their monitoring and can have implications for coping with global climate change. The data will be processed and made available to the public and cooperating scientists via the Internet (http://soils.usda.gov/survey/scan/). Selected results will be summarized and published in appropriate technical journals. ■

Mass Movements and Waste Disposal in Chicago From the 1830s to the 1950s

By Minerva Dorantes, Student Trainee, Soil Science, U.S. Department of Agriculture, Natural Resources Conservation Service, Champaign, Illinois.

Since its establishment as a city in 1837, Chicago, Illinois, has undergone numerous additions to its boundaries and the land over which it rests has experienced many changes. Throughout its history, there have been three main events that have altered Chicago's landscape and natural topography: the expansion and diversion of the Chicago River, the Great Chicago Fire, and the construction and labor within the Chicago tunnels. The city's location was essential for commerce and trade and provided the opportunity for success and urban growth. As the city grew, so did the amount of waste produced and the need to remove it. Over the years, it became customary to dispose of refuse of all sorts in exhausted quarries and soil pits. It was also common to dispose of waste in wetlands, which were then misunderstood and considered a danger to public health and a nuisance. Of greater importance to the city's geography was the mass movement of trash into the lake to extend the downtown area.

The Chicago River has been altered through various projects over a hundred-year period. Historically, the river had two branches that flowed north and south and converged into a main stem that flowed eastward into Lake Michigan. After the city had become an epicenter for trade and an invaluable port, it became necessary to change the natural flow of the river. In 1836, the first large-scale transformation of the Chicago River began. The construction of the Illinois and Michigan (I & M) Canal lasted 12 years, and it called for the excavation of the river to keep it level with Lake Michigan (Hansen, 2009). The I & M Canal stretched from the south branch of the Chicago River at Ashland Ave. to the La Salle-Peru community on the Illinois River (Solzman, 1998). It was 60 feet wide and 6 feet deep (Solzman, 1998). Soil from this first major project was used to create the North Branch Canal of the Chicago River and Goose Island located between North Avenue on the north and Chicago Avenue on the south (Hill, 2000). The construction of the canal was meant to reduce over-flooding of septic waste and the spread of cholera through the intermittent reversal of the river's natural flow, but soon after construction was finished, the problems persisted. In 1855, the sewerage system was revamped (Colten, 1994). Chief Engineer Ellis S. Chesborough was asked to develop a comprehensive sewer system to prevent sewerage from entering Lake Michigan (Hansen, 2009). Sewers were laid over the street, and then dredge spoil from the construction of the I & M Canal was used to raise the streets up to 10 feet to promote runoff (Colten, 1994). Chesborough's plan failed and aggravated the sewerage problem by increasing the waste that ended up in the Chicago River (Hill, 2000). A new plan needed to be established. Between 1865 and 1871, the canal was widened and deepened in an effort to permanently reverse the flow of the Chicago River (Hansen, 2009). This project was considered a success as the rate of the reversal of flow in the Main and South Branches increased (Hill, 2000).

Construction on the Chicago River continued over the next several decades as the trade and commerce center expanded. In 1880, the newly formed Citizen's Association of Chicago suggested that a new, larger channel be constructed to permanently reverse the flow of the River. This channel would flush pollutants down into the Mississippi River and provide a larger passage for ships headed there. In 1889, the Sanitary District of Chicago was formed and Lyman E. Cooley was appointed as chief engineer (Hansen, 2009). He oversaw the design and construction of the Sanitary and Ship Canal, which would connect the Chicago River at Bridgeport, Illinois, with the Des Plaines River in Lockport, Illinois (Hill, 2000). The construction of the Sanitary and Ship Canal lasted for a little over 7 years. Once the construction was complete, the flow of the Chicago River was permanently reversed (Hansen, 2009). See figure 1. The material excavated, a total of 43,478,659 cubic yards, was a mixture of glacial drift and solid rock. The spoils were broken into stones of different quality and sold by the Sanitary District of Chicago for crushing purposes (Sanitary District of Chicago, 1906).

Many more changes were made to the Chicago River after the construction of the Sanitary and Ship Canal. The changes to date contribute to over 52 miles of constructed or unnatural waterways and include the later additions of the North Shore Channel and the Calumet-Sag Channel. The North Shore Channel, which was completed in 1909, was constructed to divert wastes from the northern suburbs of Lake Michigan to the North Branch of the Chicago River (Nilon, 2005). The Calumet-Sag Channel was constructed from 1911 to 1922. It was created to reverse the flow of the Calumet River, and it linked the Little Calumet River at Blue Island to the Sanitary and Ship Canal (Solzman, 1998). These modifications to waterways have allowed Chicago to maintain a healthy water system and have allowed the city to grow (fig. 2).

Figure 1.—"Turning water into Chicago Sanitary and Ship Canal Jan. 12, 1900." The Sanitary and Ship Canal opened in 1900. Source: Hansen, B. 2009. "The Reversal of the Chicago River: Flushing the System." *Civil Engineering (08857024)* 79(12), p. 43.

The Great Chicago Fire was another event that led to many changes in the city's landscape. The fire began on October 8, 1871, and persisted for 2 days. By the time the fire died out, 18,000 buildings had been destroyed and 4 square miles of the city had been burned down ("Eighteen Thousand Buildings Destroyed," *Chicago Tribune*, 1871). The business district was the most damaged (fig. 3), partly because the many wooden structures that surrounded businesses near the main branch of the Chicago River and Lake Michigan fueled the fire ("The Chicago Calamity," *Chicago Tribune*, 1871). About a week after the fire, the city passed an ordinance prohibiting the construction of wooden structures within 50 feet of a brick or iron building. The ordinance also stated that no wooden building should be constructed in the central business area ("Preparing for the Next Fire," *Chicago Tribune*, 1871). Because of this new regulation, demand for clay bricks increased. Chicago's prairies were mined to accommodate the growing need for brick ("Building Material," *Chicago Tribune*, 1871). Debris from the Chicago

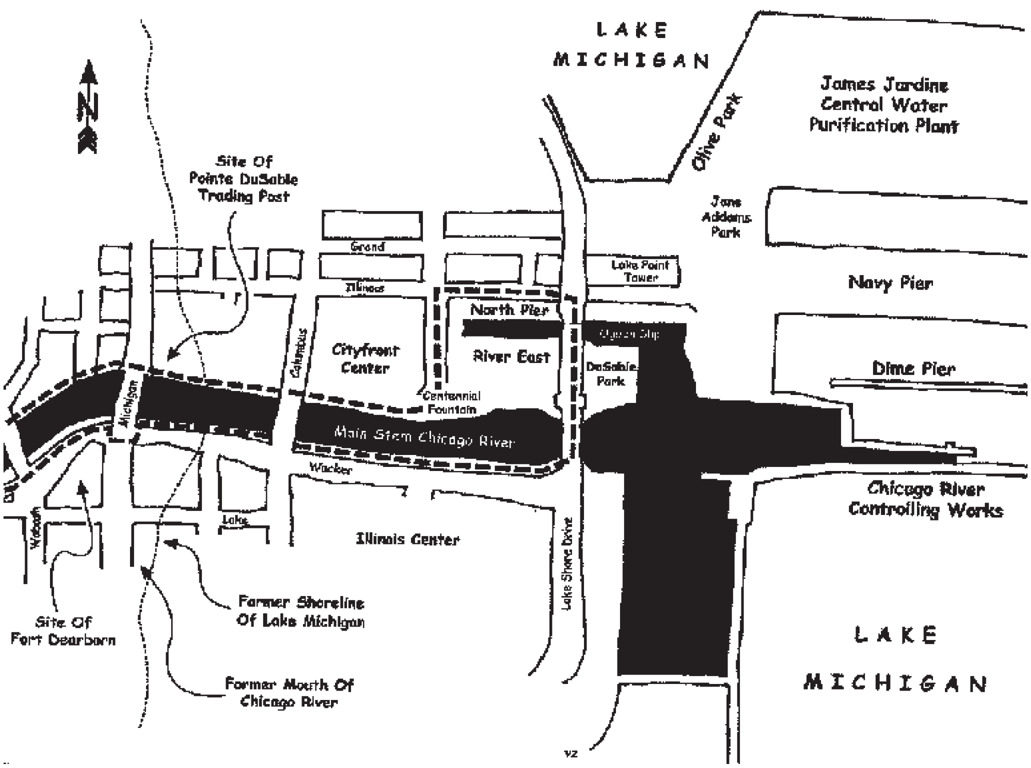


Figure 2.—Main stem of the Chicago River. The location of the original shoreline and the natural mouth of the Chicago River appear as the closely dotted line. Source: Solzman, D.M. 1998. *The Chicago River: An Illustrated History and Guide to the River and Its Waterways.* Chicago, Illinois: The University of Chicago Press. p.120.

Fire was used to fill streets and extend the lakefront. Ash and debris from the fire filled about 10 feet along the river and about 5 feet over much of the burned district (Colten, 1994). Additionally, the rubble and debris from the fire filled part of Grant Park, which was once known as Lake Park and includes the area of the old lagoon that lay between Michigan Avenue and the trestle of the Illinois Central Railroad (Solzman, 1998).

Figure 3.—View of the ruins from the Great Chicago Fire of 1871 from the corner of State and Madison. Source: The Chicago Historical Society, 1999. http://www.chicagohs.org/history/fire/fire3.html

Construction boomed after the Great Chicago Fire. As the city grew, traffic increased and the city's first underground transportation system was established. Construction of a freight tunnel system 48 feet below street level began in 1901. Oftentimes during this construction, a new hole was opened up and soil was poured into tunnel cars for disposal along the lakefront ("Business: Bowels of Chicago," *Time*, 1933). About 2,000 cubic yards of excavated material was dumped daily at present-day Grant Park (Perkins, 1905). See figure 4. By 1915, the Chicago Tunnel Company operated trains on more than 60 miles of track below the busiest parts of the city. Tunnel cars carried ashes from coal-burning buildings, merchandise and fresh goods, as well as construction material for large companies. Once the tunnel was finished, all material carried through it was deposited at the lakefront and Thirteenth Street. Over the years, the excavated material pushed back the inroads of Lake Michigan and formed the foundation for the Field Museum (Traffic Service Corporation, 1915). It was not until 1908 that all dumping on the lakefront was prohibited and the tunnel company loaded material onto railway cars and shipped it to the outskirts of the city (Perkins, 1908).

Figure 4.—Dump at present-day Grant Park. About 2,000 yards of excavated material from the construction of a tunnel system was dumped daily. Source: Perkins, F.C. December 1905. "An Electric Underground Freight Railway System." ***Modern Machinery*** **18(6), p.323.**

The addition of the tunnel system cleared the roads of city streets, allowing greater land development. Refuse disposal became an important matter as the city's population increased. Between 1840 and 1852, the city used the lakefront extensively for garbage disposal. In 1849, the city council passed an ordinance to "preserve the public health" by using refuse to fill areas that were considered a threat to public health (Colten, 1994). These areas included the lakefront, which was considered dangerous because it was too close to Michigan Avenue. In 1895, the Army Corps of Engineers constructed a breakwater in the lake and allowed the city to fill it. This area was filled with municipal garbage, refuse transported by the tunnel system, and dredge material to form Grant Park. Around that time, the Department of Public Works reported filling old brickyards with trash and municipal ashes, but by 1904, the quarries were filled and the Department declared that swamp lands could be used as landfills. Refuse of all kinds continued to fill the lake until 1910, when the Mann Act prohibited the dumping of any type of material within 8 miles of the Indiana and Illinois shorelines (Colten, 1994). In 1914, city waste was used to raise street grades in different parts of the city. Much of the refuse was dumped on waste lands west of Ashland Avenue (Stone, 1939). Open landfills replaced dumping at the lake, and later, closed sanitary landfills were established (Perkins, 1908).

Typical sanitary landfills were layered so that 1 foot of compacted refuse was covered with up to 2 feet of ashes, street sweepings, or garbage. When the landfills reached full capacity, they were coated with a land or grass cover to prevent excessive erosion (Melosi, 2000). Municipal waste deposited in landfills was classified as follows: garbage was organic waste, animal residue, fruit or vegetable matter, and anything used in the preparation or storage of meats, fruits, and vegetables; ashes were waste that resulted from the combustion of coal from homes, factories, and businesses; and street sweepings were refuse that was removed from the streets by a cleaning crew (Stone, 1939). After World War II, the sanitary landfill became the first universally accepted method of garbage disposal in part because of the recommendation of the United States Public Health Service in 1943 that sanitary fills should be viewed as emergency measures during war to conserve resources (Melosi, 2000). The volume of municipal solid waste increased to staggering proportions by the 1950s, and inner-city landfills, which were then the most economical form of waste disposal, were almost full. By the 1960s, expansion in the city led to the movement of all trash out of the city and into the suburbs (Colten, 1994).

For over 100 years, the movement of refuse, including dredged material from the modifications of the Chicago River, ashes and rubble from the Chicago Fire, and stones and soil from the construction of the tunnel system, provided the material and base for the expansion of the city into the lake. These changes to the natural geography of Chicago also led to its expansion. As the city's population increased, so did the amount of garbage produced. Garbage disposal allowed for streets to be raised and the downtown area to be expanded. Refuse disposal changed to fit the needs of the growing city, and as landfills in Chicago filled up, trash was moved to the suburbs. Many unanswered questions remain concerning the impact of each type of refuse disposal on the landscape and the exact location of these deposits. This paper may provide some insight into where the city experienced the most change and where manmade soil occurs today.

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