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Green Economy and Infrastructure Contributions of USDA Urban and Nonfarm Soil Projects in the U.S.

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This commentary expresses the author's views alone and does not represent those of the USDA Natural Resources Conservation Service. These views are based on the author's experiences as the project leader of the Soil Survey of Baltimore City, MD and as a national leader in the Soil Survey Division, USDA-NRCS, Washington, DC.

Over the last 25 years, there has been growing demand for soil information to strengthen green economy initiatives and community adaptation strategies to climate change. Despite this, USDA's funding and technical support of soil surveys in urban and nonfarm areas has been inconsistent and, in some places, nonexistent. There is plenty of evidence to support the continuing collection of urban and nonfarm soil information and increase focus for these activities. Urban soil science has progressed and pushed pedology forward to meet the needs of the increasingly complex anthropogenic ecological network. It has developed new venues for the soil survey program that complement the most recent political demands for carbon footprint analysis and emerging data needs for broad community adaptation strategies to climate change. There is a vital role for an evolving modern soil survey to address the most pressing needs of our time through open data, new technologies, digital and remote-sensing tools, outreach to new audiences, and involvement of multidisciplinary networks of scientists and practitioners. In times of financial stress for government spending, an urban/nonfarm soil survey focus of research is good value for the funds spent.

The Soil Survey for Resource Planning and Development Act (Public Law 89 560, 1966) provides detailed expectations for the soil survey program and is the principal basis for the USDA soil survey mission in urban areas. This legislation recognized the increasing need for soil surveys in connection with community planning in order to ensure sustainable resource development that protects and improves environmental quality, meets recreational needs, and conserves land and water resources. In particular, this legislation mandated that soil surveys provide vital information needed to control and reduce sediment and chemical pollution in areas of rapidly changing land uses such as urban/suburban and industrial encroachment into farmlands and rural communities, increasing transportation needs, and increasing demand for recreational and related services resulting from shifting populations and changing economies.

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The first urban soil survey, compiled in 1975, was of the District of Columbia. Ten years later, the second urban soil survey in the U.S. was compiled of the City of Baltimore, MD, a heavily urbanized area. At the time, the USDA Natural Resources Conservation Service (NRCS; formerly the Soil Conservation Service) had no specific field methodology, soil taxonomy, or interpretation classification standards to guide the field soil scientists in the urban environment, so USDA staff had to develop a whole new methodology for mapping and classifying urban soils while they mapped (USDA-NRCS, 2011). Despite the legislative mandate for the NRCS to support urban and community development and smart growth through the National Cooperative Soil Survey (NCSS), most of the support for urban soil surveys has come directly from the urban communities. Using mapping technology from agricultural interpretations, urban soil surveys were pieced together with minimal recommendations for best management practices to develop storm water and sediment pollution controls. Over the years, urban areas have experienced more environmental pressures and public demands for improved quality of life so that cities have evolved from that time to use the soils data for

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green infrastructure projects—manipulating storm water, engineered structures, the soil resource baseline, and nature to move and conserve water ecologically in the urban system. Examples of these green infrastructure projects that involve analysis of soil function are rain gardens, innovative storm water systems, urban wetlands, and permeable pavement systems.

Since the late 1980s, the USDA-NRCS Soil Survey Program; International Union of Soil Science (IUSS) Soils of Urban, Industrial, Transportation, and Military areas (SUITMA) subgroup; and a few independent academic pedologists have been actively pursuing soil survey projects, pedological classification (Technosols, World Reference Base, IUSS-SUITMA), and Soil Taxonomy (ICOMATH, IUSS, J. Galbraith) in urban and nonfarm landscapes. Projects such as the Baltimore Ecosystem Study, NSF Long-term Ecological Research (R. Pouyat, USFS, 2010) applied the digital soil survey as a baseline to look more intensely at monitoring, transport, and network science questions in the urban/industrial landscape. Working with engineers, ecologists, city and county planners, the NRCS soil survey projects have focused on developing field standards and interpretations of urban and nonfarm soil survey data and onsite sampling regimes to address community planning issues (NCSS, 2011). In our new world of community interest in climate change adaptation and green infrastructure, related scientific disciplines are discovering the importance and need of soil survey investigations in the urban environment. There is a critical need for soil survey in planning for risk management and adapting to climate change and the emerging green economy.

Urban soil surveys provide an active venue for cities and regional metropolitan areas to focus on green infrastructure planning with a science base. The USDA-NRCS Soil Survey urban and nonfarm projects of the 1970–1990s focused primarily on storm water drainage patterns but allowed for other aspects of soils in nonfarm settings to be explored. In the last few years, urban soil surveys in the Chicago, St. Louis, Los Angeles, Detroit, and New York metropolitan areas have paved the way for and developed interpretations of soil survey data to address a broader suite of community planning issues. Combined sewer overflow discharges are the biggest remaining water pollution problem in New York City and many other metropolitan areas. Hydrologic interpretations and soil ratings (water movement into and through soil) are useful for locating best management practices for storm water management. Issues of green open space and park infrastructure, wildlife buffers, watershed retention ponds and reclamation of abandoned industrial and residential land for urban gardens or inner city food production have gained equal interest with water management as applications of soil survey information. The urban soil surveys have encouraged local and regional collaboration with universities and city and county governments to study and apply best management practices for climate change adaptation strategies based on soil information.

The USDA-NRCS soil survey project of New York City provides many examples of ongoing collaboration in applying soil survey nonfarm soil interpretations to urban green infrastructure. Applications of soils information in New York City include not only storm water management but also address restoration of vegetation on many repurposed landfill, industrial, and residential areas. Open space and degraded or abandoned (industrial) open space represents 25% of New York City's surface area, critical to preserving sustainable storm water management in the city. The inventory of soils in the five boroughs region also provides valuable baseline information on wetlands, habitat for wildlife, rare and endangered species, and movement of invasive species in these open areas. The inventory is also helping to identify soil conditions most suitable for open space tree planting. For potential community garden sites, NRCS soil scientists are also using a hand-held X-ray fluorescence (XRF) analyzer to screen trace metal concentrations. The XRF methodology is widely used for elemental analysis and is being applied for rapid in situ soil assessments by field practitioners.

The ongoing soil surveys in Chicago and Detroit are also using baseline information and portable analyzers for locating open spaces, parks, and urban gardens; restoring prairies; reducing combined sewer overflow; improving quality of life; reducing food deserts; increasing biodiversity; preserving wildlife; and improving resiliency.

The Soil Survey of Los Angeles County, Southeast Part, has been conducted in the midst of dense urbanization and has illustrated the need to use new digital tools to display soils information. The landforms in this environment are mostly disturbed or transported fill. One of the objectives of the Soil Survey in Los Angeles was to define this anthropogenic landscape in terms of its natural properties and behavior. With the delineation of functional soil landscapes, this soil survey helps discern natural flow patterns of storm water both above and below the surface. These landscape patterns were significantly enhanced and made possible using digital data and remote-sensing tools.

Overlaying digitized historical soil surveys on various digital elevation models has helped to visualize natural landforms and distinctive soil patterns. These techniques have created higher quality and more precise aggregated data than any of the products used alone (Fig. 1).

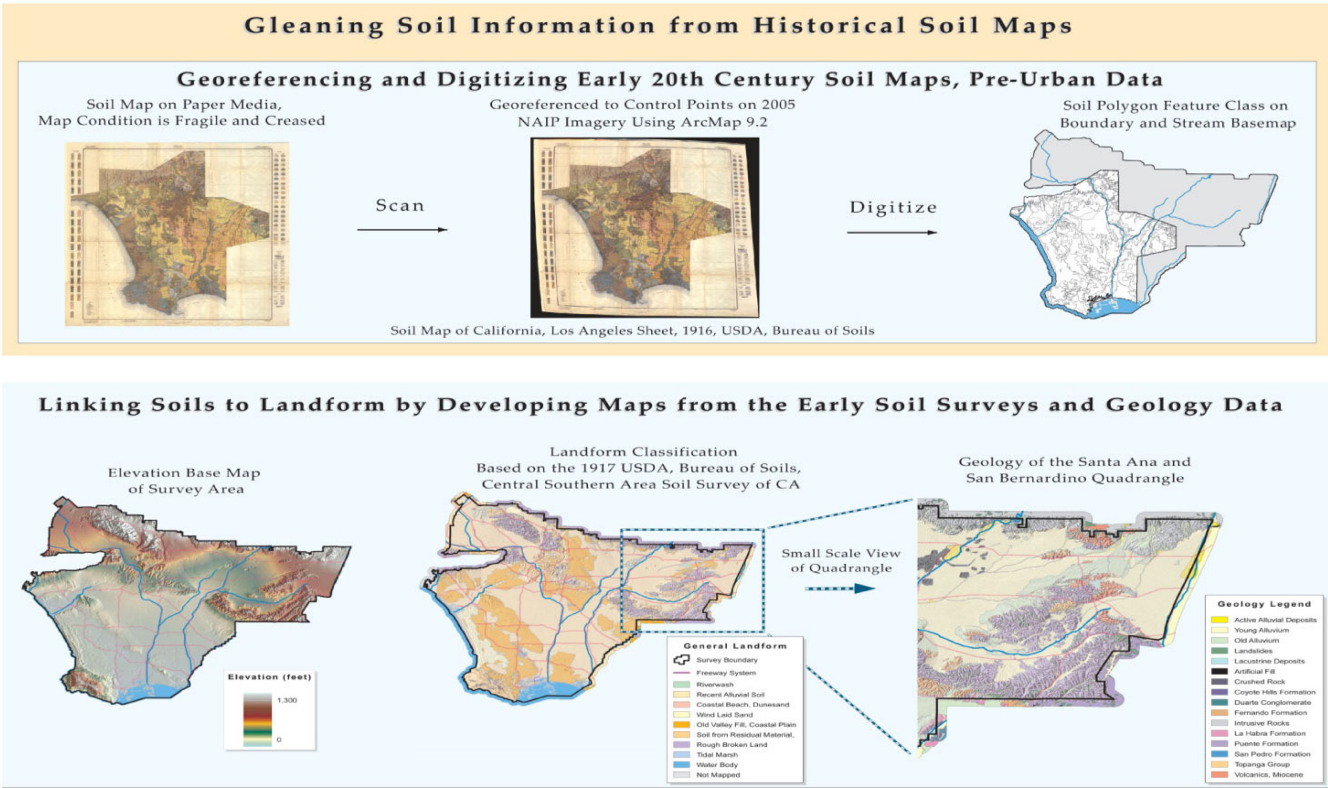

Fig. 1. Developing soil maps from historical data (Ballmer et al., 2009).

The USDA-NRCS Rapid Carbon Assessment (RaCA) is a good example of a green-based USDA soil survey application project. It was initiated in early 2009 in response to the growing need to assess and manage carbon stocks and in recognition of fact that soils contain the largest stores of terrestrial carbon. At each of 32,500 pedons at 6,500 locations across the conterminous U.S., Alaska, Hawaii, and Puerto Rico, soil and landscape characteristics are being described by soil scientists to confirm classification and map unit components represented (Fig. 2). Soil carbon and related data are being collected for benchmark and other important soils after stratification by agricultural management, ecosystem, and land use conditions. These databases can be extrapolated using statistical and modeling techniques to predict expected trends in estimated carbon sequestration or evolution from the nation's soils over the next one or two decades. The databases can also be used to aid in decisions on land use and management by conservation planners, land managers, and policy makers and to compare results from decision support tools developed from simulation modeling efforts.

Fig. 2. Soils in high-artifact fill in turf have more than twice the carbon of natural soils in woodland (New York City NRCS Soil Carbon Survey). *Photo courtesy of Rich Shaw.*

The RaCA project allowed NRCS to test the feasibility of visible and near-infrared (VNIR) spectra technology as a quick, all-inclusive tool for soil characterization (Fig. 3). This potential for in situ estimations will be particularly helpful for assessments in urban, industrial, and suburban environments where sampling and analysis may be difficult and time sensitive. In studies reported to date, statistical models to predict soil properties have been developed from samples collected at either a local or regional scale (Ben-dor et al., 1997; Brown et al., 2006; Waiser et al., 2007). The NRCS anticipates that the statistical models developed from this national effort will be applicable for rapid evaluation of soil properties such as sand, silt, clay, cation exchange capacity, mineralogy, calcium carbonate equivalent, gypsum content, micronutrients, and heavy metals (Burt, 2004, 2009). Auxiliary complementary remote sensors, supplemental local calibration samples, and theoretical spectroscopy all have the potential to improve predictions. NRCS's findings suggest that VNIR soil characterization has the potential to replace or augment standard soil characterization techniques where rapid analysis is required.

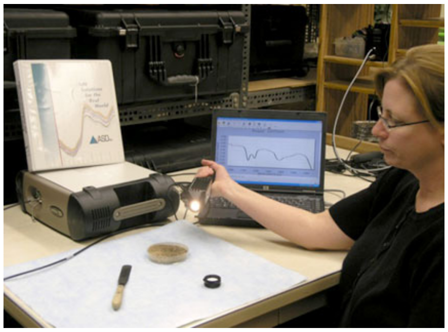

Fig. 3. Visible and near-infrared (VNIR) carbon measurements.

New Information Delivery Mechanisms

In response to the rapidly emerging needs for data delivery, NCSS developed distribution websites and applications for distribution of soil information through mobile technology programs that are actively reducing our carbon footprint. With consolidated NCSS databases such as SSURGO and the U.S. General Soil Map Database (STATSGO2), soil information is available online through http://websoilsurvey.nrcs.usda.gov or with the mobile phone application named SOILWEB APP for smart phones.

SOILWEB is an easy-to-use suite of web-based mapping tools that allow users to interact with soil survey via Google Earth, Google Maps, and an original standalone interface (Beaudette and O'Geen, 2009, 2010). This technology has revolutionized the use of digital soil survey information, allowing users to access soils information in the field where it is often most needed and to apply decision support tools directly to the customer in real time. While this technology is garnering a great deal of attention at the regional level and nationwide, it is time to scrutinize the way in which soil survey information is delivered, capitalizing on the momentum created by online soil surveys and digital soil data. Products must be easily accessible, fast, visual, versatile, adaptable, and understandable to an increasing urban, computer-absorbed society. Moreover, outreach plans need to be devised for future soil survey efforts including dynamic soil properties, urban soil surveys, updates, and data from the GlobalSoilMap.net project (see www.globalsoilmap.net/).

Dr. A. O'Geen (University of California–Davis) has proposed extending soil apps to decision support systems for the public as this logic model illustrates in Fig. 4:

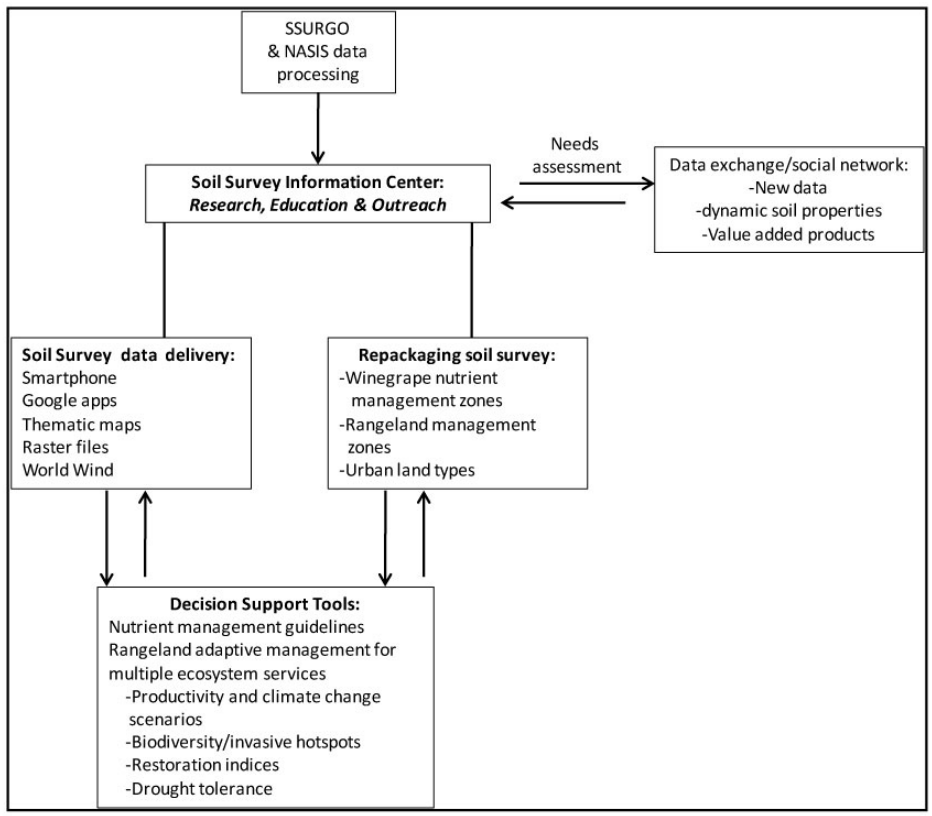

Fig. 4. Logic model for the soil survey information delivery program of the University of California–Davis and NRCS/NCSS. *Courtesy of A. O'Geen.*

Recommendation

Since my first soil survey as a project leader in 1985 in the City of Baltimore, MD, I have been tracking the use of soil survey information in urban and heavily managed areas for applications by academics, environmental professionals, city planners, and the public. In the last 15 years, the USDA as a whole has been providing encouragement to all its agencies to investigate and develop green infrastructure-related best management practices in both a farm and nonfarm context. As part of USDA's support of assessment, adaptation, and mitigation of climate change (and building an adaptation plan to maintain healthy and productive lands), the soil survey has worked throughout the country to build an infrastructure of inventory, analysis, and standard practices to address climate change issues. Surveys are providing tailored interpretations of the database to meet modern community planning needs and using digital processes to define, delineate, distribute, and convey soil information to new audiences. I am excited about these changes to the past central agricultural focus of soils and pedology to the new world of mobile technology transfer, urban green infrastructure, and global climate change adaptation research. I can see that we need to support and encourage our new, younger soil scientists and give them the lead in these endeavors.

I strongly believe that the work of NCSS partnerships in these urban ecosystem areas are providing cutting-edge soil investigations that will provide standards and techniques to address our heavily industrialized agricultural systems and provide detail for food security in intensely farmed areas. It also has opened the door to have soil science inform public health and safety issues throughout the country and participate actively in the green infrastructure movement in cities and smaller communities. It is allowing us to come to the table to inform public policy and be the experts in the network of science and analysis that is driving development and reconstruction in nonfarm environments. By blending scientists' and practitioners' interconnected data and interpretations at all levels of the network, we are able to provide clearer messages as to how ecosystems will work adaptively in both farm and nonfarm systems. Recently, the USDA (with NRCS Engineering and Soil Survey assistance) has provided some excellent examples of green infrastructure in Washington, DC, setting an example for the whole country (Fig. 5). These new initiatives include the People's Garden, the USDA Jamie Whitten Building and South Building green roofs, and the drought-tolerant landscaping and water recycling for the Washington, DC Capitol Museum Mall. The Dig It! Soil Exhibition (at the Smithsonian in Washington, DC in 2008–2009 and now travelling to various museums throughout the country) has also been a tremendous venue for illuminating the soil resource to the general public and educating folks about the potential of soils for green infrastructure impact. The current soil surveys are providing tailored interpretations to meet modern community planning needs and using digital processes to define, delineate, distribute, and convey soil information to new audiences with an eye towards establishing baselines for green infrastructure solutions and climate change adaptation strategies.

Fig. 5. The People's Garden at the USDA shows visitors to Washington, DC the great potential of growing garden vegetables.

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