Information Technologies and Ecological Site Descriptions

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Just as ecological systems are dynamic, so too are the needs for managing ecological site descriptions as part of a business system. The development of information technology (IT) as a discipline has brought increased capability to represent and communicate concepts that exist in the minds of rangeland managers and scientists. IT plays an important role throughout the processes of defining, publishing, and marketing ecological site descriptions through the collection, analysis, storage, and mining of field and supporting data. In this paper we examine the current role that IT (including recent Web-based information sources and tools) plays in the development of ecological site descriptions, as well as some of the future challenges and opportunities. Although most land management entities follow a somewhat similar data process, this example is from the USDA Natural Resources Conservation Service (NRCS), which has historically managed ecological site information for public use.

Current Status

The official database for NRCS ecological site descriptions is the Ecological Site Information System (ESIS; http://esis.sc.egov.usda.gov/; Fig. 1). The system is intended to support ecological site descriptions throughout the development process, from the identification of a new ecological site to the electronic publication of the approved ecological site description. ESIS is divided into two applications: Ecological Site Description (ESD) and Ecological Site Inventory (ESI). (Note: the acronym ESD is commonly used throughout this issue of *Rangelands* to represent the interpretive document describing an ecological site. In this paper, however, it is used specifically to designate the data storage site of these descriptions.) ESD is the repository for all NRCS ecological site descriptions, including both rangeland and forestland. It is not a database, per se, where a user can manipulate and analyze data, but would be more correctly regarded as an electronic library that houses the ecological site descriptions. Once an ecological site is designated as "approved" by the agency's technical leadership, it is available for viewing by the public. Otherwise, it is restricted to those individuals with permission to enter and edit data. ESI is the repository for the plot data that support ecological site development. Rangeland (http://esis.sc.egov.usda.gov/ESI_Rangeland/frmMain.aspx) and forestland (http://esis.sc.egov.usda.gov/Welcome/pgFSWelcome.aspx) each have a respective site for the unique inventory forms that have historically been used in NRCS. Site permission is required to enter and edit data, but once entered, the information is viewable by the public.

ESI has received minimal funding for development and maintenance in recent years and is currently little used by most technical specialists. Instead, an increasing number of NRCS specialists are using the Database for Inventory, Monitoring, and Assessment (DIMA) (http://usda-ars.nmsu.edu/monit_assess/db_main.php) for storage of vegetation and surface soils data. This database was developed by scientists and technicians at the USDA Agricultural Research Service (ARS) Jornada Experimental Range and has also been referred to as the Rangeland Database and RangeDB.

The development of an ecological site description is facilitated by mining data from other data applications. For example, all references to specific plants in an ecological site description are correlated to the species list contained in the USDA PLANTS Web site (http://plants.usda.gov/; Fig. 2).

Climate features for ecological sites are usually provided by the NRCS National Water and Climate Center (http://www.wcc.nrcs.usda.gov/climate/climate-map.html). This Web site provides temperature and precipitation data for climate stations throughout the country. Other climate data sources include the National Oceanic and Atmospheric Administration (http://www7.ncdc.noaa.gov/CDO/cdo) and the Texas A&M AgriLIFE Research Center (http://beaumont.tamu.edu/climaticdata/). Ecological site descriptions are often developed for areas that are not adequately represented by climate stations. In these cases, it is helpful to use interpolated values based on nearby stations, topography, and expert knowledge. Examples of such databases include Daymet (http://www.daymet.org/), developed and served by the University of Montana, and the Parameter-Elevation

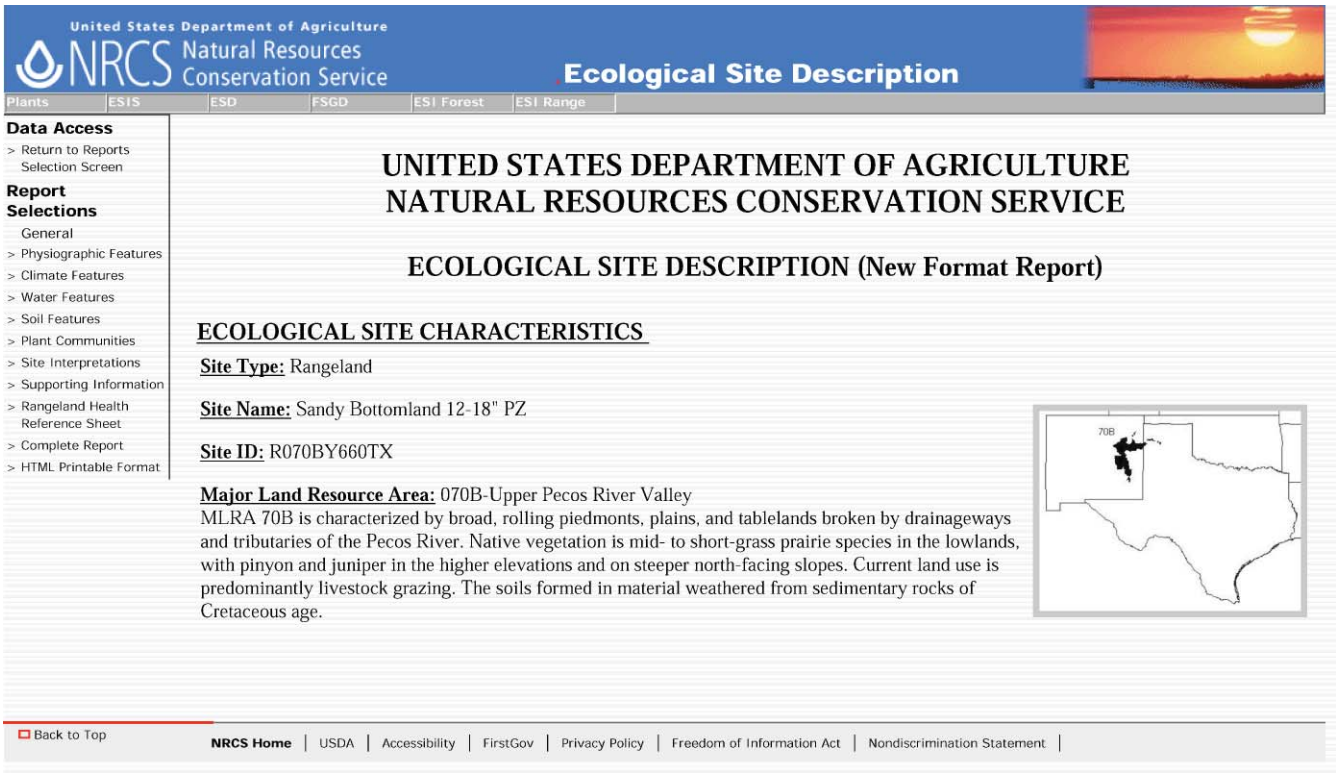

Figure 1. A screen shot from Ecological Site Information System Web page.

Regressions on Independent Slopes Model (PRISM; http://www.prism.oregonstate.edu/), developed at Oregon State University and funded in part by NRCS. PRISM data, along with Digital Elevation Model (DEM) data, are also available at NRCS' Geospatial Data Gateway (http://datagateway.nrcs.usda.gov/). The DEM data can be used in combination with soil polygon spatial data to analyze elevation range, aspect, and slope shape of soil map-unit components that are linked to a particular ecological site.

The soil and physiographic features of an ecological site are generally mined from the soils business applications, or National Soils Information System (NASIS). NASIS is not just a database but refers to the entire information system, from data collection to the public marketing of soil interpretation products. The Soil Data Viewer (http://soils.usda.gov/sdv/) is an extension for ArcMap that can be used to create maps and reports of soil properties and interpretations derived from the soils database. Frequently, if the soil map unit in question comprises more than one map-unit component, a Soil Survey Microsoft Access database is used to differentiate between individual soil components.

Although NASIS doesn't currently link soils data directly to ESIS, there is an autosynchronization process from ESIS into NASIS. NASIS populates a choice list of ecological sites from those identified in ESIS. This happens on a daily basis, so that a fresh, current list of ecological sites is always available for the field soil scientists and soil data quality specialists. The soils discipline (or others with edit privileges in NASIS) can then correlate a specific ecological site with a specific soil map-unit component.

The publication and marketing of soil survey information has taken great strides in recent years with the release of Web Soil Survey (http://websoilsurvey.nrcs.usda.gov/app/; Fig. 3). This online tool makes soils data and maps available for most of the United States and a small part of Mexico. Data are queried by selecting a spatial area of interest that doesn't exceed 10,000 acres. Included in the accessible data in the Soils Data Explorer section of Web Soil Survey is an ecological site assessment. This tool pulls approved ecological site descriptions directly from ESIS and makes them available to Web Soil Survey users. This is a particularly useful tool for land managers interested in the spatial scales associated with farms and ranches, but provides limited information to those working with larger areas of land.

Another new application for accessing digital soil information is provided by SoilWeb of the California Soil Resource Lab at the University of California, Davis[1] (http://casoilresource.lawr.ucdavis.edu/drupal/node/902). This Web tool offers several interface options, including streaming access within Google Maps and Google Earth, that is useful for public users. Further, the tool offers an application for mobile phones that relays soil map-unit information about a geographic point to users in the field via locations communicated by the mobile phone. This tool is especially useful for ecological site information users and developers alike, but at this point it does not connect directly to ecological site information.

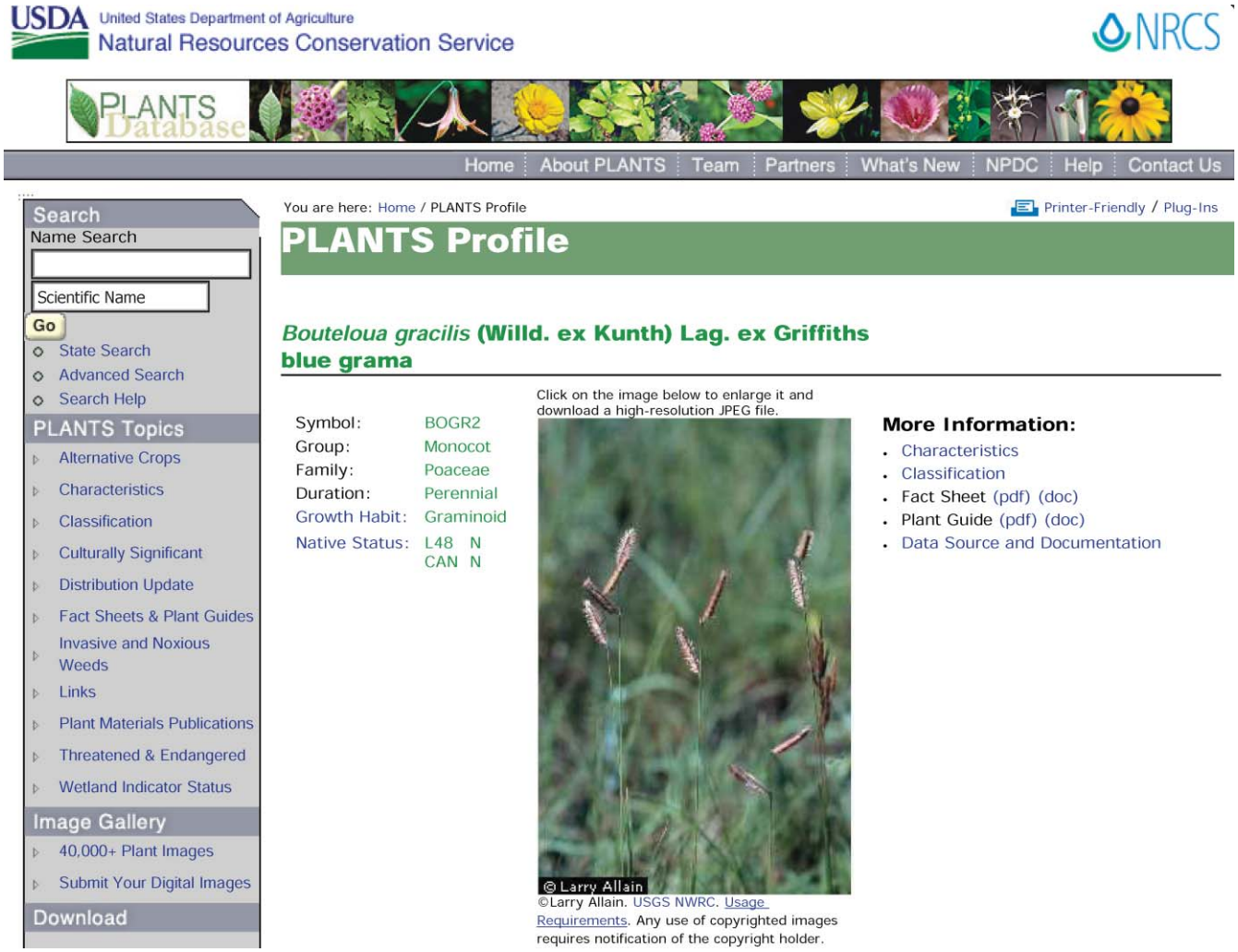

Figure 2. A screen shot from the USDA PLANTS database Web page.

Ecological sites were originally designed to facilitate management and communication at the ranch/farm scale of planning. And most of the IT developed in support of this effort has been designed with the same scale in mind. As one considers efforts at both finer and coarser scales, it is clear that ITs must be applied or developed to match the effort.

Current Limitations and Emerging Efforts

The linkage of raw soil and vegetation data in national databases is currently limited. ESIS identifies vegetation attributes associated with ecological sites (e.g., the results of high-intensity sampling discussed by Moseley et al. in this issue), but lacks an analysis tool to examine and manipulate point data from high-, medium-, or reconnaissance-intensity efforts. NASIS facilitates point data analysis through a Microsoft Access–based database called PEDON PC, but lacks the necessary vegetation attributes to adequately support ecological site descriptions. Montana NRCS soils staff (led by coauthor Hansen) have completed a draft requirements statement to join DIMA from USDA ARS with PEDON PC to facilitate the simultaneous analysis of both soils and vegetation attributes to support soil–ecological site correlation and ecological site description development. Linked output from PEDON PC and DIMA will provide access to the raw soil and vegetation data and allow multiple users to analyze and interpret the data upon which ecological site concepts are based. This effort also fills a current gap in our ability to establish ecological relationships between soils and vegetation.

The management of raw data is an additional limitation. Current procedures often dictate that data are entered twice: once into field forms and then again into databases in the office, at great expense. Multiple solutions have been explored to remedy this problem, ranging from cheaper labor to perform the data entry in the office to rugged field computers and recording devices. The latter are heavily scrutinized by both field specialists and management with regard to their durability, feasibility, and cost. NRCS (through efforts by coauthor A. B. Price) has recently approved the use of digital pens and the associated software for use on NRCS computers. The Adapx digital pen and

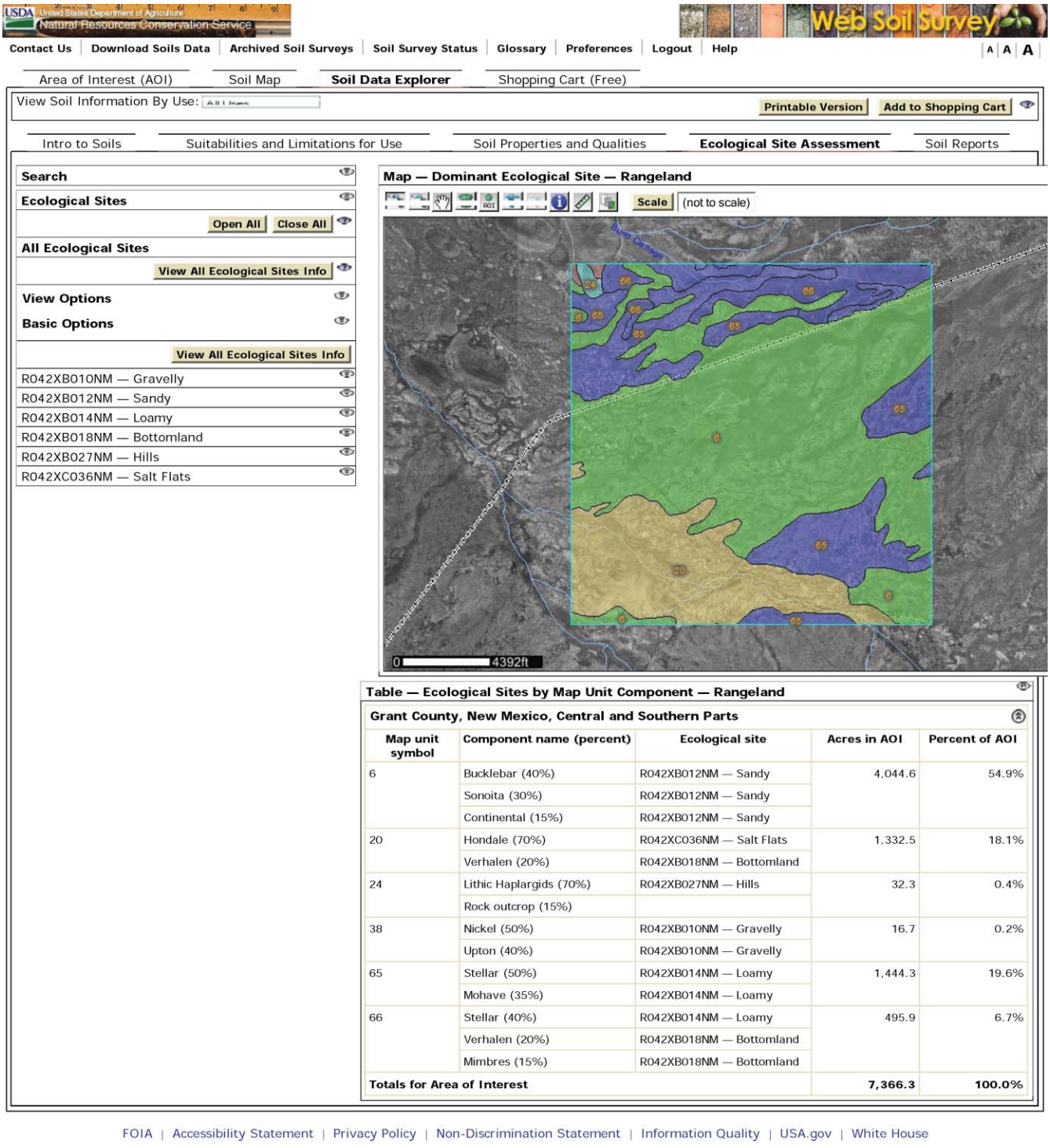

Table — Ecological Sites by Map Unit Component — Rangeland

Grant County, New Mexico, Central and Southern Parts

Map unit symbol	Component name (percent)	Ecological site	Acres in AOI	Percent of AOI
6	Bucklebar (40%)	R042XB012NM — Sandy	4,044.6	54.9%
	Sonoita (30%)	R042XB012NM — Sandy		
	Continental (15%)	R042XB012NM — Sandy		
20	Hondale (70%)	R042XC036NM — Salt Flats	1,332.5	18.1%
	Verhalen (20%)	R042XB018NM — Bottomland		
24	Lithic Haplargids (70%)	R042XB027NM — Hills	32.3	0.4%
	Rock outcrop (15%)			
38	Nickel (50%)	R042XB010NM — Gravelly	16.7	0.2%
	Upton (40%)	R042XB010NM — Gravelly		
65	Stellar (50%)	R042XB014NM — Loamy	1,444.3	19.6%
	Mohave (35%)	R042XB014NM — Loamy		
66	Stellar (40%)	R042XB014NM — Loamy	495.9	6.7%
	Verhalen (20%)	R042XB018NM — Bottomland		
	Mimbres (15%)	R042XB018NM — Bottomland		
Totals for Area of Interest			7,366.3	100.0%

Figure 3. A screen shot from the Web Soil Survey Web page.

associated Capturx software form a powerful tool that allows field staff to take pen and paper to the field, record both spatial data and attribute data, and fill out forms. Upon returning to the office, the pen is connected to a computer, and the field data stored in the pen are imported into the corresponding desktop application such as ArcMap, Excel, OneNote, and others. This way, field data are simultaneously captured on paper and in a digital format. The digital pen is more portable and less expensive than many other electronic field recording devices. This application may also be more preferred by field specialists reluctant to leave the era of pen and paper.

Another limitation of the NRCS ecological site effort is the singularity of scale at which the mapping effort is

applied. Considering that the traditional customer of NRCS is the private land rancher or farmer, it is expected that ecological sites, as a concept, match interpretations at the ranch or farm level of planning. It has been recognized that certain ecological processes are expressed more clearly at scales other than those of traditional ecological sites (i.e., soil map-unit components). It would be useful to develop a database that could identify ecological patterns and dynamics that emerge at scales broader than those of soil map-unit components and make those interpretations available to users. A national ecological dynamics database has been proposed to address this idea.[2] This product would provide a national-scale classification of ecological models and the factors driving and mediating ecological change at the ecological site to landscape or subregional scales. The vision includes a geospatial database with a Web-based interface to select both an area of interest and associated interpretations. Intended applications include providing users a rapidly accessible view of ecological patterns of change at subregional to national scales; a framework for interpreting regional and national datasets, such as the National Resources Inventory (NRI); and guidance for suggested improvements at the scale of ecological sites. The spatial unit of focus is the Major Land Resource Area (MLRA) or Land Resource Unit (LRU) and would integrate local knowledge, data analyses, and referenced literature. Interpretations would include a "benchmark ecological site," a site representing the ecological functions of broad or critical areas within the MLRA or LRU and the effects of management and climate change on those functions and plant communities. A national ecological dynamics database would interface with other datasets at this scale, including climate, geology, soils, and land uses. It would also facilitate correlation with interpretive products across agencies (e.g., LANDFIRE maps) at a similar scale.

Future Opportunities

First, the ecological site development community should consider how the multiple existing databases can be linked to ESIS and how ESIS can be modified to accommodate these linkages, particularly with regard to complementary land classification systems (e.g., ecological systems of NatureServe). One possible step in this direction is the design and construction of a single new database that would house all of NRCS' resource inventory efforts. The NRCS Ecological Site Description Inventory Business Requirements Team (of which coauthor S. B. Campbell is a member) is exploring this possibility. With the click of a mouse, an ecological site description author could link to the appropriate supporting data from multiple disciplines. This could include not only the current databases that have supported ecological site descriptions, but others as well, including NRI data that have been correlated to specific ecological sites. Gone would be the stand-alone databases or "stovepipes of excellence." Instead, field specialists would have an integrated tool at their fingertips.

Developers of an integrated database should not only consider the inclusion of other resource inventories, but should also consider the inclusion of inventory efforts at multiple scales. A nested hierarchy of ecological units occurs in concept within NRCS (and explicitly via the National Hierarchical Framework of Ecological Units), but is not clearly linked to the day-to-day uses of ecological sites. The development of a national ecological dynamics database would be a significant step in this direction, but care should be taken to ensure integration within a nested database.

Since most routine information access is increasingly reliant on IT, we can expect the rapid development of technology, systems, and tools to continue to accelerate. Thus far, the IT support for ecological sites has not kept pace with this acceleration. It is likely that the cutting edge of IT will stay ahead of our ability to integrate it into our profession. This creates challenges for the development and delivery of a robust system for the complex data embedded in ecological site descriptions. However, new concepts and technologies will bring opportunities to advance the IT associated with ecological sites. As we observe new elements of IT being applied in other areas of our lives, we would do well to ask ourselves how we can apply that element in our own work. By doing so, we will stay relevant to the needs of our customers and further our ability to convey the knowledge and expertise packaged within ecological site descriptions.

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