

The National Map - A Continuing, Critical Need for the Nation

By Charles G. Groat

The U.S. Geological Survey (USGS) is the Nation's natural science and mapping agency. We use tools from satellite sensors to the electron microscope to modeling software to bring new ways of thinking about natural science to bear on many challenges facing society today and in the future. One of our most valuable tools for science studies — and an indispensable component of our mission — is geographic information. Our charge as the Nation's lead Federal civil mapping organization is to ensure the availability of complete, consistent, and current base geographic information in order to provide a common starting point of geographic knowledge for government, industry, and the public. Rooted in a rich history, the national mapping mission of the USGS remains as vital as ever to the American people in the 21st century.

The National Map is the result of redefinition and revitalization of the USGS mapping commitment. Having the reliable and readily accessible geographic framework of *The National Map* in place makes it possible to pursue place-based analyses of diverse types of information, to monitor changes and detect trends, and to discover relationships between otherwise seemingly independent phenomena and processes. Publicly available geographic information from *The National Map* is used for a multitude of purposes in science, business, and education, and in the delivery of government services. Enhanced and extended, geographic information from *The National Map* forms the basis for a wealth of commercial products.

The need for a national map is not new. Rather, it is a continuing, critical need for the Nation. The historical context of the USGS, from its creation in 1879 through the development of its mapping mission in its formative years, illustrates this point. For this article, I have drawn extensively from published and unpublished research by the late USGS geologist-historian Mary C. Rabbitt. Included are several long quotes from the late 19th century that speak to the relevance of a national map and the value of topographic mapping. These echoes of the past accurately apply to our time and to *The National Map*. I believe they confirm our conclusions about the continuing need for an effective and efficient program of national mapping.

Early Western Surveys

In 1867, shortly after the conclusion of the Civil War, two surveys of the West were authorized by the U.S. Congress — one military, one civilian. The first, the *Geological Exploration of the Fortieth Parallel*, was administered by the War Department but directed by civilian Clarence King. The second, under the General Land Office, was a survey of resources in the new State of Nebraska, led by Ferdinand V. Hayden; it later became known as *The Geological and Geographical Survey of the Territories*. Four years later in 1871, Congress authorized two more surveys — again one military, one civilian. The third survey grew from the daring 1869 exploration of the Colorado River by Major John Wesley Powell. Although initiated under the Smithsonian Institution, it was transferred in 1874 to the Department

of the Interior. The fourth survey, *The Geographical Surveys West of the One Hundredth Meridian*, was directed by Lieutenant George M. Wheeler of the U.S. Army Corps of Engineers.

Rivalries among three of these four surveys led Congress in 1878 to ask the National Academy of Sciences to consider all surveys of a scientific character under the War or Interior Departments and to report to Congress a plan for surveying and mapping the Territories of the United States on a system that would “secure the best possible results at the least possible cost.” The National Academy of Sciences concluded that it was absolutely essential that there be only one geodetic system, one topographic system, and one land-parceling system, all under one head. To do this, the Academy also recommended that the U.S. Coast and Geodetic Survey be transferred from the Treasury Department to the Interior Department, be renamed the “Coast and Interior Survey,” and be given responsibility for all U.S. mapping and surveying. Lastly, the National Academy of Sciences recommended that a second survey, the U.S. Geological Survey, be established to classify the public lands and examine the geologic structure, mineral resources, and products of the national domain, thereby responding to pressing national needs for minerals for construction and currency. (U.S. Statutes at Large, v. 20, p. 394, quoted in Rabbitt, 1979, p. 283)

A Consolidated Survey

The U.S. Geological Survey came into being with the Organic Act of March 3, 1879, when the 45th Congress and President Rutherford B. Hayes enacted a major portion of the reforms of ongoing mapping and resource surveys recommended by the National Academy of Sciences. This seminal focus on the geographical and geological disciplines set the organizational mold for the USGS. However, Congress did not follow all the recommendations of the Academy. The legislators did not transfer the Coast and Geodetic Survey to the Interior Department, thereby postponing a decision on national mapping policy.

In April 1879, Clarence King, leader the 1867 War Department Survey and advisor to the National Academy of Sciences report and the legislation derived from it, became the first Director of the USGS. King knew the value of accurate base maps for compiling geologic and other data. Unfortunately, in King's view, the USGS's organic act made no specific provision for topographic mapping and the agency's limited funding precluded establishing a national mapping program. King and some of the other reformers strove, but failed, to convince Congress to reestablish Wheeler's survey as the national mapping agency, on the basis of Wheeler's existing proposal to extend his mapping to the lands east of the Mississippi to produce a national topographic map. Their alternate efforts to establish a new, single Federal mapping agency, like the British Ordnance Survey, also proved unsuccessful. King emphasized detailed large-scale topographic mapping (mostly at 1:10,000 scale) to support the mandated studies of mineral resources, but he also provided Powell with funds and topographers to continue (at 1:125,000 scale) the reconnaissance mapping of the Colorado Plateau.

continued on page 1088

King became Director intending to serve only for the time required to select the agency's staff and guide its activities into full operation. Before resigning two years later, King recommended to President James A. Garfield that he appoint John Wesley Powell as his successor. In 1881 Powell, who had explored the Colorado River and led the 1871 civilian survey, became the USGS's second Director. To give the USGS statutory authority to operate nationwide, King's and Powell's friends in the 47th Congress and President Chester A. Arthur approved a clause appended to the agency's appropriations legislation of August 7, 1882, that authorized the USGS "to continue the preparation of a geological map of the United States" — the map sought by King. (U.S. Statutes at Large, v. 22, p. 329, and quoted in Rabbitt, 1980, p. 66) Under this rubric, Powell remade the USGS into an agency for topographic mapping and general geology. Powell, who had long favored a single survey for topographic and geologic mapping, explained to the National Academy of Sciences:

Sound geologic research is based on geography. Without a good topographic map geology cannot even be thoroughly studied, and the publication of the results of geologic investigation is very imperfect without a good map; but with a good map thorough investigation and simple, intelligible publication is possible. Impelled by these considerations the Survey is making a topographic map of the United States. (Powell, 1885, and quoted by Rabbitt, 1980, p. 92)

Powell and a National Map

In addition to taking a strong position with the National Academy of Sciences, Powell delivered an equally strong message to Congress. Testifying at least twice before the Allison Commission, a joint commission on the organization of Federal scientific work, Powell delivered a justification for topographic mapping that, in addition to being prophetic, is as compelling and meaningful today as it was in the 1880s. Historian Mary Rabbitt characterized his testimony as follows:

The topographic maps made by the Geological Survey, . . . represented natural features, such as streams and bodies of water, valleys, hills, and mountains and showed only certain cultural features such as important highways, canals, railroads, and wagonroads, the sites of cities, towns, villages, and railway stations. The purposes served by such topographic maps were many. They were used first of all as bases for geologic maps. They could be used for the purposes of the Signal Service, [precursor of the National Weather Service, but housed in the Army] and for all purposes of military maps except battle maps. They were valuable to cities and towns in securing a proper supply of water. As the maps were constructed with grade curves [contours of elevation] and every elevation and depression was represented "with mathematic accuracy," they could be used in laying out the courses of aqueducts and in planning and protecting waterworks so that the catchment areas would not be "corrupted by foul and pestilential agencies." The maps showed the relative levels of all parts of the country to each other and to the level of mean tide, so they could be used to determine the possibility and practicability of draining marsh- and swamplands. They were

useful in planning and laying out highways, such as wagonroads, canals, and railroads. In conjunction with geologic maps, they could be used for determining the sites of artesian wells. The topographic maps were of the highest importance in areas where agriculture was dependent on artificial irrigation and streams had to be conducted from their natural channels by canals. As an illustration, he [Powell] said that every town in Utah had been moved, perhaps twice on average, after it had been built, when it was found that the water could not be economically brought to it or economically controlled. The studies that he [Powell] had made of topographic methods and of the economics of topographic surveys grew out of his interest in these arid lands, for he found in traveling through that region the people were searching for an economic but simple and practical means of learning how the streams could be utilized. The topographic map would have a high value in furnishing data to engineers to make plans for protecting the flood plains, the parts of the country that were annually or occasionally inundated by the great rivers. . . . The maps were also used by local surveyors, for general information, in the schools and for a variety of scientific purposes by naturalists, ethnologists, and archeologists. In fact, it was impossible in a reasonable space to set forth all the purposes served by the maps made by the Geological Survey. The coast charts of the Coast and Geodetic Survey did not subserve these purposes because they were constructed on another plan and for another purpose. (Rabbitt, 1980, p. 107-108)

Powell's final statement to the Allison Commission was "that the map can be completed on the present plan, with the present organization, within twenty-four years, but the demands for such a map are so urgent that the work ought properly to be completed in a shorter period. Since the organization of the Geological Survey, Congress has, by increased appropriations, expanded its work from year to year, and the Director has earnestly desired and hoped that this growth would continue, so that a map of the whole country [i.e., a national map] could be completed by the year 1900, and he has steadily and vigorously worked to that end. He has tried hard to develop a plan which should not be impracticable on account of excessive cost and which should not be without substantial value by reason of imperfect methods and results. **He has also endeavored to develop the plan in such a manner that no work would be lost, even though the needs of the distant future should demand more elaborate work than the wants of the present time, and that all work done should have enduring value.**" [Emphasis added.] Through his vision, leadership, and persistence, and undoubtedly aided by this testimony, Major John Wesley Powell had established himself as one of the leading scientists in Washington. His testimony was reprinted in *Science* and given wide circulation. (Rabbitt, 1980, p. 109)

The plan for topographic surveying and cartographic systems described to the Allison Commission was formally announced in the Survey's next annual report. Map sheets would be published at three scales, 1:62,500, 1:125,000,

and 1:250,000, the choice of scale depending on the present or prospective density of settlement, the economic importance of the area, the complexity of the geology, and the degree of detail in topography. The [map] sheets were to be engraved on copper, with three plates for each — hydrography in blue, the hypsography [elevation] in brown, and the projection lines, lettering, and culture in black. **A prime consideration in developing this system, the Director said in the announcement, was that “the map once constructed should be enduring, that the expense of frequent resurveys may be avoided.”** [Emphasis added.] (Rabbitt, 1980, p. 109)

Powell served as Director for 13 years (1881-94) and upon his resignation, Charles D. Walcott, the third Director, further fortified the USGS national mapping program by redirecting and reorganizing its activities and arranging for the USGS topographers to come under the civil service.

The Past as Prologue

I present these extended passages on the rationale for a national map from the late 19th century for several reasons. First, in accord with Powell’s vision for topographic mapping, the Survey’s tradition of cartographic excellence has served the Nation well for 125 years and provides us with a solid platform for further growth. Powell’s championing of one geodetic system and one topographic system marked the continuing importance of what is still today a core function of Federal mapping—the development of consistent national standards. Powell’s understanding that more detailed mapping would be required by future generations eventually led to the nearly national (save Alaska) 1:24,000-scale topographic map series, and arguably, even to our most recent focus on extremely detailed mapping of urban areas. The standard topographic series was started in the 1930s and essentially completed for the conterminous United States in 1991. Thirty-three million person hours and approximately \$1.6 billion were invested in this national effort, a remarkable engineering feat. The 55,000 topographic quadrangles were printed with many of the same techniques described by Powell in 1885.

Latent in Powell’s examples of the benefits of accurate topographic maps for agriculture and town development is an implicit assertion of the economic benefits of a national map. According to a study conducted by the Illinois State Geological Survey in 2000, the USGS topographic (1949-59) and geologic (1960-78) mapping of Kentucky at 1:24,000 scale, in cooperation with the State of Kentucky, returned huge economic and other dividends to the taxpayers (Bhagwat and Ipe, 2000). A British analysis (described in a following article in this issue by Murray and Shiell, “A New Geographic Information Framework for Great Britain”) demonstrates that a significant return can be expected on similar investments in geospatial data.

Unforeseen by Powell, another benefit of the comprehensive maps he advocated was brought to light by the events of September 11, 2001. In the ensuing heightened concern for national security, a blanket of standard 1:24,000-scale USGS topographic maps provided the only coast-to-coast, border-to-border coverage of our national critical infrastructure. These maps alone comprehensively portray airports, dams, reservoirs, power plants, pipelines, and structures in relation to the terrain, roads, and rivers. Some other maps may have better national coverage of one specific infrastructure component— aeronautical charts and airports, for example — and some other maps

may have better coverage of all the infrastructure components over small areas — a city map, for example. No organization, however, save the USGS, is charged with supplying national coverage for all infrastructure components and other relevant geographic data. When one considers that the average age of our topographic maps is now more than 23 years, John Wesley Powell’s strong argument for a national map begs to be reinvested.

In thinking again of the origin and early years of the USGS, it is both surprising and instructive to note that many governance issues, both positive and negative, that are referenced in the historical account still exist today. Issues about organizational placement and consolidating mapping functions are still debated. Rivalries still occur between and among civilian and defense agencies. State and local organizations are still waiting for some of their geospatial needs to be met by the Federal Government. The USGS still seeks advice and counsel from the National Academy of Sciences. Two recent National Academy of Sciences reports furnish both accolades and constructive criticism of our program. *Research Opportunities in Geography at the U.S. Geological Survey* and *Weaving a National Map* make recommendations about re-exerting leadership in the geographical sciences, continuing to strengthen our partnerships with State and local governments, other Federal agencies, universities, and the private sector, and in building *The National Map* (National Research Council, 2002 and 2003).

Mapping the Future

With *The National Map*, a new perspective on geographic base information, the USGS demonstrates its dedication to meet the Nation’s needs for critical spatial information. In implementing this vision, the USGS is redefining its mapping activities and seeking creative partnerships to ensure that current, complete, consistent, and accurate information is readily available and useful to the Nation. *The National Map* will provide publicly available core geographic data about the United States and its territories that other government agencies can extend, enhance, and reference as they concentrate on maintaining other data that are unique to their needs. *The National Map* will be a foundation of information to which the private sector can contribute feature content and to which proprietary datasets can be linked to provide access to higher resolution data and enriched attribute information. *The National Map* will promote cost effectiveness by minimizing the need to find and integrate geographic base data each time they are required for countless needs and applications.

The USGS has played a role in many mapping advances including both technology and governance activities. The articles contained in this special issue of *Photogrammetric Engineering and Remote Sensing* on *The National Map* relate advances in both these areas. As the discipline and the marketplace evolve, accessing geospatial data in near real time is becoming a reality. With the contributions of our private sector partners, Web services — specifically Web mapping services — allow the integration and dissemination of geospatial data from multiple partners in single applications. In governance, *The National Map* depends on data sharing and data stewardship partnerships. Each of the articles in this issue highlights a particular segment of our partnership community — international partners, other Federal agencies, State and local governments, and the private sector. Each of these partners in one way or another is building *The*

continued on page 1090

continued from page 1089

National Map. International partners are building national mapping programs in their countries that mirror many of the concepts embedded in *The National Map*.

An important detail in the United States is that we are working together to build a *national map* — not merely a *Federal map*. While it is true that the community has relied heavily on the Federal investment in geospatial data, we recognize that in many cases, if not most, higher resolution and more current data exist at the State and local levels. As an organization funded by taxpayers, we are committed to leveraging investments in these data regardless of their origin. With the continued involvement of all levels of government, the private sector, and the public, we can ensure that *The National Map* will be the base geographic information foundation that America needs for the 21st century.

As the USGS celebrates its 125th anniversary in 2004, I am increasingly enthusiastic about our efforts, and those of our partners, to build *The National Map*. Ensuring the availability of accurate, comprehensive, up-to-date, and integrated geographic information, science, and knowledge for the Nation is surely even more essential today than it was when John Wesley Powell extolled the virtues of a national map to Congress in 1885.

References

Bhagwat, Subhash B. and Ipe, Viju C., 2000, *Economic Benefits of Detailed Geologic Mapping to Kentucky*, Special Report 3: Champaign, IL, Illinois State Geological Survey, 39p.

National Research Council, 2002, *Research Opportunities in Geography at the U.S. Geological Survey*, Washington, DC: National Academy Press, 128 pp.

National Research Council, 2003, *Weaving a National Map: Review of the U.S. Geological Survey Concept of The National Map*, Washington, DC: National Academy Press, 128 pp.

Powell, John Wesley, 1885, *The Organization and Plans of the United States Geological Survey*, American Journal of Science, 3d series, v. 29, p. 93-102.

Rabbitt, Mary C., 1979, *Minerals, Lands, and Geology for the Common Defence and General Welfare*, Volume 1, Before 1879, A History of Public Lands, Federal Science and Mapping Policy, and Development of Mineral Resources in the United States: Washington, D.C., U.S. Government Printing Office, 331 p.

Rabbitt, Mary C., 1980, *Minerals, Lands, and Geology for the Common Defence and General Welfare*, Volume 2, 1879-1904, A History of Geology in Relation to the Development of Public-Land, Federal Science and Mapping Policy, and the Development of Mineral Resources in the United States During the First 25 Years of the U.S. Geological Survey: Washington, D.C., U.S. Government Printing Office, 407 p.



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